MICROBIOLOGY

INTRODUCTION

Microbiology is the branch of science, which deals with the study of microorganism and their process is called as microbiology. *Antony Von Leeuwenhoek is known as father of microbiology* and *father of modern microbiology is Robert Koch*. Microbiology is the study of living organism of microscopic, which include bacteria, fungi, algae, protista, viruses, etc. It is concern with their forms, structure, reproduction, physiology, metabolism and classification. It includes the study of their distribution in nature and relationship to other living organism. Their effects on human beings and on other animals and plants. Their abilities to makes physical and chemical change in our environment.

3.1 BACTERIA

Study of bacteria is called bacteriology. Linnaeous placed them under genus vermes. *Nageli* classified bacteria under schizomycetes. Bacteria are unicellular, microscopic organisms. These are the smallest cellwall having prokaryotic cell. They differ from animals in having a rigid cell wall and being capable to synthesize vitamins. Bacteria were first seen by a Dutch lens maker, *Antony Von Leeuwenhoek* (1683) who named them *animalcules*. *Louis Pasteur* (1822-95) made a detailed study of bacteria and proposed *germ theory of disease. Ehrenberg* (1829) was the first to use the *term bacterium. Robert Koch* (1881) found that some diseases like tuberculosis, cholera in man, and anthrax in cattle is caused by bacteria. *Lister* introduced antiseptic surgery he used carbolic acid for sterilization of surgical instrument. Pasturization theory was proposed by *Louis Pasteur*.

(1) **Occurrence and Distribution :** The bacteria constitute a highly specialised group of one celled plants. They are cosmopoliton. They flourish in our mouth and intestine. They live in the bodies of other organisms and their dead remains. Bacteria are not found in healthy blood, depth of some feets in the soil fire and healthy cell. Some thermophilic bacteria can tolerate the temperature upto $78^{o}C$ while in psychrophilic bacteria occurs upto the temperature of $-190^{o}C$. The features which contribute to their universal distribution are –

(i) Extremely simple structure.

(ii) Small size and consequent large surface–to–volume ratio. In order to maintain their small size, cell division occurs rapidly.

(iii) Resistance of vegetative cells to adverse environmental factors. Such as U.V. light desication. etc.

(iv) Formation of highly resistant endospores.

(v) Diversity in their modes of nutrition.

(2) **Plant characteristics :** The bacteria are microorganisms that possess rigid cell wall and when motile have flagella. They are unicellular organisms lacking true nucleus and membrane bounded cell organelles. The plant characteristics of bacteria are –

(i) Presence of a definite and rigid cell wall which in a few species contains cellulose.

(ii) The tendency of some to grow as filaments.

(iii) The ability of autotrophic bacteria to synthesize organic food from inorganic materials such as CO_2 and water.

(iv) Structure of the bacterium cell and reproductive methods are similar to that of certain algae.

(v) Ability to synthesize amino acids from inorganic nitrogen.

(3) **Size :** Bacteria are the smallest of all known cellular organisms which are visible only with the aid of microscope. They are 3 to 5 microns (1 μ = 1/1000 millimetre or about 1/25,000 inch) in length. A few species of bacteria are approximately 15μ in diameter.

(4) **Shape :** The shape bacteria usually remain constant. However, some of them are able to change their shape and size with changes in environmental conditions. Such bacteria, which change their shape, are called pleomorphic. The bacteria possess the following forms.

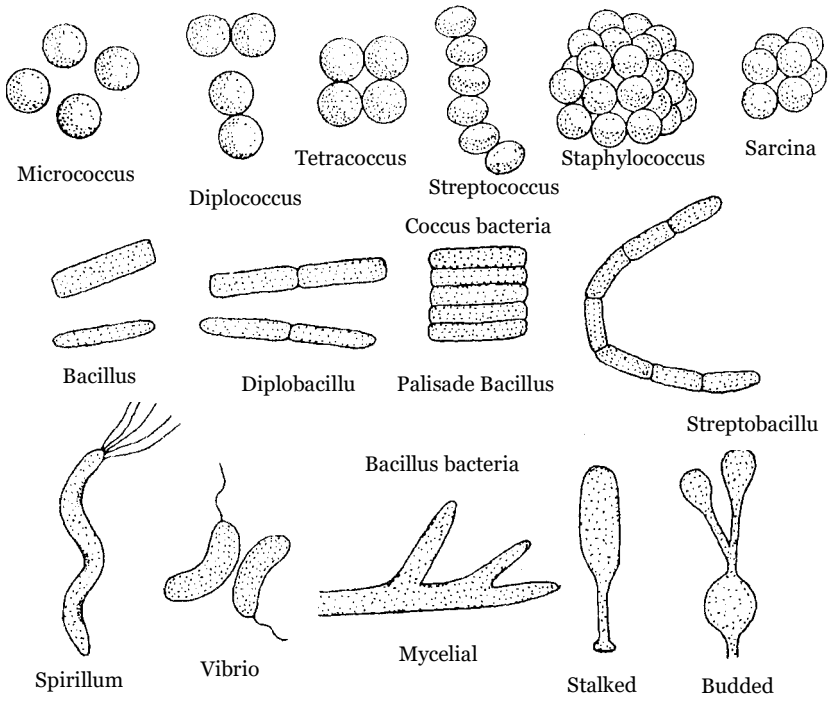


Fig Different forms of

(i) **Cocci :** (GK. Kokkos = Berry) They are oval or spherical in shape. They are called micrococcus when occur singly as in *Micrococcus,* diplococcus when found in pairs as in *Diplococcus pneumoniae,* tetracoccus in fours, streptococcus when found in chains as in *Streptococcus lactis,* staphylococcus when occurring in grape like clusters as in *Staphylococcus aureus* and sarcine, when found in cubical packets of 8 or 64 as in *Sarcina.*

(ii) **Bacilli** : They are rod–shaped bacteria with or without flagella. They may occur singly (bacillus), in pairs (diplobacillus) or in chain (streptobacillus).

(iii) **Vibrios :** These are small and 'comma like, kidney like. They have a flagellum at one end and are motile, vibrio bacteria has curve in its cell *e.g., Vibrio cholerae.*

(iv) **Spirillum (Spira = Coil) :** The spirillum bacteria (plural-spirilla). They are spiral or coiled like a cork-screw. The spirillar forms are usually rigid and bear two or more flagella at one or both the ends *e.g.* spirillum, spirochaete, etc.

(v) **Filament :** The body of bacterium is filamentous like a fungal mycelia. The filaments are very small *e.g.* Beggiota, Thiothrix etc.

(vi) **Stalked :** The body of bacterium posses a stalk *e.g.* Caulobacter.

(vii) **Budded :** The body of bacterium is swollen at places *e.g.* Retrodomicrobiom.

(5) **Flagellation :** Depending upon the presence or absence of flagella, the bacteria are of following types :–

(i) **Atrichous :** When the flagellum is absent it is called atrichous. *e.g. Pasturella, Lactobacillus*

(ii) **Monotrichous :** Only one flagellum is found at one end. *e.g. Vibrio, Cholerae.*

(iii) **Lophotrichous :** When a group of flagella is present at one end *e.g. Vibrio.*

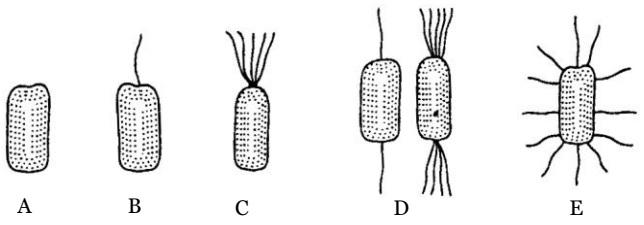


Fig : Different types of bacteria on the basis of flagellation : (A) Atrichous (B) Monotrichous (C) Lophotrichous (D) Amphitrichous (E) Peritrichous

(iv) **Amphitrichous :** When single or group of flagella is present at both the end *e.g. Nitrosomonas.*

(v) **Peritrichous :** A number of flagella are present all over the body. *e.g. E. coli.*

(6) **Staining of bacteria**

(i) **Simple staining :** The coloration of bacteria by applying a single solution of stain to a fixed smear is termed simple staining. The fixed smear is flooded with a dye solution for a specified period of time, after which this solution is washed off with water and the slide blotted dry. The cells usually stain uniformly. However, with some organisms, particularly when methylene blue is used, some granules in the interior of the cell may appear more deeply stained than the rest of the cell, indicating a different type of chemical substance.

(ii) **Gram staining :** This technique was introduced by *Hans Christian Gram in* 1884. It is a specific technique which is used to classify bacteria into two groups Gram +ve and Gram –ve. The bacteria are stained with weakly alkaline solution of crystal violet. The stained slide of bacteria is then treated with 0.5 percent iodine solution. This is followed by washing with water or acetone or 95% ethyl alcohol. The bacteria which retain the purple stain are called as Gram +ve. Those which become decolourised are called as Gram –ve. In general the wall of Gram +ve bacteria have simpler nature as compared to Gram –ve bacteria. *E.coli* is a Gram –ve bacterium. Gram negative bacterium can be seen with other stain safranin.

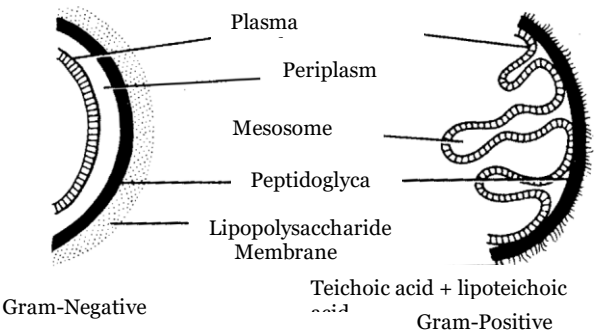


Fig : Difference between cell walls of Gram-negative and Gram-

The most plausible explanations for this phenomenon are associated with the structure and composition of the cell wall. Differences in the

thickness of cell walls between these two groups may be important the cell walls of Gram-negative bacteria are generally thinner than those of Gram- positive bacteria. Gram-negative bacteria contain a higher percentage of lipid (11 to 22%) than do Gram-positive (1 to 4%), bacteria, Experimental evidence suggests that during staining of Gram-negative bacteria. The alcohol treatment extracts the lipid, which results in increased porosity or permeability of the cell wall. Thus crystal violet- iodine (CV-I) complex can be extracted and the color of the safranin counterstain. The cell walls of Gram-positive bacteria, because of their different composition, lower lipid content, become dehydrate during treatment with alcohol. The pore size decreases, then permeability is reduced, and the CV-I complex cannot be extracted. Therefore these cells remain purple-violet.

S.No.	**Gram - Positive**	**Gram - Negative**
(1)	Cell wall thick (250 – 300 Å).	Cell wall thin (100 – 150 Å)
(2)	Cell wall homogenous.	Cell wall heterogenous.
(3)	Cell wall single layered.	Cell wall 3-layered.
(4)	Cell wall more rigid.	Cell wall less rigid
(5)	Cell wall made up of mucopeptide (80%).	Cell wall made up of lipoprotein, lipopolysaccharide and mucopeptide.
(6)	Teichoic acid (5 – 10%) present.	Teichoic acid absent.
(7)	Spore producing forms included.	No spore producing form.
(8)	Polar flagellum usually absent.	Polar flagellum usually present.
(9)	Contain *Mg*-ribonucleate.	*Mg*-ribonucleate absent.
(10)	Not soluble in 1% KOH.	Soluble in 1% KOH.
(11)	May produce exotoxins.	May produce endotoxins.
(12)	Sensitive to penicillin.	Not sensitive to penicillin.
(13)	L-lysin present in peptide	Diamino palmilic acid present in peptide.
(14)	O-antigen absent.	O-antigen present.

(7) **Structure of bacterial cell**

(i) **Capsule :** In a large number of bacteria, a slimy capsule is present outside the cell wall. It is composed of polysaccharides and the nitrogenous substances (amino acids) are also present in addition. This slime layer becomes thick, called capsule. The bacteria, which form a capsule, are called

capsulated or virulent bacteria. The capsule is usually found in parasitic forms *e.g. Bacillus anthracis, Diplococcus pneumoniae, Mycobacterium tuberculosis*.

Function of capsule

(a) It provides protection against phagocytosis and antibiotics.

(b) Capsule also protects the cell against dessication and viral attack.

Type of capsule

(a) **Homopolysaccharide :** When capsule are made by one type sugar *e.g.* Streptococcus mutans.

(b) **Heteropolysaccharide :** When capsule are made by many type sugar *e.g.* Streptococcus pneumonae.

(ii) **Cell wall :** 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.

(a) 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 α- or D - alanine, glutamic acid and diaminopimelic acid are also found.

(b) One of the unique components of cell wall of bacteria is peptidoglycan or mucopeptide or murien (made of mucopolysaccharide + poly peptide).

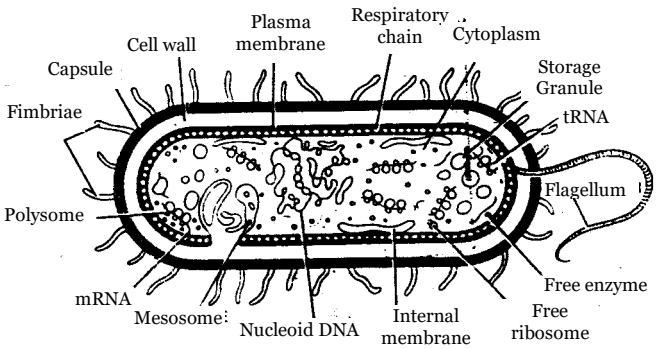


Fig : Electron microscope structure of a bacterium cell

(c) In peptidoglycan, NAG and NAM are joined by short peptide chains or cross bridges of amino acids.

(d) Outer layer of cell wall of Gram –ve bacteria is made up of lipopolysaccharides and cell wall of Gram +ve bacteria of teichoic acid.

(e) The cell wall of Gram positive bacteria is much thicker and contains less lipids as compared to that of Gram +ve bacteria.

(iii) **Plasma Membrane :** Each bacterial cell has plasma membrane situated just internal to the cell wall. It is a thin, elastic and differentially or selectively permeable membrane that allows passage of dissolved substances in and out of the cell. It is composed of large amounts of phospholipids, proteins and some amounts of polysaccharides but lacks sterols. The plasma membrane of bacteria provides site for most of the anabolic and catabolic pathways. It is characterised by possessing respiratory enzymes, which are bound to its inner surface some exoenzymes are also associated with its outer surface which catalyze digestion of insoluble materials.

(a) **Mesosome :** On the plasma membrane generally at mid point, there are present some circular coiled bodies called mesosomes. If plasma membrane is stretched then mesosomes are disappeared. So mesosomes are simply infoldings of plasma membrane. Mesosomes contain respiratory enzymes like oxidases and dehydrogenases and hence they help in respiration. Hence mesosomes are also known as "mitochondria of bacterial cell" or chondrioides. Mesosomes are more prominent in Gram +ve bacteria.

- Mesosomes are present at mid point, so they help in equal distribution of nuclear material during binary fission.
- It help in secretion and synthesis of material for cell wall.
- It receive DNA during conjugation and DNA replication enzyme.
- Mesosome participate in the formation of septa during cell division.

(iv) **Cytoplasm and cytoplasmic inclusions :** The cytoplasm is a complex aqueous fluid or semifluid ground substance (matrix) consisting of carbohydrates, soluble proteins, enzymes, co-enzymes, vitamins, lipids, mineral salts and nucleic acids. The organic matter is in the colloidal state.

The cytoplasm is granular due to presence of a large number of ribosomes (about 20,000 to 30,000), which occur singly or in small groups called polyribosomes. The ribosomes in polyribosomes are held together by means of messenger RNA. The ribosomes of bacteria are smaller (70S) as compared to those of eukaryotic cells. Ribosomes in bacteria are found in the form of polyribosome. Membranous organelles such as mitochondria, endoplasmic reticulum; Golgi bodies, lysosomes and vacuoles are absent. In some photosynthetic bacteria the plasma membrane gives rise to large vesicular thylakoids which are rich in bacteriochlorophylls and proteins.

(a) **Volutin granules :** These are so called because they were first reported in Spirillum volutans bacteria. These are also known as metachromatic granules, which are composed of polyphosphate. They stain an reddish purple colour with dilute methylene blue. By electron microscopy they appear as round dark areas. Volutin serves as a reserve source of phosphate.

(b) **Fatty acids granules or poly-β-hydroxy butyric acid granules (PHB) :** These are polymer of lipid like material and chloroform soluble which are often found in aerobic bacteria especially under high carbon low nitrogen culture conditions. Granules can serve as a reserve carbon and energy source. PHB granules can be stained with lipid soluble dyes such as nile blue. By electron microscopy they appear as clear round areas.

(c) **Glycogen and sulphur granules :** Glycogen are also known as polysaccharide granules. It can be stained brown with Iodine. By electron microscopy they appear as dark granules. Another type of inclusion is represented by the intracellular globules of elemental sulfur that may accumulate in certain bacteria growing environments rich in hydrogen sulfide.

(v) **Nucleoid :** It is also known as genophore, nacked nucleus, incipient nucleus. In contrast to eukaryotic cells, bacterial cells contain neither a distinct membrane enclosed nucleus nor a mitotic apparatus, However, they contain an area near the center of the cell that is regarded as a nuclear

structure. There is present nuclear material DNA. DNA in bacteria is double helical and circular. It is surrounded by some typical protein (polyamine) but not histone proteins. Histones (basic proteins) are altogether absent in bacteria. This incipient nucleus or primitive nucleus is named as nucleoid or genophore.

(vi) **Plasmid :** In addition to the normal DNA chromosomes many bacteria (*e.g.* E.coli) have extra chromosomal genetic elements or DNA. These elements are called plasmids. Plasmids are small circular double stranded DNA molecules. The plasmid DNA replicates independently maintains independent identity and may carry some important genes. Plasmid terms was given by *Lederberg* (1952). Some plasmids are integrating into the bacterial DNA chromosome called episomes. Plasmids are following type.

(a) **F-factor or fertility factor or F-plasmid :** Which is responsible for transfer of genetic material from donar to recepient bacteria.

(b) **R-factor or resistance factor or R-plasmid :** It provides resistance against drugs. Some of the R-plasmid can be transferred to other cells by conjugation, hence the term infectious resistance. Each form of resistance is due to a gene whose product is an enzyme that destroys a specific antibiotic.

(c) **Colicinogenic factor :** Which produces 'colicines' which kill other bacteria (other than which produce these colicines).

(8) **Flagella :** These are fine, thread-like, protoplasmic appendages which extend through the cell wall and the slime layer of the flagellated bacterial cells. These help in bacteria to swim about in the liquid medium. Myxobacteria donot has flagella and move by gliding movement. Bacterial flagella are the most primitive of all motile organs. Each is composed of a single thin fibril as against the 9+2 fibrillar structure of eukaryotic cells. It consists of a few fine fibrils twisted tightly together into a rope-like helical structure. The flagellum is composed entirely of flagellin protein.

According to Low and Hanson (1965), bacterial flagellum is composed of globular subunits arranged in helices of various kinds.

The diameter of each subunit is about 40-50Å. These subunits are arranged around a hollow axis. A flagellum is usually 4.5 μ long and 120-185 Å in diameter. Flagellum is attached to cell membrane by a special terminal hook, which is attached to the basal body called (bleferoplast). A bacterial flagellum can be divided into three parts.

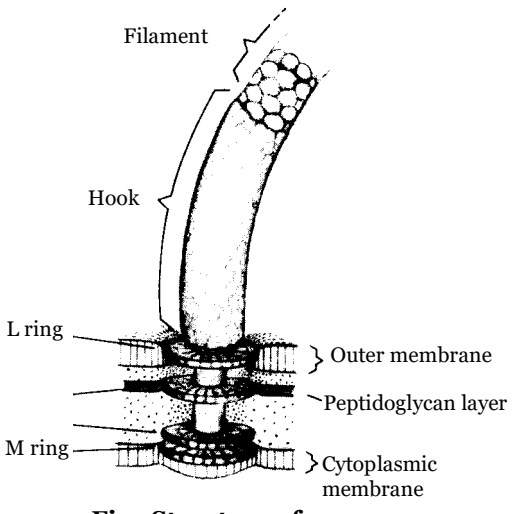


Fig : Structure of

(i) **Basal granule :** It is like a rod it lies with in the cell wall and cell membrane and bears ring like swellings in these regions.

(ii) **A hook :** It represent the middle and thickest part of flagellum. Hook is curved tubular structure which connects the

filament with the basal body.

(iii) **Filament :** It represents cylindrical hollow structure made up of protein monomers.

(9) **Pili or Fimbriae :** Besides flagella, some tiny or small hair-like outgrowths are present on bacterial cell surface. These are called pili and are made up of pillin protein. They measure about 0.5–2μm in length and 3–5μm in diameter. Pilin are arranged helically around a central hollow core. These are present in almost all Gram-ve bacteria and few Gram +ve bacteria. These are of 8 types I, II, III, IV, V, VI ,VII, and F types. I to F are called sex pili.

Functions

(i) The function of pili is not in motility but they help in the attachment of the bacterial cells.

(ii) Some sex pili acts as conjugation canals through which DNA of one cell passes into the other cell.

(10) **Normal Growth cycle or Growth curve of bacteria :** When we inoculate a fresh medium with a given number of cells, determine the bacterial population intermittently during an incubation period of 24*h* (more or less), and plot the logarithms of the number of cells versus time, we obtain a curve of the type illustrated figure from this it can be seen that there is an initial period of what appears to be no growth (the lag phase), Followed by rapid growth (the exponential or logarithmic phase), then a leveling off (stationary phase), and finally a decline in the viable population (death or decline phase). Between each of these phases there is a transitional period (Curved portion). This represents the time required before all cells enter the new phase.

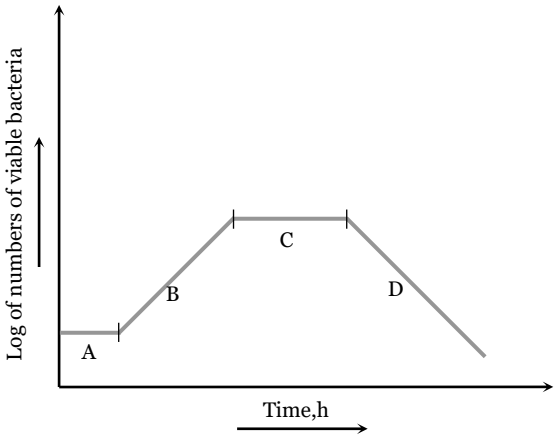


Fig : Growth curve of bacteria

(11) **Reproduction in bacteria :** Methods of reproduction are following.

Vegetative reproduction

(i) **Budding :** It is a rare method of reproduction and is reported in *Bigidi bacterium bifidus*.

(ii) **Binary fission :** It is the most common type of reproduction in bacteria during favourable conditions. When the conditions of food, water and temperature are favourable. Here bacterial cell

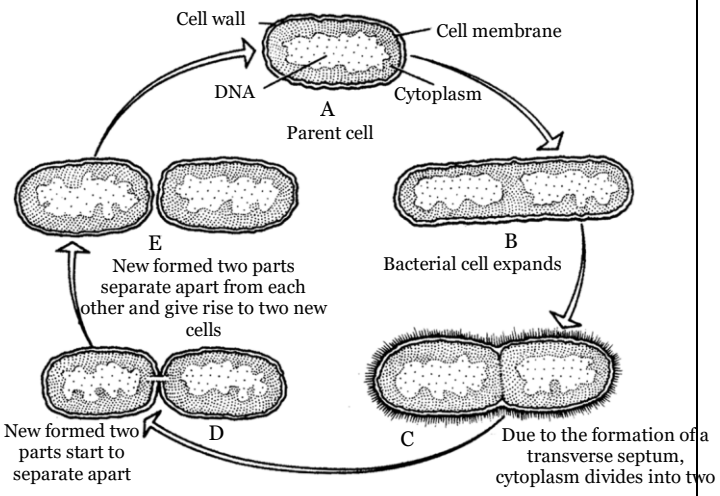


Fig : Different stages in the binary fission of a rod shaped bacteria

divides by a constriction into two halves. At the same time nuclear material elongates and divides into 2 equal halves probably helped by mesosomes. During this process, the single circular chromosomes duplicates it self a long with DNA duplication under favourable conditions of binary fission. Bacterial cell divides into two after every 20 minutes and at this rate in 24 hours period, a single bacterial cell produces 4×10^{21} bacteria, but only about 10% of them survive, The speed of binnary fission is decreased due to low temperature. Therefore, food is preserved in the cold storage. The cause of food spoilage and bacterial infection is the rapid multiplication of bacteria.

Asexual reproduction

(i) **By endospore formation :** During unfavourable condition, highly resistant single spore is formed inside the bacterial cell, which is known as endospore. (Endo means inside or within + spore) Endospore means spore inside bacterial cell or cell inside cell.

(a) Endospore formation is more common in rod-shaped bacterial or bacillus forms. Position of single endospore may be terminal or sub-terminal or intercalary.

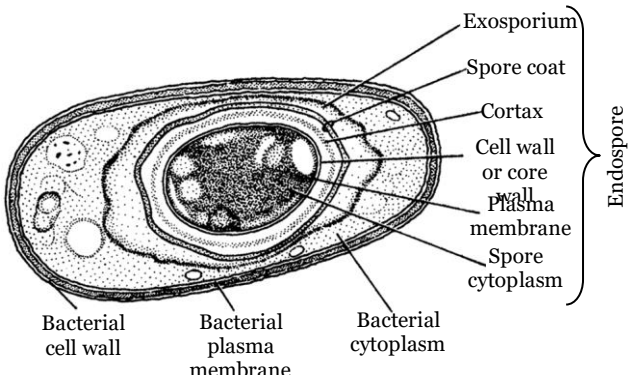


Fig : Detailed structure of endospore

(b) Endospore is having a characteristic structure, *i.e.,* having outer thin exosporium followed by one or many layered spore coat, followed by cell many concentric layers of cortex, which if followed by cell wall, cell membrane and matrix.

