The Description of Different Structural Feature of Prokaryotic Cells

1. Outer Flagella: A flagellum attached to the bacterial capsule is a central feature of most of the prokaryotic cell especially of the motile bacteria. It provides motion or locomotion to the bacteria and be responsible for chemotaxis of bacteria. Movement of bacteria towards a chemical gradient (such as glucose) is known as chemotaxis. Flagellum is a part of cell wall and its motion is regulated by motor proteins present inside the cell. Flagellar motion is an energy consuming process and it is governed by an ATPase present at the bottom of the shaft. It is made up of protein flagellin and reduction or suppression of flagellar protein reduces bacterial infectivity (pathogenicity) and ability to grow.

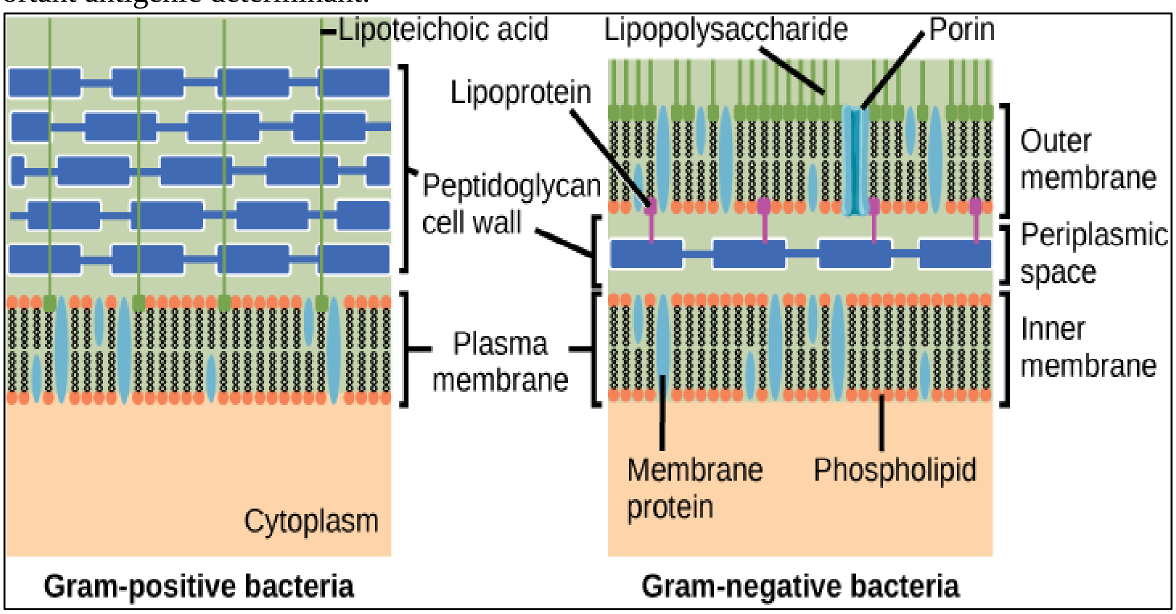
2. Bacterial surface layers: Bacteria possess 3 anatomical barriers to protect the cells from external damage. Bacterial capsule is the outer most layers and made up of high molecular weight polysaccharides. It is impermeable to the water or other aqueous solvent and it is responsible for antigenicity of bacterial cells. Cell wall in bacteria and its response to gram staining is the basis of classification of bacterial species.

Cell wall composition in gram negative and gram positive bacteria is different. Bacterial cell wall has different constituents and be responsible for their reactivity towards gram stain.

A. Peptidoglycan layer: peptidoglycan layer is thick in gram +ve bacteria and thin in gram –ve bacteria. Peptidoglycan is a polymer of NAG (N-acetyl-glucosamine) and NAM (N-acetyl-muramic acid) linked by a β-(1,4) linkage. Sugar polymers are attached to peptide chain composed of amino acids, L-alanine, D-glutamic acid, L-lysine and D-alanine. Peptide chain present in one layer cross linked to the next layer to form a mesh work and be responsible for physical strength of the cell wall. Peptidoglycan synthesis is targeted by antibiotics such as penicillin whereas lysozyme (present in human saliva or tears) degrades the peptidoglycan layer by cleaving glycosidic bond connecting NAG-NAM to form polymer.

B. Lipoteichoic acids: Lipoteichoic acid (LTA) are only found in gram +ve bacteria cell wall and it is an important antigenic determinant.

C. Lipopolysaccharides (LPS)- Lipopolysaccharides (LPS) are found only in gram –ve bacterial cell wall and it is an important antigenic determinant.



