**Dr. Rima Kumari: Date: 23/09/2020**

Online class and e- content for BSc IIIrd year students

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| Date and Time | Online class medium  | E. content topic |
| 23/09/202011:30 p.m to 12.10 p.m | Via Google meetLink: Meeting URL: https://meet.google.com/uoe-bjbh-hdd | **Prokaryotic cell structure** |

### The Prokaryotic Cell

Prokaryotes are unicellular organisms that lack organelles or other internal membrane-bound structures. Therefore, they do not have a nucleus, but, instead, generally have a single chromosome: a piece of circular, double-stranded DNA located in an area of the cell called the nucleoid. Most prokaryotes have a cell wall outside the plasma membrane.



The composition of the cell wall differs significantly between the domains Bacteria and Archaea, the two domains of life into which prokaryotes are divided. The composition of their cell walls also differs from the eukaryotic cell walls found in plants (cellulose) or fungi and insects (chitin). The cell wall functions as a protective layer and is responsible for the organism’s shape. Some bacteria have a capsule outside the cell wall. Other structures are present in some prokaryotic species, but not in others. For example, the capsule found in some species enables the organism to attach to surfaces, protects it from dehydration and attack by phagocytic cells, and increases its resistance to our immune responses. Some species also have flagella used for locomotion and pili used for attachment to surfaces. Plasmids, which consist of extra-chromosomal DNA, are also present in many species of bacteria and archaea.

### The Cell Wall

The cytoplasm of prokaryotic cells has a high concentration of dissolved solutes. Therefore, the osmotic pressure within the cell is relatively high. The cell wall is a protective layer that surrounds some cells and gives them shape and rigidity. It is located outside the cell membrane and prevents osmotic lysis (bursting due to increasing volume). The chemical composition of the cell walls varies between archaea and bacteria. It also varies between bacterial species.

Bacterial cell walls contain peptidoglycan composed of polysaccharide chains that are cross-linked by unusual peptides containing both L- and D-amino acids, including D-glutamic acid and D-alanine. Proteins normally have only L-amino acids; as a consequence, many of our antibiotics work by mimicking D-amino acids and, therefore, have specific effects on bacterial cell wall development. There are more than 100 different forms of peptidoglycan. S-layer (surface layer) proteins are also present on the outside of cell walls of both archaea and bacteria.

Bacteria are divided into two major groups: gram-positive and gram-negative, based on their reaction to gram staining. Note that all gram-positive bacteria belong to one phylum; bacteria in the other phyla (Proteobacteria, Chlamydias, Spirochetes, Cyanobacteria, and others) are gram-negative. The gram-staining method is named after its inventor, Danish scientist Hans Christian Gram (1853–1938). The different bacterial responses to the staining procedure are ultimately due to cell wall structure. Gram-positive organisms typically lack the outer membrane found in gram-negative organisms. Up to 90 percent of the cell wall in gram-positive bacteria is composed of peptidoglycan, with most of the rest composed of acidic substances called teichoic acids. Teichoic acids may be covalently linked to lipids in the plasma membrane to form lipoteichoic acids. Lipoteichoic acids anchor the cell wall to the cell membrane. Gram-negative bacteria have a relatively thin cell wall composed of a few layers of peptidoglycan (only 10 percent of the total cell wall), surrounded by an outer envelope containing lipopolysaccharides (LPS) and lipoproteins. This outer envelope is sometimes referred to as a second lipid bilayer. The chemistry of this outer envelope is very different, however, from that of the typical lipid bilayer that forms plasma membranes.



**Gram-positive and gram-negative bacteria**: Bacteria are divided into two major groups: gram-positive and gram-negative. Both groups have a cell wall composed of peptidoglycan: in gram-positive bacteria, the wall is thick, whereas in gram-negative bacteria, the wall is thin. In gram-negative bacteria, the cell wall is surrounded by an outer membrane that contains lipopolysaccharides and lipoproteins. Porins, proteins in this cell membrane, allow substances to pass through the outer membrane of gram-negative bacteria. In gram-positive bacteria, lipoteichoic acid anchors the cell wall to the cell membrane.

