

PUC 1ST YEAR –SEMESTER-2

UNIT I: Cell Biology

Module No: 01: Cell theory – Prokaryotic cell structure and function

All living organisms are composed of cells. Anton Von Leeuwenhoek in late 1600s first saw and described a cell in a living organism. Robert Hooke observed for the first time the cells in a dead cork and named them as cells because they resembled the rooms of monastery. Robert Brown later discovered the nucleus.

The cell is defined as the smallest structural basic unit of an organism that is able to function independently.

All living organisms generally begin life as a single cell. This cell divides and redivides repeatedly until it forms into an organism. A mature plant or an animal usually consists of billions of cells. In the beginning, the cells formed from a single cell are alike in form and function. But later the cells modify into different types and perform different functions of the body.

CELL DOCTRINE

The **CELL THEORY**, or cell doctrine, was proposed by Schleiden and Schwann in 1839 independently. They described the cell as a functional biological unit. It states that both the plants and animals possess almost the same internal organization, though they differ in their external forms. Both the plant and animal body is made of cells and each cell can be compared to a miniature organism in its function. This theory however, did not explain how new cells were formed.

Rudolf Virchow (1855) first explained that cells divide and new cells are formed from pre-existing cells. The cell theory explains:

- 1) All living things are made up of cell (s).
- 2) The cell is structural and functional unit of all living organisms.
- 3) The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.
- 4) Cells arise from preexisting ones and undergo multiplication.
- 5) Cells contain hereditary information which is passed from cell to cell during cell division.
- 6) All cells are basically the same in chemical composition.
- 7) All energy flow (metabolism & biochemistry) of life occurs within cells.

PROKARYOTIC CELL

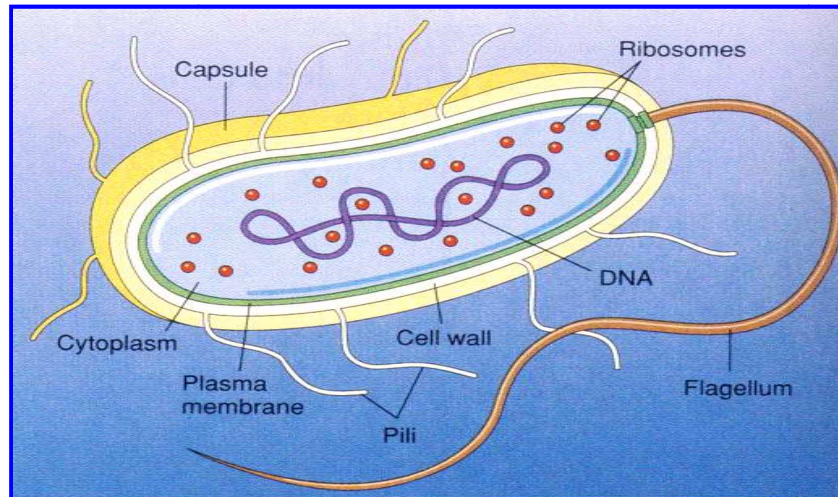
Prokaryotes are microscopic unicellular organisms of universal occurrence. Prokaryotes are defined as the cells which do not contain a distinct nuclear membrane. The prokaryotes are the most primitive cells from morphological point of view because the cytoplasm is devoid of well defined organelles such as mitochondria, endoplasmic reticulum, golgibodies, centrioles etc but contain cell membrane and having organelles with single membrane. Bacteria, virus, blue green algae are the best examples for prokaryotes.

Some prokaryotic cells have external whip-like flagella for locomotion or hair like pili for adhesion.

The Ultra structural details (details seen under electron microscope) of prokaryotes is presented below. A prokaryotic cell has three regions:

