EXTENSIVE QUESTIONS

27. Describe the taxonomic position of prokaryotes.

Ans: Discovery of bacteria:

The Dutch scientist **Antonie van Leeuwenhoek** first discovered bacteria in 1674, using a single-lens microscope of his own design. He called them **"animalcules".**

Bacterium:

Ehrenberg introduces the name **bacterium** in 1882. It derived from the **Greek** word **bacterion-a** meaning **"small stuff".**

Taxonomic Position Prokaryotes:

The taxonomic position of prokaryotes has been continuously changed since their discovery. There are two separates system of classification are followed in which the prokaryotes are accommodated in different ways.

Taxonomic Position of Prokaryotes as "Kingdom Monera":

1. In traditional two kingdom system of classification all microorganisms including prokaryotes were placed in plant kingdom.
2. In 1861, John Hog proposed kingdom Protista to accommodate microorganism so prokaryotes were also placed in this kingdom.
3. In 1866, Ernst Haeckel made a separate group, the Monera for prokaryotes within the same kingdom Protista.
4. In 1938, Herbert Copland elevated the status of Monera to kingdom level, so first time: prokaryotes were recognized as a separate kingdom "Monera".

5. In 1969, American biologist Robert H. Whittaker proposed five-kingdom system that incorporated the basic prokaryotic-eukaryotic distinction which has been modified by Lynn Margulis and Karlene V. Schwartz in 1988. They also assigned a separate kingdom "Monera" for all the prokaryotes.

Taxonomic Position of Prokaryotes as "Domain Bacteria" and "Domain Archaea":

The term **"bacteria"** was traditionally applied to all microscopic, **single-celled** prokaryotes. However molecular systematics studies, showed prokaryotic life to consist of two rwo separate domains (group of kingdom i.e. a taxonomic category above the kingdom level) originally called **Eubacteria** and **Archaebacteria,** but now called **Bacteria** and **Archaea** that evolved independently from and ancient common ancestor.

These two domains along with Eukarya, are the basic of the three-domain system which is currently the most widely used classification system in bacteriology.

Phylogenetic position of prokaryotes:

The evolutionary relatedness among various groups og organisms (e.g. species, populations) is called **phytogeny.**

A major step forward in the study of phylogey of bacteria was the recognition in 1977 that archaea has a separate line of evolutionary descent from bacteria. This new phylogenetic taxonomy was based on the discovery that the genes encoding ribosomal RNA are ancient and distributed over all lineages of life with little or no lateral gene transfer.

Therefore, rRNA are commonly recommended as **molecular clocks** for reconstructing phytogenies, and divided prokaryotes into two evolutionary

domains as part of the three domain system, eubacteria archaea and eukaryotes.

Gene sequences can be used to reconstruct the bacterial phylogeny, and these studies indicate that bacteria diverged first from the archaeal/eukaryotic lineage. The most recent common ancestor of bacteria and archaea was probably a hyperthermophile that lived about 2.5 billion to 3.2 billion years ago.

28. Explain the phylogenetic position of prokaryotes.

Ans: Phylogenetic position of prokaryotes:

The evolutionary relatedness among various groups of organisms (e.g species, populations) is called **phytogeny.** A major step forward in the study of phylogeny of bacteria was recognition in 1977 that archaea has a separate line of evolutionary descent from bacteria. This new phylogenetic taxonomy was based on the discovery that the genes encoding ribosomal RNA are ancient and distributed over all lineages of life with little or no lateral gene transfer. Therefore, rRNA are commonly recommended as **molecular clocks** for reconstructing phytogenies and divided prokaryotes into two evolutionary domains as part of the three-domain system, eubacteria archaea and eukaryotes.

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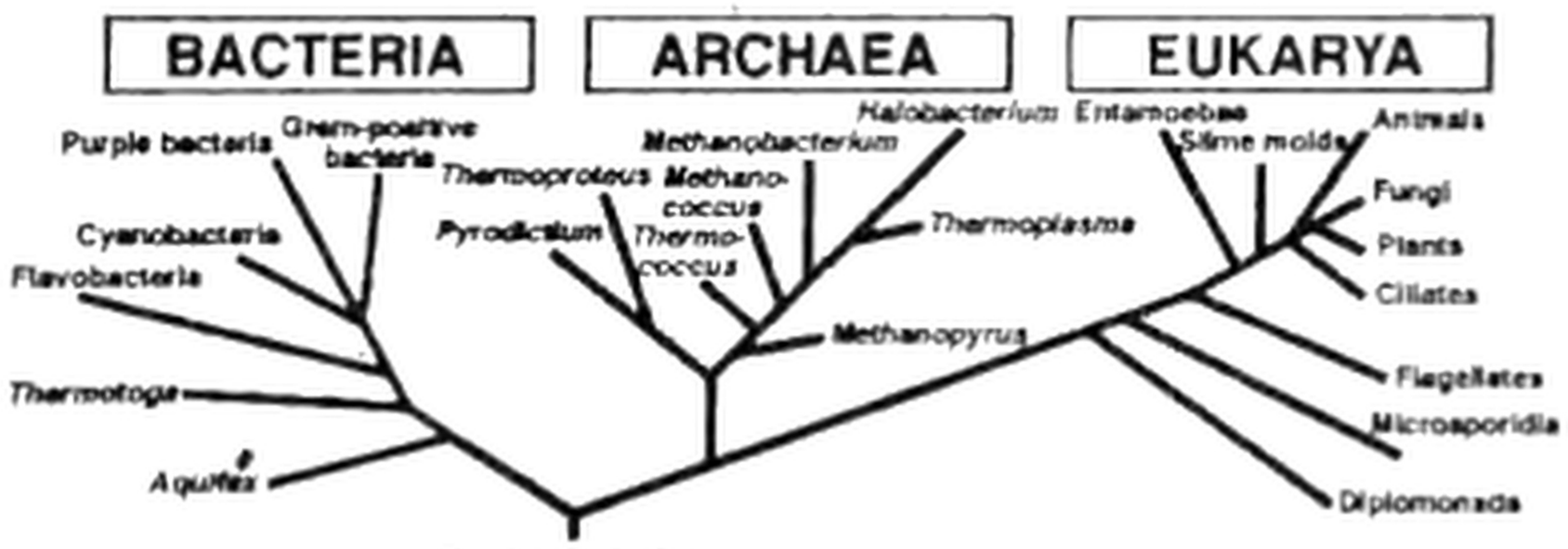
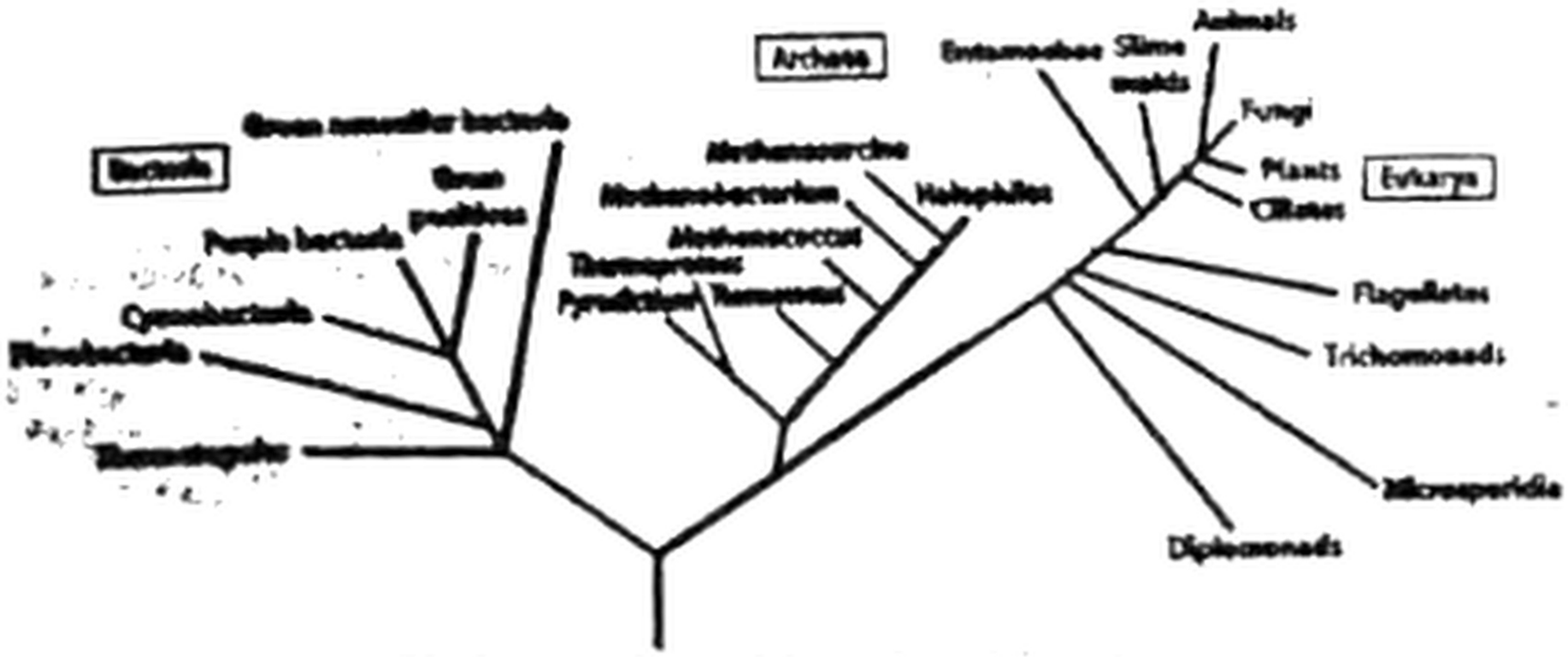


Phylogenetic position of prokaryotes



Phylogenetic position of prokaryotes

29. What are the unifying archaeal features that distinguish them from bacteria?

Ans: Archaea:

The microorganisms Archaea were previously called archaeobacteria (GK; archaios, ancient). Archaea shares certain traits with bacteria and other traits with eukaryotes. However, archaea also have unique characteristics and are different enough from bacteria to be incorporated into their own domain, archaea.