### The Plasma Membrane

The plasma membrane is a thin lipid bilayer (6 to 8 nanometers) that completely surrounds the cell and separates the inside from the outside. Its selectively-permeable nature keeps ions, proteins, and other molecules within the cell, preventing them from diffusing into the extracellular environment, while other molecules may move through the membrane. The general structure of a cell membrane is a phospholipid bilayer composed of two layers of lipid molecules. In archaeal cell membranes, isoprene (phytanyl) chains linked to glycerol replace the fatty acids linked to glycerol in bacterial membranes. Some archaeal membranes are lipid monolayers instead of bilayers.



**Plasma membrane structure**: Archaeal phospholipids differ from those found in Bacteria and Eukarya in two ways. First, they have branched phytanyl sidechains instead of linear ones. Second, an ether bond instead of an ester bond connects the lipid to the glycerol.

## Nucleid:

The nucleoid (meaning nucleus-like) is an irregularly-shaped region within the cell of a prokaryote that contains all or most of the genetic material. In contrast to the nucleus of a eukaryotic cell, it is not surrounded by a nuclear membrane. The genome of prokaryotic organisms generally is a circular, double-stranded piece of DNA, of which multiple copies may exist at any time. The length of a genome varies widely, but is generally at least a few million base pairs.

The nucleoid can be clearly visualized on an electron micrograph at high magnification, where it is clearly visible against the cytosol. Sometimes even strands of what is thought to be DNA are visible. The nucleoid can also be seen under a light microscope.by staining it with the Feulgen stain, which specifically stains DNA. The DNA-intercalating stains DAPI and ethidium bromide are widely used for fluorescence microscopy of nucleoids.

Experimental evidence suggests that the nucleoid is largely composed of about 60% DNA, plus a small amount of RNA and protein. The latter two constituents are likely to be mainly messenger RNA and the transcription factor proteins found regulating the bacterial genome. Proteins helping to maintain the supercoiled structure of the nucleic acid are known as nucleoid proteins or nucleoid-associated proteins, and are distinct from histones of eukaryotic nuclei. In contrast to histones, the DNA-binding proteins of the nucleoid do not form nucleosomes, in which DNA is wrapped around a protein core. Instead, these proteins often use other mechanisms, such as DNA looping, to promote compaction.

**The Genophore**

A genophore is the DNA of a prokaryote. It is commonly referred to as a prokaryotic chromosome. The term “chromosome” is misleading, because the genophore lacks chromatin. The genophore is compacted through a mechanism known as supercoiling, but a chromosome is additionally compacted through the use of chromatin. The genophore is circular in most prokaryotes, and linear in very few. The circular nature of the genophore allows replication to occur without telomeres. Genophores are generally of a much smaller size than Eukaryotic chromosomes. A genophore can be as small as 580,073 base pairs (Mycoplasma genitalium). Many eukaryotes (such as plants and animals) carry genophores in organelles such as mitochondria and chloroplasts. These organelles are very similar to true prokaryotes.

## Prokaryotic Reproduction

Prokaryotes reproduce asexually by binary fission; they can also exchange genetic material by transformation, transduction, and conjugation.

* **Binary fission**: Binary fission is a type of reproduction in which the chromosome is replicated and the resultant prokaryote is an exact copy of the parental prokaryate, thus leaving no opportunity for genetic diversity. It is the process whereby a cell divides asexually to produce two daughter cells
* **transformation**: Transformation is a type of prokaryotic reproduction in which a prokaryote can take up DNA found within the environment that has originated from other prokaryotes, especially if pathogenic
* **transduction**: Transduction is a type of prokaryotic reproduction in which a prokaryote is infected by a virus which injects short pieces of chromosomal DNA from one bacterium to another. horizontal gene transfer mechanism in prokaryotes where genes are transferred using a virus
* **Conjugation**: Conjugation is a type of prokaryotic reproduction in which DNA is transferred between prokaryotes by means of a pilus. the temporary fusion of organisms, especially as part of sexual reproduction by using sex pili

**Different types of Prokaryotes:**

The 'group of procaryotes' is known as **Monera.** This group includes eubacteria, archaebacteria, green bacteria, purple bacteria, virus, prochlorophyta, cyanophyta and mycoplasma. Here we will describe the structure of two procaryotes viz. bacteria and virus.

**Bacteria:** Bacteria have a protective covering called 'cell wall'. Beneath this, there is a plasma membrane which encloses protoplasm of the bacterium containing various types of **RNA,** DNA, proteins and organic molecules. In bacteria, **DNA** molecule and enzymes involved in oxidation of food are found associated with the plasma membrane. Bacteria, though simple in their structure, are the most abundant of all the life forms on earth today. This is due to their rapid rate of multiplication and the ability to adapt to any nutrient and environment.

