Course- B.Sc. (Honours), Part -1

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Topic- Modern concepts about bacterial cell.

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Bacteria Cell

The bacteria are unicellular, achlorophyllous prokaryotic micro-organisms leading either saprophytic or parasitic mode of life. An average bacterial cell may measure 1.25 μ in diameter. The smallest among the known bacteria is dialister pneumosintes (0.15 to 0.3 μ in length) and the largest bacterium is spirillum volutans (13 to 15 μ in length).

The bacterial cell may be:

(i) Spherical (coccus),

(ii) Rod shaped or cylindrical (bacillus), and

(iii) Spiral (spirillum) or spirochetes.

The spherical bacteria (cocci) may occur either singly (micro or monococci) or in pairs (diplococci) or in a group of 4 (tetracocci) or in chains (streptococci) or in irregular bunches (staphylococci). Rod shaped bacteria occur usually singly but may occasionally be found in pairs (diplobacilli) or in chains (streptobacilli).

Structure of the Bacteria Cell:

The bacterial cells show a typical prokaryotic organization consisting of the following parts (Fig. 1.11):

1. Outer covering,
2. Cytoplasm, and
3. Nucleoid.

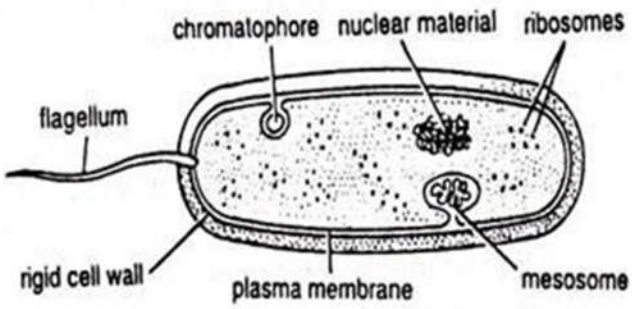

Fig. 1.11 A generalized structure of a bacterium.

1. Outer Covering of the Cell:

The outer covering in most of the bacterial cells consists of the following layers:

(a) Capsule,

(b) Cell wall, and

(c) Plasma membrane.

(a) Capsule:

In some bacteria there may be a slimy layer outside the cell wall which is called capsule. The slimy capsule is secreted by protoplasm and is made up of di or polysaccharides. The polysaccharides of most bacterial capsules contain more than one type of sugar residues and so they are heteropolysaccharides such as D-glucose, D-galactose, D-Mannose, D-glucouronic and L-rhamnose residues etc.

In some bacteria the polysaccharides do contain single sugar residue and so they are homopolysaccharides such as polyfructose.

Capsules may be divided into two categories:

(i) Macrocapsules and

(ii) Microcapsules.

Macrocapsules are about 0.2 m thick and can be seen under light microscope after special staining. Microcapsules are extremely thin and cannot be seen under light microscope. They can, however, be demonstrated immunologically. The capsule layer serves as a protective covering for bacterial protoplasm. In pathogenic bacteria capsule provides enough resistance against drugs and phagocytes.

Appreciable number of bacterial species is motile and they are provided with flagella. Bacterial flagella are about 100 to 200 A thick and show varied length. They develop from basal granules lying below the cell wall. The bacterial flagella, unlike multi-stranded flagella of eukaryotes, are made up of special type of proteins (Fig 1.12).

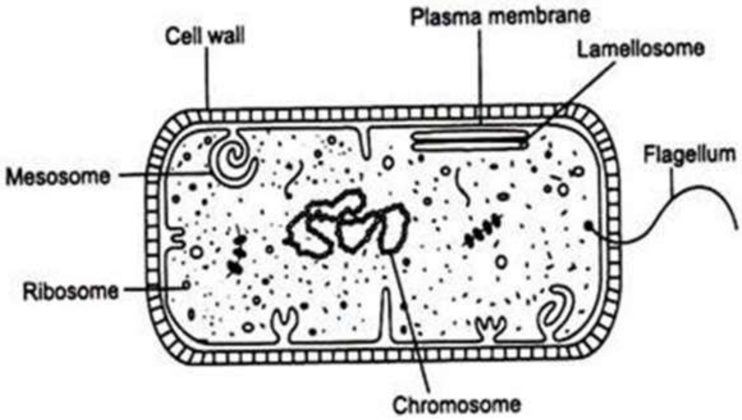

Fig. 1.12 Structure of a bacterial cell.