Unifying Features of Archaea:

The unifying features of archaea are:

Composition of cell wall:

The cell walls of archaea do not contain peptidoglycan. In some archaea the cell wall is largely composed of polysaccharides and in others, the wall is pure protein. In a few there is no cell wall.

Composition of cell membrane:

The plasma membranes of archaea contain unusual lipids that allow them to function at high temperatures. Lipids of archaea contain glycerol linked to branched chain hydrocarbons in contrast to lipids of bacteria that contain glycerol linked to fatty acids.

Methanogenesis:

Methanogenesis the ability to form methane is one type of metabolism that is performed only by some archaea.

Mode of nutrition:

Most archaea are autotrophs and use molecular hydrogen and reduces elemental Sulphur, carbon dioxide and water. There is no photosynthetic archaea.

Ribosomal RNA sequence:

The most fundamental difference between archaea and eubacteria is in their nucleic acid e.g. rRNA. For instance, near nucleotide number 910 (out of 1500) in one type of rRNA researchers have found the following difference.

30. How are most Archaea inhabiting extreme environments?

Ans: Most Archaea Inhabit Extreme Environments:

The first prokaryotes that were classified in domain Archaea are species that live in extreme environments.

(a) Methanogens **(b)** Halophiles **(c)** Thermoacidophiles

(a) Methanogens:

The methanogens (methano, methane, gen, producer), are found in anaerobic environments in swamps, marshes and in the intestinal tracts of human and other animals where they produce methane from hydrogen gas and carbon dioxide coupled to the **formation of ATP.** This methane, is also called **biogas.**

Example: Methanobacterium formicum

(b) Halophiles:

The halophiles (halo, salt, philes, lover) grow where nothing else can live such as on fish and meat that have been heavily salted to keep most bacteria way. The halophiles require high salt concentrations for growth.

Example: Halobacterium halobium.

(c) Thermoacidophiles:

The thermoacidophiles (heat and acid lovers) are isolated from extremely hot, acidic environments such as hot springs, geysers, submarine thermal vent and around volcanoes.

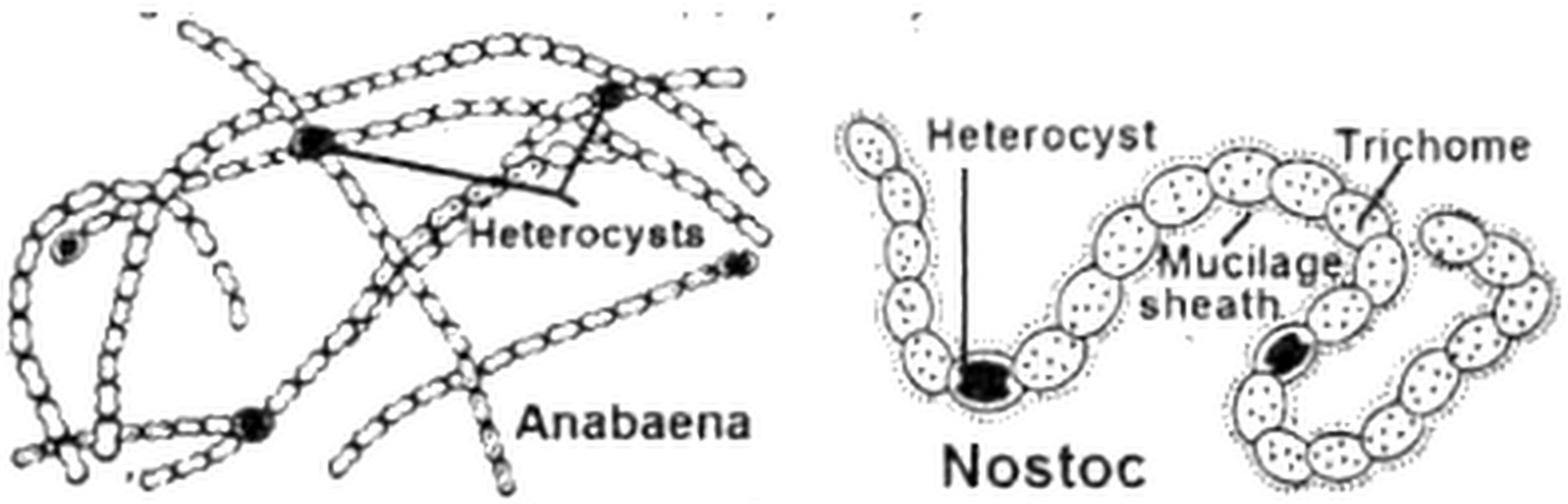
Example: Pyrolobus fumarii.

31. Why cyanobacteria are considered as the most prominent of the photosynthetic bacteria?

Ans: Cyanobacteria-The Most Prominent Photosynthetic Bacteria:

Introduction:

Cyanobacteria (Gk. Kyanoa, blue and bacterion, rod) are the most prominent photosynthetic bacteria which are found in any damp place. Majority of them are free living while some are found as epiphytic or symbiotic forms.



Examples of cyanobacteria

structure and organization:

cyanobacteria have Gram-negative type of cell wall. The body may be unicellular and solitary or in the form of filaments which may form colonies. In filamentous forms the cells are arranged in linear row, the trichome which is emedded in mucilage sheath e.g. Anabaena, Nostoc etc.

Photosynthesis:

Photosynthesis takes place in the extensive system of membrane (thylakoid membranes), which is located in the outer zone of the cytoplasm inner to the cell membrane.

Photosynthetic events:

Like algae and plants, they use carbon dioxide as a source of carbon, water as hydrogen donor, both photosystems (non-cyclic photophosphorylation) to harvest light energy and release oxygen during photosynthesis. They are believed to be responsible for first introducing oxygen into the primitive atmosphere.

Pigment composition:

In addition to chlorophyll-a, cyanobacteria also use phycobilins as accessory pigment. **Phycocyanin**, a blue pigment is their predominant phycobilins.

Nitrogen fixer:

About one third of cyanobacteria are able to fix atmospheric nitrogen. In most cases nitrogen fixation occurs in **heterocycts**, which are without nuclei thick walled cell found at certain intervals in the **trichome.** In Pakistan cyanobacteria eg. **Nostoc and Anabaena** are purposely cultivated to increase the soul fertility, because of nitrogen fixation by these organisms.

32. Give an account of glycocalyx. What are the functions of glycocalyx?

Ans: Glycocalyx:

The glycocalyx is an outer coating that covers the outside of bacterial cell wall.

Forms of glycocalyx:

The glycocalyx exist in two forms i.e. capsule and slime.

Capsule:

The **capsule** is a condensed layer that is relatively tightly associated with the underlying cell wall and gives sticky or gummy nature to the cell.

Slime:

Slime is a more loosely attached layer that gives slimy or slippery nature to the cell and can be removed from the cell more easily.

Structure and chemical composition:

Structure and chemical composition of glycocalyx is variable, depending upon the growth conditions and availability of nutrients. Generally, the

glycocalyx is made of polysaccharide. However, in some cases, protein can also be present.

Functions of the glycocalyx:

There are two prominent functions of the glycocalyx. In the form of **slime** it prevents the phagocytosis of bacteria by the cells of immune system called **macrophages.** This is because the presence of glycocalyx increases the effective diameter of a bacterium and also covers up components of the bacterium that the immune system would detect and be simultaneously by.

Thus, in a sense a bacterium with a gkycocalyx becomes more invisible to the immune system of a host and becomes more pathogenic.

The second function of a bacterial glycocalyx is to promote the **adhesion** of the bacteria to living and inert surfaces and the subsequent formation of adherent, glycocalyx-enclosed populations that are called **biofilms.**

Biofilms bacteria can become very hard to kill partly due to the presence of the glycocalyx material.

33. Describe the detailed structure and chemical composition of bacterial cell wall.

Ans: Bacterial cell wall:

Cell wall is the part of bacterial envelop (to cover by wrapping, noun: envelope: something which wraps or covers).

Location: It is situated outer to the cell membrane.

Composition:

It is composed of an inner layer of **peptidoglycan** and an outer **lipoprotein membrane** (found only in Gram negative bacteria).