**Bacterial structure**



**Structure of a bacterium:** The bacterial cell is enclosed by a cell wall, which Is furthersurrounded by capsule. Infolding of plasma membrane forms mesosomes. The nuclear material **is** concentrated in a specific region **of** the cell called nucieoid. **One** or **more** flagella may **be** present for locomotion. Small appendages that are called flmbriae **arise** from the cytosol and help the bacterium in **getting** attached to a surface.

Bacteria single-celled prokaryotic organism (microorganisms having) the absence of the nucleus and other cell organism hence, they classified as prokaryotic organisms. A bacterial cell has five essential structural components: a nucleoid (DNA), ribosomes, cell membrane, cell wall, and some sort of surface layer, which may or may not be an inherent part of the wall. Structurally, there are three architectural regions: appendages (attachments to the cell surface) in the form of flagella and pili (or fimbriae); a cell envelope consisting of a capsule, cell wall and plasma membrane; and a cytoplasmic region that contains the cell chromosome (DNA) and ribosomes and various sorts of inclusions. Bacterial DNA are naked, independent in cytoplasm region t/a nucleoid. Great variation in size from average 1.25 µ to 2 µ diameter. Length can varied.

A bacterial cell remains surrounded by an outer layer or cell envelope, which consists of two com¬ponents – a rigid cell wall and beneath it a cyto¬plasmic membrane or plasma membrane. Bacterial cell wall is extremely thin (10-25 nm thick) and provides rigidity and a definite shape to the cell. Chemically, the cell wall is composed of mucopeptide (murein) scaffolding or platform formed by N- acetyl glucosamine and N-acetyl muramic acid mol¬ecules arranged in alternate chains. According to Peberdy (1980) the compound present in the cell walls of both Gram-negative and Gram-positive bacteria is ‘peptidoglycan’. The cell walls of Gram-positive bacteria contain up to 95% peptidoglycan and up to 10% teichoic acids. The cell envelope in some bacteria may be enclosed in a loose slimy layer or capsule.

2. Cytoplasmic membrane is a thin (5-10 nm) layer lin¬ing the inner surface of the cell wall. It separates the cell wall from the cytoplasm. It functions as a semipermeable membrane that keeps control over the inflow and outflow of metabolites to and from the protoplasm. Chemically, the cytoplasmic (plasma) membrane consists of lipoprotein with small amounts of car¬bohydrates. The lipid may reach up to 30% and protein up to 75%. Some vesicular, pocket-like structures are formed as invaginations of the cytoplasmic membrane into the cytoplasm. These are called mesosomes. They are supposed to be the principal sites of respiratory enzymes.

3. The cell encloses the protoplasm, made up of the cytoplasm, cytoplasmic inclusions (such as ribosomes, mesosomes, fat globules, inclusion bodies, vacuoles) and the nuclear material nucleoid (nacked DNA). Cytoplasm is present in the form of a colloidal system of several organic and inorganic solutes in a viscous watery solution. It does not show the protoplasmic streaming. Membrane-bound organelles, such as endoplasmic reticulum, mitochondria and Golgi- bodies are also absent in bacteria. The bacterial cytoplasm contains several ribosomes which occupy the most part of the cytoplasm. These are the centres of protein synthesis. Ribosomes are the ribonucleoprotein particles of approximately 100 Å in diameter. Intracytoplasmic inclusions are volutin, polysac¬charide, lipid, crystals and vacuoles.

4. Nuclear material is present in each bacterial cell, but there is no nuclear membrane or nucleolus. Bacteria are, therefore, prokaryotic. The low electron-density regions in the cell are actually the densely-packaged DNA regions, called ‘nuclear bodies’ or ‘nucleoids’. Nucleoid is, therefore, made up of DNA, the genetic material of the cell.

Some bacteria possess some extranucelar genetic elements made up of DNA. These cytoplasmic carriers of genetic information are called ‘plasmids’ and ‘episomes’.

5. Some bacteria also carry flagella. Flagella are long, fine, hair-like, locomotory appendages, found commonly in rod-shaped and spiral bacteria.

6. Some very fine, hair-like, surface appendages, found in some Gram-negative bacilli are called fimbriae or pili.