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

(d) When favourable conditions come, outer layers rupture and active bacterial cell comes out. So this is a method of perennation (*i.e.,* to tide over unfavourable condition) and some people say it " reproduction wihtout multiplication".

(e) The bacterial spore or endospore is perhaps the most resistant living structure known to science.

(f) Tetanus causing and anthrax causing bacteria produce endospores.

(ii) **By conidia** : These are found in filamentous bacteria like streptomyces. The conidia are spore like structure formed in chains. Each conidium gives rise to a new bacterium.

(iii) **By zoospores :** Motile spores are formed in Rhizobium bacteria, but are rare in other bacteria

Sexual reproduction (Genetic recombination or parasexuality)

Sexual reproduction in bacteria is not of the kind as found in eukaryotic organisms. In case of bacteria, the sex organs are not formed, meiosis and mitosis does not occur, the two gametes do not fuse with each other and the diploid zygote (having two set of chromosomes within a true nucleus) is

not formed. Instead, a portion of genetic material (DNA) is transferred from a 'donor' cell (male) to a 'recipient' cell (female) making it an; incompletely diploid zygote. The process is actually called genetic 'recombination' which occurs in three ways.

(i) **Transformation :** In this process one kind of bacterium is transformed into another kind. It takes place by transferring DNA from one bacterium to another bacterium. It was first reported by *Griffiths* (1928). *Avery, Mcleod* and *Mc Carthy* (1944) perform a detailed study of transformation in *Diplococcus pneumoni.* In this experiment one type bacteria are virulent (pathogenic) having an extracovering of polysaccharids. These are called capsulated bacteria or (rough bacteria) or R-bacteria. Another type are avirulent non-pathogenic are called non-capsulated bacteria or (smooth bacteria) or S bacteria. This experiment was completed in 4 steps.

(a) Avirulent strain $\xrightarrow{\text{Inject in mice}}$ Healthy mice.

(b) Virulent strain $\xrightarrow{\text{Inject in mice}}$ Mice die.

(c) (Heat killed virulent strain) Bacterial strain $\xrightarrow{\text{Inject in mice}}$ Healthy mice.

(d) Avirulent +(Heat killed virulent bacterial strain) $\xrightarrow{\text{Inject in mice}}$ Mice die

In his experiments, *Griffith* mixed R-types with the heat killed S-type cells and injected them into a laboratory mice. He observed that non- capsulated R-type cells became converted into capsulated types. This shows that a small portions of DNA from heat killed S-type cells have entered into non-capsulated R-type cells and transformed them into capsulated types.

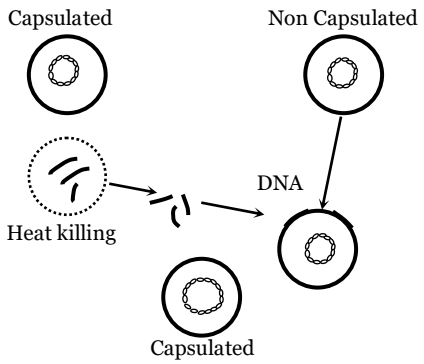


Fig : Transformation of a non capsulated *pneumococcus bacterium* into a capsulated type

Transformation are not common in nature because the large fragments of DNA molecules can not pass through the recipient's cell walls or membranes, However, this process has been made possible experimentally by protoplast fusion and other related techniques. It has been shown that small amount of DNA (*i.e.*, less than 5% of the total genome) is actually transferred during transformation. Some of the important characters transferred from one bacterial cell to another bacterial cell by transformations are development of pathogenicity, drug resistance, formation of capsules and change in the nutritional patterns.

(ii) **Transduction :** Transduction is the process in which the genetic material (a portion of DNA) of one bacterium is transferred to another through the agency of temperate (lysogenic) bacteriophage (*i.e.*, bacterial virus). The process was discovered by *Zinder* and *Lederberg* (1952) in bacteria-*Salmonella typhimurium*.

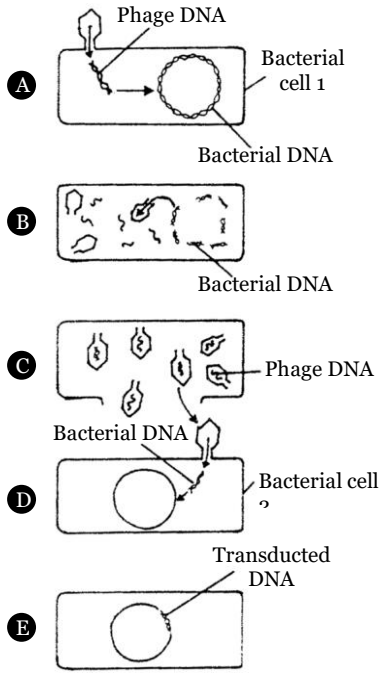


Fig : Transduction where fragment of one bacterial cell is passed on to another bacterial cell through the agency of a phage

During this process a donor bacterial cell gets infected with a bacterial virus. The viral DNA, instead of multiplying itself, becomes associated and integrated with bacterial DNA. Thus the genes of bacterium get linked with the genes of virus. It is followed by the multiplication of virus inside the bacterial cell.

Bacterial cell resulting in the formation of normal (containing viral DNA) and defective (containing broken fragments of the host DNA) bacteriophage. The defective viruses containing the fragments of bacterial DNA are liberated along with the normal viruses after the lysis of bacterial cell. These viruses attacks the other bacterial cells infection of a recipient cell by a normal bacteriophage usually leads to lysis. A few recipient bacterial cells, however, become infected with a defective transducing bacteriophages. Thus the viral DNA, which consists of bacterial DNA, gets associated and integrated with the recipient bacterial cell completing the process of transduction. In this way, the DNA fragment of one bacterial cell is transferred to another bacterial cell.

Transduction has been observed in many bacterial genera such as Salmonella, Escherichia, Shigella, Bacillus, pseudomonas, etc. Two kinds of transduction can be distinguished.

(a) Generalised (non-specific) transduction which can transfer any phage sized fragment of host DNA.

(b) Specific transduction which is restricted to the transfer of specific portion of DNA.

(iii) **Conjugation :** Transfer of DNA by the process of conjugation was first described by two American scientists *Lederberg* and *Tatum* (1946) in *Escherichia coli*. It occurs between two sexually different strains of the bacteria (*E.coli*)- one acts as donor of genes (male) and the other as recipient of genes (female) both are haploid. The donor (or male) cells prossess sex-factor or fertility factor (F-factor). F-factor is a small genetic particle of circular DNA. It replicates at the time of cell division and inherited by the progeny. The F-factor codes for the special type of protein that determines the formation of sex pili in donor cells and formation of conjugation bridge or conjugation tube between the donor and recipient cells. The F-factor may remain free in the cytoplasm (*i.e.*, independent of bacterial chromosome) or it may be integrated with the bacterial chromosome. If it remains free in the cytoplasm, the bacterial cell is called F^+ strain donor (Male) and if it is attached to bacterial chromosome, the cell is called Hfr (High frequency of recombination) strain donor (Super male).

During the conjugation between F^{+--} (male) and F^- (female) strains, the two bacterial cells come close to each other in pair. The F^+ cell sends sex pilus which gets attached to F^- cell forming a conjugation bridge between them. The F-factor then divide into two, out of which one remains in the donor cell and the other migrates into recipient cell through the conjugation bridge. As a result, the F^- cell now becomes F^+ cell. Thus, a conjugation between F^+ and F^- strains always yields F^+ progeny. $(F^+ + F^- \rightarrow F^+)$.

During the conjugation between Hfr (donor) and F^-(recipient), the two come close to each other forming a pair. The sex pilus develops from Hfr and gets attached to the wall of F^- cell. The common wall dissolves and a conjugation bridge is established. The chromosome of Hfr breaks at one point and both the strands of broken end begin to replicate. The chromosome of Hfr becomes linear and have a directional orientation so that the daughter DNA moves into F^- cell through the conjugation bridge. The migration of DNA into F^- is such that the F-factor is last to enter. Sometimes complete transfer of DNA from Hfr to F^- is interrupted due to repture at some point, called R-point. Since complete transfer of DNA occurs only rarely, the F-factor does not usually enter the F^- and the resulting zygote is not converted to F^+. Thus, the newly formed zygote receives only those genes from Hfr which have been transferred during conjugation.

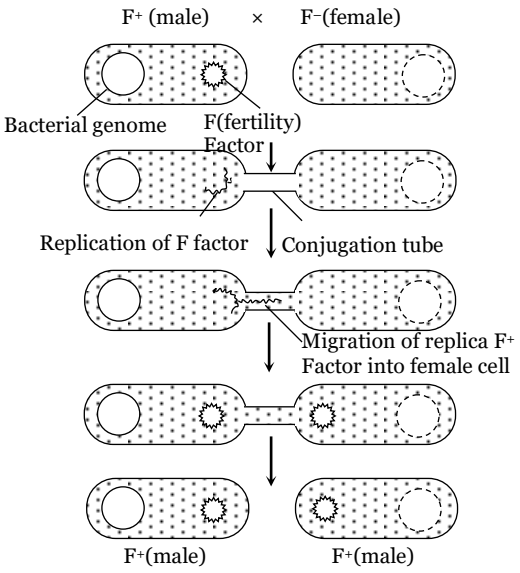


Fig : Conjugation between F^+ male and F^- female

Sex-duction : As stated earlier the F-factor (fertility factor or sex-factor) remains free in the cytoplasm of F^+ strain donor cell and remains attached to bacterial chromosome in Hfr strain donor cell. Sometimes the F-factor gets detached from the bacterial chromosome of Hfr strain cell and resumes an independent status inside the cytoplasm. During faulty separation from the chromosome of Hfr, the F-factor sometimes carries away a small portion of chromosomal DNA along with it. Such F-factor with extra DNA, when transferred from donor to recipient cell during conjugation, becomes part and parcel of recipient chromosome making it heterozygous (or partial diploid). This process is called Sex-duction.

Such F-factor with extra DNA, when transferred from donor to recipient chromosome making it heterozygous (or partial diploid). This process is called conjugation. The bacterium which shows genetic recombination after conjugation is called “Merozygote”.

(12) **Respiration in bacteria :** With respect to oxygen requirement and mode of cellular respiration, bacteria distinctly belong to two broad categories- (i) aerobic and (ii) anaerobic. These are further divided into obligate and facultative types. thus, the bacteria can be grouped into four general categories on the basis of their oxygen requirement.

(i) **Aerobic respiration**

(a) **Obligate aerobes :** These bacteria grow exclusively in presence of molecular oxygen and fail to survive in its absence, *e.g., Bacillus subtilis, Azotobactor, Arthrobactor, Mycobacterium,* etc.

(b) **Facultative anaerobes :** The aerobic bacteria which can also survive in absence of oxygen, *e.g., Aerobacter, Klebsiella, Pseudomonas,* etc.

(ii) **Anaerobic respiration**

(a) **Obligate anaerobes :** These bacteria grow and multiply in the absence of free oxygen. They fail to survive under aerobic conditions, *e.g., Clostridium botulinum*.

(b) **Facultative aerobes :** The anaerobic bacteria which can also survive in presence of oxygen, *e.g., Chlorobium limicola*.

(13) **Mode of nutrition in bacteria :** On the basis of mode of nutrition, bacteria are grouped into two broad categories. First is autotrophic and second is heterotrophic bacteria.

Autotrophic bacteria : These bacteria are able to synthesis their own food from inorganic substances, as green plants do. Their carbon is derived from carbon dioxide. The hydrogen needed to reduce carbon to organic form comes from sources such as atmospheric H_2, H_2S or NH_3**.** These are divided into two categories.

(i) **Photoautotrophic bacteria :** These bacteria are mostly anaerobic bacteria. They use sunlight as source of energy to synthesize food. But unlike other type of photosynthesis as found in eukaryotic cells, they do not "split water" to transfer energy or to obtain reducing power. Instead they split hydrogen sulphide, thiosulphate, hydrogen or some other organic compound and oxygen is not evolved as a byproduct. They possess a pigment called bacteriochlorophyll which is different from the chlorophyll pigment found in higher plants. This is known as anoxygenic photosynthesis. *e.g.* **Green sulphur** (*thiothrix*) and **purple sulphur** (*chromatiun*) bacteria. They can perform photosynthesis in far-red light. Rhodospirillum bacteria fixes CO_2 into carbohydrate (Photoautotrophic).

The green sulphur bacteria such as Chlorobium sp. and *Chloropseudomonas* sp., contain the pigment bacterioviridin (similar to chlorophyll) and thrive well in illuminated environments. These bacteria produce chemical sulphur by removing hydrogen from hydrogen sulphide.

$$6CO_2 + 12H_2S \xrightarrow{\text{Light}} C_6H_{12}O_6 + 12S + 6H_2O + \text{Energy}$$

The purple sulphur bacteria such as Thiospirillum sp. and Chromatium sp., contain the pigments bacteriochlorophyll and carotenoids. Theses bacteria utilize inorganic sulphur compounds, selenium compounds or molecular hydrogen.

$$6CO_2 + 15H_2O + 3Na_2S_2O_3 \xrightarrow[\text{Propyl alcohol}]{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6NaHSO_4 + \text{Energy}$$

The purple non-sulphur bacteria posses the pigment bacteriochlorophyll and accomplish photoreduction of carbondioxide in presence of alcohol, organic acids, etc., *e.g.,* Rhodospirillum sp. Rhodomicrobium sp and Rhodopseudomonas sp.

$$6CO_2 + 12CH_3CHOHCH_3 \xrightarrow{\text{Light}} C_6H_{12}O_6 + 12CH_3COCH_3 + 6H_2O$$

The photoautotrophic bacteria thrive well below the surface of lakes and ponds where oxygen content is low and reduced sulphur or other compounds are available.

(ii) **Chemoautotrophic bacteria :** Some bacteria manufacture organic matter form inorganic raw materials (such as carbon dioxide) and utilize energy liberated by oxidation of inorganic substances present in the external medium such as ammonia, ferrous ion, nitrates, nitrites, molecular hydrogen, etc. The energy liberated from exergonic chemical reactions is trapped in the ATP molecules which is used in carbon assimilation to synthesize organic matter. There are several types of chemoautotrophic bacteria which are commonly named after the chemical compound they use as source of energy.

(a) **Sulphur bacteria :** These bacteria derive energy by oxidizing hydrogen sulphide or molecular sulphur. Beggiatoa, a colourless sulphur bacterium oxidises hydrogen sulphide (H_2S) to water and sulphur. The energy released is used up and the sulphur granules are deposited inside or outside the body of bacterial cell.

$$2H_2S + O_2 \longrightarrow 2H_2O + 2S + \text{Energy}$$

The elemental sulphur is oxidized to sulphuric acid by denitrifying sulphur bacteria (*e.g.*, thiobacillus denitrifying) and the energy released during the process is utilized in reproduction, growth and synthesis of other chemical substances.

$$2S + 2H_2O + 3O_2 \longrightarrow 2H_2SO_4 + \text{Energy}$$

These bacteria usually live at the mid-oceanicridge system (2.5 *km* below sea level). They generally live both freely and with in the bodies of giant tube worms. They can even survive under extremely acidic conditions. Examples of sulphur bacteria are- *Beggiatoa, Thiobacillus, Thiothrix* etc. They participate in the sulphur cycle in nature.

(b) **Iron bacteria :** Some chemoautotrophic bacteria such as *Gallionella, Sphaerotilus, Ferrobacillus*, etc, inhabit the environments where irons to ferric form. The Ferric ions are deposited in the form of soluble Ferric hydroxide and the energy released during the conversion is used in the production of carbohydrates.

$$4FeCO_3 + O_2 + 6H_2O \longrightarrow 4Fe(OH)_3 + 4CO_2 + \text{Energy (81 k.cal)}.$$

(c) **Hydrogen bacteria :** These bacteria utilize free molecular hydrogen and oxidize to hydrogen into water with the help of either oxygen or oxidize salts *e.g. Hydrogenomonas.* $2H_2 + O_2 \rightarrow 2H_2O + \text{Energy}$ (56 kcal).

(d) **Amonifying bacteria :** They oxidise protein and amino acid into NH_3 (amonia). *e.g.* Proteus vulgaris, *Bacillus mycoids*.

(e) **Nitrifying bacteria :** They oxidise ammonia to nitrites and then into nitrates.

$$NH_3 + O_2 \xrightarrow{\text{Nitrosomonas}} NO_2 + H_2O + \text{Energy} \quad \& \quad 2NO_2 + O_2 \xrightarrow{\text{Nitrobacter}} 2NO_3 + \text{Energy}.$$

(f) **Denitrifying bacteria :** They change nitrogen compound into molecular nitrogen. So that they reduce fertility of soil *e.g. Micrococcus denitrificans, Pseudomonas denitrificans*.

(g) **Methane bacteria :** The bacterium *Methanomonas* utilizes methane as source of carbon and energy.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Energy}\ .$$

(h) **Methane producing bacteria :** These are spherical or rod shaped bacteria which produce methane (CH_4) from hydrogen gas and carbon dioxide *e.g. Methanobacterium*.

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O\ .$$

The synthesis of ATP and reduction of carbon dioxide are linked reactions and used as sources of energy by methanogens (*e.g. Methanobacterium*). Methane (swamp gas) is produced under anaerobic conditions and can be used as a "biogas", otherwise it is a pollutant that contributes to the green house effect and global warming.

(i) **Carbon bacteria :** These bacteria oxidize carbon monoxide into carbon dioxide and use the liberated energy, *e.g.*, *Bacillus oligocarbophilus*.

$$2CO_2 + O_2 \longrightarrow 2CO \ + \text{Energy}$$

(iii) **Heterotrophic bacteria :** Most of the bacteria can not synthesize their own orgainc food. They are dependent on external organic materials and require atleast one orgainc compound as a source of carbon of their growth and energy. Such bacteria are called heterotrophic bacteria. Heterotrophic bacteria are of three types. Parasites, Saprotrophs and Symbionts.

(a) **Parasites :** They obtain their organic food or special organic compounds required for their growth from living cells of plants and animals. Some parasitic bacteria are relatively harmless and nonpathogenic, i.e., do not produce disease in hosts. However, majority of parasitic bacteria are pathogenic and cause serious diseases in plants and animals either by exploiting them or by secreting poisonous substances called toxins. Parasites contain several chemical substances (*i.e.*, enzymes, toxins and growth substances) to establish themselves in the host tissues. Some of these chemicals are – agressins (to breakdown connective tissue), leucocides (to kill host phagocytes), streptokinase (to prevent blood clotting) and cellulase (to digest cellulose).

Some examples of pathogenic parasitic bacteria which cause human diseases are

- Paratyphoid – *Salmonella paratyphi*
- Gastroenteritis – *Salmonella* sp. and *Escherichia coli*
- Dysentery – *Shiegella dysenteriae, S. Sonnei, S. Boydii*
- Tularaemia (infected lymph nodes) – *Francisella tularensis*
- Influenza– *Haemophilus influenzae*
- Botulism (acute food poisoning) – *Clostridium botulinum*

Many pathogenic bacteria cause destructive diseases of economically important plants. The usual symptoms of bacterial plant diseases are leafspots, rot, blight, wilt, gummosis, canker, scab and crown galls.

Some of the common plant diseases caused by bacteria are listed below.

- Black chaff of wheat caused by *Xanthomonas translucens*.
- Wilt of maize caused by *Xanthomonas stewartii*.
- Gummosis of sugarcane caused by *Xanthomonas asculorum*.
- Red stripe of sugarcane caused by *Pseudomonas rubrilineans*.
- Ring rot of potato caused by *Corynebacterium*.
- Canker of tomato caused by *Corynebacterium michiganense*.
- Leaf spot of Lady's finger caused by *Xanthomonas esculenti*.
- Hairy rot of apple caused by *Agrobacterium rhizogenes*.
- Black knot of grapes caused by *Pseudomonas tumefaciens*.

(b) **Saprotrophic bacteria :** These bacteria obtain their nutritional requirements from dead organic matter (such as animal excreta, corpses, fallen leaves, bread, fruits, vegetables, jams, jellies, etc.). These bacteria breakdown the complex organic matter into simple soluble forms by secreting exogenous digestive enzymes. Then they absorb the simple nutrient molecules and assimilate them. During assimilation, the bacterial cells oxidize the organic matter to obtain the energy.

Aerobic break down of organic matter is called decomposition or decay. It is usually complete and not accompanied by the release of foul gases. On the other hand, break down of organic matter in absence of oxygen is not always complete and is accompanied by release of foul smell. Anaerobic break down of carbohydrates is usually called fermentation whereas that of proteins is called putrifaction. During putrifaction, the putrifying bacteria cause degradation of proteins in absence of oxygen and convert them into simple ammonium compounds accompanied by evolution of foul gases (hydrogen sulphide, methane, ammonia).

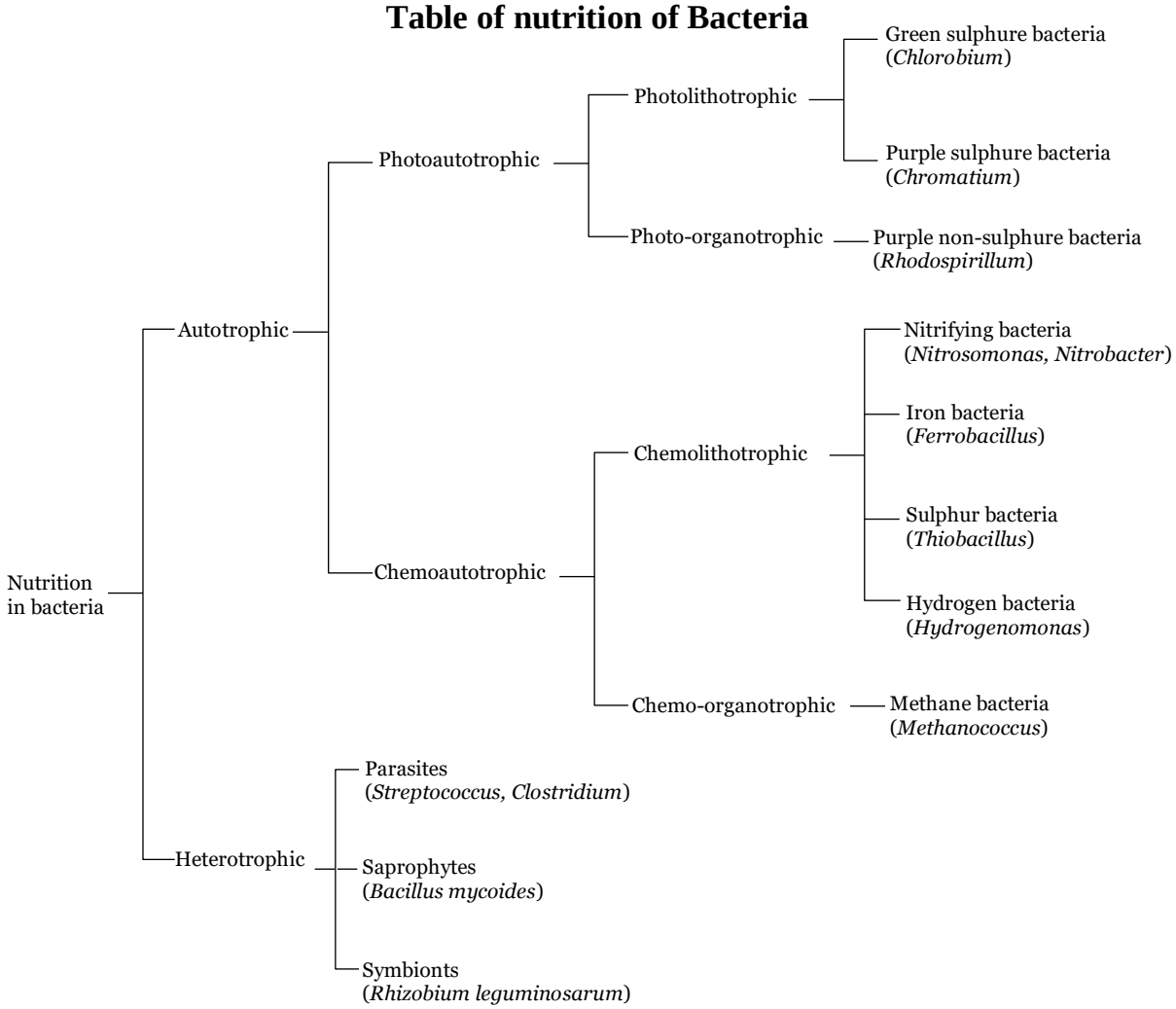
The decomposition caused by bacteria plays very important role in nature by recycling the matter in ecosystems. It also provides inorganic molecules to photosynthesizing orgainsms. The decaying property of bacteria is also used in ripening of cheese, 'curing' of tobacco and 'retting' of flax. Some free living bacteria (*e.g.*, Azotobacter, Clostridium, Aerobactor, etc.) fix atmospheric nitrogen and improve the fertility of soil.

(c) **Symbiotic bacteria :** Symbiosis is the phenomenon in which the two orgianisms live in close association in such a way that both the partners get mutual benefit from this association. For example, a very well known nitrogen fixing bacteria – Rhizobium forms a symbiotic association with roots of leguminous plants (soyabean, clover, alfalfa, etc.). Producing root nodules. These bacteria reside inside the nodules and reduce atmospheric nitrogen (N_2) to ammonia. The fixed nitrogen is taken up by the plant. In return, the plant provides nutrients and protection to bacteria.