Function:

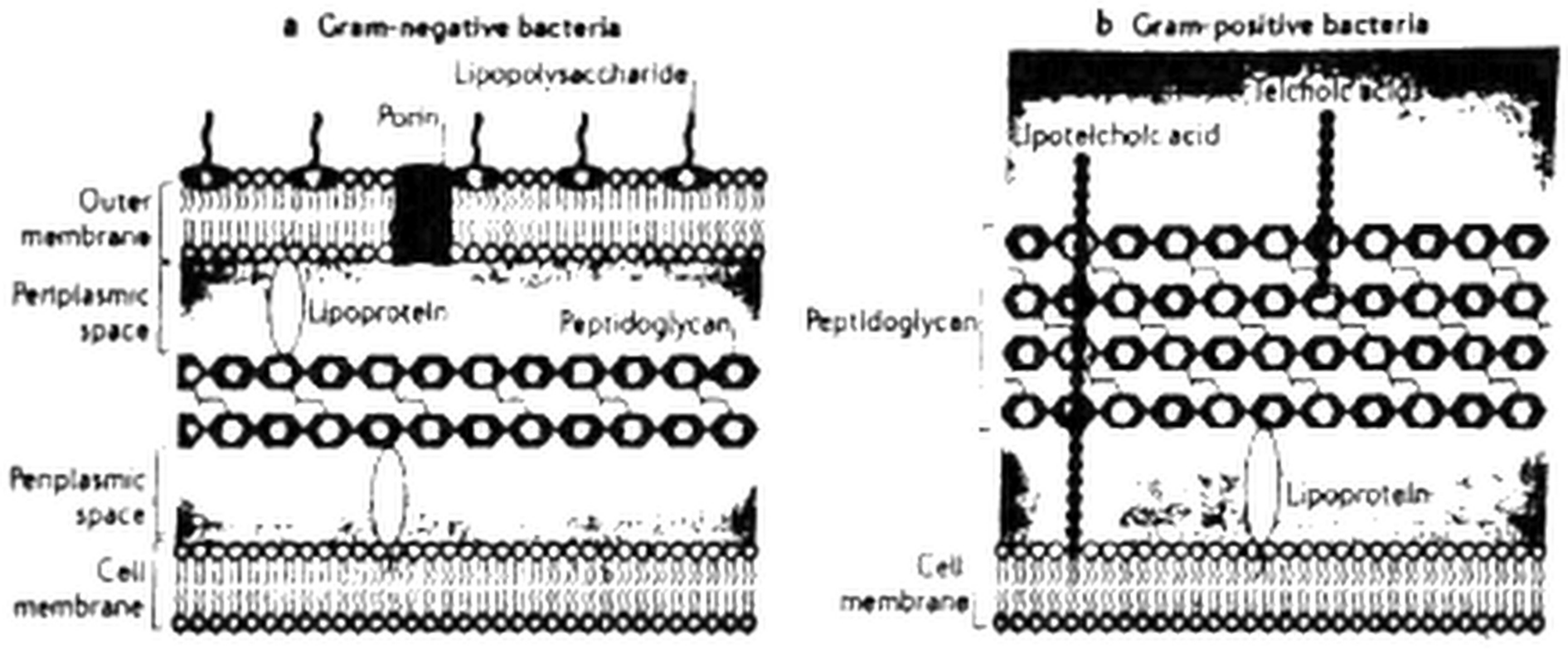
The peptidoglycan provides structural support and maintains the characteristics shape of the cell.

Composition of Gram-positive and Gram-negative cell wall:

The peptidoglycan layer is much thicker in Gram-positive than in Gram-negative bacteria. Some Gram-positive bacteria also have fibre of **teichoic acid** that protrudes outside the peptidoglycan whereas Gram-negative bacteria do not have it. In contrast, the Gram-negative have a complex outer layer consisting of lipopolysaccharide and lipoprotein.

The Gram-negative cell wall also contains a protein, the **porins** in outer membrane which act like pores for particular molecules. Lying between the peptidoglycan layer of cell wall and the cytoplasmic membrane in Gram-negative bacteria is the **periplasmic space** which is the site of enzymes called β-lactamases that degrades penicillins and other β-lactam drugs (antibiotics).

Pilus is present only in Gram-negative bacteria. They allow bacterial cell to adhere to tissue and can help the bacterial cell resist attack from immune system cells in the human body.



34. Explain the great diversity of shapes and sizes found in bacteria.

Ans: Diversity in Size of Bacteria:

The smallest known bacteria belong to the type called Phytoplasma, which infect plants and Myco(lasmas, which infect animals. They are spherical bacteria and have approximate diameter of 100 to 200ŋm (0.1 to 2.0µm).

Escherichia coli, the bacteria used in testing water for faecel contamination have rod shape and are about 7µm long and 1.8µm in diameter. Many bacteria are long but narrow. One of the larger species is **Spirochaeta plicatilis, 250µm** long by **0.75µm thick.** For comparison, a human red blood cell is 8µm in diamerter. Among the largest bacteria, Epulopiscium fishelsoni, an organism that only lives in the gut of a beown surgeonfish found in the Red Sea, is an extraordinary kind of bacteria. Individual specimens have been measured at **80 mm thick** and more than **600µm long** (more than half a milimeter, making them visible to the naked eye).

Diversity in Shapes of Bacteria:

Bacteria have three main shapes: spherical, rod shaped and spiral. However, it has recently beenb shown that certain bacteria are capable of dramatically changing shape, for example Helicobacter pylori exists as both a **helix-shaped** form and a spherical form,. Such bacteria are called **pleomorphic.**

Cocci:

Cocci (singular coccus, kok-us) are spherical bacteria. Cocci (kok-si) generally appear in groups which can be distinguished on the basis of plane of cell division and number of cells.

Diplococci and streptococci:

As a result of single (vertical) plane of cell division, bacteria appear in paris, called **diplococci** or in chain of many cells , called **streptococci.**

Tetrad:

As a result of two plane of cell division (first vertical then again vertical but at right angle to the first), bacteria appear in a square of four cells, called **tetrad.**

Sarcane:

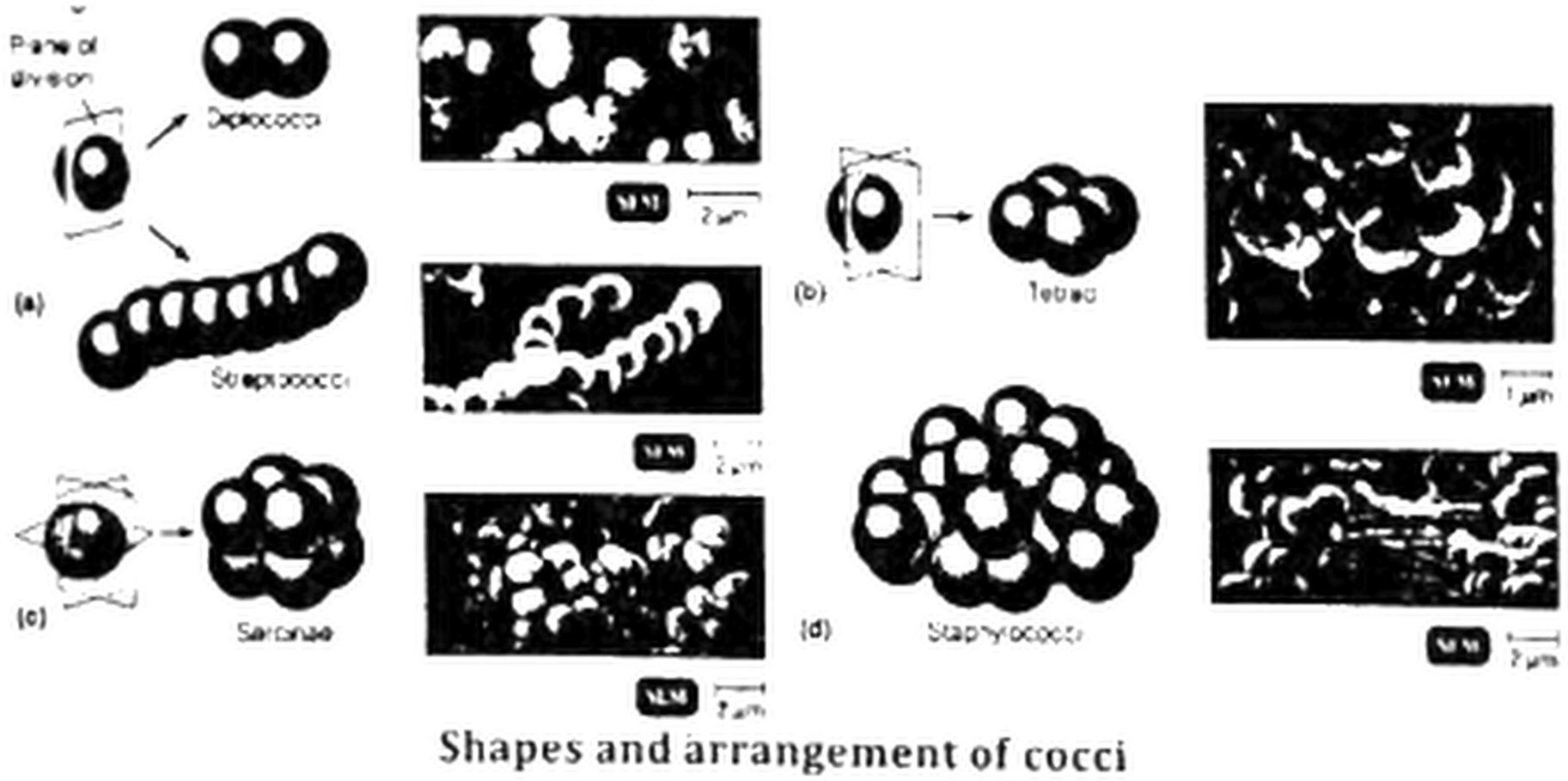
As a result of three plane of cell divisions (first vertical then again vertical but at right angle to the first and then horizontal), bacteria appear in a cubical arrangement of eight cells, called **sarcinae.**

Staphylococci:

If plane of cell division becomes irregular and many bacteria are produced which arrange like bunches of grapes,called **staphylococci.**

Examples of cocci:

The examples of cocci are Streptococcus pneumoniae, Neisseria meningtidis.