Gram positive and negative bacterial cell wall

3. Cytosol: part of the cytoplasm that remains when organelles and internal membrane systems are removed.

4. Chromosome and extra chromosomal DNA-Prokaryote cell contains genetic material in the form of circular DNA, known as "bacterial chromosome". It contains genetic elements for replication, transcription and translation. Bacterial chromosome follows a rolling circle mode of DNA replication. The genes present on chromosome does not contains non coding region (introns) and it is co-translated to protein. Besides main circle DNA, bacteria also contains a small, independently replicating piece of cytoplasmic DNA called plasmid that can be transferred from one organism to another.

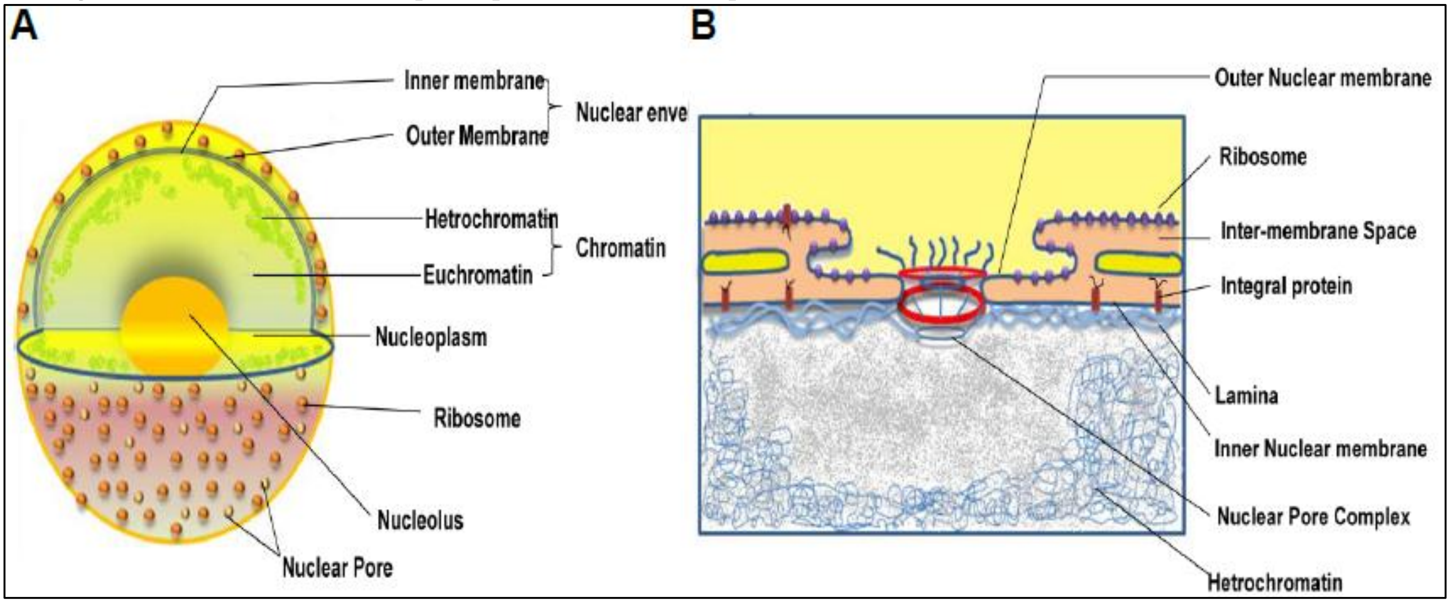
Structure of Eukaryotic cell

The eukaryotic cell is much more complex and it contains many membrane bound organelles to perform specific functions. It contains a nucleus isolated from cytosol and enclosed in a well-defined double membrane.

Different Organelles of Eukaryotic Cells

1. Cytosol: Cytosol is the liquid part filled inside the cell and it contains water, salt, macromolecules (protein, lipid, RNA). It has an array of microtubule fiber running throughout the cytosol to give vesicular structure to its destination. Besides this, cytosol exhibits "Sol" to "Gel" transition and such transition regulates multiple biochemical and cellular processes.

2. Nucleus: Nucleus is the central processing unit of cell and homologous to the processor in a typical computer. The liquid filled inside nucleus is called as nucleoplasm. It is a viscous liquid containing nucleotides and enzymes to perform replication, transcription, DNA damage repair etc. It contains genetic material (DNA) in a complex fashion involving several proteins (histones) to pack into nuclear bodies or chromosomes. The chromatin in eukaryotic nucleus is divided into euchromatin or heterochromatin. Euchromatin is a part of chromatin where DNA is loosely packed and it is transcriptionally active to form mRNA whereas Heterochromatin is more densely packed and it is transcriptionally inactive. Nuclei in eukaryotic cells are present in a double layer of membrane known as nuclear envelope. Outer membrane of nuclear envelope is continuous with the rough endoplasmic reticulum and has ribosome attached to it. The space between these two membranes is called as perinuclear space. Nuclear envelope often has nuclear pore and as per calculation an average nucleus has 3000-4000 pores per nuclear envelope.