Another example of symbiosis is the presence of enteric bacterium *Escherichia coli* (*E. Coli*) in human intestine. The bacteria shares our food but at the same time checks the growth of harmful putrefying bacteria and releases vitamins K and B_{12} which help to produce blood components. Similarly

cellulose degrading bacteria present in the stomach of cows and goats help these animals in digesting grasses. In return, they get their nutritional requirements.

Table of nutrition of Bacteria



(14) **Spirochaetes :** These are free inhabitants of mud and water, and are chemoheterotrophic bacteria. These are spiral or helicoid in shape, covered by flexible cell wall and swim actively with flagella present at both poles or ends. Many diseases are caused by them as *Treponema pollidum causes syphilis, Leptospira* causes infectious *Jaundice* and *Berrelia* causes relapsing *fever*. Besides some spirochaetes are found in teeth.

(15) **Archaebacteria :** They are present in rumen of cattles. This is simplest and most primitive group of bacteria. The cell wall of these bacteria is made of polysaccharides and proteins (peptidoglycans and muramic acid are absent in cell wall). Further branched chain lipids are present in plasma membrane of archaebacteria, due to which these can face extremes of conditions of temperature and *pH*. Archaebacteria are considered to be *'oldest of living fossils*'. Three main groups of archaebacteria are following.

(i) **Methanogens :** These are strict anaerobic bacteria and mainly occur in muddy areas and also in stomach of cattle, where cellulose is fermented by microbes. These are responsible for methane gas (CH_4) formation in bio-gas plants, because they have capacity to produce CH_4 from CO_2 or formic acid (*HCOOH*).

(ii) **Salt lovers archaebacteria or halophiles :** These are also anaerobic bacteria, which occur in extreme saline or salty conditions (upto 35% of salt or *NaCl* in culture medium). A purple pigmented membrane containing bacteriorhodopsin is developed in sun-light in these bacteria, which utilizes light energy for metabolic activities (different from photosynthesis).

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

(16) **Actinomycetes :** It is a group of unicellular branched filamentous bacteria which resemble fungal mycelia. They grow in the form of radiating colonies in cultures and therefore, commonly called ray fungi. They are Gram +ve chemo-organotrophic, saprotrophic bacteria. Most species are facultative anaerobic. These are filamentous bacteria (like moulds or fungi). These are generally present as decomposers in soil. These occur most commonly and abundantly in soil, fresh water, manure, food products etc. The filaments are aseptate (non-septate) branched and very thin (about 0.2 to 1.2 μm in width). The wall contains mycolic acid. They reproduce asexually by means of conidia which produced at tips of filaments. The endospores are not formed. Most of these secrete chemical substances having antimicrobial activities called antibiotics.

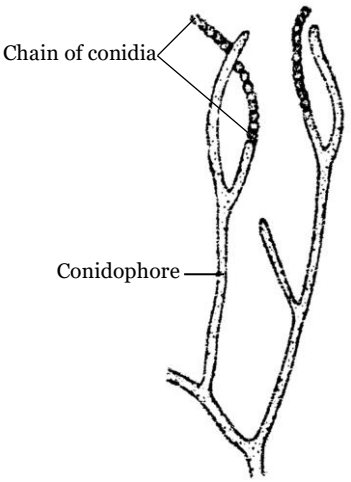


Fig : Actinomycetes : A mycelium of streptomyces bearing conidia

Some of the most common and affective antibiotics are obtained from the different species of the genus streptomyces. For example – Streptomycin (from *S. griseus*), Chloromycetin (from *S.venezuelae*), Terramycin (from *S. rimosus*), Aureomycin (from *S.aureofaciens*), Erythromycin (from *S. erythreus*), Neomycin (from *S. fradiae*), Carbomycin (from *S. halstedii*), Amphotericin B (from *S. nodosus*), etc.

Some species are pathogenic and cause diseases, *e.g. Mycobacterium*. Some common diseases in plants are yellow ear rot of wheat (Tondu disease) caused by *corynebacteriom tritici* and scab of potato by *streptomyces scabies*.

(i) **Diseases in human beings**

(a) **Tuberculosis** is caused by *Mycobacterium tuberculosis hominis.*

(b) **Leprosy** is caused by *Mycobacterium leprae.*

(c) **Buruli's ulcer** is caused by *Mycobacterium ulcerans.*

(d) **Actinomycosis** is caused by *Actinomyces israelii.*

(e) **Diphtheria** is caused by *Corynebacterium diptheriae.*

(ii) **Animal diseases**

(a) **Tuberculosis of cattle** is caused by *Mycobacterium bovis.*

(b) **Lumpy jaw** is caused by *Actinomyces bovis.*

Note **:** ❑ **Zoogloea stage :** The bacterial cells often become attached from end to end forming long filamentous chain which are embedded in a mass of mucilage forming a scum layer on substratum. It is called as Zoogloea stage.

(17) **Rickettsias (Ricketts 1909) :** They are Gram negative obligate pleomorphic but walled intercellular parasites which are transmissible from arthropods. They are intermediate between true bacteria and viruses. Rickettsiae require exogenous factors for growth. Cell wall is like typical bacterial wall. ATP synthesis is absent but ADP is exchanged with host cell ATP. They have genome and size (0.3-0.5 μm) smaller than true bacteria but have a longer generation time. Internally the cells of rickettsias contain DNA as well as RNA in a ratio of 1 : 3 : 5. The cell walls contain muramic acid and are sensitive to lysozyme. Flagella, pilli and capsule are absent reproduction occurs by binary fission. The natural habitat of rickettsiae is in the cells of arthropod gut. they cause typhus group of fevers. Spread by droplet method, lice, ticks, fleas, etc.

(i) **Diseases in human beings**

(a) **Typhus fever** is caused by *Rickettsia prowazekii.*

(b) **Rocky mountain spotted fever** is caused by *Rickettsia rickettsii.*

(c) **Q fever** is caused by *Coxiella burnetti.*

(d) **Scrub typhus** is caused by *Rickettsia trutsugamushi.*

(18) **Importance of bacteria :** Bacteria are our ‘friends and foes’ as they have both useful and harmful activities.

Useful activities

(i) **Decay of organic wastes :** Many saprotrophic bacteria act as natural scavengers by continuously removing the harmful organic wastes (*i.e.*, dead remains of animals and plants) from man's environment. They decompose the organic matter by **putrifaction** and **decay**. The simple compounds produced as a result of decomposition and decay (*viz*., carbon dioxide, carbon monoxide, nitrates, sulphates, phosphates, ammonia, etc.) are either released back into the environment for recycling or absorbed by the plants as food. Thus, the bacteria play duel role by disposing of the dead bodies and wastes of organisms and by increasing the fertility of soil.

(ii) **Role in improving soil fertility :** Saprotrophic bacteria present in soil perform various activities for their survival. Some of these activities improve the fertility of soil by formation of humus, manure, etc.

(a) **Humus :** The microbial decomposition of organic matter and mineralization results in the formation of complex amorphous substance called **humus**. The humus improves the aeration, water holding capacity, solubility of soil minerals, oxidation-reduction potential and buffering capacity of the soil.

(b) **Composting :** It is conversion of farm refuse, dung and other organic wastes into **manure** by the activity of saprotrophic bacteria (*e.g., Bacillus stearothermophilus, Clostridium thermocellum, Thermomonospora* spp, etc.)

(c) **Adding sulphates :** A few sulphur bacteria (*e.g., Beggiatoa*) add sulphur into the soil by converting H_2S into sulphates.

(iii) **Role in nitrogen cycle :** Nitrogen cycle existing in nature, comprises of –

(a) **Nitrogen fixation :** Many free-living soil inhabiting bacteria such as, *Azotobacter* (aerobic), *Clostridium* (anaerobic), etc. have ability to fix atmospheric nitrogen into ammonia. The other group of nitrogen fixing bacteria live in symbiotic association with other plants. The most important symbiotic nitrogen fixing bacteria is *Rhizobium* spp. The various species of *Rhizobium* inhabit different leguminous plants. For example, *R. leguminosarium* infects soyabeans, etc. They develop root nodules and fix atmospheric nitrogen into ammonia in symbiotic association with leguminous plants. The fixed nitrogen is partly taken up by the leguminous plants and metabolised. A part of fixed nitrogen is diffused out into the surrounding soil.

(b) **Ammonification :** The nitrogenous compounds of the dead remains of plants, animals and their excretory products are decomposed into ammonia by a number of bacteria and other microorganisms. The conversion of nitrogenous organic compounds into ammonia is termed as ammonification. It is carried by many ammonifying bacteria such as *Bacillus ramosus, B. vulgaris, B. mycoides,* etc.

(c) **Nitrification :** Many bacteria enhance the nitrogen fertility of soil by converting ammonium compounds to nitrites (*e.g., Nitrosomonas*) and nitrites into nitrates (*e.g., Nitrobacter*).

The *Nitrosomonas* group oxidizes ammonia into nitrite –

$$NH_4^+ + 3/2\,O_2 \longrightarrow NO_2^- + H_2O + H^+ + \text{Energy} \uparrow$$

The *Nitrobacter* group oxidizes nitrite to nitrates –

$$NO_2^- + 1/2\,O_2 \longrightarrow NO_3^- + \text{Energy} \uparrow$$

(d) **Denitrification :** The nitrates and ammonia are converted to nitrous oxide and finally to nitrogen gas by several denitrifying bacteria, *e.g., Pseudomonas fluorescence, P. denitrificans, Bacillus subtilis, Thiobacillus denitirficans,* etc.

(iv) **Sewage, disposal :** Ability of anaerobic bacteria to purify the organic matter is used in the the sewage disposal system of cities. The faeces are stored in covered reservoirs and allowed to purify. The solid matter is decomposed into liquidy sludge which is passed through coarse filters. The effluent is finally purified and drained out into the river or used as fertilizer in the fields. The common bacteria

involved in sewage disposal are – *Coliforms* (*E. coli*), *Streptococci, Clostridium, Micrococcus, Proteus, Pseudomonas, Lactobacillus,* etc.

(v) **Role in Industry :** Useful activities of various bacteria are employed in the production of a number of industrial products. Some of these are given below –

(a) **Lactic acid :** Lactic acid is commercially produced from pasteurized whey (the watery part of milk) through fermentation caused by *Lactobacilus bulgaricus* and *L. delbrueckii*.

(b) **Curd :** Curd is prepared from pasteurized milk by the process called curdling. It is initiated by adding a starter culture of *Lactobacillus bulgaricus* and *Streptococcus thermophillus,* into the milk at 40°*C*. *Lactobacillus* converts lactose to lactic acid whereas *Streptococcus* causes coagulation of casein due to acidity.

(c) **Cheese :** Preparation of cheese from the milk involves two main steps – first curdling of milk, and second the subsequent ripening of solid curd by the use of different bacterial strains.

(d) **Butter :** It is prepared by churning of sweet or sour cream. The microorganisms responsible for preparation of butter cream are – *Streptococcus lactis* and *Leuconostoc citrivorumare*. The characteristic butter aroma develops due to a volatile substance – diacetyl. It is produced by the action of *streptococcus* on pasteurized milk.

(e) **Retting process :** Fibres of flax, hemp and jute are separated by the process called retting. During this process the stems of the plants are submerged in water, where the bacterial activity results in the rotting of softer parts. The tough bast fibres become loosened and easily separated from each other. These fibres are spun and woven into various articles.

(f) **Vinegar :** Country made vinegar is a fermentation product of cane juice, molasses or fruit juices. It is produced in two steps – first conversion of sugars into alcohols by alcholic fermentation carried by *yeast,* and the second, conversion of alcohol to acetic acid by the action of bacteria *Acetobacter* (*A. orieansis, A. acetic, A. schuizenbachi,* etc.). Vinegar is used in the preparation of pickles or in place of acetic acid. It is used as preservative of meats and vegetables.

(vi) **Role of bacteria in human being :** E.coli (gram-ve) bacteria live in colon region of intestine of man and other animals and play an important role in digestion process.

(vii) **Medicinal uses**

(a) **Vitamins :** Production of riboflavin (vitamin B_2) involves the activity of bacterium – *Clostridium butyticum*. The well known vitamin C (ascorbic acid) is produced from sorbital by the action of *Acetobactor* spp.

(b) **Serum and vaccines :** Many bacteria are used in the preparation of serums and vaccines. These substances induce immunity to various diseases in man. Serums are effective against certain diseases like diphtheria, pneumonia, etc., whereas the vaccines are effective against *typhoid, smallpox, cholera,* etc.

(c) **Enzymes :** Some bacteria live in the alimentary canal of herbivorous animals like cow, horse, goat, etc. and help in the production of certain enzymes which digest the cellulose. The enzymes proteases are produced by bacteria *Bacillus subtilis*. Similarly, the enzyme pectinase is produced by *Clostridium* sp, which is used in retting of flax.

(d) **Antibiotics :** These are the chemical substances produces by living microorganisms capable of inhibiting or destroying other microbes. These are the products of secondary and minor metabolic pathways, mostly secreted extracellularly by the microorganisms. These are used in controlling various infectious diseases.

At present more than 5000 antibiotic substances are known and approximately 100 are available for medicinal use. The most important bacterium which produces maximum number of antibiotics is *Streptomyces*.

A list of some common antibiotics, their sources and their applications.

S. No.	Antibiotic	Obtained from	Used against
A	Streptomycin	*Streptomyces griseus*	Gram-positive and Gram-negative bacteria, TB, tularemia (rabbit fever), influenza, meaningitis, baciltary dysentery, etc.
B	Actidine	*S. griseus*	Plant diseases caused by fungi.
C	Chloromycetin	*S. venezuelae*	Gram-positive and Gram- negative bacteria, typhoid, rickettsias
D	Tetracycline	*S. aurefaciens*	Gram-positive and Gram-negative bacteria, rickettsiae.
E	Terramycin	*S. ramosus*	Gram positive and Gram-negative bacteria.
F	Erythromycin	*S. erythreus*	Gram positive bacteria, whooping cough, diphtheria.
G	Neomycin	*S. fradiae*	Gram- positive, Gram negative and TB bacteria.
H	Amphomycin	*S. carus*	Gram-positive bacteria,
I	Amphotericin B	*S. nodosus*	Yeast, fungi
J	Leucomycin	*S. kitasoensis*	Gram-positive bacteria.
K	Trichomycin	*S. hachijoensis*	Yeast and fungi.
L	Viomycin	*S. floridae*	Gram-positive, Gram-negative and TB bacteria.
M	Bacitracin	*Bacillus subtilis*	Gram-positive bacteria
N	Gramicidin	*B. brevis*	Gram-positive bacteria.
O	Tyrothricin	*B. brevis*	Gram-positive and Gram-negative bacteria.
P	Polymyxin B	*Aerobacillus polymyxa*	Gram-negative bacteria.

Harmful activities

(i) **Food poisoning :** Some saprotrophic bacteria cause decay of our food, *i.e.*, they alter their normal form and induce unpleasant aroma, taste and appearance. Some bacteria produce powerful toxins in food to cause **"food poisoning"**. Consumption of such food may cause serious illness or even death. Symptoms and causal organism of some important types of bacterial food poisoning are listed below :–

(a) **Botulism :** It is caused by *Clostridium botulinum.* The main symptoms are vomitting followed by paralysis and death.

(b) **Perfringens poisoning :** It is caused by *Clostridium perfringens*. Symptoms appear in the form of diarrhoea and acute abdominal pain.

(c) **Staphylococcal food poisoning :** It is caused by *Staphylococcus aureus*. Common symptoms are nausea, vomitting and diarrhoea.

(ii) **Spoilage of food :** Some examples of bacterial food spoilage are listed below :–

(a) Salmonellosis in poultry and eggs is caused by *Salmonella*.

(b) Red rot of eggs is caused by *Serratia marcescens.*

(c) Greening on meat surface is caused by *Lactobacillus* and *Leuconostoc*.

(d) Black rot of eggs is caused by *Proteus.*

(e) Green rot of eggs is caused by *Pseudomonas*.

(f) Souring of milk is caused by *Lactobacillus* and *Streptococcus*.

(g) Explosion of curd (gas production) is caused by *Clostridium* and *Coliform* bacteria.

(h) Ropiness (*i.e.*, slimy milk) is caused by *Klebsiella* sp. *Enterobacter* spp.

(iii) **Pollution of water :** There are reports of epidemics of cholera, typhoid, jaundice and other infectious diseases, which were caused by polluted water. Many pathogenic bacteria such as, *Vibrio cholerae, Salmonella typhi, Leptospira cetero-haemorrhagiae,* etc. pollute water and make it unfit for drinking. These are eliminated by chlorination.

(iv) **Deterioration of textiles :** Some bacteria (*e.g. Cytophaga, Vibrio* and *Cellulomonas*) damage cellulose of textiles.

(v) **Abortion :**Bacteria like salmonella induce abortion in goats, horses, sheep etc.

(vi) **Biological warfare :** Some bacteria which cause diseases like anthrax, black- leg, tuberculosis etc, are employed as secret war agents.

(vii) **Denitrification :** Denitrification bacteria like *bacillus licheniformis, Pseudomonas aeruginosa* convert nitrates and nitrites into free nitrogen, thus responsible for the process of denitrification. Thus soil is depleted of essential nutrient like usable form of nitrogen.

(viii) **Putrefaction :** It is the spoilage of protein in the absence of O_2 by the putrefying bacteria *e.g., Proteus, Mycoides.*

(ix) **Retting of fibres :** It is the hydrolysis of pectic substances that bind the cells together.

(x) **Diseases :** Bacteria are the causative agents of a large number of human diseases such as pneumonia, typhoid, dysentery, cholera, plague, influenza, tetanus, diphtheria, tuberculosis, leprosy, syphilis, whooping cough etc. They are also responsible for several plant diseases and animal diseases.

Most of the pathogenic bacteria are Gram – ve, rod-shaped (Bacillus) and non-spore forming.

Name of Disease	Bacteria
(a) **In human beings**	
Pneumonia	*Diplococcus pneumoniae*
Typhoid	*Salmonella typhosa*
Cholera	*Vibrio cholerae*
Plague (Black death)	*Pasteurella pestis*
Meningitis	*Neisseria meningitides*
Gonorrhoea	*Neisseria gonorrhoeae*
Syphillis	*Treponema pallidum*
Diorrhoea	*Bacillus coli*
Gastroenteritis	*E.coli*
Diptheria	*Corynebacterium diptheriae*
Tuberculosis	*Mycobacterium tuberculosis*
Gangarin	*Clostridium perfringens*
Jaundice	*Leptospira ictero haemorrhagae*
Whooping cough	*Haemophilus pertussis or Bordetella pertussis*
Tetanus (lockjaw)	*Clostridium tetani*
Bacterial dysentry	*Shiegella dysentriae*
Leprosy	*Mycobacterium leprae*
(b) **In animals**	
Anthrax	*Bacillus anthracis*
Black leg disease	*Clostridium chauvi*
(c) **In plants**	
Soft rot of potato	*Pseudomonas solanacearum*
Citrus canker	*Xanthomonas citri*
Bacterial blight of paddy	*Xanthomonas oryzae*
Tundu disease in wheat	*Corynebacterium tritici*
Potato wilt	*Pseudomonas solanacearum*
Fire blight of apple and peach	*Erwinia amylovora*
Crown gall of sugar beet	*Agrobacterium tumefaciens*
Black rot of cabbage	*Xanthomonas compestris*

Important Tips

- **Robert Koch (1881)** is the father of modern bacteriology.
- Bacteria are studied under bacteriology.
- Mycobacterium leprae is exception of koch's postulate because it can not grow in culture medium.
- Bacteria are unicellular prokaryotes. They were first seen by a Dutch lens marker, Anton Von Leeuwenhock (1683).
- Bacteria differ from animals in having a rigid cell wall.
- A scientist named Gram, stained the bacteria with crystal violet and Iodine solution.
- After washing them with acetone or alcohol $Gram^+$ bacteria retain deep violet or purple colour.
- Bacterial cell wall is made up by peptidoglycans and muramic acid.
- Father of modern antiseptic surgery. Joseph Lister.
- Insulin is the first hormone which obtained from genetically engineered bacteria.
- Free living N_2 fixing bacteria – Azatobacter and polymyxa.
- Clostridium butyticum has been used in the synthesis of vitamin B.
- Commonsals : Those microorganism which are living in large intestine of human and that feed on undigested food without harming the host are termed as.
- By the hanging drop slide we can see movement of bacteria.
- Capsule is made up by polysaccharides and polypeptides.
- Mesosomes contain oxidative enzymes of electrons transport system. It is the folding of plasmamembrane which also help in respiration so they are called chondriods.
- External DNA enters in bacteria through mesosomes.
- In the bacterial cystoplasm, membranous organelles like (mitochondria, chloroplast, ribosome, endoplasmic, reticulum, Golgy body, etc.) are absent.
- In bacteria flagella may be present, PS II absent, photosynthesis is a nonoxygenic.
- In the cytoplasm 70 S ribosomes present. Bacteria also contain fats, glycogen, protein and photosynthetic pigment (carotenoids).
- True nucleus is absent in them. Their nucleus is called nucleoid.
- Histone proteins are absent in bacterial cell (Prokaryotic cell).
- Flagella of salmonella bacteria contain H-antigens.
- Bacterial flagella is composed of 1 or 3 tubuline fibril organisation against 9+2 fibril organisation in eukaryotes.
- Bacteria – have two important factors located on plasmid. (1) F.factor (sex factor). (2) R-factor (resistance factor).
- Gram +ve bacteria (Bacillus and Clostridium) produce resting spores called endospores which are formed in unfavourable conditions.
- Transformation process is reported by **Griffiths (1928)** in mice.

- Polyribosome always attached with m RNA.
- Volutin granules are the source of energy in bacteria.
- Transduction was first reported by **Zinder** and **Lederberg** in (1952). In this process DNA of a bacterial cell transfer to another bacterial cell by Bacteriophage.
- Conjugation – was discovered by Lederberg and Tatum. In this process two different types of bacteria are connected by conjugation. The bacterium which contains F-factor is called F^+/donor, the other bacterium which lacks this factor is called F^- or the recepient.
- Iron bacteria – they oxidise ferrous compound to ferric forms eg. **Thiobacillus.**
- Chemoautotrophic bacteria – these bacteria oxidise a number of inorganic compounds to obtain energy for the assimilation of CO_2. they cannot make use of light energy.
- **Escherichia coli** (E. coli) is a facultative aerobic bacteria found in the colon region of intestine of human being. this bacterium was discovered by Escherisch (German scientist).
- Chemically E.coli has about 70% H_2O, 15% proteins, 6% RNA, 1% DNA. 2% Lipid, 3% carbohydrates, etc.
- Rhizobium bacteria found in a symbiotic relationship with leguminous plant. They fix N_2 in root nodule from atmosphere. It has nifgene.
- Non symbiotic anaerobic non-photosynthetic N_2 fixing bacteria is clostridium.
- Azotobacter is found freely in the soil as saprophyte. It is estimated that such bacteria are capable of adding 5-25 Kg. of nitrogen per acre per year.
- Nitrifing bacteria transform NH_3 into nitrates.
- Bacterial size ranges between $2-5\mu$, Smallest bacterium – **Dialister pneumosintes**. Largest bacteria are – Spirillum laid.
- Plasmid is the extra DNA structure. They can independently replicate. Plasmid are not essential for normal life process.
- Eukaryotic flagella is formed of tubulin protein while bacterial flagella is made up of flagellin protein.

3.2 MYCOPLASMA

Mycoplasmas were discovered by ***E. Nocard*** and ***E. R Roux*** (1898). They were first isolated from bovine sheep suffering from pleuropneumonia. They are often designated as pleuropneumonia–like organisms (PPLO). These organisms were later put under the generic name mycoplasma by *Nowak* (1929). In 1966 international commitee of Nomanclature of bacteria, placed mycoplasmas under the class *mollicutes*, which consists of two genera Mycoplasma and Acholeplasma. These are the simplest unicellular non-motile known aerobic prokaryotes

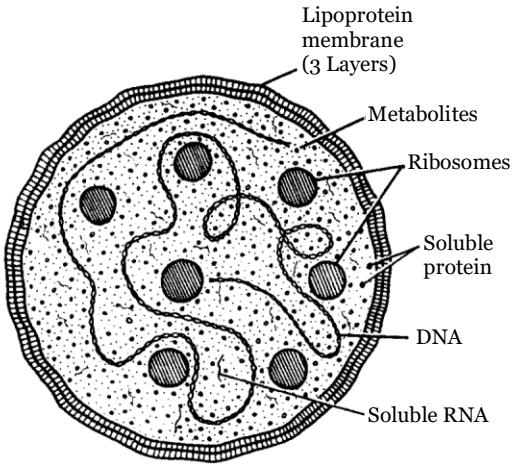


Fig : Mycoplasma–showing structural details

without cell wall. So that they can change their shape therefore called Jockers of microbiological park. They are considered to be intermediate between bacteria and viruses. They have smallest living cells of prokaryotes. They are known to cause a number of diseases in human beings, animals and in plants. Mycoplasma can grow out side the host cell. Thus it is clear that mycoplasma are not obligate parasites like viruses. They are gram-negative.

(1) **Distribution :** Mycoplasmas occur in soil, sewage water, different substrates, and in human beings, animals and plants. They have also been found in hot water springs and other thermal environments. They are the frequent contaminants in tissue cultures rich in organic matter.