Shapes and arrangement of cocci

Bacilli:

Bacilli are straight or rod shaped organisms.

Diplobacilli and streptobacilli:

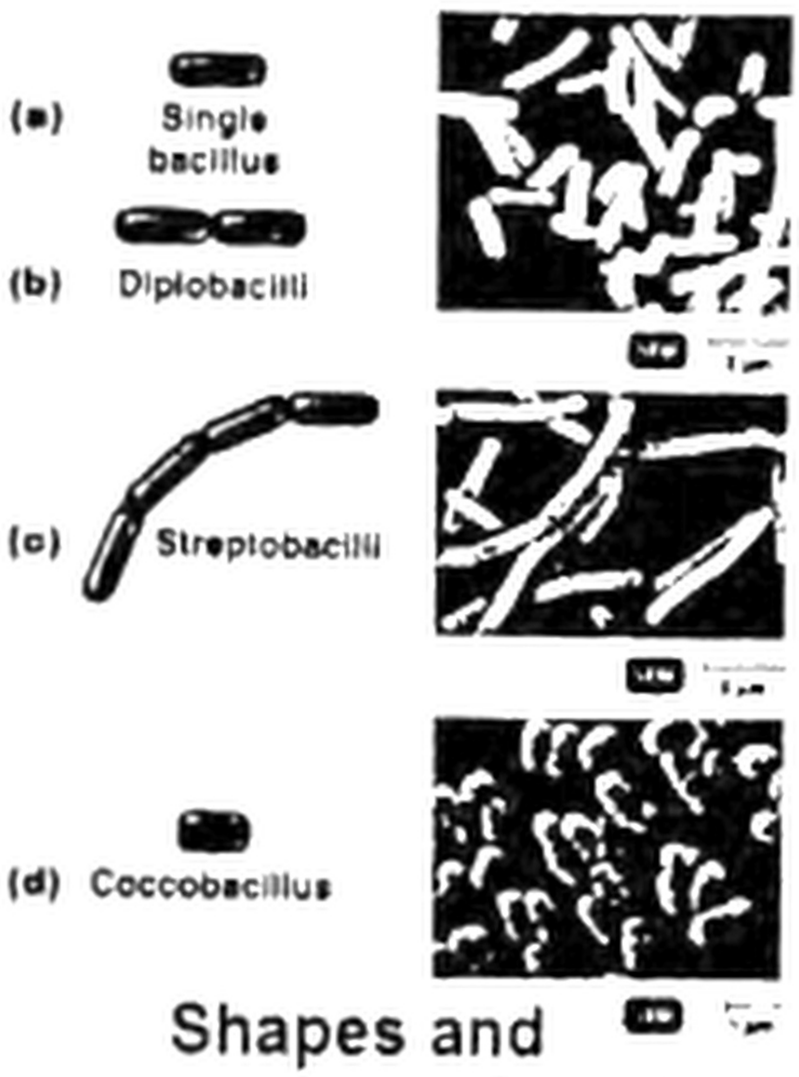
They always divide in vertical plane so they are found either in Paris, called **diplobacilli** or in chains of many cells, called **streptobacilli.**

Coccobacilli:

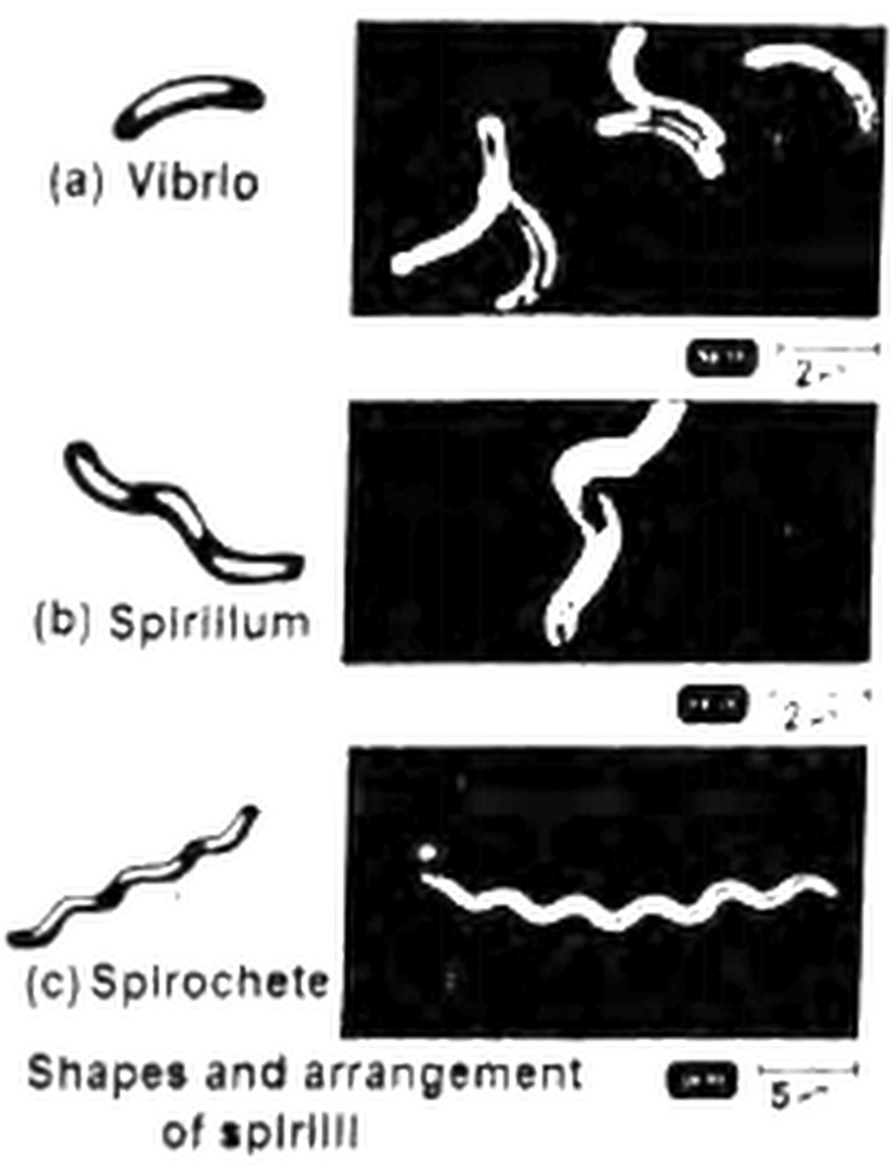
Some rod shape bacteria have spherical ends like cocci. Such bacteria are called **coccibacilli.**

Examples:

The examples of rod shaped bacteria are Escherichia coli, Pseudomonas.



Shapes and arrangement of bacilli



Shapes and arrangement of spirilll

Spirilli:

Spirilli are spiral shaped bacteria.

Spirochetes:

They usually occur singly, sledom form colonies. Thin and flexible spiral shaped bacteria are called **Spirochetes.**

Example: treponema pallidum.

Vibrio:

Curved or comma shaped bacteria which are intermediate to spiral and rod shape, are called **Vibrio.**

Example: Vibrio cholarae.

35. Describe the bacterial spores and cyst.

Ans: Bacterial spores and Cysts:

During late stage of growth when essential nutrients are depleted in the environment and other conditions such as temperature, pH of the medium and availability aof water become unfavorable certain bacteria form resistant and mwetabolically dormant bodies. Depending on the type of bacteria, these bodies are divided into endospores, exospores and cysts.

Endospores:

Especially endospores are characterized by a complex structure abd resistance to high temperatures. That is why this dormant form is capable of surviving for periods longer than thousand years. The spores develops within the vegetative cell inside the cell wall, so it has been named **endospore.**

The original cell forms a copy of its chromosome and suurounds it with a tough wall, forming the endospore. Water is removed from the endospore. The metabolism inside it stops. The rest of the original cell then disintegrates. The endospores germinate when their environmental conditions become favorable.

Exospores:

On the other hand, the Actinomycetes, which are a large group of spore forming, Gram-positive bacteria that grow by forming long tubules called **filaments.** Under nutrient poor conditions these filaments differentiate into round thick-walled resting structures termed **exospores.**

Cysts:

In contrast to endospores, these structures are part of the reproductive process and are formed outer to the cell wall. Azotobacter species and several others are known to form **cysts,** which are dormant cells with thickened cells walls. Encystment (cyst formation) occurs by changes in the cell wall; the cytoplasm contracts and the cell wall thicken.