In addition to flagella, there occur some hair-like or peg-like outgrowths on the surface of some bacterial cells. These are called pili or fimbriae. They are composed of helically arranged units of special protein called pilin. Pilin helps in the attachment of bacterial cells to some other objects, and in some they act as conjugation channels through which DNA of donor cell moves into the female cell.

(b) Cell wall:

Cell wall is rigid structure, 10 nm thick which is present just below the capsule and outside the plasma membrane. The cell wall maintains the shape of the cell and protects the cell from high osmotic pressure gradient. The chemical composition of bacterial cell wall is different from that of higher plant cell. It does not contain cellulose.

The main structural components of almost all bacterial cell walls are peptidoglycans or mucopeptides consisting of acetylglucosamine and acetyl muramic acid molecules linked alternately in chain. In certain bacteria, Teichoic acid molecules are covalently linked to peptidoglucan.

Other compounds found in the cell wall are proteins, polysaccharides, lipids, certain inorganic salts, phosphorous and aminoacids, diaminopimallic acid (a substance found only in bacteria and blue-green algae).

The polysaccharides of bacterial cell wall consist of different sugars such as glucose, galactose and mannose or corresponding aminosugars depending upon bacteria. The electron microscopy of bacterial cell wall reveals that it is composed of granular units of 50 to 140 nm diameter arranged in regular hexagonal or rectangular pattern.

(c) Plasma membrane:

Beneath the cell wall there lies a thin living membrane, the plasma membrane which forms the outer boundary of cytoplasm. The plasma membrane is 75 Å thick unit membrane and is composed chiefly of proteins and phospholipids.

Some amount of carbohydrate, DNA and RNA have also been reported from plasma membrane but it still needs substantial proof. The lipids in the prokaryotic plasma membrane are polar lipids which may be glycophosphates or glycolipids. Small amount of quinone, Co-enzyme-Q, vitamin K and carotenoids may also be found in the bacterial plasma membrane.

This membrane is a selective barrier to the surrounding medium. The plasma membranes of bacteria contain enzymes involved in oxidation of metabolites or respiratory chain and many multienzyme complexes. It performs the functions including oxidative phosphorylation which are usually done by mitochondria in eukaryotic cells.

Bacterial plasma membrane contains many specific transport systems for compounds of the sugars, aminoacids, mineral ions etc. The plasma membrane is capable of not only transporting materials by simple diffusion but is also involved in active transport against concentration gradient.

At certain places membrane may be infolded to form whorls of convoluted membranes called mesosomes. The mesosomes perform several important metabolic activities such as respiration, secretion, etc. They are thought to increase the surface area for transporting systems of the cells. They are also sites of DNA replication enzymes and nucleoid separation.

2. Cytoplasm:

The cytoplasm of bacterial cell is dense and colloidal substance containing a variety of organic compounds such as proteins, glycogens and lipids. Besides, granulose (a polymer of glucose), volutin (polymetaphosphate), polybeta-hydroxibutyric acid and elemental sulphur may also be found in the form of granules.

The majority of cytoplasmic organelles such as endoplasmic reticulum, golgi complex, plastids, mitochondria, lysosomes and centrioles are lacking in the bacterial cytoplasm. Photosynthetic bacteria contain a pigment called bacteriochlorophyll which is somewhat different from the chlorophylls found in eukaryotes.

The photosynthetic pigments and enzymes are generally found in the groundplasm associated with the lamellae, tubules or vesicles called chromatophores. The bacterial cells contain ribosome particles of about 25 nm diameter which exist in the cytoplasm in free state or in the form of polysomes but are not attached to the membrane.

Ribosome particles constitute upto 30% of the bacterial weight and they are the sites for protein synthesis.

3. Nucleoid:

Nuclear region or nucleoid contains genophore which is single circular double stranded molecule of deoxyribonucleic acid (DNA). DNA molecule of bacterium is about 1mm long (lO^6nm) and contains all the genetic information.

One molecule is sufficient to code for about 2000 to 3000 different proteins. DNA molecule is folded and packed within the nuclear region. It lies free in the cytoplasm and is not bounded by nuclear membrane.

DNA molecule of bacterial cell appears to be free and not complexed with histone but contains polyamines (non-histone type) which may be linked to some of its phosphate groups. Under certain conditions bacterial cell may contain two or more DNA molecules, because of replication of original DNA.

Evidence from studies of Bacillus subtitles indicates that the circular DNA may be attached to the plasma membrane via mesosome. So, it is possible that mesosome plays an important role in DNA replication by providing a mechanism for unwinding of DNA double helix as well as energy. In general, during division of the bacterial cell DNA molecule replicates and the two molecules go to different daughter cells.