(2) **Structure :** They are one of simplest prokaryotic organisms. Their size varies from 0.1 – 0.15 μm. They lack the cell wall. Due to the absence of the cell wall, these organisms are highly elastic and readily change their shape; hence the mycoplasmas are irregular and quite variable in shape. This nature is called pleomorphism. They may be coccoid, granular, pear–shaped, cluster–like or filamentous. Mycoplasma cells are covered with three layered plasma memberane. Unit membrane is made up of lipoprotein. Normally there are no mesosomes but in stationary phase, some time mesosomes are also present on plasma membrane. They lack the well organised nucleus, endoplasmic reticulum, mitochondria, plastids, golgi bodies, centrioles, flagella, *etc.* The genetic material is present in the form of a nucleoid. The latter consists of a single, circular, double–stranded molecule of DNA, without a nuclear envelope. Unlike other prokaryotes, it is coiled throughout the cytoplasm. The cytoplasm contains the ribosomes which are 70S. It also contains RNA, proteins, lipids and many kinds of enzymes used in biosynthetic reactions. Lipids include cholestrol and cholestrol esters which are characteristic of animal cells and are not found in true bacteria and cyanobacteria. The amount of DNA and RNA in the cells is usually less than half of that which occurs in other prokaryotes. There is 4% DNA and 8% RNA. It is perhaps the lowest limit required for a cellular organism. Sterol is must compulsary for growth of mycoplasma. Mycoplasmas are Gram–negative.

(3) **Physiology and reproduction :** Mycoplasmas are usually non–motile. They are sensitive to tetracycline and resistant to penicillin. These are destroyed usually by treatment of heat at 50° C for 6 hours mycoplasma are osmotically inactive. Some forms, show gliding movements. Mycoplasmas are heterotrophic in their mode of nutrition. Some of them are saprotrophs, but most of them are parasitic on plants and animals including man. They reproduce by budding or binary fission. Fragmentation specially in filamentous forms. Besides this, Mycoplasma reproduces by elementary cell bodies also. It is also called baby particle. It is a kind of vegetative reproduction.

Culture of mycoplasma : These can be cultured in non-living medium, although they grow well in living medium, contain chick tissue. In non-living medium, they require agar-agar and blood serum.

(4) **Economic importance :** Mycoplasma cause serious diseases in human beings, animals and plants. Some of these are given below.

(i) **Diseases in Human beings :** *Mycoplamsa hominis* causes pleuropneumonia, inflammation of genitals and endocarditis, *etc. Mycoplasma pneumoniae* causes primary a typical pneumonia (PAP),

haemorrhagic laryngitis, *etc. Mycoplasma fermentatus* and *M. hominis* cause infertility in man, otitis media (inflamation of middle ear).

(ii) **Diseases in animals :** *Mycoplasma mycoides* causes pneumonia in cattle. *Mycoplasma bovigenitalum,* causes inflamination of genitals in animals. *Mycoplamsa agalactia* causes agalactia of sheep and goat.

(iii) **Diseases in plants :** Common Mycoplasmal diseases of plants are: Bunchy top of papaya, witches' broom of legumes, yellow dwarf of tobacco, stripe disease of sugarcane, little leaf of brinjal, clover phylloidy, big bud of tomoto, *etc.* Mycoplasma are the smallest organisms which produce diseases in plants.

(5) **Difference between L-form bacteria and mycoplasma :** In the culture of bacteria, some bacterial cells are developed which are without cell wall and such bacterial cells which are without cell wall are known as L-form bacteria ('L' for Lister institute, where these were reported).

Important difference between L-form bacteria and mycoplasma is that under optimum nutritional conditions. L-form bacteria will develop cell walls whereas mycoplasma will never develop cell wall.

Important Tips

- Mycoplasma is the smallest cell of prokaryotes.
- Mycoplasma are also called Joker of plant kingdom.
- They lack cell wall. They are covered by three layers of plasmamembrane
- Mycoplasma are sensitive to tetracycline and resistant towards penicillin.
- Bleb and infra bleb – These are peculiar structures which are formed at both ends during binary fission in mycoplasma and as soon as binary fission is complete, these structures disappear. So the significance of bleb and infra bleb is not known.

3.3 Cyanobacteria

The new name of cyanobacteria has been given to myxophyceae or cyanophyceae. Cyanobacteria form a group of ancient Gram negative, photosynthetic prokaryotes. Many botanists prefer to call them blue-green algae. They have survived successfully for about 3 billion years. They may cause water blooms.

(1) **Distribution :** Cyanobacteria are predominantly fresh water forms, a few are marine. They are found growing even under extreme situations such as in hot springs and the undersides of icebergs. The fresh water forms occur in ponds, lakes, pools and reservoirs. They impart unpleasant taste and smell to the water. One species of cyanobacteria containing red pigment (*Trichodesmium erythracum*) flourishes in Red Sea and is responsible for the red colour of its water. Some grow in the soil and help in fixation of nitrogen and utilize it in metabolism. Nostoc colony is found into the thallus of

Anthoceros. Colonies of *Nostoc* and *Anabaena* grow in paddy fields. Some live in symbiotic relationship with other organisms. In *Oscillatoria* filaments show oscillating motion.

(2) **Organisation of Thallus :** The organisation of thallus ranges from unicellular to branched heterotrichous forms.

(i) Unicellular forms, *e.g., Chroococcus*, etc.

(ii) Unicellular polar thalli with a definite base and apex, *e.g., Dermocarpa, Chamaesiphon*, etc.

(iii) Multicellular colonial forms, *e.g., Gloeocapsa, Trichodesmium, Merismopedia, Microcystis*, etc.

(iv) Simple unbranched filamentous forms without heterocysts and akinetes, *e.g., Arthrospira, Oscillatoria, Spirulina, Phormidium, Lyngbya, Symploca, Microcoleus, Schizothrix*, etc.

(v) Simple unbranched filaments with heterocyst, *e.g., Nostoc, Anabaena, Aulosira, Anabaenopsis, Cylindrospermum*, etc.

(vi) Unbranched heterocystous filaments with base and apex, *e.g., Rivularia, Gleotrichia*, etc.

(vii) Heterotrichous filaments with false branching, *e.g., Scytonema, Plectonema*, etc.

(viii) Heterotrichous filaments with true branching, *e.g., Haplosiphon, Stigonema*, etc.

(3) **Oxygen revolution :** They are said to be earliest oxygenic photosynthesizers. Due to their activity atmosphere turned aerobic, thus providing favourable conditions for the evolution of aerobic bacteria and other eukaryotes.

(4) **Symbiotic forms :** There is a long list of cyanobacteria which are found in symbiosis with plants and animals. They may be associated with lichens. Many members are associated with liverworts, mosses, ferns, flowering plants, fungi, protozoa, sponge, shrimp and sometimes a mammal. They have been reported in bryophytes like *Anthoceros, Anabaena cycadeae* is found in coralloid roots of cycads.

(5) **Movement of cyanobacteria :** Flagella are completely absent but the movement occurs in some genera by special gliding motion. Such movements are connected with the secretion of mucilage. The genus oscillatoria exhibits pendulum like oscillating movement of its anterior region.

(6) **Ultrastructure :** The cyanobacterial cell is normally larger than a bacterial cell. Like a bacterial cell, it consists of a tiny mass of protoplast surrounded by cell wall. It is differentiated into cell wall, cytoplasm and a nucleoid.

(i) **Cell wall :** The cell wall completely surrounds the protoplast. Cell wall is made up of muramic acid, Lipopolysaccharides, Glucosins, Glutamic acid and α-diaminopimalic acid. It is a thin structure made up of cellulose and peptidoglycan. External to the cell wall is a mucilaginous sheath. It has a great water absorbing and retaining capacity. The sheath is made up of reticulated arranged microfibrils within an amorphous matrix. The fibrils may be composed of pectic acid and mucopolysaccharides, sheath may be thin or thick, hyaline

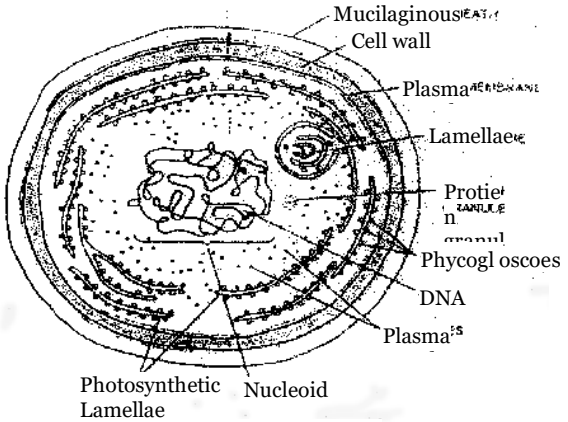


Fig : A cyanobacterium

or pigmented, homogenous and stratified. The cell wall is firm and rigid. It is two layered. The outer layer is convoluted and inner layer is smooth. The inner layer is made up of peptidoglycan similar to bacterial cell wall.

(ii) **Cytoplasm :** The cell wall is followed by plasma membrane made up of lipid and proteins. Inner contents of the cell can be distinguished into two regions-outer pigmented region called chromatoplasm and central hyaline centroplasm. The membrane bound structures like true mitochondria, chloroplasts, endoplasmic reticulum, golgi bodies, true vacuoles, etc. are absent. The photosynthetic pigments are located in broad sheet like lamellae, called thylakoids. The thylakoids are restricted to peripheral region of cytoplasm usually arranged in two or more parallel stacks. Some lipid globules occur within the thylakoids whereas phycobilisome particles are attached to their surfaces. Some authors suggest that these lamellae also provide the sites for cellular respiration. The photosynthetic pigments present in the cell are – chlorophyll *a*, β carotene, Myxoxanthophyll, myxoxanthin, C-phycocyanin and C-phycoerythrin. The C-phycocyanin is blue and C-phycoerythrin is red in colour. If C-phycocyanin is more as compared to C-phycoerythrin, it gives characteristic blue-green colour to the algae. Other cellular inclusions are gas vacuoles, cyanophycin granules, volutin granules, β- granules (lipid droplets), polyhedral bodies, 70*s* ribosomes, etc. The gas vacuoles are common in planktonic forms. They are the vesicles filled with gas and bounded by single membrane. They serve to regulate the buoyancy of the planktonic forms. In diffuse or low light intensities, they are large and help to bring the cyanobacteria at the surface. Cyanophycin granules are made up of stored protein. Volutin granules store phosphate, α-granules contain cyanophycean starch, β-granules contain lipid droplats.

(iii) **Nucleoid or genophore :** It lacks a definite nucleus. The nuclear material consists of a single chromosome made up of a naked strand of DNA helix which lies in the centre. DNA is not associated with histone proteins. In this respect, they resemble the circular chromosome of bacteria. The nucleolus is absent and the nucleoid is not bounded by a nuclear membrane (This type of nucleus called incipient nucleus).

(7) **Nutrition :** Because of the presence of chlorophyll–*a*, cyanobacteria synthesis their own food from carbon dioxide and water in the presence of sunlight. Certain cyanobacteria like *Nostoc* and *Anabaena* fix atmospheric nitrogen in the presence of oxygen. They are obligate photoautotrophs. They do not grow in darkness. Cyanobacteria are the earliest photosynthesizers which made the earth's atmosphere aerobic.This provided the suitable condition for the evolution of aerobic bacteria and eukaryotes.

(8) **Reproduction :** Cyanobacteria reproduce asexually by fission and fragmentation. Unicellular forms multiply by binary fission flagella are absent in vegetative as well as reproductive phase. The filamentous forms reproduce by fragmentation of their thallus into hormogonia (as in *Nostoc* and *Oscillatoria*). Heterocysts and akinites are used in propagation. These serve as vegetative means of propagation. Except oscillatoriaceae all cyanophycean member contain heterocyst. It is a special type of cell of cynobacteria. Food material, stored in them in the form of cyanophycean starch.

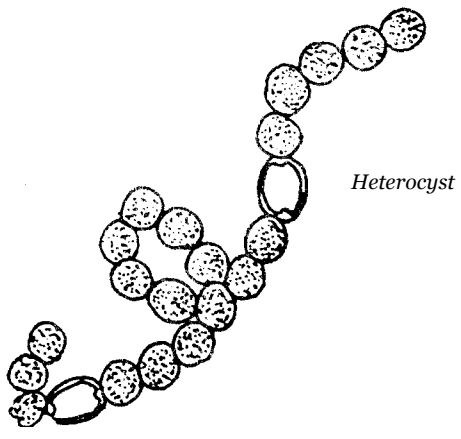


Fig : Nostoc Habit and

(9) **Nitrogen fixation in cyanobacteria :** Like many bacteria, several forms of blue green algae have the capacity to fix atmospheric nitrogen into nitrogenous compounds. This capacity is restricted to filamentous heterocystous forms like *Nostoc, Anabaena, Aulosira, Mastigocladus, scytonema* and *calothrix*. Under anaerobic conditions, some nonheterocystous forms can also fix atmospheric nitrogen (*Oscillatoria, Plectonema, Phormidium*). This additional capacity of N_2 – fixation along with CO_2 – fixation makes them truely autotrophic plants. In this sense, they are considered to be largely responsible for the maintenance of soil fertility in tropical and temperate regions. Some species of blue-green algae have a great contribution to increase the fertility of rice fields in tropical countries like India (*e.g., Anabaena, Aulosira, Zolypothrix*).

Biochemistry and mechanism of nitrogen fixation in blue- green algae have been studied in detail. The radioactive tracer technique and other. Researches have shown that the atmospheric dinitrogen $(N \equiv N)$ is reduced to ammonia in the presence of a reducing agent. The reaction is a stepwise process and is catalyzed by the nitrogen fixing enzyme- nitrogenase utilizing energy. The enzyme nitrogenase works under anaerobic conditions.

The fixed nitrogen can be utilized in its own metabolism by blue-green algae. The nitrogenous compounds come to the soil after death and decay of blue –green algae or by direct leaching of the soluble nitrogenous compounds. In soil, the nitrogenous compounds are available for use by higher plants.

As stated earlier, the enzyme nitrogenase works anaerobic conditions. The thick walled heterocysts provide a suitable anaerobic environment for nitrogenase, even under aerobic conditions. Under anaerobic conditions both heterocystous and non- heterocystous forms can fix nitrogen because of the proper functioning of the nitrogenase. Leghaemoglobin present in leguminous root nodules that act as oxygen scavenger because nitrogenase works under anaerobic condition.

(10) **Economic importance**

(i) **Useful activities**

(a) Spirulina is cultivated in tanks as a protein rich food for fish and other animals.

(b) Some cyanobacteria like *Nostoc, Anabaena, Scytonema* etc. increase the soil fertility by fixing the free nitrogen of the atmosphere. So that it is used as a biofertilizer.

(c) **Reclamation of soil :** Certain cyanobacteria like *Nostoc commune, scytonema ocellantum, Aulosira fertissima* are used for reclamation of usar (sterile alkaline) soil. These organisms secrete acidic chemicals which counteract the alkalinity of the usar soil.

(d) **Food :** *Nostoc community* are as food by Chinese and South Americans. Food is called yoyucho.

(e) **Prevention of growth of mosquito larva :** Few species of *Anabaena* and *Aulosira* are inoculated in ponds to check the development of mosquito larvae.

(f) **Green manure :** In sambhar lake of Rajasthan, *Anabaena* and *Spirulina* are produced in large number. Local people use it as green manure.

(g) **Soil erosion :** Some cyanobacteria, such as *Anabaena, Lyngbya* etc. help in conservation of soil, thus checking soil erosion.

(h) **Plant succession :** few cyanobacteria located inside lichens help in plant succession due to their growth on barren land.

(ii) **Harmful activities**

(a) **Spoilage of drinking water :** Forms like *Anabaena* not only spoil the taste of drinking water but also produce toxic effect.

(b) **Diseases :** Skin infections may be caused by cyanobacteria like *Lyngbya*.

(c) **Toxin secreting cyanobacteria :** They are mainly responsible for water blooms. By the death and decomposition water gets contaminated and unfit for normal use some cyanobacteria like *Ribularia* release toxins which is harmful for aquatic fauna.

NOSTOC –

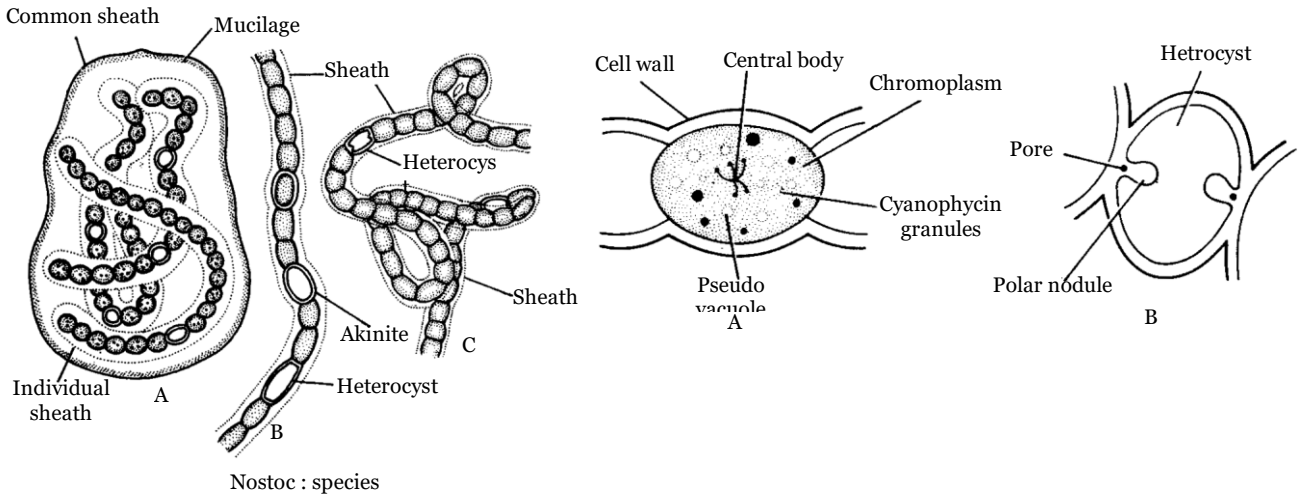
Systematic position –

Kingdom	–	Plantae
Sub kingdom	–	Thallophyta
Phylum	–	Cyanophyta
Class	–	Myxophyceae (Cyanophyceae)
Order	–	Nostocales
Family	–	Nostocaceae
Genus	–	*Nostoc* (Nostoc name is given by *Vaucher*)
Common Name	–	Fallen stars

(11) **Habitat :** This is an alga of both terrestrial and aquatic habitats. Terrestrial species grow commonly either on bare soil or intermingled with plant parts. Sometimes aquatic species submerged lying on the bottom of the pools, or attached to a substratum and some time free floating *Nostoc* is found in a colony. All colonies are covered by mucilaginous covering. Nostoc associate with fungi to form lichens.

They behave as “space parasites” in the thalli of filamentous *Anthoceros*.

(12) **Morphology :** The Nostoc plant is filamentous and the trichomes are unbranched and appear moniliform. Individual cells are mostly spherical but some times barrel shaped or cylindrical also. Single filament of Nostoc without mucilagenous sheath is called Trichome. Trichome with mucilaginous sheath is called filament.



All the cells of the trichome are similar in structure but at some intervals are found slightly larger rounded light yellowish thick walled cells called as heterocysts it can fix N_2. It is formed from normal cell when dim light is present. Trichome mostly breaks near heterocyst and forms hormogonia and thus they help in its multiplication.

The heterocysts are intercalary and posses a very thick outer wall. Each heterocyst is connected with vegtative cells, on two sides through the prominent pores in to the wall. Which later on are occupied by a refractive cyanophycean granule called polar nodule.

Each cell of *Nostoc* has a primitive nucleus or (prokaryotic).

(13) **Reproduction :** There is no sexual reproduction in *Nostoc* but it reproduces asexually by the following methods.

(i) **Hormogonia :** The filaments break at number of place into smaller pieces, called as hormogonia. By decay of an ordinary cell they slip out of the mucilaginous sheath and grow into new plants.

(ii) **Resting spores or akinites :** Under certain condition some of the vegetative cells enlarge and accumulate food material and develop thick walls. These are called akinites. The akinites germinate after a period of rest and their contents are liberate out through a pore. Protoplast by further division forms the new filament.

(iii) **Heterocysts :** In exceptional case heterocyst may become functional and on germination develops a new colony.

(iv) **Endospores :** *Nostoc microscopium, Nostoc commune*.

(14) **Economic importance**

(i) Many species of *Nostoc* fix atmospheric nitrogen and thus increase the soil fertility. Heterocysts "the unique structure" of *Nostoc* filament function as sites for nitrogen fixation. In heterocysts the free nitrogen (N_2) of the air is converted into (NO_3) nitrate.

(ii) Reclamation of alkaline "usar soils" can be done by employing some species of Nostoc.

(iii) Nostoc use as vegetable in China and Japan.

Important Tips

- Cyanobacteria form a group of ancient gram negative photosynthetic prokaryotes.
- Nostoc colonies are found into the thallus of **Anthoceros**.
- Heterocyst is the special cell in cyanobacteria which can fix to N_2 from atmosphere.
- Some blue green algae live in protozoans are called “cyanellae”.
- The blue-green colour of cells is due to the presence of phycocyanin pigment.
- Blue green algae were first placed under algae but now they are kept under bacteria
- BGA produce oxygen during photosynthesis so these are called “oxyphotobacteria”.
- A filament without mucilaginous sheath is called trichome.
- In cyanobacteria, flagella are absent, PS-I and PS-II are present, photosynthesis is oxygenic.
- Thick walled hormogonia or multicellular akinite found in blue green algae are called hormocysts.
- Symbiotic N_2 fixing algae is Anabaena.
- Trichodesmium a non-heterocystous nitrogen fixing colonial aerobic cyanobacterium which occurs as phytoplankton throughout tropical and subtropical oceans and fixes atmospheric nitrogen while evolving photosynthetic oxygen.

3.4 Viruses

The term 'virus' has been derived from Latin, which means poison or venom or viscous fluid. These are highly controversial group of microscopic objects (smaller than bacteria, mycoplasma, nostoc, etc.) and are most perfect obligate intracellular parasites of the world. They remain inactive outside a living host but become active inside the host and multiply in it. They represent a transitional form of life between non–living and living world. Nowadays, these are defined as "Viruses are infectious nucleoproteins". The definition given by *Green* (1935) states that the viruses are the smallest units showing reproductive properties considered typical of life.

According to *Bawden* (1949), "Viruses are obligate parasites, too small to be seen."

Luria (1953) defined virus as "Sub-microscopic entities capable of being introduced into specific living cells and reproducing inside such cells only. "Single virus is called 'Virion', most of the plant virus are RNA virus. Must of the animal virus are DNA virus.

(1) **Important discovery of virus**

(i) **Carolous causius (1576)** recorded first viral disease in tulips.

(ii) **A. Mayer (1886)** found a disease in tobacco caused by virus and called it tobacco mosaic disease.

(iii) **D. Ivanowski (1892)**, a Russian Botanist, discovered the infectious nature of the viruses. He was the person, who discovered the virus. He found that juice of an infected tobacco when filtered through bacteria–proof filter, caused disease in healthy plants of tobacco.

(iv) **Beijerinck (1898)** repeated the same experiment and called it infectious fluid–“contagium vivum fluidum”, therefore, he first used the word Virus.

(v) **Popper (1908)** reported poliomyelitis virus.

(vi) **W. Twort (1915) and D. Herelle (1917)** discovered bacteriophages, a kind of virus which infected bacteria and destroyed them.

(vii) **M. Schelsinger (1933)** for the first time isolated a virus by using the technique of ultracentrifugation

(viii) **W. M. Stanley (1935)** first time isolated tobacco mosaic virus (TMV) in crystalline form and showed that crystals were made up of proteins. Nobel prize was awarded to him for this work.

(ix) **Bawden and Pirie (1938)** purified TMV and found it to be a nucleoprotein containing RNA.

(x) **Saffermann and Morris (1963)** discovered Cyanophages that infect blue–green algae.

(2) **Nature of viruses :** Viruses are regarded as intermediate between non-living entities and living organisms. It is very difficult to ascertain whether they are living or non-living. Some characters of viruses suggest their non-living nature whereas many other characters suggest their living nature. The two views are listed below –

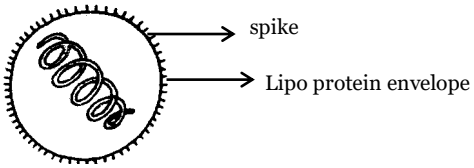


Fig : Influenze

(i) **Viruses are non-living :** The following characters state that they are non-living.

(a) Viruses have no complete cellular structure. They are not surrounded by cell membrane or cell wall.

(b) They do not show cellular metabolism and lack respiration.

(c) They possess high specific gravity unlike living organisms.

(d) Viruses are active only when they are inside the living host cells. Out side the host, they are good as chemical substances. Thus, they do not have their independent existance.

(e) *Stanley* (1935) isolated the viruses in a crystalline form and kept for a long period. In this form they neither grow nor reproduce but remain in a crystalline form. This phenomenon has not been observed in any living organism.

(f) The viruses can be precipitated just like chemical substances.

(g) Postulates of *Robert Koch* are not true for the viruses. Virus cannot grow in "*invitro*" condition in lab.

(ii) **Viruses are living organisms :** The following characters state that they are living organisms –

(a) They have definite shape and morphology like that of a living organism.

(b) They possess genetic material (DNA or RNA), which determine their structure and development. Genetic material passes from generation to generation in usual manner.

(c) All viruses are intracellular obligate parasite and attack specific hosts. The bacteriophages recognise the real bacterial surface. The viruses produce characteristic symptoms on their particular host.

(d) They show property of mutation.