Cysts are resistant to desiccation and some chemicals, but cannot withstand high temperatures as endospores can.

36. Explain motility in bacteria.

Ans: Motility in Bacteria:

Motility or movement is an important aspect of bacterial life in that the organism can swim toward optimal concentrations of nutrients and away from toxic substances.

Chemotaxis:

The type of purposeful movement in response to chemical stimuli is called **chemotaxis.**

Phototaxis:

Sometime bacteria show movement toward optimal light concentration or away from string light. Such movement in response to light stimuli is called **phototaxis.**

Motility in bacteria is achieved by any of several mechanisms, such as flagellar movement, spirochaetal movement and gliding motility.

Flagellar movement:

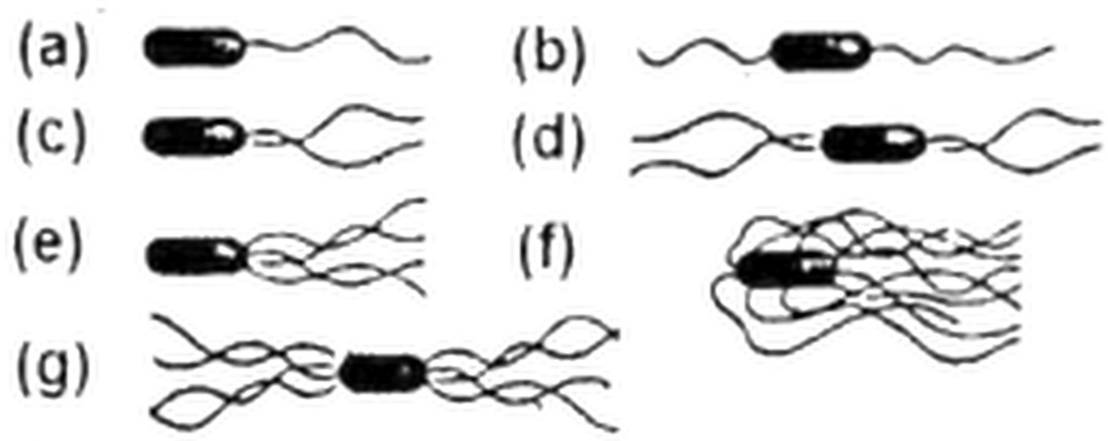
The most widespread mechanism in flagellar movement which allows travel in a liquid medium and is mediated by special threadlike organelles extending from the cell surface called **flagella.**

Most rods and spirilli such as Pseudomonas, Vibrio, and Salmonella etc. are motile by means of flagella; cocci are usually non-motile.

The presence of flagella, as well as their number and distribution on the cell, are important characteristics for purposes of identification and classification of bacteria. When one or more flagella arise only from one or both ends of a rod or spiral-shaped cell the arrangement is termed **polar.**

For example: if a bacterium possesses single flagellum at one end called **monopolar monotrichous;** if the bacterium possesses single flagellum at both ends, is called **bipolar monotrichous** or **amphitrichous.** Similarly, if a bacterium possesses a pair of flagella at one end called **monopolar bitrichous;** if the bacterium possesses a pair of flagella at both ends, is called **bipolar bitrichous** or **amphibitrichous.** But if a tuft (more than two) of flagella is present at one end of a bacterium called iophotrichous, and if a tuft of flagella is present at both ends of a bacterium called **amphilophotrichous.**

When flagella arise randomly over the entire surface of the cell, the arrangement is termed **peritrichous.**



Arrangements of bacterial flagella:
(a) Monopolar monotrichous, (b) Bipolar monotrichous, (c) Monopolar bitrichous, (d) Bipolar bitrichous, (e) Lophotrichous, (f) Peritrichous, (g) Amphilophotrichous.

Spirochaetal movement:

A somewhat modified version of the bacterial flagellum is responsible for the movement of the bacteria known as spirochetes. These organisms possess flagella-like axial filament buried in space between inner and outer membrane of the cell wall along the length of the cell. Spirochetes can perform flexing, swimming, creeping or spinning type of movements with the help of axial filament.

Gliding motility:

Like spirochaetal movement, the gliding motility is also represented by some genera of the cyanobacteria and myxobacteria such Oscillatoria, Myxococcus. These organisms can move slowly over solid surfaces. They do not have filamentous structures either internally like axial filament of spirochetes or externally flagella of bacilli but they secrete a slimy substance like garden snails during locomotion. The exact mechanism of gliding motility is still unknown but some scientists have suggested generation of contractile waves or surface tension or pushing by secreted slime as possible mechanism of gliding.

37. Describe the structure of bacterial flagellum.

Ans: Structure of Bacterial Flagellum:

General characteristics:

Bacteria flagellum is non-contractile, and lacks microtubules unlike eukaryotic flagellum. It is about 20mm diameter and up to 20 urns in length.

Parts of flagellum: It consists of three parts:

(1) Basal body **(2)** Hook **(3)** Filament

(1) Basal body:

The **basal body** originates from cytoplasm just beneath the cell membrane. It consists of two pairs of discs/rings (Gram-positive bacteria have only one pair) which are connected by a central rod. The basal body anchors the flagellum in cell envelop.

(2) Hook:

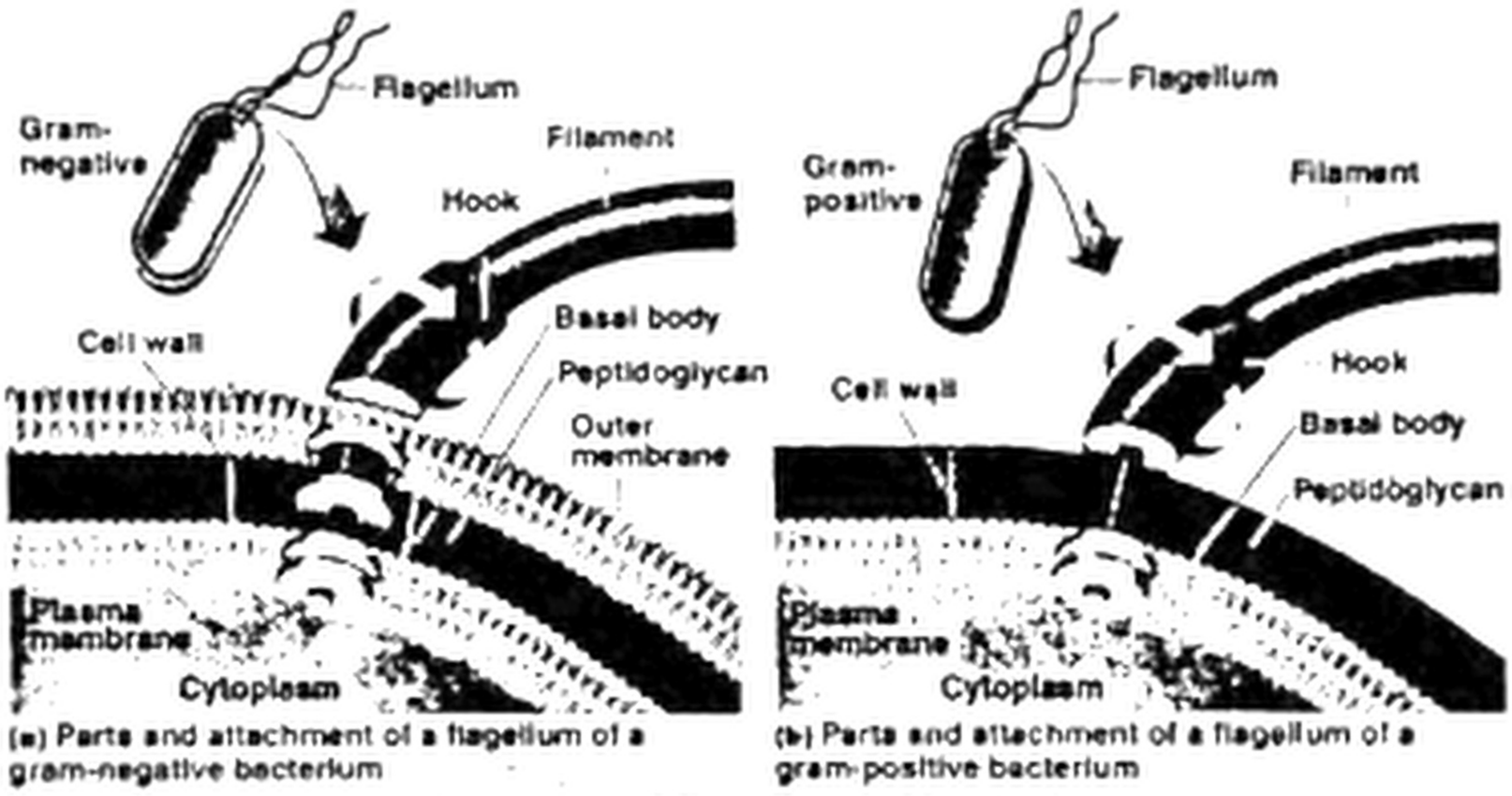
The **hook** is curved structure which connects the basal body to the filament. It is projected from the cell surface.