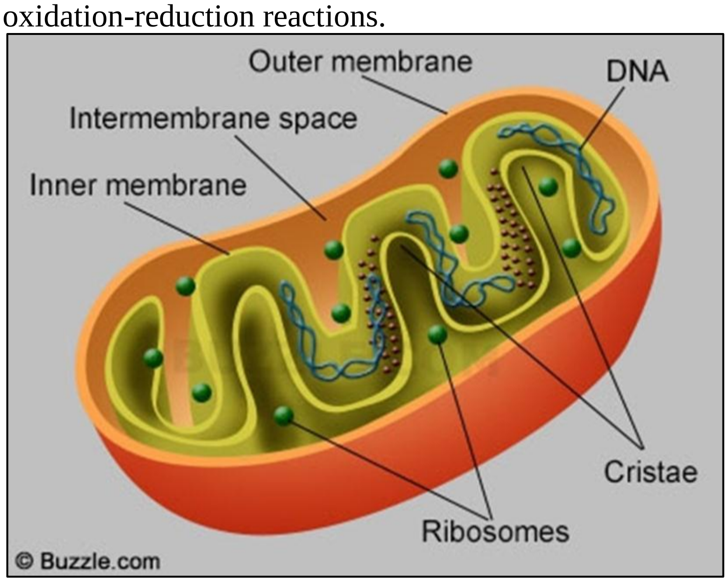


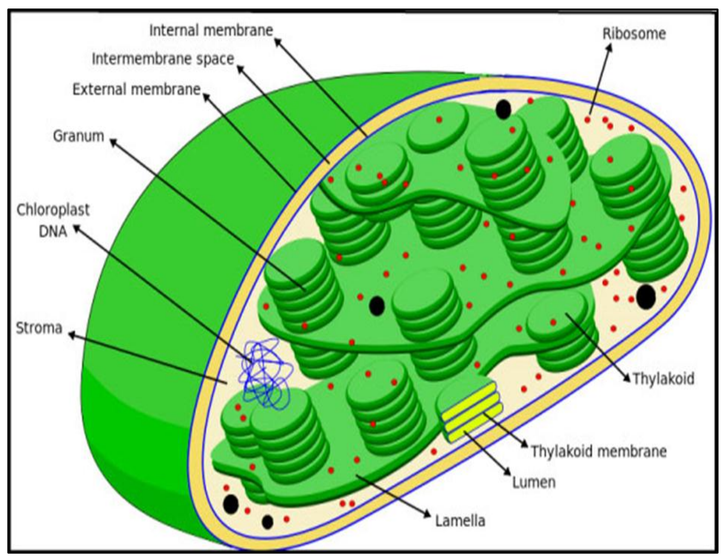
Structural details of nucleus (A) whole and (B) enlarged view of nuclear pore

Nuclear pore is 100nm is diameter and consists of several proteins. It is a gateway for transfer of material between nucleus and cytosol. RNA formed after transcription from DNA within the nucleus and move out of the nucleus into the cytosol through nuclear pore. Similarly protein from cytosol crosses nuclear pore to initiate replication, transcription and other processes.

Mitochondria and Chloroplasts

Both organelles are bounded by an external membrane that serves as a barrier by blocking the passage of cytoplasmic proteins into the organelle. An inner membrane provides an additional barrier that is impermeable even to small ions such as protons. The membranes of both organelles have a lipid bilayer construction. Located between the inner and outer membranes is the intermembrane space. In mitochondria the inner membrane is elaborately folded into structures called cristae that dramatically increase the surface area of the membrane. In contrast, the inner membrane of chloroplasts is relatively smooth. However, within this membrane is yet another series of folded membranes that form a set of flattened, dislike sacs called thylakoids. The space enclosed by the inner membrane is called the matrix in mitochondria and the stroma in chloroplasts. Both spaces are filled with a fluid containing a rich mixture of metabolic products, enzymes, and ions. Enclosed by the thylakoid membrane of the chloroplast is the thylakoid space. The extraordinary chemical capabilities of the two organelles lie in the cristae and the thylakoids. Both membranes are studded with enzymatic proteins either traversing the bilayer or dissolved within the bilayer. These proteins contribute to the production of energy by transporting material across the membranes and by serving as electron carriers in important oxidation-reduction reactions.