(e) They show irritability and respond to environmental conditions such as heat, ultraviolet rays, humidity, drought, alcohol, etc.

(f) They can grow inside the host and multiply enormously showing one of the most important property of living organisms.

(3) **Chemical composition :** Chemically viruses are nucleoproteins. They are made up of central core of nucleic acid. Nucleic acid is only one, either DNA or RNA. This nucleic acid (DNA or RNA) represents the genetic characters of virus. TMV has RNA (like most plant viruses have) 10% RNA and 90% protein is present in influenza virus and PSTV (Potato Spindle Tuber Viroid) also has RNA but it does not have capsid (protein coat). Plant viruses contain RNA but in cauliflower mosaic virus contain DNA. Bacteriophages contain DNA and almost half animal viruses contain RNA and half contain DNA. But it is called that often animal viruses contain DNA. Cancer causing viruses reovirus contain both RNA and DNA, protein is not genetic material and is left outside the host cell and nucleic acid enters into the cell during the process of infection virus can performs division only inside the host cell. Therefore, their metabolism is not independent. Some animals viruses may be coverd by a lipo-proteinaceous envelope Such viruses are called as Lipovirus. Influenza virus also contains carbohydrates. The envelope is made up of virus protein and host cell lipids. One specific feature of the envelope is that it is covered with projections called spikes. Only some enzymes are detected in viruses such as – Lysozyme in bacteriophages, transcriptase in vaccinia virus, reverse transcriptase and DNA or RNA polymerase in retroviruses.

(4) **Shape :** There is variation in shapes of viruses. Viruses are always found in geometrical shapes. The virion may be spherical, oval, rod–like, brick–shaped or tadpole–like in shape. On the basis of shape viruses have been placed in the following categories.

(i) Straight, rigid rods with helical architecture, *e.g. TMV, Barley stripe mosaic virus* (BSMV).

(ii) Long flexous thread–like rods, *e.g. Potato latent mosaic, Wheat streak mosaic virus.*

(iii) Polyhedral virions, *e.g. Turnip yellow mosaic, Tobacco ring spot virus.*

(iv) Tadpole like – *Bacteriophages*.

(v) Spherical – *Influenza virus*.

(5) **Size :** Viruses have a long range of size. They range from 10 mμ to more than 300 mμ in size. The virus of foot and mouth disease (FMD) of animals is smaller than the largest protein molecule. The size of some viruses is as follows–**Alfalfa mosaic virus** is about 17 mμ. **Turnip yellow mosaic virus** 20–30 mμ, **Maize stunt virus** 240×50mμ and **Hydrangia spot virus** is 44 × 16 mμ. Smallest virus is foot and mouth disease virus (10 $m\mu$). Largest virus is smallpox virus – variola (250 mμ).

(6) **General structure of virus**

Structurally viruses are made up of envelope, capsid, nucleoid and occasionally one or two enzymes.

(i) **Envelope :** Some viruses possess an outer thin loose covering, called envelope. It is composed of proteins (from virus), lipids and carbohydrates (both from host). The smaller subunits of envelope are called **peplomers**. Envelope is mainly found in some animal viruses (*e.g.*, Herpes Virus, HIV, Influenza virus, Rous sarcoma virus) and rarely in some plant viruses (*e.g.*, Potato yellow dwarf virus)

and bacterial viruses (*e.g.*, *Pseudomonas* Z). The viruses, which do not possess envelope, are called naked.

(ii) **Capsid :** It is the protein coat that surrounds the central portion of nucleoid and enzymes (if present). The capsid consists of a specific number and arrangement of small sub-units called capsomeres. These sub-units possess antigenic properties.

(iii) **Nucleoid :** The nucleic acid present in the virus is called nucleoid. It is the infective part of virus which utilizes the metabolic machinery of the host cell for synthesis and assembly of viral components. The genetic material of viruses are of four types :

(a) **Double stranded DNA (ds DNA) :** Occur in Herpes virus, Pox virus, Cauliflower mosaic virus (linear), Hepatitis–B virus (circular).

(b) **Single stranded DNA (ss DNA) :** Occur in Coliphage *fd* (linear), coliphage $f \times 174$ (cyclic).

(c) **Double stranded RNA (ds RNA) :** Occur in Reo virus, wound tumour virus.

(d) **Single stranded RNA (ss RNA) :** Occur in Tobacco mosaic virus, Influenza virus, Foot and Mouth virus, Polio virus, Retroviruses (*e.g.* HIV), etc.

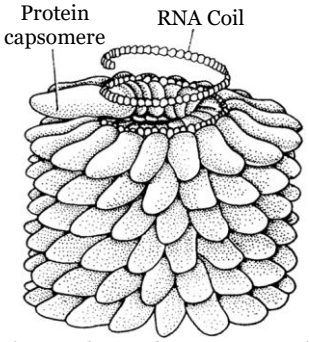


Fig : The tobacco mosaic virus

Tobacco mosaic virus (TMV) : It was discovered by the Russian worker D. Ivanowski. Franklin etal (1957) described the ultrastructure of (TMV) – It is a rod–shaped virus having a central core of RNA surrounded by protein coat (capsid) to form the nucleocapsid. The nucleocapsid may be naked or may be surrounded by a loose membranous envelope. It is composed of a number of subunits called capsomeres. The protein coat (capsid) consists of 2130 identical subunits (capsomeres). The protein is 94% and RNA is only 6%. In the entire length a single RNA molecule runs in the form of spiral coils. The molecular weight of RNA molecule is about 2 million. It provides a code which controls the amino acid sequence in the capsid. This virus measuring 300 × 18 *nm*.

Cryptogram of TMV- $\frac{R}{1} : \frac{2}{5} : \frac{E}{E} : \frac{S}{*}$

1st pair : Type of nucleic acid / Number of strands in nucleic acid.

2nd pair : Molecular weight of nucleic acid in million / Percentage of nucleic acid in virus.

3rd pair : Shape of virus / Shape of capsid.

4th pair : Type of host infection / Type of vector

Bacteriophage : The viruses which attack bacteria are called bacteriophages. In outline they look like tadpole or sperm. The body can be divided into a hexagonal head neck and a tail. The hexagonal head has a central core of DNA, which is surrounded by protein coat. The DNA is double helix, coiled molecule, about 50 mμ in length. It is different from cellular DNA because it has hydroxymethyl cytosine (HMC) in place of cytosine. The cylindrical tail is hollow and is entirely made up of proteins. At the end of this, there are six long threads called tail fibres or caudal fibres. These fibres help the virus while

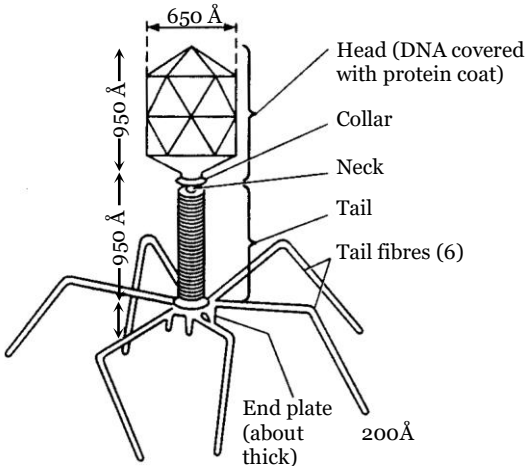


Fig : Structure of bacteriophage

attaching to bacteria. Bacteriophage contain lysozyme enzyme. The water of holy Ganga river contains bateriophage therefore bacteria cannot grow in the water of Ganga.

Cyanophages : Generally some of the viruses are found which attack on blue green algae. *Sofferman* and *Morris* (1963) reported 11 filamentous forms of blue green algae (Lyngbya, plactonema and phormidium, hence called LPP-1) which were attacked by viruses. These viruses are usually called cyanophages. Cyanophages contain DNA as their genetic material. These viruses resemble with bacteriophages in morphology and behaviour. The cyanophages which acttack Nostoc (called N-1) and Anabaena variabilis (called An-1) are tadpole like whereas those which attack oscillatoria are rodshaped.

Mycophages : Some fungi such as, *Mushrooms*, *Penicillium*, etc have also been found to be infected by viruses. These are isometric in shape and contain double stranded RNA.

Phycophages : These are virus which attack on Algae.

(7) **Life cycle :** The word reproduction is not appropriate in case of viruses because they have no cellular components or cell organelles. They do not reproduce themselves but divide by a special mechanism as follows.

(i) **Attachment :** The bacteriophage gets attached to bacterial cell wall with the help of caudal fibres.

(ii) **Penetration :** Bacteriophage dissolves the bacterial wall by an enzyme *Lysozyme* and makes a pore in cell wall. Through this pore DNA molecule enters in the cell after contraction of head protein, entire protein coat remains outside.

(iii) **Latent period** : Phage DNA controls hosts cellular machinery. Instead of formation of bacterial protein, phage protein formation begins. Cellular DNA and RNA is broken down and from this cellular DNA, phage DNA is formed. Now protein covers the DNA fragments to form a kid virus.

(iv) **Maturation :** This young virion is changed into an adult virus hence this process is called maturation. Head tail and tail fibres are formed independently in the cytoplasm and join in the main body.

(v) **Release :** The viruses are mature, cell wall of bacterial cell is weakened by enzyme lysozyme. The release of viruses takes place by bursting of host cell and these are again ready for next infection or attack on other bacteria.

(8) **Transmission :** It takes place by following means

(i) **By vegetative parts** : This is the chief method of transmission of viruses in case of potato, raspberry, strawberry and other fruit trees.

(ii) **By seed :** This method is found in few cases only like legumes, wild cucumber and tomato.

(iii) **By mechanical means :** Sometimes direct contact or mechanical media also transmits them. It may be by direct contact of healthy leaf to infectious leaf, rubbing infected juice on a healthy leaf.

(iv) **By soil :** Soil is a good media of transmission in case of potato mosaic virus, wheat mosaic virus, etc.

(v) **Insect transmission :** Some insects like Aphids and leaf hoppers play role of vector similar to pollen transmission, *e.g.* leaf curl top.

(vi) **By fungi :** Viruses like Tobacco mosaic virus and Lettuce infecting virus are transmitted by fungi.

(9) **Symptoms of viral disease :** The main symptoms are.

(i) **Mosaic spotting :** Leaves show circular or irregular patches of white, light green or yellow colour, *e.g.,* tobacco mosaic.

(ii) **Ring spotting :** This appears in localised spots in the form of concentric rings.

(iii) **Chlorosis :** It shows uniformly disappearing of chlorophyll.

(iv) **Distortion :** It is a common symptom showing rolling and curling of leaves.

(v) **Necrosis :** In this symptom the host cells die. The symptoms may appears in various forms; it may be as patches on apical bud, on leaves or on stem.

(10) **Economic importance of viruses**

Uses of viruses

(i) Specific viral strains are cultured and attenuated to be used as vaccines against specific diseases.

(ii) The addition of cyanophages **LPP-1** and **SM-1** are useful in controlling water blooms.

(iii) Bacteriophage was used by *Hershey* and *Chase* to prove that DNA is the chemical basis of heredity.

(iv) Bacteriophages are of interest to geneticists because these bring about transduction.

(v) Water of river Ganga is believed to have phages which destroy bacteria. That is why its water does not get spoiled.

Viral diseases (Related to blood and organs)

(i) **Rabies or Hydrophobia (Highest mortality rate)**

(a) This virus is having single stranded RNA.

(b) The shape or appearance of virus is bullet shaped.

(ii) **AIDS :** (Acquired Immuno Deficiency syndrome).

(a) First case of AIDS was reported in Atlanta (1981).

(b) This is suspected to be a monkey's virus.

(c) 5-10 million people in the world are infected with this virus and in America alone 80% cases.

(d) Males are more susceptible to this disease than females. (92.5% in males, 6.5% in women and about 1% in children).

(e) This virus spreads through blood transfusion, sexual contact, etc.

(f) This AIDS virus is known by different names as :

ARV : AIDS associated Retrovirus.

LAV : Lymphoadenopathy Associated Virus.

HTLV- III : Human T-cell Lymphotropic Virus Type –III.

HIV : Human Immunodeficiency virus.

(g) This virus contains single stranded RNA.

(h) AIDS virus likes T-lymphocytes which provide resistance to the organism through production of antibodies. This virus infects and kills T-lymphocytes (T-helper cells) and hence resistance of host is collapsed. Thus man is infected with different types of infections. This is also known as Death Warrant.

(iii) **Yellow fever :** Transmitted by *Aedes aegypti* mosquito.

(iv) **Dengue fever :** Transmitted by *Aedes aegypti* and *Culex fatigans* mosquito.

(v) **Polio :** Transmitted through food, water and contact, in five years below children. The polio virus is small, about 30 μm in dimeter and contains about 75% protein and 25% RNA polio and common colds are caused by picornaviruses having single stranded RNA.

(vi) **Hepatitis A :** Transmitted through food, water and contact.

(vii) **Hepatitis B :** Transmitted through contact and body fluids.

(11) **Viroids : Diener** and **Raymer (1967)** discovered very simple smallest infectious agents called Viroids. Viroids consist of RNA only and capsid is lacking. Viroids contain only very low mol. weight. *Diener* and *Raymer* reported that causal agent of potato spindle tuber disease was a free RNA and no viral nucleoprotein particles were present in the infected tissue. *T.O. Diener* (1971) termed it viroid. Viroids are single–stranded, covalently closed circular as well as linear RNA molecules that occur in the form of collapsed circles and hairpin structures. Viroid RNA molecules are so small that the largest one so far described (CEV – citrus exocortis viroid) is only 371 nucleotides long–about one tenth of the size of the smallest RNA virus. Transmission is mechanical. The symptoms on host plants are almost similar to those of viruses. Viroids cause persistent infections. A number of other diseases caused by viroids are – Cadang Cadang of coconut, Cucumber pale fruit, Chrysanthemum stunt, Avacado sunblotch, etc.

(12) **Prions : Prusiner (1982)** discovered it as a human disease causal agents. ***Stanley B. Prusiner*** discovered infectious agents which were prions. Prions are proteinaceous particles thought to cause a number of diseases including the slow virus diseases, therefore also called as **slow viruses**. They are made of proteins molecules only. Genetic material (DNA and RNA) is absent in prions. These can multiply themselves and are infectious also. Prions can survive in heat, radiation and chemical treatment that normally inactivate viruses. Prions affect the central nervous system and one of the best known is the scrapie agent of sheep and goat which causes the animal to scrap itself against some objects. *Kuru*, a disease of central nervous system found in few canniblastic tribes of *New Guinea* is caused by prions. Other such disease is *Creutzfeld–Jacob disease of humans* and *animals*, similar to *scrapie, gerstmann – strassler – scheinker syndrome*. These all are diseases of central nervous system.

(13) **Interferons : *G.M. Findley*** and ***McCallum*** (1937) reported a phenomenon called viral interference in which the cell infected with one type of virus becomes resistant to superinfection by other viruses. Alliac Issacs and Lindeman (1957) gave the term interferons to the chemical substances responsible for viral interference.

(i) Interferons are produced by cells in mammals, rodents, birds, etc., and provide resistance against viruses.

(ii) ***Hilleman*** and ***A. Tydall*** (1963) isolated interferons from hen's egg infected with influenza virus.

(iii) Interferons are **protein** molecules or polypeptides of low molecular weight which prevent viral multiplication.

(14) **Some important- Aspects of virus**

(i) **Plaque :** Bacterial viruses are easily isolated and cultivated in young actively growing cultures of bacteria in broth or on agar plates, In liquid cultures, lysing of the bacteria may cause a cloudy culture to become clear, whereas in agar plate cultures, clear zones, or plaques, become visible to the unaided eye

(ii) **The origin of Hela cells :** It was in the winter of 1951 when Henrietta Lacks, a young black woman of 31, went to the medical clinic of Johns Hopkins University in Baltimore to seek medical treatment. The examining physician found a malignant tumor within her cervix. Some of this cancerous tissue was taken to a laboratory for cultivation.

In spite of intensive radiation treatment, the tumor continued to grow. Eight months after her first visit to the clinic, the cancer had spread throughout her whole body and she died. But the tumor cells taken form Henrietta Lacks thrived they divided and doubled their number every 24 hours. Cells taken previously from the tumors of dozens of other patients had not grown at all, or grew only poorly and then died off.

The cancer cells of Henrietta Lacks continued to flourish in culture in petridishes. These cells, now code named Hela cells, became one of the best known continuous tissue culture cell lines. Hela cells are widely used in research because they are so readily available, so versatile and so easy to propagate serially. They have been double the "cells that would not die." Thus *Henrietta Lacks* left behind her the first widely available model of human tissue in vitro for scientific investigation. Perhaps her legacy will help to conquer the disease that vanquished her in 1952.

(iii) **Plant viruses do not invade apical meristems**

(a) Apical meristems of even virus-infected plants are free from viruses. Majority of systemic viruses are not able to attack apical meristems.

(b) Length of apices remaining free from the virus varies in different virus- host combinations as

100-200 μm for potato viruses, 400-1000 μm for sweet potato internal cork virus.

(c) By excising and culturing the virus-free apical meristem, it is possible to prepare disease-free plants.

Type of nucleic acid and number of strands in different viruses

DNA Viruses	Strands	RNA Viruses	Strands
Adenoviruses	DNA (2)	Avian leukemia virus	RNA (1)
Bacteriophage ϕ X 174	DNA (1)	Bacterial virus F2	RNA (1)
Bacteriophage M13	DNA (1)	Bacteriophage MS–2	RNA (1)
Coliphage lambda (λ)	DNA (2)	Coliphage R17	RNA (1)
Coliphage T2, T4, T6	DNA (2)	Influenza virus	RNA (1)
Coliphage T3, T7	DNA (2)	Poliomylitis virus	RNA (1)
Pox virus	DNA (2)	Tobacco mosaic virus (TMV)	RNA (1)

Herpes viruses	DNA (2)	Reovirus	RNA (2)
Popilloma virus	DNA (2)	Rice dwarf virus	RNA (2)
Polyoma virus SV 40	DNA (2)	Wound Tumour virus	RNA (2)

Families of animal viruses, grouped by type of nucleic acid

Family	Virion Structure	Diameter (nm)	Examples/ Diseases
dsDNA			
Papova virus	Naked polyhedral	40–57	Papilloma (human warts, cervical cancer); polyoma (tumors in certain animals).
Adeno virus	Naked polyhedral	70 – 80	Viruses that cause respiratory disease; some that cause tumors in certain animals.
Herpes virus	Enveloped polyhedral	150–250	Herpes simplex I (cold sores); herpes simplex II (genital); varicella zoster (chicken pox, shingles); Epstein–Barr virus (infectious mononucleosis, Burkitt's lymphoma).
Pox virus	Enveloped complex	200–350	Variola (smallpox); vaccinia; cowpox.
ss DNA			
Parvo-virus	Naked polyhedral	18–26	Most depended on coinfection with adenoviruses for growth
ss RNA that can serve as mRNA (+ strand RNA)			
Picorna virus	Naked polyhedral	18–38	Poliovirus; rhinovirus (common cold); enteric viruses
Toga virus	Enveloped polyhedral	40–60	Rubella virus; yellow fever virus; encephalitis virus (transmitted by insects).
Retrovirus	Enveloped polyhedral; two copies of genome per virion.	100–120	RNA tumor viruses (solid tumors and leukemia); AIDS
ss RNA that is a template for mRNA (– strand RNA)			
Rhabdovirus	Enveloped helical	70–180	Rabies
Paramyxovirus	Enveloped helical	150–300	Measles, mumps
Orthomyxovirus	Enveloped helical; RNA in eight segments.	80–200	Influenza viruses

ds RNA			
Reovirus	Naked polyhedral; RNA in ten segments.	60–80	Diarrhoea viruses
***ds = double– stranded; ss = single–stranded.**			

Important plant diseases caused by viruses

S.No.	Disease	Causal organism
(1)	Abutilon mosaic	Abutilon mosaic virus
(2)	Bunchy top of banana	Banana bunchy top virus
(3)	Cucumber mosaic	Cucumber mosaic virus
(4)	Little leaf of brinjal	Brinjal little leaf virus
(5)	Little leaf of cotton	Cotton little leaf virus
(6)	Papaya mosaic	Papaya mosaic virus
(7)	Potato leaf roll	Potato leaf roll virus
(8)	Potato mild mosaic	Potato virus X
(9)	Potato rugose mosaic	Potato virus X and Y
(10)	Stunt of S. C.	Ratoon stunt virus
(11)	Rosette of groundnut	Groundnut mosaic virus
(12)	Sugarcane mosaic	Sugarcane virus I
(13)	Tobacco mosaic	Tobacco mosaic virus
(14)	Tomato leaf curl	Tomato curl virus
(15)	Tristeza of citrus	Citrus Tristeza virus

Important human diseases caused by viruses

S.No.	Disease	Host	Causal organism
(1)	Encephalitis	Man	Encephalitis virus
(2)	Infectious hepatitis	Man	Hepatitis virus
(3)	Herpetic Keratitis	Man	Herpes virus
(4)	Influenza	Man	Influenza virus–a
(5)	Measles	Man	Measles virus
(6)	Viral bronchitis	Man	Parainfluenza virus
(7)	Poliomyelitis	Man (children)	Polio virus

(8)	Small Pox	Man	Pox virus
(9)	Common cold	Man	Rhino virus
(10)	Yellow fever	Man	Yellow fever virus

Important Tips

- **D. Ivanowski (1892)** a Russian botanist discovered virus.
- Father of Virology **W.M. Stanley** (American Microbiologist).
- Professor **K.S. Bhargava** is the specialist of virology in india.
- **Pasteur. (1892)** studied canine rabies and used the term virus for the first time.
- **Edward Jenner (1796)** developed the first successful vaccine against viral disease small pox.
- **D' Herelle (1917)** coined the term "bacteriophage" for bacterial virus.
- **Stanley (1985)** an American biochemist, isolated and crystalized T.M.V.He was awarded Nobel Prize.
- Caulimo virus (cauliflower mosaic virus) are double stranded DNA virus.
- **Franklin etal (1957)** described the ultrastructure of T.M.V.
- **Lindemann (1957)** did the first successful vaccination against Polio.
- Virus are made up genetic material and capsid. Capsid is made of protein. Unit of capsid is called capsomeres.
- Single virus observed under electron microscope, outside host is called "Virion".
- The first virus to be cultured in human cells was Polio virus.
- Most of the phase are DNA virus.
- Mostly plant viruses have RNA and animal viruses have DNA as genetic material.
- Single stranded RNA is found in T.M.V. and polio viruses.
- Retroviruses have single stranded RNA.
- Retroviruses and reverse transcription were reported by Temin and Baltimore.
- Bacteriophage have single stranded DNA.
- Viruses can pass through bacteria proof filters. These are the intermediate connection between living and non living.
- Viruses can not grow (multiply) out side a host cell. They can grow in living cell only.
- Some animal viruses covered by a lipo-proteinacous envelope. It also contains carbohydrate (found in influenza virus).
- Viruses have host specificity. A specific virus infects only a particular host.
- Polio vaccine was discovered by Salk and Sabine in 1957.

- Virus are lack protoplasm.
- In the world which do not have cell are virus, viroids and prions.
- Substance which can inactivate to viral activities are known as antiviral agents or virucide.
- The synthesis of viral proteins takes place on host ribosomes.
- Viruses lack pigments metabolic activity, they made up by RNA only movement and sex organs, but some enzyms are found in them.
- Viroids : They are the smallest known disease causing agents in plants.
- Prions : They are causal agent of human disease and have no nucleic acid, only made up by protein molecules.
- AIDS is caused by HIV. It infects T–lymphocytes. HIV virus remains dormant for about 8 years. Infected person does not suffer a symptoms during this period. AIDS day is 1st December.
- Size of virus is 20nm. – 300 nm. Largest virus is – **vaccinia** or **cow pox-virus** (500nm). Smallest virus is – **Alfa-alfa virus** (17 nm).
- Smallest virus is Satellite virus or tobacco necrosis virus – 17 nm.
- Viral diseases – yellow fever, influenza, small pox, polio, mumps etc.
- Pox virus is also known as vip virus.
- Five genes are present in a simplest virus.