(3) Filament:

The **filament** is a hollow structure which originates from the hook. The filament is composed of the globular protein **flagellin**, which is arranged in several intertwined chains that form a helix around a hollow core.

Mechanism:

The mechanism of movement of bacteria flagella is quite different from eukaryotic flagella. Its basal body produces rotatory motion. The 360° rotation of paired discs or rings of basal body enable the flagellum to rotate which in turn causes the cell to spin and move forward.



Structure of flagellum of bacteria

38. Describe the genomic organization of bacteria.

Ans: Genomic Organization of Bacteria:

Bacteria have a single circular double stranded DNA which is not enclosed by any membrane even though; it is called **nuclear DNA** because it controls growth and metabolic activities.

However, it is not organized like typical eukaryotic chromosomes but often it is also referred as **bacterial chromosomes.** Since bacteria have only one chromosome therefore, they are supposed to be **haploid organisms.**

A brief diploid phase comes in their life only during cell division when they duplicate their DNA. Apart from nuclear DNA some bacteria also have one or more copies of an extra nuclear small circular double stranded DNA called **plasmids** which contain genes for antibiotic resistance.

39. Describe autotrophic and heterotrophic nutrition in bacteria.

Ans: Modes of Nutrition in Bacteria:

Bacteria can be classified on the basis of method of obtaining energy and carbon. They may be either heterotrophic which make their organic compounds from other organic sources, or autotrophic which make their organic compounds from inorganic sources i.e. carbon dioxide.

Autotrophic Bacteria:

There are two major groups of autotrophs.

Photoautotrophs and Chemoautotrophs.

Photoautotrophs:

Photoautotrophs bacteria are generally called photosynthetic bacteria. With exception to the cyanobacteria all the other photosynthetic bacteria contain unique type of chlorophyll called bacteriochlorophyll. The chlorophyll is incorporated in the membrane of their mesosomes. Unlike green plants, algae and oxygen. Instead they use hydrogen sulphide which is oxidized to produce granules of elemental Sulphur. This in turn may be oxidized to form sulphuric acid. However, like green plants, the photosynthetic bacteria use the energy of sunlight to make carbohydrates from CO_2

$$2H_2S + CO_2 \xrightarrow[\text{Chlorophyll}]{\text{Light}} (CH_2O)_n + H_2O + 2S$$

The examples of anoxygenic photosynthetic bacteria are green Sulphur bacteria, green non-sulphur bacteria and purple Sulphur bacteria.

Chemoautotrophs:

The **chemoautotrophic bacteria** make carbohydrates from inorganic substance. They do not use light energy. They oxidize inorganic substance. The

$$\xrightarrow{\text{Energy}}$$

energy produced by this oxidation is then used to make carbohydrates. Sulphur bacteria oxidizes Sulphur to produce energy.

$$2H_2S + CO_2 \quad (CH_2O)_a + H_2O + 2S$$

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

The energy this produces is used by bacteria to make carbohydrate $(CH_2O)_n$. The examples of chemoautotrophic bacteria are nitrifying bacteria, Sulphur bacteria.

Heterotrophic Bacteria:

Heterotrophic bacteria cannot synthesize their organic compounds from simple inorganic compounds, so they depend on the organic compounds present in the environment. There are two types of heterotrophic bacteria: saprotrophs and parasites.

Cellular respiration is the breakdown of complex compounds into simpler for the release of energy which may be aerobic or anaerobic, accordingly bacteria are known as aerobic bacteria e.g. Psedomonas and anaerobic bacteria e.g. Spirochete. Some are facultative bacteria e.g. E.coli which grow either in the presence or absence of oxygen. The bacteria which require a low-concentration of oxygen for growth are known as microaerophilic e.g. Campylobacter.

Saprotrophs:

Saprotrophic bacteria contain extensive enzymes system that breakdown the complex substances of humans (decaying dead organic matter) to simpler compounds. The bacteria then absorb the simpler compounds, for example many soil bacteria e.g. Streptococcus pneumonia.

40. Explain the phases of growth of bacteria.

Ans: Growth and Reproduction in Bacteria:

Microbes that are provide with nutrients and the required environmental factors become metabolically active and grow.

Phase of Bacterial Growth:

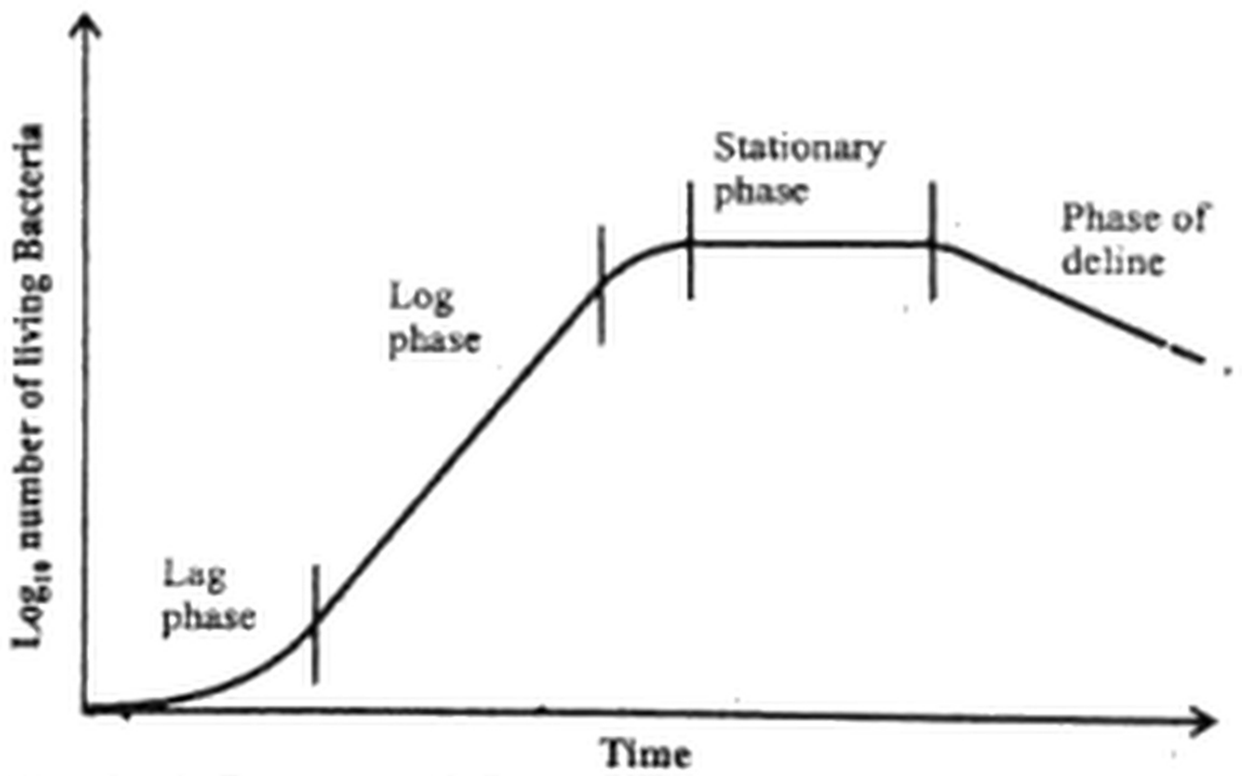
Bacterial growth takes place on two levels. On one level a cell builds up protoplasm and increases its size; on the other level, the number of cells in the population increases. Bacterial growth occurs on four major phases which can be represented by bacterial growth curve.

Lag phase:

In this phase there is increase in cell size but not multiplication. Time is required for adaptation (synthesis of new enzymes) to new environment. During this phase vigorous metabolic activity occurs but cells do not divide. Enzymes and intermediates are formed and accumulate until they are present in concentration that permits growth to start.

Log or Exponential phase:

In log or exponential phase, the number of cells increases exponentially with respect to time i.e. the number of cells doubles with each doubling time. The average time required for the population, or the biomass to double is known as the **generation time** or **doubling time.** The cells multiply at the maximum rate in this exponential phase i.e. there is linear relationship between time and logarithm of the number of cells. This continues until one of two things happens; either one or more nutrients in the medium become exhausted, or toxic metabolic products, accumulate and inhibit growth. Nutrient oxygen becomes limited for aerobic organisms.



Typical Growth of Curve of a Bacterial Population

Stationary phase:

In this phase, due to exhaustion of nutrients or accumulation of toxic products death of bacteria starts and the growth case completely. The count remains stationary due to balance between multiplication and death rate.

Death or Decline phase:

In this phase there is progressive death of cells. The rate of cell division is gradually decreased and eventually cells stop multiply. However, some bacteria may survive by forming resistant spores or cysts during this phase.

41. Describe asexual and sexual methods of reproduction in bacteria.

Ans: Reproduction in Bacteria:

Bacteria generally reproduce by asexual method. In true sense sexual reproduction is absent in bacteria but various methods of genetic recombination are misleadingly called sexual reproduction.