Mitochondria and Chloroplast

Endoplasmic Reticulum

The endoplasmic reticulum (ER) is a system of membranous cisternae (flattened sacs) extending throughout the cytoplasm. Often it constitutes more than half of the total membrane in the cell. The endoplasmic reticulum can be classified into two functionally distinct forms, the smooth endoplasmic reticulum (SER) and the rough endoplasmic reticulum (RER). The morphological distinction between the two is the presence of protein-synthesizing particles, called ribosomes, attached to the outer surface of the RER. The functions of the SER, a meshwork of fine tubular membrane vesicles, vary considerably from cell to cell. One important role is the synthesis of phospholipids and cholesterol, which are major components of the plasma and internal membranes.

In liver cells, the SER is specialized for the detoxification of a wide variety of compounds produced by metabolic processes. In cells of the adrenal glands and gonads, cholesterol is modified in the SER at one stage of its conversion to steroid hormones. Finally, the SER in muscle cells sequesters calcium ions from the cytoplasm. When the muscle is triggered by nerve stimuli, the calcium ions are released, causing muscle contraction.

The RER is generally a series of connected flattened sacs. It plays a central role in the synthesis and export of proteins and glycoproteins and is best studied in the secretory cells specialized in these functions. The many secretory cells in the human body include liver cells secreting serum proteins such as albumin, endocrine cells secreting peptide hormones such as insulin, salivary gland and pancreatic acinar cells secreting digestive enzymes, mammary gland cells secreting milk proteins, and cartilage cells secreting collagen and proteoglycans.

Ribosomes are particles that synthesize proteins from amino acids. They are composed of four RNA molecules and between 40 and 80 proteins assembled into a large and a small subunit. Ribosomes are either free (i.e., not bound to membranes) in the cytoplasm of the cell or bound to the RER.

Golgi apparatus

The Golgi apparatus (also known as the Golgi complex or Golgi body) is a membrane-bound organelle of eukaryotic cells that is made up of a series of flattened, stacked pouches called cisternae. The Golgi apparatus is responsible for transporting, modifying, and packaging proteins and lipids into vesicles for delivery to targeted destinations. It is located in the cytoplasm next to the endoplasmic reticulum and near the cell nucleus. While many types of cells contain only one or several Golgi apparatus, plant cells can contain hundreds.

Secretory Vesicles

The release of proteins or other molecules from a secretory vesicle is most often stimulated by a nervous or hormonal signal. For example, a nerve cell impulse triggers the fusion of secretory vesicles to the membrane at the nerve terminal, where the vesicles release neurotransmitters into the synaptic cleft (the gap between nerve endings).

Lysosomes

Lysosomes are subcellular organelles that are found in all eukaryotic cells. They are responsible for cellular digestion of macromolecules, old cell parts, and microorganisms. Each lysosome is surrounded by a membrane that maintains an acidic environment within the interior via a proton pump. Lysosomes contain a wide variety of hydrolytic enzymes (acid hydrolases) that break down macromolecules such as nucleic acids, proteins, and polysaccharides. These enzymes are active only in the lysosome’s acidic interior.

Microbodies and Peroxisomes

Microbodies are roughly spherical in shape, bound by a single membrane, and are usually 0.5 to 1 micrometre in diameter. There are several types, by far the most common of which is the peroxisome. Peroxisomes contain enzymes that oxidize certain molecules normally found in the cell, notably fatty acids and amino acids. These oxidation reactions produce hydrogen peroxide, which is the basis of the name *peroxisome*. However, hydrogen peroxide is potentially toxic to the cell, because it has the ability to react with many other molecules. Therefore, peroxisomes also contain enzymes such as catalase that convert hydrogen peroxide to water and oxygen, thereby neutralizing the toxicity. In this way peroxisomes provide a safe location for the oxidative metabolism of certain molecules. The plant glyoxysome is a peroxisome that also contains the enzymes of the glyoxylate cycle, which is crucial to the conversion of fat into carbohydrate.

Vacuoles

Most plant cells contain one or more membrane-bound vesicles called vacuoles. Within the vacuole is the cell sap, a water solution of salts and sugars kept at high concentration by the active transport of ions through permeases in the vacuole membrane. Proton pumps also maintain high concentrations of protons in the vacuole interior. These high concentrations cause the entry, via osmosis, of water into the vacuole, which in turn expands the vacuole and generates a hydrostatic pressure, called turgor that presses the cell membrane against the cell wall. Turgor is the cause of rigidity in living plant tissue. In the mature plant cell, as much as 90 percent of cell volume may be taken up by a single vacuole. Immature cells typically contain several smaller vacuoles.

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