***

ASSIGNMENT

STRUCTURE OF BACTERIA

Basic Level

1. Smallest bacteria is
   (a) Spirillum (b) Bacillus (c) Dialister (d) None of these
2. Antony Von Leeuwenhock was first discovered bacteria. He belongs to which country
   (a) France (b) Swedan (c) Holland (d) United kingdom
3. Who is the father of microbiology
   (a) Antony Von Leeuwenhock (b) Alexander Flemming
   (c) Anoton De Berry (d) Robert Koch
4. The archaebacteria occurring in marshes, swamps, rumens of cattles are
   (a) Methanogens (b) Halophiles (c) Thermoacidophiles (d) None of these
5. Chromosomes in a bacterial cell can be 1-3 in number and
   (a) Are always circular
   (b) Are always linear
   (c) Can be either circular or linear, but never both within the same cell
   (d) Can be circular as well as linear within the same cell
6. The characteristic cells wall material peptidoglycan has another covering of lipopolysaccharides. This specialised condition is found in
   (a) Eubacteria Gram (+) ve (b) Eubacteria Gram (–) ve
   (c) All Eucaryotes (d) Both (a) and (b)
7. An example of iron bacteria is
   (a) Beggiatoa (b) Geobacillus (c) Thiobacillus (d) None of these
8. In which kingdom would you classify the archaea and nitrogen fixing organisms, if the five kingdom system of classification is used
   (a) Plantae (b) Fungi (c) Protista (d) Monera
9. Photoautotrophic bacteria are
   (a) Anaerobic (b) Aerobic (c) Chemosynthetic (d) Oxygenic
10. Green sulphur bacteria look green due to
    (a) Bacterioviridin (b) Bacteriochlorophyll (c) Carotenoids (d) Thylakoids
11. Circular DNA molecule occurs in
    (a) Viruses (b) Bacteria, chloroplasts and mitochondria
    (c) Bacteria and chloroplasts only (d) Bacteria only
12. Name the bacterium that gets its energy by fermentation and if oxygen is given, it dies
    (a) Obligate aerobe (b) Facultative anaerobic (c) Obligate anaerobe (d) Aerobe

13. Lipid and protein are the components of cell walls in
(a) Gram positive bacteria (b)Gram negative bacteria
(c) Colourless fungal cells (d)All plant cells

14. Photosynthetic bacteria have
(a) Pigment system I (only one pigment system) (b) Pigment system II
(c) Both (a) and (b) (d) Some other types

15. A cell wall material present only in bacteria and blue-green algae is
(a) Pectin (b) Cellulose (c) Muramic acid (d) Chitin

16. *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

17. Bacterial ribosomes are called
(a) Autosomes (b) Dictyosomes (c) Centrosomes (d) Polyribosomes

18. Antibiotic resistant genes in bacteria are found in
(a) Bacterial chromosome (b)Plasmids (c) Bacterial cell wall (d) Mesosomes

19. The size of bacterial cells ranges between
(a) 0.1-5 μ (b) 0.5-3 μ (c) 0.5-3 Å (d) 0.1-0.3 μ

20. Bacteria differ from virus in the presence of
(a) True nucleus (b) Cytoplasm (c) Causing disease (d) All of these

21. Nostoc is characteristic in having
(a) Cellulose cell wall (b) Uniflagellated zoospores
(c)Chlorophyll 'e' (d) Sexual reproduction

22. Nitrosomonas and Nitrobacter oxidises
(a) Nitrate to nitrogen (b) CO_2 to carbohydrates (c) N_2 to NO_3^- (d) NH_3 to NO_3

23. What is the nuclear material of a bacterium
(a) Nucleic acid and histone protein (b)Nucleic acid and cytoplasm
(c) Only nucleic acid (d) All of these

24. Mucopeptide is most abundant matter in the cell wall of
(a) Cyanophages (b) Cyanobacteria (c) Gram positive bacteria (d)All of these

25. Bacteria flagella do not show ATPase activity and 2+9 organisation these are chemically made up of
(a) Tubulin (b) Flagellin (c) Pilin (d) Bactericin

26. In bacteria, enzymes involved in the oxidation of metabolites are associated with
(a) Mitochondria (b) Nucleoid (c) Mesosomes (d) Chloroplast

27. Which one of the following is correct for structure of cell wall of fungi and bacteria
(a) Both have glycopeptide (b)Both are made up of N-acetyl glycosamine
(c) Both are made up of N- acetyl muramic acid (d) Both are made up of chitin

28. An oxygenic photoautotroph requires
(a) O_2, H_2O and light (b) CO_2 and H_2O (c) CO_2 and light (d) CO_2, light and H_2S

29. In bacteria, sexual conjugation is promoted by
(a) R-factor (b) Col-factor (c) F-factor (d) None of these

30. Hay bacteria is
(a) Bacillus subtilis (b) E.coli (c) Spirillum (d) Clostridium

31. In photoautotrophic bacteria, the reaction centre in chloroplast of bacteria is
(a) P_{700} (b) B_{690} (c) B_{890} (d) B_{1700}

32. Whose cell wall dissolves by antibiotic action
(a) Actinomycetes (b) Mycoplasma (c) Bacteria (d) L-form bacteria

33. Halophillic bacteria are able to survive in salt rich media due to
(a) Accumulation of halogens (b) Bacteriorhodopsin
(c) Delytic enzymes (d) All of these

34. Chemosynthetic bacteria are characterized by
(a) Synthesis of food without light (b)Synthesis of food in light
(c) Synthesis of simpler elements (d)Lack of ability to sythesize

35. Cyanobacteria living inside the protozoans are called
(a) Cyanelle (b) Blue green algae (c) Myxophycease (d) Euglenoids

36. Pili in bacteria represent
(a) Extra-chromosomal genetic element (b) Protoplasmic outgrowths of donor cells
(c) Small flagella (d) Special bacterial cilia

37. The cells of bacterium *Staphylococcus* remain arranged in the form of
(a) Plate (b) Cube (c) Irregular cluster (d) Chain

38. *Vibrio* bacteria have the following shape
(a) Rods (b) Spherical (c) Spiral (d) Comma

39. Which of the following is not found in bacteria
(a) Endoplasmic reticulum (b)Cell wall (c) DNA (d) Cell cytoplasm

40. Many bacteria bear minute hairy structures on their cell wall. These are called
(a) Hairs (b) Flagella (c) Pili (d) Cilia

41. Bacterial cells can be stained with
(a) Mercuric chloride (b) Crystal violet
(c) Crystal violet and iodine (d)Safranin

42. Genes which confer antibiotic resistance on bacteria are located on
(a) Polysome (b) Circular DNA molecule (c)Plasmid (d) RNA

43. The gram negative bacteria detect and responsed to chemicals in their surroundings by
(a) Lipopolysaccharide (b) Muramic acid (c) Porins (d) Volutin granules

44. The cells of the bacterium *streptococcus* remains arranged in the form of
(a) Chain (b) Irregular cluster (c) Cube (d) Plate

45. The murein found in bacterial cell is
(a) Derivative of protein (b)Derivative of fat
(c) Derivative of organic acids (d)Derivative of sugars

46. Mucopeptide in cell wall is more in
(a) Gram-positive bacteria (b)Gram-negative bacteria
(c) Cyanobacteria (d)Bacteriophage

47. When a bacterium is provided with flagella arising from two opposite ends. It is called
(a) Monotrichous (b) Lophotrichous (c) Amphitrichous (d) Polytrichous

48. Genes for antibiotic resistance are located in
(a) Chromosome (b) Nucleus (c) Cell wall (d) Plasmid

49. The microflora occuring in largest number in soil are
(a) Grasses (b) Fungi (c) Bacteria (d) Algae

50. The site of respiration in bacteria is
(a) Episome (b) Mesosome (Cytoplasmic membrane)
(c) Ribosome (d) Microsome

51. Bacteria are considered as plants, because
(a) These have a rigid cell wall (b)They have a green colour
(c) They can reproduce (d) They are present everywhere

52. In bacteria
(a) DNA is enclosed in nucleus (b) DNA is scattered
(c) DNA is double straned and ringed (d) None

53. Bacteria whose cell has only a curve is
(a) *Vibrio* (b) *Cocci* (c) *Spirilli* (d) *Bacilli*

54. The microbial conversion of ammonia to nitrate is called as
(a) Ammonification (b) Nitrification
(c) Denitrification (d) Nitrogen fixation (N_2-fixation)

55. Gram –ve and +ve bacteria have cell membrane made up of
(a) Proteins and lipids (b) Cellulose (c) Fats (d) Chitin

56. The main difference between Gram positive and Gram negative bacteria lies in the composition of
(a) Cilia (b) Cell wall (c) Neucleolus (d) Cytoplasma

57. Muramic acid is present in the cell wall of
(a) Bacteria (b) Green algae (c) Red algae (d) *Rhizopus*

58. Bacteria bearing flagella all over the body are called
(a) Peritrichous (b) Atrichous (c) Monotrichous (d) Cephalotrichous

59. *Salmonella* sp. is
(a) Monotrichous (b) Lophotrichous (c) Amphitrichous (d) Peritrichous

60. Mitochondria are absent in
(a) Yeast (b) Bacteria (c) Fungi (d) Green algae

61. Photosynthetic bacteria have pigments in
(a) Leucoplasts (b) Chloroplasts (c) Chromoplasts (d) Chromatophore

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

63. The DNA of *E.coli* is
(a) Single stranded and linear (b) Single stranded and circular
(c) Double stranded and linear (d) Double stranded and circular

64. Which one of the following organisms may respiration in the absence of oxygen

(a)Azotobacter (b) Clostridium (c) Rhizobium (d)Lactobacillus

65. Who classified bacteria under Schizomycetes

(a) Nageli (b) Linnaeus (c) Leeuwenhock (d) Sadashivan

66. Plasmids occur in

(a) Viruses (b) Bacteria (c) Chloroplasts (d) Chromosomes

67. Bacteria are included in which of the following kingdoms

(a) Protista (b) Plantae (c) Monera (d) Animalia

68. Bacteria generally move due to

(a) Chemotaxis (b) Thermotaxis (c) Phototaxis (d) Thermotropism

69. Rounded bacteria are

(a) Bacillia (b) Vibrio (c) Spirilla (d) Cocci

70. Bacterial ribosomes lie in

(a) Cytoplasm (b) E.R. (c) Nuclear membrane (d) On wall of the cell

71. Mitotic apparatus is absent in

(a) Green algae (b) Fungi (c) Bacteria (d) Higher plants

72. Thermal bacteria survive in

(a) Hot water near 100°*C* (b) Hot water near 85°*C* (c) Hot sulphur spring near 70°*C* (d) All the above

73. Endospores develop in

(a) *Mucor* and *Bacillus* (b) *Saccharomyces* and *Clostridium*

(c) *Monococcus* and *Clostridium* (d) *Bacillus* and *Clostridium*

74. Bacterial protoplasm is granular due to

(a) Golgisomes (b) Lysosomes (c) Ribosomes (d) Endoplasmic reticulum

75. Some bacteria produce resting spores during unfavourable conditions. They are

(a) Exospores (b) Endospores (c) Aplanospores (d) Chlamydospores

76. A Dutch scientist A.V. Leeuwenhock discovered bacteria for the first time in

(a) Soil (b) Air (c) Rain water (d) Garden soil

77. Genes are packed in bacterial chromosome by

(a) Acid proteins (b) Histones (c) Basic proteins (d) Actin

78. Bacteria lacking flagella and moving by gliding are

(a) Rickettsiae (b) Eubacteria (c) Spirochactes (d) Myxobacteria

79. Which one is peritrichous

(a) *Pseudomonas* (b) *Bacillus typhosus* (c) *Spirillum* (d) *Vibrio*

Advance Level

80. The bacteria grown in the medium containing S^{35} as alone source of sulphur show its incorporation into

(a) DNA (b) Protein (c) RNA (d) None of these

81. Which of the following process is the source of energy in chemoautotrophs for fixation of CO_2 into carbohydrates

(a) Reduction/ oxidation of any matter present in medium

(b) Reduction of organic compounds

(c) Oxidation of organic molecules (d)Oxidation of inorganic molecules

82. In alcohol fermentation

(a) Triose phosphate is the electron donor while acetaldehyde is the electron acceptor

(b) Triose phosphate is the electron donor while pyruvic acid is the electron donor

(c) There is no electron donor

(d) Oxygen is the electron acceptor

83. Thermoacidophiles are facultative anaerobes and can tolerate high temperature $(80^{o}C)$ and high acidity $pH = 2$ due to

(a) High KCl conc, and resistant enzymes (b) Mucilage covering

(c) Branched chain lipids in cell membrane (d) All of these

84. Most of the bacteria can tolerate high temperatures due to

(a) Type of cell wall (b) Cell organization

(c) Homopolar bonds in their proteins (d) Absence of phospholipids in their walls

85. The smallest eubacterium Dialister pneumon-sintes (0.15-0.3 μm) occurs in

(a) Colon of man (b) Fat body of cockroach (c)Nasal chamber of man (d)Soil

86. Fimbriae are

(a) Organs of adhesion

(b) Antigenic

(c) Organs which form conjugation tube through which genetic material is transferred from donor to recipient cell

(d) All of these

87. A strain of *E.coli* cannot grow in absence of lactose, it means that

(a) Iac operon is constitutively working (b) β galactosidase is not made

(c) In presence of glucose *E.coli* cannot utilize lactose (d) It is unable to take up lactose molecule

88. A substance that causes the disintegration of bacteria is

(a) Bacteriocin (b) Bacterin (c) Barophile (d) Bacteriolysin

89. Mycolic acid is present in cell wall of pathogen causing

(a) Tetanus (b) Cholera (c) Diphtheria (d) Tuberculosis

90. All life on earth derive its energy directly or indirectly from sun except

(a) Mushroom and mould (b)Chemosynthetic bacteria

(c) Symbiotic bacteria (d)Pathogenic bacteria

91. 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

92. 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 reducees 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

93. R-gene present on plasmid is meant for
(a) Drug resistance (b) Nitrogen fixation
(c) Locomotion (d) Exchange of genetic material

LIFE CYCLE / REPRODUCTION OF BACTERIA

Basic Level

94. The Pneumococcus experiment proves that
(a) DNA is the genetic material
(b) Bacteria undergo binary fission
(c) Bacteria do not reproduce sexually
(d) RNA sometime controls the production of DNA and proteins

95. 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

96. Which of the following terms is not concerned with genetic recombination in bacteria
(a) Transformation (b) Transduction (c) Translation (d) Conjugation

97. The suggestion that "strains arise by mutation" was given by
(a) Takahashi (b) Bawden (c) Rawlins (d) Mc.Kinney

98. Organisms multiplying at temperature 100-105^oC belong to
(a) Thermophilic fungi (b) Hot spring cyanobacteria
(c) Thermophilic sulphur bacteria (d) All of these

99. Elementary bodies characteristic of Chlamydia help in
(a) Reproduction (b) Respiration (c) Secretion (d) Food storage

100. When a temperate bacteriophage breaks loose from its host chromosome and carries some to the chromosome with it to another host cell, the process is called
(a) Conjugation (b) Transformation
(c) General transduction (d) Restricted transduction

101. Bacteria reproduce sexually by
(a) Endospores (b) Transformation (c) Conidia (d) Exospores

102. In bacteria, sex is determined by

(a) Presence of episomes (b) Presence of flagella

(c) Presence of pili (d) Presence of mesosomes

103. Transformation experiment was first performed on which of the following bacteria

(a) *E. coli* (b) Salmonella

(c) Pasteurella pestis (d) Diplococcus pneumoniae

104. The genome of transducting phages is

(a) Single stranded RNA (b)Double stranded RNA

(c)Single stranded DNA (d)Double stranded DNA

105. Transfer of DNA from one bacteria to another by contact is known as

(a) Conjugation (b) Transformation (c) Transduction (d) Transcription

106. Genetic recombination and first indication of sexuality in bacteria was discovered by

(a) Lederberg and Tatum (b)Griffith (c) Wollmen (d) Zinder

107. Organelle/organoid involved in genetic engineering is

(a) Plasmid (b) Mitochondrion (c) Golgi apparatus (d) Lomasome

108. Extrachromosomal DNA of bacteria is

(a) Mesosome (b) Microsome (c) Plasmid (d) Chromosome

109. Dehydrated thick-walled bacterial cells having dipicolinic acid are

(a) Endospores (b) Conidia (c) Exospores (d) Oidia

110. Pili are employed by bacteria for

(a) Locomotion (b) Sexual contact (c) Asexual reproduction (d) Location of prey

111. Form of sexual reproduction where genetic material is carried from one strain of bacteria to another by bacteriophage by virulent or temperate phage is

(a) Transformation (b) Generalized transduction

(c) Specialized transduction (d)Conjugation

112. The extrachromosomal part of bacteria, the plasmid contains

(a) RNA (b) RNA+protein (c) DNA (d) All above

113. Some bacteria are not easily killed because of

(a) Chitinous wall (b) Endospore formation (c) Presence of mesosome (d)High tolerance

114. On the basis of which activity of bacteria it has been proved for the first time that DNA is genetic material

(a) Conjugation (b) Transformation (c) Transduction (d) Asexual reproduction

115. Bacteria commonly reproduce vegetatively by

(a) Binary fission (b) Budding (c) Conjugation (d) Oidia

116. The process in which viruses are involved in sexual reproduction of bacteria is called

(a)Transduction (b) Transcription (c) Transformation (d)Translation

117. 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

118. Sex factor in bacteria is

(a) F- replicon (b) Chromosomal replicon (c)RNA (d) Sex pili

119. Transformation in bacteria was discovered by

(a) Lederberg (b) Griffith (c) Avery et al (d) Tatum

120. Who discovered transduction in bacteria

(a) Wollmen and Jacob (b) Zinder and Lederberg (c) Lederberg and Tatum (d)Herelle and Twort

121. Reproduction of cyanobacteria is different from bacteria as they reproduce only by

(a) Binary fission (b) Fragmentation (c) Conjugation (d) Transduction

122. Sexual reproduction does not occur in

(a) Nostoc (b) Riccia (c) Ulothrix (d) Rhizopus

123. How many bacteria are produced in four hours if a bacterium divides once in half an hour

(a) 8 (b) 64 (c) 16 (d) 256

124. The bacterial genome is

(a) Circular (b) Filamentous (c) RNA-DNA hybrid (d) Both (a) and (b)

125. Nucleic acids in chromosomes in bacteria are

(a) Two types of DNA and RNA (b) Linear DNA

(c) Circular DNA (d) Linear RNA

126. 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*

(a) 175×10^5 *cells* (b) 85×10^5 *cells* (c) 35×10^5 *cells* (d) 32×10^5 *cells*

127. During bacterial conjugation there is usually

(a) Only a partial transfer of genetic material from one conjugant to the other

(b) A partial but mutual exchange of genetic material between the conjugants

(c) A mutual and complete exchange of genetic material between two conjugants

(d) Complete transfer of genetic material from one conjugant to other

128. Plasmids are ideal vectors for gene cloning as they

(a) Can be multiplied in a laboratory using enzymes (b)Can be multiplied by culturing

(c) Are self- replicating (d)Replicate freely outside the bacterial cells

129. In the bacterium Bacillus subtilis the cells often become attached form end to end forming long filamentous chains, which are embedded in a mass of mucilage forming a scum layer on the substraturm. It is called as

(a) Zooglea stage (b) Palmella stage (c) Torula-stage (d) None of these

130. During translation initiation in prokaryotes, a GTP molecule is needed in

(a) Formation of formyl-met- tRNA (b)Binding of 30S *m*RNA with formyl - met- tRNA

(c) Association of 30S *m*RNA with formyl- met- tRNA

(d) Association of 50S subunit of ribosome with initiation complex

131. 'Generation time' of bacteria means time period required

(a) For the population to double (b)To produce daughter cells by one binary fission

(c) To grow endospores (d)For bacteriophage infection

132. A plasmid is a

(a) Bacteriophage

(b) DNA molecule incorporated in the bacterial chromosome

(c) DNA molecules present in mitochondria

(d) A small circular DNA molecule capable of self replication and that can carry genes into host organism

133. Bacteria living in human large intestine that feed on undigested food without harming the host is termed as

(a) Predators (b) Commensals (c) Symbionts (d) Parasites

134. The cycle of events which has the same outcome as sexual cycle without the regular alternation of meiosis and fertilization, is known is

(a) Parthenogenesis (b) Parasexual cycle (c) Somatoplastic sterility (d) Self fertility

135. We can keep food for longer duration in cold storage than in ordinary cupboard because

(a) Low temperature causes plasmolysis (b) Insects can not cause infection

(c) Bacterial multiplication is greatly increased

(d) Bacterial multiplication is completely prevented

136. Bacteroids are

(a) Enlarged non-motile cellular bacteria *Rhizoblum leguminosarum* in root nodules of legumes

(b) A bacterial cell infected with viruses

(c) A motile bacterium

(d) *Nitrosomonas* bacteria in soil

137. Bacteria lack alternation of generation as they

(a) Lack distinct chromosomes (b)Lack both syngamy and meiosis

(c) Involve exchange of genetic material (d) Lack conjugation

ECONOMIC IMPORTANCE OF BACTERIA

Basic Level

138. The following is an aerobic, free living nitrogen fixing soil bacterium

(a) Clostridium (b) Azotobacter (c) Klebsiella (d) Rhizobium

139. Which of the following organism fix atmospheric nitrogen in free state (without association with a plant)

(a) Rhizobium (b) Thiobacillus (c) Nitrobacter (d) Bacillus polymyxa

140. Two bacteria found to be very useful in genetic engineering experiments are

(a) Nitrosomonas and klebsiella (b)Escherichia and Agrobacterium

(c) Nitrobacter and Azotobacter (d)Rhizobium and Diplococcus

141. Which is must for N_2 fixation

(a) Leg-haemoglobin (b) Haemocyanin (c) Anthocyanin (d) Phytocyanin

142. The yield of paddy can be increased by the application of
(a) Nostoc (b) Symbiotic bacteria (c) Iron bacteria (d) Archaebacteria

143. Dinitrogen fixation by Nostoc takes place in
(a) Heterocysts (b) Vegetative cells (c) Akinetes (d) Hormogonia

144. Nitrogen fixing aerobic photosynthetic and Gram (-) bacteria are
(a) Archaebacteria (b) Cyanobacteria (c) Chlorobacteria (d) Rickettsiae

145. Which changes proteins into ammonia
(a) Rhizobium (b) Nitrobacter (c) Beggiatoa (d) Bacillus mycoides

146. Nitrogen fixation organism is
(a) Nitrosomonas (b) *E.coli*
(c) Nitrobactor (d) Rhizobium and Azotobacter

147. Pasteurization makes food stuff free from
(a) All living organisms (b) Vegetative forms of all pathogenic microbes
(c) All vegetative forms of bacteria (d) All bacteria

148. The symbiotic nitrogen fixing bacteria present in root nodules of legumes belongs to genus
(a) Xanthomonas (b) Pseudomonas (c) Rhizobium (d) Acetobacter

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

150. Which of the following is recently discovered gram positive non-leguminous nitrogen fixing bacterium
(a) Azospirillum (b) Rhizobium (c) Nitrosomonas (d) Spirillum

151. Which of the following is non-symbiotic nitrogen fixing bacteria
(a) Clostridium (b) Nostoc (c) Rhizobium (d) Anabaena

152. The nitrogen fixing and photosynthesizing gram negative bacteria (aerobic) belong to
(a) Archaebacteria (b) Heterotrophic bacteria (c) Cyanobacteria (d) None of these

153. Streptomyces ramosus is the source of the antibiotic
(a) Chloromycetin (b) Erythromycin (c) Aureomycin (d) Terramycin

154. Streptomyces venezuelae yields
(a) Aureomycin (b) Chloromycetin (c) Tetracycline (d) Streptomycin

155. Bacteria can prepare food from
(a) NO_3 (b) N_2 (c) O_2 (d) Glycogen

156. The biological process carried on by Rhizobium is called
(a) Nitrification (b) Ammonification (c) Nitrogen fixation (d) Fermentation

157. Azolla is used as a biofetilizer because it
(a) Multiplies very fast to produce massive bioma
(b) Has association of nitrogen fixing Rhizobium
(c) Has association of nitrogen –fixing cyanobacteria (d)Has association of mycorrhiza

158. Which bacteria convert ammonium salts into nitrite
(a) Nitrobacter (b) Nitrosomonas (c) Azotobacter (d) None of these

159. Nitrogen fixing bacteria are associated with
(a) Leguminaceae (b) Cruciferae (c) Gramineae (d) Malvaceae

160. Which one of the following pairs is correctly matched
(a) Rhizobium- Parasite in the roots of leguminous plants
(b) Mycorrhizae – Minral uptake from soil
(c) Yeast – Production of biogas (d)Mycomycetes- The disease ringworm

161. The nitrifying bacteria are
(a) Autotrophic (b) Saprophytic (c) Parasitic (d) Chemosynthetic

162. Which of the following fix the atmospheric nitrogen
(a) Rhizobium (b) Fungi (c) Viruses (d) Spirogyra

163. Which one of the following bacteria has potential for nitrogen fixation
(a) Nitrosomonas (b) Nitrobacter (c) Nitrosococcus (d) Rhizobium

164. Which of the following fixes CO_2 in carbohydrates
(a) Bacillus (b) Rhizobium (c) Nitrobacter (d) Rhodospirillum

165. Retting of fibres is caused by
(a) Bacillus (b) Clostridium (c) Nitrobacter (d) Rhizobium

166. Nitrifying bacteria, nitrosomonas and nitrobactor
(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

167. Root nodules for nitrogen fixation in non leguminous trees are produced by species of the genus
(a) Rhizobium (b) Azotobacter (c) Frankea (d) Thiobacillus

168. Which of the following is non-symbiotic biofertilizer
(a) VAM (b) Azotobacter (c) Anabaena (d) Rhizobium

169. Which of the following is non-symbiotic nitrogen fixing bacteria
(a) Clostridium (b) Nostoc (c) Rhizobium (d) Anabaena

170. Milk is changed into curd by
(a) Acetobacter aceti (b) Bacillus megatherium (c) Xanthomonas citri (d) None of these

171. Which are of the following bacteria has been genetically improved for controlling pollution
(a)Nitrobacter (b) Rhizobium (c) Nitrosomonas (d)Pseudomonas

172. The Ti plasmid is often used for making transgenic plants
(a) Agrobacterium (b)Yeast as a $2\mu m$ plasmid
(c) Azotobacter (d)Rhizobium of the roots of leguminears plants

173. Azotobacter and Bacillus polymyxa are the examples of
(a) Symbiotic nitrogen fixers (b) Non-symbiotic nitrogen fixers
(c) Disease causing bacteria (d) Ammonifying bacteria

174. Which of the undermentioned is a free-living aerobic non- photosynthetic nitrogen fixer
(a) Azotobacter (b) Azosprillum (c) Rhizobium (d) Nostoc

175. A large number of organic compounds can be decomposed by
(a) Chemolithotrophs (b) Pseudomonas (c) Azotobacter (d) Mycoplasma