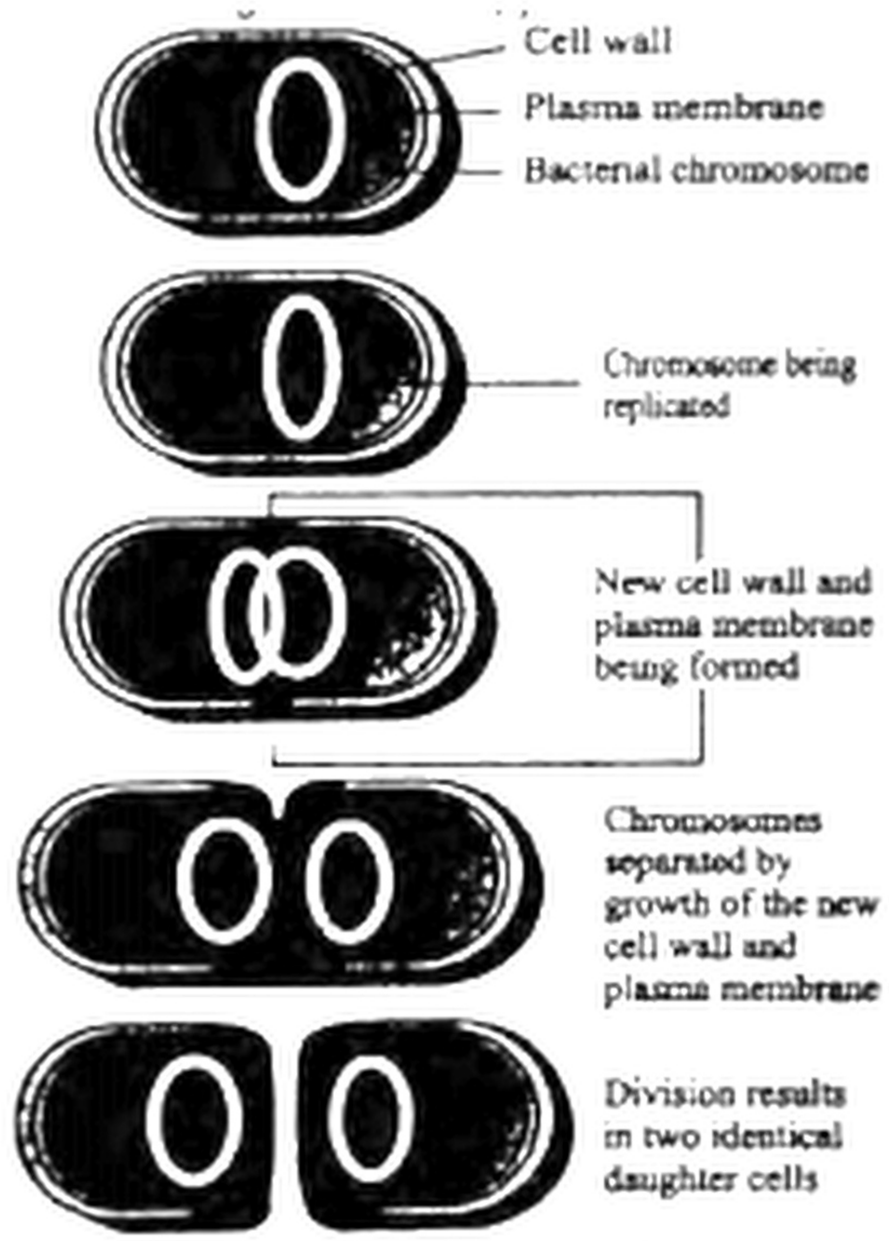
Asexual reproduction:

Most common method of asexual reproduction in bacteria is binary fission. However, some bacteria reproduce by budding.

Binary fission:

Binary fission is the commonest type of reproduction under favorable conditions in which cell divides or splits into two similar daughter cells. During the process the bacterial DNA gets attached to the cell membrane and undergoes replication.

As the cell enlarges the daughter DNA gets separated. A cross wall is formed between the separating daughter DNA. It divides the cell into two daughter cells. The daughter cells soon grow to maturity within 20 minutes and divide again.



Binary Fission in Bacteria

Budding:

In case of budding, a small protuberance, called **bud**, develops at one end of the cell. Genome replication follows, and one copy of the genome gets into the bud. Then the bud enlarges eventually become a daughter cell and finally gets separated from the parent cell.

Sexual reproduction:

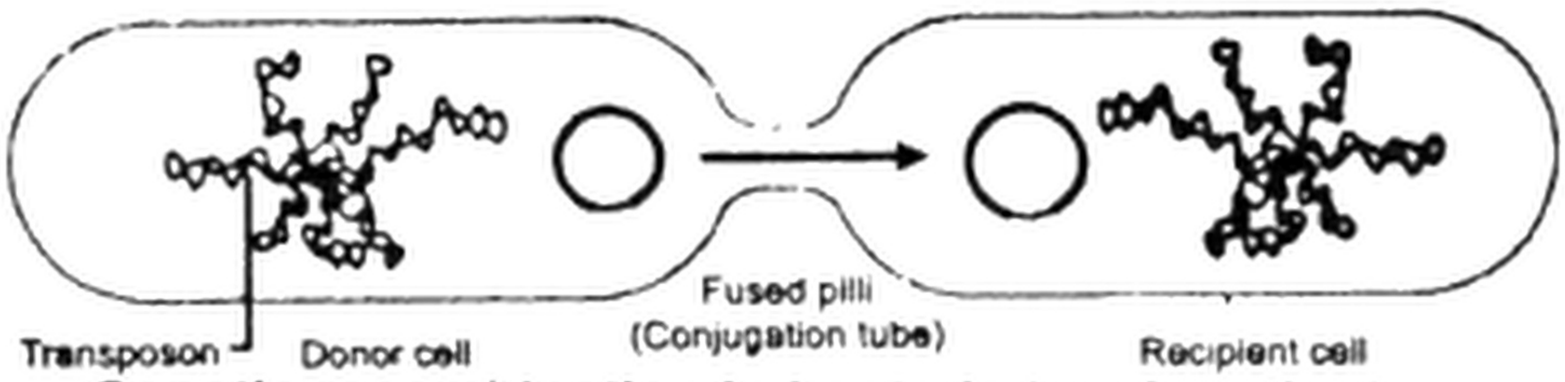
In bacteria, there is no true sexual reproduction because there is no meiosis, formation of gametes and zygote. Instead, it involves transfer of a portion of genetic material (DNA) from a donor cell to a recipient cell. This process is called genetic recombination or parasexuality.

It occurs in three ways:

(1) Conjugation **(2)** Transduction **(3)** Transformation

(1) Conjugation:

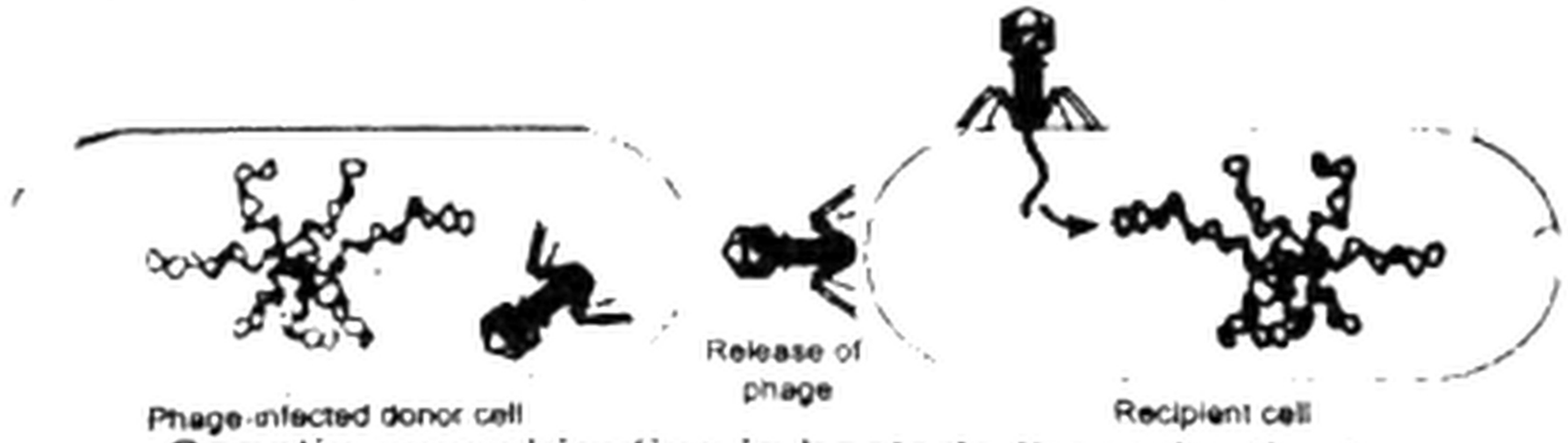
Conjugation takes place only between bacteria of the same or closely related species. Two bacteria of different mating types come together. Sex pilus forms a conjugating bridge, which temporarily joins the two cells together. The bacterium that will give the DNA is called **donor** and the bacterium that will receive the DNA is called the recipient. Often a plasmid rather than the main bacterial DNA is transferred.



Genetic recombination in bacteria (conjugation)

(2) Transduction:

The transfer of genetic material from one bacterium to another bacterium through the third party, the bacteriophage virus, is called **transduction.** Actually, it occurs when a bacteriophage is replicated in a bacterial cell, at the time of assembly of its components a portion of host bacterium may be enclosed into



Genetic recombination in bacteria (transduction)

the viral capsid. When such viruses cause infection to other bacterial cells the DNA fragment of the previous host bacterium is thus transferred to the new host bacterium.