176. Vitamin B_{12} is produced by the fermentative activity of

(a) Bacillus amylobacteria (b)Clostridium acetobutyticum

(c) C. felcinium (d)Acetobacter aceti

177. The most throughly studied of the known bacteria plant interactions is the

(a) Nodulation of sesbania stems by nitrogen fixing bacteria

(b) Plant growth stimulation by phosphate solubilising bacteria

(c) Cyanobacterial symbiosis with some aquatic ferms

(d) Gall formation on certain angiosperms by agrobacterium

178. The Streptococcus lactis is responsible for

(a) Conversion of milk into curd (b)Conversion of molasses into alcohol

(c) Tanning of leather (d) Flavouring the leaves tea and tobacco

179. Nitrifying bacteria are those which can convert

(a) Atmospheric nitrogen into ammonia (b) Ammonia into nitrites

(c) Nitrites into nitrates (d) Nitrates into ammonia

180. Bacteria which directly convert atmospheric nitrogen into nitrogen compounds are called

(a) Denitrifying bacteria (b)Putrefying bacteria

(c) Nitrogen fixing bacteria (d)Nitrifying bacteria

181. Which one of the following can utilize molecular nitrogen (N_2)as nutrient for growth

(a) Rhizobium (b) Spirogyra (c) Mucor (d) Methanococcus

182. A free living anaerobic bacterium capable of N_2 fixation in soil is

(a)Rhizobium (b) Azotobacter (c) Streptococcus (d) Clostridium

183. The term "antibiotic" was coined by

(a) Edward Jenner (b) Louis Pasteur (c) Selmen Waksman (d) Alexander Flemming

184. Which of the following bacterium is photosynthetic free living aerobic N_2 fixer

(a) Anabaena (b) Rhizobium (c) Azospirillum (d) Azotobacter

185. Biofertilizers include

(a) Nitrogen fixing bacteria (b)Nitrogen fixing cyanobacteria

(c) Mycorrhiza (d)All of these

186. Nitrosomonas and Nitrobacter convert

(a) Carbon dioxide to carbohydrates (b)Ammonium ion into nitrate

(c) Nitrate ion into nitrogen molecule (d) Nitrogen into nitrate

187. Maximum number of antibiotics got from any group is

(a) Actinomycetes (b) Fungi (c) Eubacteria (d) Viruses

188. Which of the following is a non-symbiotic anaerobic non-photosynthetic nitrogen fixing bacterium

(a) Chromatium (b) Chlorobium (c) Clostridium (d)Azotomonas

189. Farmers have reported over 50% higher yields of rice by using biofertillzer

(a) Cyanobacteria (b) Azolla pinneta

(c) Rhizobium legume-symbiosis (d) Both (a) and (b)

190. Bacteria used in genetic engineering are

(a) Vibrio cholerae (b) Agrobacterium tumefaciens

(c) Azotobacter (d) Clostridium septicum

191. Ammonification of protein by $\text{Protein} \xrightarrow{\text{Putrefaction}} \text{Amino acid} \rightarrow \text{Ammonium compounds}$

(a) *Nitrosomonas* (b) *Nitrobacter* (c) *Bacillus mycoides* (d) *Azotobacter*

192. Wine turns sour because of

(a) Heat (b) Aerobic bacteria (c) Anaerobic bacteria (d) Exposure to light

193. The bacteria which convert $NO_3 \rightarrow$ Free N_2 are called as

(a) Nitrifying bacteria (b) Ammonifying bacteria

(c)Denitrifying bacteria (d) None of these

194. The main role of bacteria in the carbon cycle involves

(a) Photosynthesis (b)Assimilation of nitrogenous compounds

(c) Chemosynthesis (d)Digestion or breakdown of organic compounds

195. Bacteria which directly convert atmospheric nitrogen into nitrogen compounds are called

(a) Denitrifying bacteria (b)Putrefying bacteria

(c) Nitrogen fixing bacteria (d) Nitrifying bacteria

196. One of the useful activities of several bacteria is

(a) Nitrogen fixation (b) Nitrification

(c) Operation of biogeochemical cycles (d) All of the above

197. Which vitamin is synthesised by bacteria in human gut

(a) A (b) C (c) D (d) K

198. Bt gene occurs in

(a) *Bacillus thuringenesis* (b)*Escherichia coli*

(c) *Agrobacterium tumefaciens* (d) Rhizobium leguminosarum

Advance Level

199. Against one of the following, vaccination is prepared using scaly ant eater, Armadillo

(a) Clostridium botulinum (b)Vibrio cholerae

(c) Mycobacterium leprae (d)Mycobacterium tuberculi

200. Activity of one of the following bacteria is very helpful in the preparation and flavouring of tea leaves

(a)Bacillus subtilis (b) Bacillus megatherium (c)Bacillus aceti (d)Bacillus radicicola

201. Why surgical instruments are boiled in water before use

(a) For killing the pathogens present on them (b) So that doctors can use them easily

(c) Provides pleasure to the patient

(d) All the saprophytes die on the operative surface

202. Pasteurization of milk involves heating for

(a) 60 minutes at about 100^oC (b)60 minutes at about 90^oC

(c) 30 minutes at bout 60^oC (d)30 minutes at about 90^oC

203. Which of the following soil micro organisms breaks down plant and animal protein into ammonia

(a) Bacillus vulgaris (b) Nitrosomonas (c) Pseudomonas (d) None of these

204. A sewage treatment process, in which a portion of the decomposer bacteria present in the waste is recycled into the beginning of the process, is called.....treatment

(a) Cyclic (b) Primary (c) Activated sludge (d) Tertiary

205. Activity of nitrogenase in nitrogen fixing micro organisms can be seen when

(a) Methane is converted to ethane (b)Ethane is converted to methane

(c) Ethylene is converted to acetylene

(d) Acetylene is converted or reduced to ethylene

206. *Escherichia coli* is used as an indicator organism to determine pollution of water with

(a) Heavy metals (b) Faecal matter

(c) Industrial effluents (d) Pollen of aquatic plants

207. Anaerobic digestion of cowduing and agriculture wastes to generate biogas utilises the organism belonging to the genus

(a) Methanobacterium (methanobacillus) (b) Aspergillus

(c) Fusarium (d) Alternaria

208. Penicillin antibiotic which effects bacterial

(a) DNA replication (b) Protein synthesis

(c) Plasma membrane properties (d) Peptidoglycon synthesis (cell wall)

209. Anaerobic bacterial synthesis is

(a) Endergonic (b) Exergonic (c) Isothermal (d) None of these

210. Streptococcus lactis causes the souring of milk as

[(1) It products lactic acid (2) Coagulates the milk proteins (3) Lowers pH < 5.1]

(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2 and 3

211. Consumption of antibiotics lead to glossites and chelosis if not consumed with vitamin B complex as

(a) Antibiotics supress vitamin absorption

(b) Antibiotics kill intestinal bacteria which synthesize vitamins

(c) Antibiotics degrade vitamins

(d) Antibiotics are highly acidic

212. Bioluminiscence is caused by oxidation of

(a) Cytochroms (b) Luciferin (c) Phytochromes (d) Chlorophyll

213. To develop flavour and taste in tobacco leaves are processed with bacterium

(a) Mycococcus candisans (b)Megathenium mycococcus

(c) Aerobacter (d) None of these

DISEASES BY BACTERIA

Basic Level

214. Which of the following is bacterial disease
(a) Meases (b) Small pox (c) Rabies (d) Tuberculosis

215. Typhoid fever is caused by
(a) Giardia (b) Salmonella (c) Shigella (d) Escherichia

216. Bacterial leaf blight is a serious disease of
(a) Paddy (b) Wheat (c) Potato (d) Tomato

217. The poisonous substances commonly produced by bacteria are known as
(a) Toxin (Exotoxins) (b) Auxins (c) Antibiotic (d) Antitoxins

218. 'Citrus canker' is caused by a
(a) Fungus (b) Bacterium (c) Virus (d) Nematoda

219. Bordetella pertussis causes
(a) Influenza (b) Pneumonia
(c) Meningitis in young children (d) Whooping cough

220. Meningitis a disease is responsible for membrane damage of the brain in caused by
(a) A fungus (b) Bacillus (c) Neisseria (d) Bordetella

221. Which among the following plant diseases is caused by bacteria
(a) Smut disease of oats (b)Crown galls of sugarbeets
(c) Soft rot of papaya (d)Soft rot of rice

222. Neomycin is extracted from
(a) Streptomyces griseus (b)Streptomyces venezuelae
(c) Streptomyces fradiae (d)Streptomyces rimosus

223. Red stripe of sugarcane is caused by
(a) Bacillus amylovora (b) Erwinia vitrivora
(c) Xanthomonas rubrilineans (d) Xanthomonas campestris

224. Botulism is
(a) Human disease due to parasitic bacteria (b) Disease of various organisms
(c) A type of food poisoning (d) A viral disease

225. Yersinia pestis causes
(a) Syphilis (b) Leprosy (c) Whooping cough (d) Plague

226. Streptomycin was first isolated in 1944-45 by
(a) Burkholder (b) Waksman (c) Leeuwenhock (d) Flemming

227. Passive immunity was discovered by
(a) Edward Jenner (b) Emil Von Behring (c) Robert Koch (d) Louis Pasteur

228. Which of the following has the capacity to create resistance against infection
(a) Glycine (b) Immunoglobulins (c) Secondary proteins (d) Tyrosine

229. Which of the following is not caused by a bacterium
(a) Typhoid (b) Tetanus (c) Kwashiorker (d) Diphtheria

230. Plague is a bacterial disease caused by
(a) *Posteurella pestis* (b) *Clostridium* (c) *Mycobacterium* (d) *Vibrio*

231. Which is the cause of Anthrax disease
(a) Virus (b) Bacteria (c) Mycoplasma (d) Algae

232. Which of the following is a disease causing bacterium in human beings
(a) Escherichia coli (b) Xanthomonas citri (c) T.M.V (d) Pilobolus

233. Agrobacterium tumefaciens causes
(a) Wilt (b) Damping off (c) Rust (d) Crown gall

234. Tuberculin produced by the bacterium causing tuberculosis is
(a) Hormone (b) Enzyme (c) Exotoxin (d) Endotoxin

235. Which of the following pairs is not correctly matched
(a) Dengue fever.....Arbovirus (b)Plague.....Yersinia pestis
(c) Syphilis.....Trichuris trichiura (d)Sleeping sickness.....Trypanosoma

236. Food poisoning is caused by
(a) Entamoeba hystolytica (b)Clostridium botulinum
(c)Escherichia coli (d)Corynebacterium diphtheriae

237. Citrus canker is caused by
(a) Xanthomonas citri (b) Xanthomonas oryzae
(c) Pseudomonas scrables (d) Pseudomonas solanacearum

238. A chemo-therapeutic substance derived from living organisms that has inhibitory effect on disease producing bacteria is known as
(a)Bactericide (b) Antibody (c) Antibiotic (d) Exotoxin

239. The most common indicator organism of polluted water is
(a) E. coli (b) P. typhi (c) C. vibrio (d) Entamoeba

240. A membranous mucous lining blocks the throat in which of the following bacterial disease
(a) Tuberculosis (b) Whoophing cough (c) Diphtheria (d) Influenza

241. Bacterial pathogens such as few strains of Escherichia coli, Campylobacter and Salmonella are responsible for diseases like
(a) Diarrhoea (b) Whoophing cough (c) Cholera (d) Diptheria

242. Streptomycin is used for curing the diseases caused by the bacteria
(a) Gram-negative (b) Gram-positive
(c) Gram-neutral (d) Both gram-positive and gram- negative

243. Insulin, interferons and somatostatin are synthesized using plasmids of
(a) Bacillus subtilis (b) Escherichia coli (c) Streptomyces (d) All of these

244. Sterilisation by autoclaving is carried out to
(a) Kill bacteria and other pathogens (b)Kill viruses
(c) Kill bacteria and enzymes (d)Inactivate enzymes

245. Match the bacterial disease given under column-I with the causative bacteria give under column-II , choose the answer which gives the correct combinations of the alphabets of the two columns

Column-I (Bacterial disease)	Column-II (Causing bacteria)
A. Pneumonia	p. Vibrio comma
B. Citrus canker	q. Mycobacterium leprae
C. Cholera	r. Yersinia pestis
D. Leprosy	s. Xanthomonas citri
	t. Diplococcus pneumoniae

(a) A = *t*, B = *q*, C = *p*, D = *s* (b)A = *t*, B = *s*, C = *p*, D = *q*

(c) A = *t*, B = *p*, C = *s*, D = *q* (d)A = *t*, B = *s*, C = *q*, D = *p*

246. A bacterium which is commonly present in the intestine of man and animal is

(a) *Bacillus brevis* (b) *Escherichia coli* (c) *Streptococcus lactis* (d) *Pseudomonas citri*

247. The disease 'pneumonia' is caused by

(a) Virus (b) Cyanobacteria (c) Bacteria (d) Cold

248. The bacteria (Clostridium botulinum) that cause botulism are

(a) Obligate aerobes (b) Facultative aerobes

(c) Obligate anaerobes (d) Facultative anaerobes

249. Koch's postulates are not applicable to

(a) T. B. (b) Leprosy (c) Cholera (d) Diphtheria

250. Cause of 'Mad Cow' disease of England

(a) Virions (b) Mycoplasma (c) Scrapie Protein (d) Viral protein

251. What is the disease Tetanus also known as

(a) Gangrene (b) Shingles (c) Lockjaw (d) Whooping cough

Advance Level

252. The most important diagnostic test for typhoid during the first week of fever is

(a) Widal test (b) Blood culture

(c) Stool culture (d) Peripheral blood smear examination

253. The most important complication of typhoid fever is

(a) Intestinal obstruction (b)Intestinal perforation (c)Anaemia (d) Constant fever

254. Triple antigen is or DPT is meant for

(a) A vaccine against malaria, typhoid and cancer

(b) A vaccine against polio, rabies and hepatitis

(c) A vaccine against tetanus, pertussis and diphtheria

(d) A mixture of bacteria that causes tetanus, diphtheria and polio

255. Which of the following is not true about the antibiotics

(a) The term antibiotic was given by Selmen Waksman in 1942

(b) First antibiotic was discovered by Alexander Flemming

(c) Each antibiotic is useful for special type of germs or bacteria

(d) Some people are allergic for one specific antibiotics

256. Antibody molecules have
(a) Two pairs of polypeptide chains of equal length
(b)Two pairs of polypeptide chains of unequal length
(c) Four pairs of polypeptide chains of equal length
(d)Four pairs of polypeptide chains of unequal length

257. The main reason why antibiotics could not solve all the problems of bacteria mediated diseases is
(a) Insensitivity of the individual following prolonged exposure to antibiotics
(b) Inactivation of antibiotics by bacterial enzymes
(c) Decreased efficiency of the immune system
(d) The development of mutant strains resistant to antibiotics

258. Diphtheria is caused by
(a) Poisons released by living bacterial cells into the host tissues
(b) Poisons released from dead bacterial cells into the host tissues
(c) Poisons released by virus into the host tissues
(d) Excessive immune response by the host's body

259. Main function of leghaemoglobin is
(a) Promotes oxygen availability to nodules (b) Generate ATP for nitrogen fixation
(c) Generate hydrogen ions for ammonia form (d) Scavenge oxygen

260. Bacteria cannot survive on honey because
(a) They cannot consume it (b)It inhibits their reproduction
(c) They get plasmolysed and killed (d) It is their poison

261. Antibiotics cure diseases by
(a) Removing pain (b) Competitive inhibition
(c) Turning the pathogen out of the body (d) Fighting with the disease causing organism

262. Most bacteria which cause plant diseases are best described as
(a) Gram (+) ve, non-spore forming rods (b) Gram (–) ve, non-spore forming rods
(c) Gram (+) ve, spore forming cocci (d) Gram (–) ve, spore forming cocci

263. Crown galls are produced due to infection of
(a)Insect (b) Virus (c) Fungus (d) Bacterium

264. A stage in the replication during which a virus particle can not be detected in the infected cell is known as
(a) Maturation stage (b) Eclipse stage (c) Absorption (d) Lysis

265. The tissue widely used for cultivating animal viruses is
(a) Tobacco pith (b) Chorioallontoic membrane
(c) Parenchyma (d) Phloem

STRUCTURE OF VIRUS

Basic Level

266. Genetic material in TMV is

(a) DNA (b) RNA (c) Capsid (d) Both DNA and RNA

267. Animal virus contain mostly

(a) RNA (b) DNA (c) RNA or DNA (d) None of these

268. On the basis of host attacked viruses are classified into

(a) Two types (b) Three types (c) Four types (d) Five types

269. Viroids differ from 'viruses' in being

(a) Naked RNA molecules only (b) Naked DNA molecules only

(c) Naked DNA packaged with viral genome (d) Satellite RNA packaged with viral genome

270. The virus responsible for AIDS is an example of a (an)

(a) Adeno virus (b) Mosaic virus (c) T-even virus (d) Retrovirus

271. Genetic material of reovirus is

(a) *ds* DNA (b) *ss* DNA (c) *ds* RNA (d) *ss* RNA

272. The genetic material of retroviruses is (AIDS virus)

(a) Single stranded RNA (b)Double stranded RNA

(c)Double stranded DNA (d)Single stranded DNA

273. The nature of nucleic acid in viroids is

(a) *ss* RNA (b) *ds* RNA (c) *ds* DNA (d) *ss* DNA

274. Tobacco mosaic virus is a tubular filament of size

(a) 300 × 10 *nm* (b) 300 × 5 *nm* (c) 300 × 20 *nm* (d) 700 × 30 *nm*

275. A naked RNA particle causing the symptoms like that of a virus disease is known as

(a) Viroid (b) Virion (c) Viral (d) None of these

276. Naked DNA containing virus is

(a) Reovirus (b) Adenovirus (c) Ribovirus (d) Poliovirus

277. Which one of the following statement about viruses is correct

(a) Viruses possess their own metabolic system (b) Viruses contain either DNA or RNA

(c) Viruses are facultative parasites (d) Viruses are readily killed by antibiotics

278. Polio virus contains

(a) Single stranded RNA (b)Double stranded RNA

(c)Single stranded DNA (d)Double stranded DNA

279. The process conspicuously absent in viruses is

(a) Mutation (b) Production of energy (c) Replication (d) Protein synthesis

280. Influenza virus has

(a)RNA (b) DNA (c)Neither RNA nor DNA (d)Both DNA and RNA

281. Caulimo virus (Cauliflower mosaic virus) are a group of viruses which have
(a) Double stranded RNA (b)Single stranded RNA
(c)Single stranded DNA (d)Double stranded DNA

282. Which one of the following statement about viruses is correct
(a) Viruses possess their own metabolic system (b) All viruses contain both RNA and DNA
(c) Viruses are obligate parasites (d)Nucleic acid of viruses is known as capsid

283. The Tobacco mosaic virus was crystallized for first time by
(a) W.M. Stanley (b) Louis Pasteur (c) Edward Jenner (d)Andre Lwoff

284. One of the living symbols of virus is
(a) Obligate parasite (b) Sporophyte (c) Saprophyte (d) None of these

285. Plant viruses have
(a) DNA (b) RNA (c) Both DNA and RNA (d) Coiled nucleolus

286. The genetic material in viruses is
(a) Only RNA (b) Only DNA
(c) RNA and DNA both (d) RNA or DNA i.e. one nucleic acid in a virus

287. Algal viruses are known as
(a) Binal viruses (b) Cyanophages (c) Mycophages (d) Phycophages

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

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

290. Virus was discovered by
(a) D. Ivanowsky (b) Beijerinck (c) Stanley (d) Herelle

291. Which of the following is a DNA containing plant virus
(a) Tobacco mosaic virus (b)Tomato mosaic virus
(c)Cauliflower mosaic virus (d)Potato mosaic virus

292. One important characteristic of viruses is that they
(a) Can multiply outside a living cell (b)Can be cultured in a cell-free medium
(c) Have an independent metabolism (d) Do not have an independent metabolism

293. The protein coat of virus is called
(a) Capsid (b) Cosmid (c) Capsomere (d) Chromophore

294. Temin worked on which virus
(a) Herpes virus (b) Rhino virus (c) Retro virus (d) Dengu virus

295. The capsid of tobacco mosiac virus (TMV) has capsomers numbering
(a) 1230 (b) 2130 (c) 2310 (d) 3120

296. Viral capsid is made of

(a) Carbohydrates (b) Lipid (c) Protein (d) All the above

297. A polyhedral virus is

(a) TMV (b) Polio virus (c) Adeno virus (d) Both (b) and (c)

298. RNA containing viruses belong to

(a) Ribocubica (b) Ribobinala (c) Ribovira (d) Deoxyvira

299. Viruses are

(a) Obligate parasites (b) Obligate saprophytes (c) Partial parasites (d) Facultative parasites

300. Largest known virus is

(a) TMV (b) T_1 phage (c) Citrus tristeza (d) $\phi \times 174$

Advance Level

301. Viruses are no more "alive" than isolated chromosomes because

(a) They require both RNA and DNA (b) They both need food molecules

(c) They both require oxygen for respiration

(d) Both require the environment of a cell to replicate

302. Which of the following characters justifying living nature of viruses

(a) Multiplicity (b) Mutability

(c) Capability of protein (Capsid) (d) All of these

303. AIDS virus contains OR Human immuno deficiency (HIV) virus has protein coat and genetic material which is

(a) Single stranded RNA with protein (b) Double stranded RNA

(c) Single stranded DNA with protein (d) Double stranded DNA

304. Which of the following viruses is devoid of protein coat with their body constituted by only RNA

(a) Tobacco mosaic virus (TMV) (b) Potato spindle tuber virus (PSTV)

(c) Polyoma virus (d) Mumps virus

305. ELISA is used to detect viruses, where

(a) Alkaline phosphatase is the key reagent (b) Catalase is the key reagent

(c) DNA probes are required (d) Southern blotting is done

306. Virus free plant from virus infected plant can be obtained from

(a) Meristem zone culture (b) Tissue culture (c) Phloem culture (d) Stem cutting

LIFE CYCLE OF VIRUSES

Basic Level

307. Viruses multiply in

(a) Bacteria only (b) All living cells (c) Specific living cells (d) Rotten food

308. Which of the following was used by Hershey and Chase to prove that DNA is the chemical basis of heredity

(a)TMV (b) Cauliflower mosaic virus (c)Dahlia mosaic virus (d) T_2 bacteriophage

309. An antiviral substance known to prevent the synthesis of new virus in the cell is known as

(a) Transferons (b) Antibody (c) Interferon (d) Inferon

310. Phages that show lysogenic cycle are called

(a) Temperate phages (b) Virulent phages (c) Avirulent phages (d) Lytic phages

311. Which of these cannot be grown in an artificial nutrient medium

(a) Bacteria (b) TMV (c) Fungus (d) All the above

312. Of the following which will not grow on enriched agar is

(a) Penicillium (b) Viruses (c) Yeast (d) Bread mould

313. Which of the following sequence is found in Rous sarcoma virus

(a) DNA $\rightarrow$ RNA $\rightarrow$ Protein (b)RNA $\rightarrow$ RNA $\rightarrow$ Protein

(c) RNA $\rightarrow$ DNA $\rightarrow$ RNA $\rightarrow$ Protein (d)DNA $\rightarrow$ DNA $\rightarrow$ Protein

314. Which of the following statements is not true for retroviruses

(a) The genetic material in mature retroviruses is 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

315. 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

316. The plant viruses that multiply with in their insect vectors are called

(a) Circulative (b) Propagative (c) Non-persistent (d) Persistent

317. Which of the following is true for viruses

(a) They invariably contain DNA (b)They multiply only in host cell

(c) They occur only inside bacteria (d)Their genetic material is RNA

318. An extreme example of latency in which DNA of the phage is integrated with the DNA of host cell chromosome is

(a) Lysis (b) Lysogeny (c) Attenuated virus (d) Prophage

319. Which one of the following statement about viruses is not correct

(a) Can multiply outside a living cell (b) Can be cultured in a cell free medium

(c) Have an independent metabolism (d) Viruses are facultative parasite

320. The part of the virus which gives to it the hereditary feature, is

(a) Capsid (b) Capsomere (c) Nucleic acid (d) Nucleotide

321. Prophage is viral genome

(a) Freshly synthesised (b) Inoculated to a bacterium

(c) Outside the host cell (d) Incorporated and integrated to host genome

322. Viruses that infect bacteria multiply and cause their lysis are called

(a) Lytic (b) Lysogenic (c) Lysosymes (d) Lipolytic

323. The virus which was first isolated

(a) Polio virus (b) Influenza virus (c) Tobacco mosaic virus (d)Cyanophage

324. Reverse transcriptase

(a) Disintegrates host DNA (b)Polymerises host DNA

(c) Translates host DNA (d)Transcribes viral RNA to cDNA

325. Viruses cannot multiply of their own because they

(a) Do not have sex organs (b)Lack genetic material

(c) Lack cellular machinery to use its genetic material

(d) None of the above

Advance Level

326. The transference of a gene or of several genes from doner bacterial cell by bacteriophage acting as an intermediate agent is known as

(a) Transition (b) Translation (c) Transduction (d) Transformation

327. Interferon is a

(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

328. A temperate bacteriophage

(a) Causes complete bursting of the infected bacterial cell after the latent period

(b) Does not cause bursting of the infected bacterial cell after the latent period

(c) Does not cause the death of the infected bacterial cell but continues to exist there and this cell divides almost like a normal cell

(d) Does not cause the death of the infections bacterial cell but the infected cell ceases to divide

329. A substance (low molecular weight protein) produced by host cells in response to viral infection and protect other cells against further viral infection is

(a) Phytotoxin (b) Antibody (c) Interferon (d) Hormone

330. Cancer cells are more easily damaged by radiations than normal cells because they

(a) Are undergoing rapid division (b)Are starved by nutrition

(c) Are different in structure (d)None of these

331. Some viruses have only RNA but no DNA this would indicate that

(a) Their nucleic acid must combine with host DNA for virus duplication

(b) These viruses can not replicate

(c) RNA too can transmit hereditary information (d) The viruses have non heritable information

332. **Assertion A :** Viruses are more analogous to a chromosome than to a living organism
Reason R : Viruses are unable to reproduce themselves unless their genetic material (DNA or RNA) is within the host cell
(a) Both A and R are true, but R is the correct explanation of A
(b) Both A and R are true, but R is not the correct explanation
(c) A is true but R is false (d) A is false but R is true

333. Certain RNA viruses carry an enzyme or its gene that uses viral RNA as a template for synthesis of DNA. The enzyme is
(a) RNA replicase (b) RNA polymerase (c) Reverse transcriptase (d) Viral nuclease

DISEASES BY VIRUS

Basic Level

334. Mumps is a
(a) Viral disease (b) Fungal disease (c) Bacterial disease (d) Protozoan disease

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

336. Hydrophobia is caused by a
(a) Bacterium (b) Fungus (c) Virus (d) Protozoan

337. Interferon suppresses the pathogenic activity of
(a) Bacteria (b) Viruses (c) Protozoans (d) Helminths

338. Common cold is caused by
(a) Bacteria (b) Virus (c) Unicellular algae (d) Protozoa

339. 'Little leaf disease' of brinjal is caused by
(a) Fungi (b) Bacteria (c) Viruses (d) None of these

340. First vaccine (the antirabeic vaccine) was prepared by
(a) Salk (b) Pasteur (c) Jenner (d) Koch

341. What is produced by vaccination in man and animals
(a) Interferons (b) Antigens (c) Antibodies (d) Antibiotics

342. Virus causes swollen shoot disease in
(a) Tomato (b) Brinjal (c) Potato (d) Cocon

343. What is vector
(a) Disease transmitted by host (b) Natural reservoir of disease
(c) Human parasite (d) Pathogenic protozoa

344. In which one of the following pairs of disease both are caused by viruses
(a) Tetanus and typhoid (b) Syphilis and AIDS
(c) Whooping cough and sleeping sickness (d) Measles and rabies

345. Chicken pox is caused by
(a) Bacteria (b) Bacteriophage (c) Varicella virus (d) Pox virus

346. Mosaic of sugarcane is caused by
(a) Bacteria (b) Fungi (c) Algae (d) Virus

347. If a person shows production of interferons in his body, he might have got an infection of
(a) Typhoid (b) Measles (c) Malaria (d) Tetanus

348. Influenza is caused by
(a) Bacillius hamemophilus influenza (b) Pox virus
(c) Myxovirus (d) Pneumococcus

349. AIDS is caused by virus
(a) HTLV II/LAV/ARV-2 (b) $\phi \times 174$ (c) SV-40 (d) Any of the above

350. Which of the following viruses causes common cold
(a) Adeno virus (b) Simian virus-40 (c) T_4 virus (d) MSZ virus

351. The first to isolate plant virus was
(a) W.M Stanley (b) Stackmann (c) Smith (d) Ivanowski

352. To get viral plant which part must be excluded
(a) Cortex (b) Phloem (c) Pith (d) Apical meristem

353. Oral vaccine for polio was discovered by
(a) Sinsheimer (b) Salk and Sabin (c) Temin (d) Lwoff

354. Salk vaccine is used to combat
(a) Herpes virus (b) Polio virus (c) AIDS (d) Rabies

355. Arbovirus causes
(a) Malaria (b) Dengue (c) Fileriasis (d) None of these

356. Which of the following is not an oncogenic (cancer causing) virus
(a) Myxovirus (b) Rubella virus (c) S.V-40 (d) Polyoma virus

357. The carries of virus causing human yellow fever is
(a) Mosquito (b) Bug (c) Louse (d) Beetle

358. Which of the following is the correct statement
(a) Small pox virus is the smallest known virus
(b) Wuchereria bancrofti is transmitted by culex
(c) Leprosy is caused by varicella virus
(d) Diphtheria is a bacterial disease and is caused by Vibrio comma

359. The group of viruses which causes plant diseases is called
(a) Moulds (b) Rusts (c) Mosaics (d) Phages

360. Interferon β is also termed as
(a) Immune interferon (b) Fibroblast interferon
(c) Leucocyte interferon (d) Anti-immune interferon

361. Who is credited to show that "Viruses are the cause of cancer"
(a) Mendel (b) Khorana (c) Swaminathan (d) Dulbecco

362. The diseases now considered to be nearly eradicated from India is
(a) Small pox (b) Poliomyelitis (c) Plague (d) Kala azar

363. Interferons are useful in controlling

(a) Cancer (b) TB (c) Blood pressure (d) Malaria

364. AIDS is due to

(a) Deficiency of T_4 lymphocytes (b)High blood pressure

(c) Deficiency of riboflavin (d)Bacterial infection

365. Leaf roll of potato is caused by

(a) Potato virus I (b) Potato virus X(PVX)

(c) Potato virus Y(PVY) (d) A combination of PVX and PBY

366. The smallest known agents of infections diseases are

(a) Viroids (b) Bacteria (c) Viruses (d) Fungi

367. Antibodies are

(a) Globular proteins (b) Immuno globulins (c) Carbohydrates (d) None of these

368. Prions are

(a) Infectious nucleo proteins (b) Infectious nucleic acids

(c) Infectous lipids (d) Infections proteins

369. Dengue is caused by

(a)Culex (b) Aedes egypti (c) Male anapheles (d) Female anapheles

370. AIDS can be transmitted by

(a) Blood circulation (b) Handshake (c) Courtship (d) All of these

371. Edward Jenner discovered

(a) Vaccination against chicken pox (b) Vaccination against small pox

(c) Immunization against chicken pox (d) Immunization against small pox

372. In the following which disease is caused by virus

(a) Diphtheria (b) Polio (c) Tuberculosis (d) Typhoid

373. Virus causes

(a) Malaria (b) Common cold (c) Tetanus (d) None of these

374. Potato leaf-roll disease is caused by

(a) Mycoplasma (b) Virus (c) Microspores (d) Bacterium

Advance Level

375. 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 of these

376. Pulse polio immunization is being carried out with the aim

(a) To treat polio (b) To prevent deformities due to polio

(c) To contain polio (d) To eradicate polio

377. Jenner prepared the vaccine for small pox virus by using

(a) Attenuated small pox virus (b) Small does of small pox virus

(c) Attenuated cow pox virus (d) Large does of small pox virus

378. The genetic material in Hepatitis β virus is DNA which is

(a) Double stranded linear (b)Single stranded linear

(c)Single stranded circular (d)Double stranded circular

379. A horticultural plant infected with a viral disease is not allowed to be imported to our country but its seeds can be imported because

(a) Viruses infect only the easily eliminated from seeds

(b) Viral particles can be easily eliminated from seeds

(c) Spread of disease is far less from seed than from other plant parts

(d) Viruses generally do not enter seeds

380. A strain of virus is made with nucleic acid of TMV (Tobacco mosaic virus) and protein coat of HRV (Holmes rib-grass virus) and then the tobacco leaf is infected

(a) Symptoms of TMV will appear (b)Symptoms of HRV will appear

(c) Symptoms of both TMV and HRV will appear (d) Symptoms of none of these will appear

381. Negri bodies were found in

(a) Nerve cells infected by rabies virus (b) Nerve cells infected by influenza virus

(c) Both (a) and (b) (d) None of these

BACTERIOPHAGE

Basic Level

382. Bacteriophage is made up of

(a) Carbon and nitrogen (b) DNA (c) Nucleoprotein (d) Protein only

383. Which one is the smallest among the following

(a) Bacteriophage (b) TMV (c) E. coil (d) Neurospora

384. In cyanophage, the genetic material is

(a) RNA (b) DNA (c) RNA and DNA (d) Protein

385. Coliphage T_2 has

(a) *ss* RNA (b) *ss* DNA (c) *ds* RNA (d) *ds* DNA

386. 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

387. The group of viruses which causes bacterial disease is called

(a) Slime moulds (b) Smuts (c) Bacteriomosaics (d) Bacteriophages

388. Bacteriophages have

(a) Carbon and hydrogen (b)DNA and RNA

(c) Nucleic acid and protein (d)Nucleic acid, protein and lipid

389. A phage that invades but does not destroy the host is known as
(a) Phycophages (b) Temperate phage (c) Sexduction (d) Virul

390. Organization of cell is not present in
(a) Mycoplasma (b) Bacteria (c) Bacteriophage (d) Diatoms

391. Tailed bacteriophages are
(a) Motile on surface of bacteria (b)Non motile
(c) Actively motile on water (d)Motile on surface of plant leaves

392. Which of the virus has tadpole like shape
(a) TMV (b) DMV (c) Human polio virus (d) Bacteriophage

393. The bacteriophage contain an enzyme known as
(a) Lysozyme (b) Urease (c) Protease (d) Dehydrogenase

394. Which of the following is acellular
(a) Diatom (b) Mycoplasma (c) Bacteriophage (d) Bacteria

395. 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

396. The water of Holy Ganga river is pure due to the presence of
(a) Cyanophages (b) Hydrophytes (c) Bacteria (d) Bacteriophages

397. Bacteriophages kill
(a) Fungi (b) All monerans (c) Bacteria (d) Viruses

Advance Level

398. The best procedure to label the protein coat of a T_2 bacteriophage is
(a) To grow T_2 phage on S_{35} containing medium
(b) Introduce T_2 phage into a bacterium containing S_{35}
(c) Exposure of protein coat to S_{35}
(d)Bombarding of protein coat with electrons

399. In phage (plaque) culture
(a) Only protein of virus enters and multiplies
(b) Only DNA of virus enters the bacterium and multiplies
(c) Whole virus enters the bacterium and multiplies (d)None of these

400. A single stranded DNA molecule is the genetic material of bacteriophage
(a) T_2 (b) T_4 (c) $\phi \times 174$ (d) λ

MYCOPLASMA

Basic Level

401. An organism having cytoplasm DNA and RNA but no cell wall is
(a) Cyanobacterium (b) Mycoplasma (c) Bacterium (d) L-form bacteria

402. Mycoplasma is
(a) Gram positive (b) Gram negative
(c) Some species are gram positive (d) None of these

403. Among the following which are the smallest organisms
(a) Bacteria (b) Mycoplasma (c) Nostoc (d) Virus

404. Which of the following is not caused by Mycoplasma
(a) Little leaf of brinjal (b) Stubborn disease of citrus
(c)Citrus canker (d) Potato witches broom

405. Mycoplasma differ from bacteria is not possessing
(a) Cell membrane (b) Ribosome (c) Cell wall (d) DNA

406. Mycoplasma hominis causes
(a) Small pox (b) Brain fever
(c) Tuberculosis (d) Infertility in males (human)

407. Mycoplasma mycoides causes which of the following diseases
(a) Bovine pleuropneumonia (b) Inflammation of genitals
(c) Agalactia (d) None of these

408. Blebs can be noted in
(a) Spirogyra (b) Mycoplasma galisepticum
(c) Pseudomonas cola (d) None of these

409. The smallest free living organisms which cause disease among plants are
(a) Viruses (b) Fungi (c) Mycoplasma (d) Bacteria

410. The 'witches broom' of legumes is caused by a
(a) Virus (b) Mycoplasma (c) Bacterium (d) Fungus

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

412. Which type of organism are PPLO
(a) Virus (b) Viroid (c) Mycoplasma-like (d) Bacteria

413. Which of the following is called “jockers of microbiological park”
(a) Bacteria (b) Mycoplasma (c) Nostoc (d) None of these

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

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

416. Who discovered Mycoplasma
(a) Ivanowsky (b) Lederberg (c) Nocard and Roux (d) Lister

417. Which one is the smallest organism capable of autonomous growth and reproduction
(a) Virus (b) Viroid (c) Mycoplasma (d) None of the above

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

419. Mycoplasma is a
(a) Eukaryotic and multicellular (b)Prokaryotic and multicellular
(c) Prokaryotic and unicellular (d)Eukaryotic and unicellular

420. Which of the following statement is true for Mycoplasma
(a) Presence of cell wall (b) Presence of nucleus (c) Absence of cell wall (d) Definite shape

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

422. Mycoplasma are not sensitive to
(a) Streptomycin (b) Penicillin (c) Erythromycin (d) Neomycin

Advance Level

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

424. Mycoplasma can live successfully in phloem due to being]
(a) Osmotically active (b) Osmotically inactive
(c) Some species are osmotically active only (d) None of these

425. Deoxycycline treatment cure
(a) Common cold caused by virus (b) Polio caused by virus
(c) Male sterility caused by mycoplasma (d) None of these

426. What is incorrect for mycoplasma
(a) Show osmotic response (b)Show absence of cell wall
(c) Are sensitive to modern antibiotics (d) Are obligate intracellular parasites

CYANOBACTERIA

Basic Level

427. Which one of the following is also algae
(a) Cyanobacteria (b) Rhodospirillum (c) Green bacteria (d) Purple bacteria

428. Cyanobacteria of great nutritive value is
(a) Gloeocapsa (b) Scytonema (c) Stigonema (d) Spirulina

429. The characteristic of blue green algae is
(a) DNA without histone (b)Nuclear membrane absent
(c) 70s-ribosomes (d)All of these

430. Hormogonia help in reproduction of
(a) Cladophora (b) Bacteria (c) Archaebacteria (d) Cyanobacteria

431. In Oscillatoria, the cell area around the nucleoid is called
(a) Centrosome (b) Nucleoplasm (c) Centroplasm (d) Chromoplasm

432. Which of the following may manufacture the food material
(a) Mycoplasma (b) Virus (c) Nostoc (d) All the above

433. Single filament of *Nostoc* without mucilage sheath is known as
(a) Hyphae (b) Colony (c) Trichome (d) Mycilium

434. In which of the following there is no sexual reproduction
(a) *Ulothrix* (b) *Nostoc* (c) *Aspergillus* (d) *Volvox*

435. Unilamellate thylakoids occur in
(a) *Chlamydomonas* (b) *Nostoc* (c) *Euglena* (d) *Laminaria*

436. The name cyanobacteria refers to
(a) Bacteria (b) Blue-green algae (c) Yeast (d) Fungi

437. Cyanophages attack
(a) Cyanobacteria (b) Bacteria (c) Fungi (d) Lichens

438. The characteristic pigment of cyanobacteria is
(a) Fucoxanthin (b) Chlorophyll *b* (c) Anthocyanin (d) Phycocyanin

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

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

441. Unicellular cyanobacteria reproduce asexually by
(a) Conjugation (b) Fragmentation (c) Binary fission (d) Hormogones

442. Cyanobacteria originated about how many years ago
(a) 1 billion (b) 2 billion (c) 3 billion (d) 4 billion

443. In cyanophyceae, flagella are
(a) Absent (b) Present
(c) Present in gamete stage only (d) Present in Zoospores only

444. Nitrogenase enzyme is found in *Nostoc* in the cell of
(a) Vegetative (b) Heterocyst (c) Both (a) and (b) (d) None of these

445. Teichoic acid is absent in the cell wall of
(a) Bacteriophage (b) Mycoplasma (c) Nostoc (d) Virus

446. Cyanobacteria is the modern name of
(a) Myxomycetes (b) Myxophyceae (c) Schizomycetes (d) Mycoplasma

447. Helical contractile sheath occurs in
(a) Bacteria (b) Bacteriophage (c) Riboviruses (d) Fungi

448. The stored food in blue-green algae is
(a) Starch (b) Glucose (c) Cellulose (d) Related to glycogen

449. Water bloom is commonly caused by
(a) Bacteria (b) Green algae (c) Blue-green algae (d) *Hydrilla*

450. In cyanobacteria, reproduction is
(a) Vegetative (b) Asexual and vegetative (c)Asexual and sexual (d)Sexual

451. Blue-green alga that causes red blooms is
(a) *Anabaena* (b) *Gleocapsa* (c) *Trichodesmium* (d) *Nostoc*

452. A free living nitrogen-fixing cyanobacterium, which can also form symbiotic association with the water form azolla is
(a) Nostoc (b) Anabaena (c) Tolypothrix (d) Chlorella

Advance Level

453. *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

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

455. Temperature tolerance of thermal blue-green algae is due to
(a) Cell wall structure (b) Cell organisation
(c) Mitochondrial structure (d) Homopolar bonds in their proteins

456. Land becomes slippery during rains due to growth of
(a) Moss (b) Brown Algae (c) Green Algae (d) Blue-green algae

457. Cyanobacteria are/*Nostoc* is

(a) Oxygenic with nitrogenase (b)Oxygenic without nitrogenase

(c) Nonoxygenic with nitrogenase (d)Nonoxygenic without nitrogenase

MISCELLANEOUS QUESTIONS

Basic Level

458. The germ theory of disease was putforth by

(a) Koch (b) Pasteur (c) Rayer (d) Devaine

459. 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, mucopolysaccharides and absence of cell organelles like mitochondria and chloroplasts

(d) Autotrophic in nature and only DNA is present

460. For the production of which of the following, the activity of the fungus or micro-organisms is not required

(a) Casein (b) Panir (Cheese) (c) Curd (d) Wine

461. Following characters are found both in prokaryotic and eukaryotic cells

(a) Presence of DNA and RNA (b) Presence of mitochondria

(c) Presence of more than one chromosomes (d) Presence of microtubules

462. Eukaryote does not have

(a) Nuclear membrane (b) Cytoskeleton (c) Histone (d) Mesosome

463. The cells of cyanobacteria and bacteria exhibit similarity in having

(a) Plastids (b) Nuclei (True) (c) Centrosome (d) DNA

464. Which of the bacterium is useful in preparing Idli

(a) *Leuconostoc mesenteroides* (b) *Clostridium*

(c) Both (a) and (b) (d) None of the above

465. Organism which bear morphological resemblance to bacteria but are biologically related to viruses are known as

(a) Virion (b) Bacteriophage (c) Viriod (d) Reckettsiales

466. Leprosy is caused by

(a) *Spirillum* (b) *Flagellum* (c) *Mycobacteria* (d) *Pseudomonas*

467. Organisms which have cells but no distinct nucleus

(a) Bacteria (b) Cyanobacteria (c) Both (a) and (b) (d) None of these

468. Gram negative heterotrophic bacteria that can biodegrade a variety of natural as wall as man made organic compounds such as petroleum products, include

(a) Cyanobacteria (b) Clostridia (c) Archaebacteria (d) None of these

469. 'Peptidoglycan' is a characteristic constituent of the cell wall of

(a) Eubacteria and unicellular eukaryotes (b) Bacteria and cyanobacteria

(c) Archaebacteria and eukaryotes (d) All members of 'monera' and 'protista'

470. Antibiotic flavicin (Neomycin) is obtained from
(a) *Aspergillus fumigatus* (b)*Aspergillus clavatus*
(c)*Streptomyces griseus* (d)*Streptomyces fradiae*

471. Ringworm is due to
(a) Fungus (b) Algae (c) Bacteria (d) Virus

472. In prokaryotes, the genetic material is
(a) Linear DNA with histones (b)Circular DNA with histones
(c) Linear DNA without histones (d)Circular DNA without histones

473. The process of replication in plasmid DNA, other than initiation, is controlled by
(a) Plasmid gene (b) Bacterial gene (c) Cytoplasmic gene (d) Mitochondrial gene

474. Which is not help in N_2 fixation
(a) Anabaena (b) Nostoc (c) Oscillatoria (d) Rhizobium

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

476. Fermentation is by
(a) All micro organism (b) All fungi
(c) All bacteria (d) Some fungi and some bacteria

477. A major component of gobar gas is
(a) Ethane (b) Butane (c) Ammonia (d) Methane

478. First organisms to evolve on the earth were
(a) Saprotrophs (b) Chemohetrotrophs (c) Photoautotrophs (d) Chemoautotrophs

479. A mutant micro-organism unable to synthesize a compound required for its growth but able to grow if the compound is provided, is known as
(a) Auxotroph (b) Prototroph (c) Autotroph (d) None of these

480. Which one of the following pairs is not correctly matched
(a) Spirulina – Single cell protein (b) Rhizobium – Biofertilizer
(c) Streptomyces – Antibiotic (d) Serratia – Drug addiction

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

482. Plasmid is used as carrier because
(a) It has antibiotic resistance genes (b)Its both ends are replicating points
(c) It can go between eukaryotic and prokaryotic cells
(d) It is circular DNA which has capacity to bind eukaryote DNA

483. When the procedure of bacterial staining is carried out, the negative bacteria stains
(a) Red (b) Green (c) Purple (d) Black

484. Heat killed S-cells alongwith live R-cell of *Diplococcus pneumoniae* were injected in mice
(a) Mice survived and had live S-cells (b) Mice survived and had dead R-cells
(c) Mice died and had dead R-cells (d) Mice died and showed live R-cells
(e) Mice died and show live R-cells

485. Fruit, meat and milk are preserved at room temperature through the process of
(a) Pasteurization (b) Fridge (c) Dehydration (d) Vernalisation

486. Trachoma is caused by
(a) *Spirochaete* (b) *Chlamydia* (c) *Trichonympha* (d) *Paramaecium*

487. Maximum number of bases in plasmids in
(a) 50 kilobase (b) 500 kilobase (c) 5000 kilobase (d) 50, 000 kilobase

488. Food can be kept unspoiled at
(a) High temperature (b) Low temperature (c) Osmotic temperature (d)All the above

489. An antibiotic is
(a) Chloramphenicol (b) Ethephon (c) Phosphon – D (d) AMO – 1618

490. First hormone obtained from genetically engineered bacteria is
(a) Adrenaline (b) Thyroxine (c) Humalin (d) Testosterone

491. Rickettsiae constitute a group under
(a) Bacteria (b)Viruses
(c) Independent group between bacteria and viruses (d)Fungi

492. Osmotrophs are
(a) Bacteria (b) Fungi (c) Both (a) and (b) (d) Algae

493. Black death is
(a) Cancer (b) Plague (c) AIDS (d) Gonorrhoea

494. Gram stain represents
(a) A technique for staining bacteria and developed by Gram
(b) A stain got from Gram
(c) A cytochemical technique for differentiation of mitochondria (d)A trade name

495. If bacteria and fungi are destroyed
(a) Antibiotics will disappear
(b) Living beings will becomes immortal
(c) Earth will become packed with excretions and dead bodies
(d) The soil will be depleted of nitrogen

496. Bovine spongiform encephalopathy disease is equal to
(a) Kala-azar (b) Parkinson's disease
(c) Crcutzfeldt-Jacob disease (d) None of the above

497. A vertebrate virus which replicates in an arthropod is
(a) Papova virus (b) Parvo virus (c) Adeno virus (d) Reo virus

498. Which is correctly matched
(a) Ligase – Breaking DNA strand (b) Flame cells – Roundworms
(c) Rous Sarcoma – Reverse transcriptase (d) Thyroxine – Adrenal

ANSWER

ASSIGNMENT (BASIC AND ADVANCE LEVEL)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
c	c	a	a	a	b	d	d	a	a	b	c	b	a	c	a	d	b	b	b
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
a	d	c	c	b	c	b	d	c	a	c	c	b	a	a	b	c	d	a	c
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
c	c	c	a	d	a	c	d	c	b	a	c	a	b	a	b	a	a	d	b
60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
d	d	d	b	a	b	c	a	d	a	c	c	d	c	b	c	c	d	b	b
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
d	a	d	c	c	d	a	d	d	b	c	a	a	a	b	c	d	c	a	d
100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
b	a	d	d	a	a	a	c	a	b	b	c	b	b	a	a	a	a	b	b
120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
b	a	d	a	c	d	a	c	a	c	b	d	b	b	d	a	b	b	d	b
140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
a	a	a	b	d	d	b	c	c	a	a	c	d	b	d	c	c	b	a	b
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179
d	a	d	d	b	a	c	b	a	d	d	a	b	a	a	b	d	a	b	c
180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199
a	d	c	a	d	b	a	c	d	b	c	c	c	d	c	d	d	a	c	b
200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219
a	c	a	c	d	b	a	d	a	c	b	b	b	d	b	a	a	b	d	c
220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
b	c	c	c	d	b	b	b	c	a	b	a	d	d	c	b	a	c	a	c
240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259
a	d	b	a	b	b	c	c	b	c	c	a	b	c	c	a	d	a	d	c
260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279
b	b	d	b	b	b	b	b	a	d	c	a	a	c	a	b	b	a	b	a
280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299
d	c	a	a	b	d	d	a	a	a	c	d	a	c	b	c	d	c	a	c

300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319
d	d	a	b	a	a	c	d	c	a	b	b	c	c	c	b	b	b	d	c
320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339
d	a	c	d	c	c	a	c	c	a	c	b	c	a	d	c	b	b	c	b
340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359
c	b	a	d	c	d	b	a	a	a	d	d	b	b	b	a	a	b	c	b
360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379
d	a	a	a	a	a	b	d	b	a	b	b	b	b	d	d	c	d	c	a
380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399
a	c	b	b	d	a	d	c	b	c	a	d	a	c	a	d	c	b	b	c
400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419
b	b	b	c	c	d	a	b	c	b	c	c	b	a	d	c	c	b	c	c
420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439
b	b	c	b	c	d	a	d	d	d	c	c	c	b	b	b	a	d	c	d
440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459
c	c	a	b	c	b	b	d	c	b	c	b	b	c	d	d	a	b	c	a
460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479
a	d	d	a	d	c	c	c	b	d	a	d	b	c	c	d	d	b	a	d
480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497		
c	d	a	e	c	b	b	b	a	c	c	c	b	a	c	c	c	c		

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