(3) Transformation:

When bacteria die or when they are reproducing vary rapidly, they release fragments of their DNA into their immediate environment. Such DNA fragments may be up taken by other bacteria by means of diffusion in that environment. This process of absorption of DNA into a cell from its immediate environment is called **transformation.** As a result the cell is transformed into new type of cell. These cells are called transformed cells.

Genetic recombination in bacteria (transformation)

42. What is the ecological importance of bacteria?

Ans: Ecological Importance of Bacteria:

Ecological Importance refers to the role of bacteria in environment, such as decomposition of dead/complex organic matter, human's formation to increase the fertility of soil, bioremediation etc.

Role of bacteria in decomposition of dead/complex organic matter:

Recyclers:

Bacteria serve as **recyclers of nature** as they are involved in decomposition of dead/complex organic matter in the environment. If the dead bodies are not decomposed, the organic nutrients present in their bodies would not be released in the environment. The organic carbon present in dead bodies might diminish all the carbon dioxide from the atmosphere if there were no decomposers present on earth. There would have been no photosynthesis in the plants and as a result no food would have been produced by plants.

Environment role:

Bacteria play a very crucial role in environment through the decomposition of dead organic matter. Bacteria use them as a source of nutrients, and in turn help in recycling the organic compounds trapped in the dead matter. Through this process, other organisms also get benefited, who can use the simpler forms of organic compounds/nutrients released from the dead matter by various bacteria.

Role of bacteria to increase soil fertility by human's formation and nitrogen fixation:

Humus:

The partially decaying organic matter of dead organisms is called humus. It contains nutrients and increase soil fertility for the growth of plants. It also increases the water retaining capacity of the soil. Bacteria and fungi are the

only organisms that decompose dead animals and plants and thus, take part in humans' formation.

Nitrogen fixers:

Nitrogen is the most important element for plants for their growth and metabolic activities. Soil is the only source of nitrogen for plants as they cannot inhale nitrogen directly from the atmosphere. Nitrogen from the atmosphere can be available to the plants through the process of **nitrogen fixation.**

This process takes place with the help of nitrogen fixing bacteria like **Rhizobium and Cyanobacteria** in the soil. These species of bacteria convert the atmospheric nitrogen into nitrates and nitrites as a part of their metabolism, and make it available to the plants. Some plants (leguminous plants) have a mutualistic association with the bacteria (root nodulus bacteria) living into their tissues for this purpose.

Role of bacteria in removal or degradation of environmental pollutants:

Removal or degradation of environmental pollutants by using living organisms is called **bioremediation.** It involves the use of many bacteria that either naturally love to eat contaminants or have been genetically altered to give them the taste for toxins. Scientists are designing or deploying microbes to purge sites of contaminants such as oil, radioactive waste, gasoline and mercury and new bioremediation research appears regularly.

43. What is the economic importance of bacteria?

Ans: Economic Importance of Bacteria:

The economic importance of bacteria refers to the role of bacteria in research and technology, plant diseases and inhuman diseases.

Role of bacteria in research and technology:

When we think of bacteria, we usually think about the illness it can cause and our need to get rid of it. However, bacteria play a lot of positive roles in our lives which are unknown to many of us.

Bacteria play an important role in many technological fields, mainly in biological research, mining, medicine, production of food products, plastics synthesis and sewage treatment. The overall commercial worth of bacteria in these operations is immense.

Biological research:

Bacteria have been used and being continuously used in the study of genetics and **genetic engineering**. Bacteria were used as model organism in number of famous experiments such as the discovery of DNA **as heredity material**, discovery of semi **conservative replication** of DNA and etc. Many components of bacterial cell are also being used as tools in genetic engineering experiments.

Mining:

The miners can extract metal from low grade ores in a relatively ecologically friendly way by using certain bacteria. The bacterium **Thiobacillus ferrooxidans** is the important organism here.

It works by catalyzing the oxidation of metal sulphides, particularly copper sulphate so that they are soluble in water i.e. **CU_2S to $2Cu^{2+}$** and **SO^{2-}_4.** This allows the copper to be leached out of the rock. **T ferrooxidans** is also used in the organic leaching of gold and uranium with the help of other bacteria such as **T.thiooxidans** and **Leptospirillum ferrooxidans.**

Medicine:

Bacteria are useful to mankind is in the production of complex organic molecules that are of use in small amounts as part of the normal process of living, these include antibiotics, vitamins, amino acids and enzymes.

Production of food products:

In addition to these compounds, the dairy products such as yogurt, cheese, butter etc. are also produced with the help of bacteria.

Plastics synthesis:

Now a day's biodegradable plastic is made by using two bacterially produced molecules. Poly-B-hydroxybuterate and Poly-B-hydroxyvalerate. These molecules make a polymer just like ordinary plastic but having the essential difference that once left out in the compost or in a landfill they can be broken down by bacteria and fungi to become part of the cycle of life again.

Sewage treatment:

Owing to their characteristics of degrading harmful chemicals and pollutants, bacteria naturally (as well as deliberately used by industries), help in treatment of waste water.

Role of bacteria in causation of diseases and spoilage of food:

Beside lot of benefits some bacteria are harmful for us. Parasitic bacteria attack plants and cause various diseases e.g. fire blight in apple, ring diseases in potatoes, crown gall etc. many human diseases are caused by bacteria e.g. diphtheria, tetanus, leprosy, meningitis, sore throat, whooping cough (also called: pertussis) etc.

Bacteria cause decay of wood, leather, fabrics etc. Bacteria spoil the food materials by decomposition.

44. Explain the use of bacteria in research and technology.

Ans: Role of bacteria in research and technology:

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45. Describe symptoms, causative bacteria, treatments and preventive measures of the following bacterial diseases in man:

(a) Cholera **(b) Typhoid**

(c) Pulmonary tuberculosis **(d) pneumonia**

Ans: Bacterial diseases in man:

Bacteria cause many diseases in man such as tetanus, diphtheria, meningitis, plague, typhoid fever etc. Here we will discuss only cholera typhoid, pulmonary tuberculosis and pneumonia.

(a) Cholera:

Symptoms: Watery diarrhea in large volume is the hallmark of cholera.

Cause: It is caused by Vibrio cholera.

Treatment: It consists of prompt, adequate replacement of water and electrolytes, either orally or intravenously.

Prevention: It is achieved mainly by public health measures that ensure a clean water supply.

(b) Typhoid:

Symptoms: High fever, tender abdomen and enlarged spleen occur.

Cause: It is cause by Salmonella typhi.

Treatment: Antibiotics should be used.

Prevention: It is prevented mainly by public health and personal hygiene measures. Vaccine are available for the prevention of typhoid.

(c) Pulmonary tuberculosis:

Symptoms: The symptoms include mild fever lasts for 7-14 days and mild dry cough. Later on, night sweats, weight loss, anorexia, and weakness, dry hacking cough with blood stained sputum.

Cause: The causative agent is Mycobacterium tuberculosis.

Treatment: Multiple-drug therapy is used during the long 6 to 9-month duration of treatment or DOTS (directly observed treatment short course) of only two months duration.

Prevention: A vaccine containing a strain of live Mycobacterium bovis (Bacillus Calmette-Guerin or BCG) can be used to induce partial resistance to tuberculosis.

(d) Pneumonia:

Symptoms: Pneumonia often begins with sudden chill, cough and pleuritic pain. Sputum is red brown "rusty" color.

Cause: The causative agent is Streptococcus pneumonia.

Treatment: Antibiotics are used.

46. Describe the symptoms, causative bacteria, and preventive measures of the following bacterial diseases in plants:

(a) Leaf spots **(b) Soft rots**

(c) Wilting **(d) Galls**

Ans: Bacterial diseases in plants:

The important bacterial plant diseases are leaf spots, blights, soft rots, wilts and galls.

(a) Leaf spots:

Symptoms: The most common symptoms of plant diseases are discrete or spreading type lesion on leaf blade.

Cause: It is caused by Xanthomonas campestris on tomato and pepper. Other genera cause the disease in tobacco and potato.

Prevention: Prevention of contact between the pathogen and the host, use of disease free seeds.

(b) Soft rots:

Symptoms: When the cells of plant tissue die because of the action of pathogen, produce rot type symptoms. Rotting may affect any organ of plant. The necrotized tissue becomes wet to touch and soft inconsistency hence termed soft rot.

Cause: Erwina anylovora causes soft rot in potato. Corynebacterium causes ear rot of wheat.

Prevention: For preventing removal of diseases plants by physical method is done.

(c) Wilting:

Symptoms: Loss of turgidity in the leaf blade increased with time and ultimately leads to wilting of leaf and drying.

Cause: Psedomonas solanocaerum causes wilt disease in potato.

Prevention: Selection of disease-free seeds and allowing proper spacing between the plants.

(d) Galls:

Symptoms: These are localized outgrowth mostly small but may be very large in some diseases.

Cause: Rhizobium leguminosarum causes small galls called root nodule in legumes.

Prevention: Crop rotation, removal of diseased plants etc.