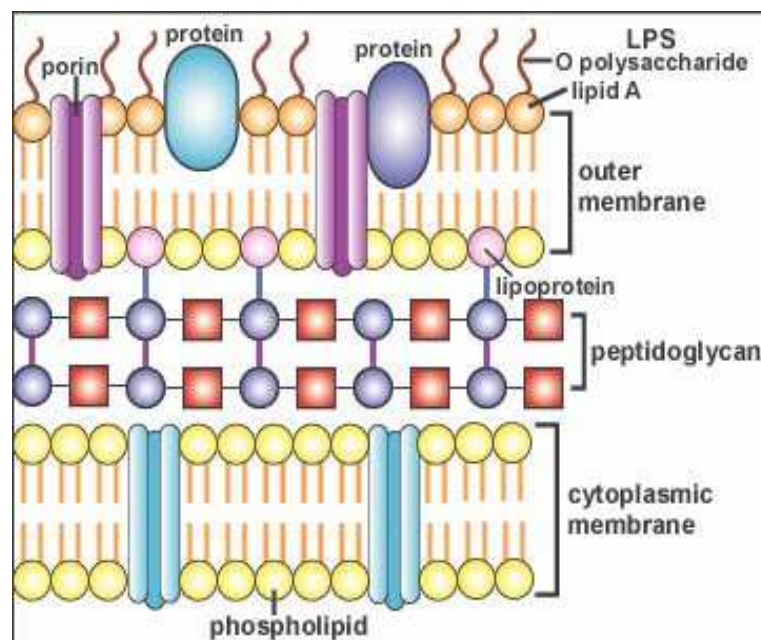
- a) Cell envelope consisting of a capsule, cell wall and plasma membrane.
- b) Appendages attached to the cell surface such as Flagella and Pili.
- c) Cytoplasmic region that contains DNA, Ribosomes and other inclusions.

STRUCTURE OF PROKARYOTIC CELL (Bacterial cell)



Cell Wall

This rigid structure of prokaryotes contains peptidoglycan giving the cell shape and surrounding the cytoplasmic membrane. The cell wall provides the cell with protection from environment.



PLASMA MEMBRANE

A phospholipid bilayer separates the cell from its environment. Phospholipid molecules are oriented so that hydrophilic (water-loving) heads are directed outward and hydrophobic (water-hating) tails are directed inward. The plasma membrane is selectively permeable to allow substances to pass into and out of the cell. The plasma membrane gives out certain infoldings called mesosomes. The mesosome plays an important role in generating energy for the cell as they contain respiratory enzymes.

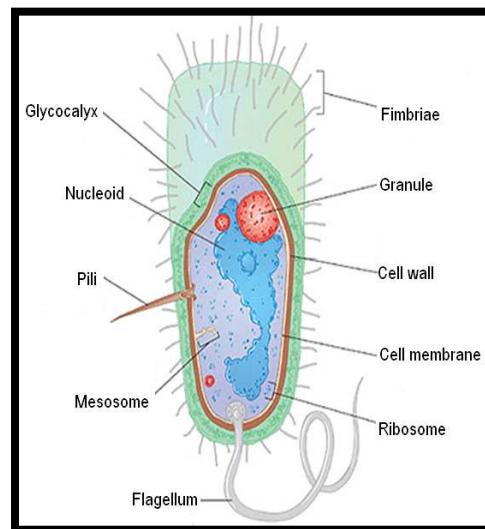
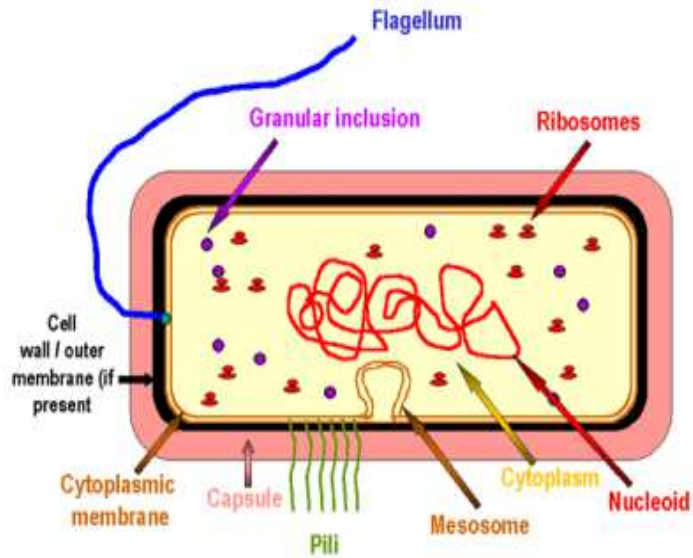
LPS MEMBRANE:

Gram-negative bacteria have this outer membrane, i.e., outside the cell wall made up of Lipopolysaccharides (LPS) and that is similar to the plasma membrane, but less permeable. LPS is a harmful substance classified as an endotoxin which is toxic to animals.

GLYCOCALYX:

Some bacteria have an additional layer outside the cell wall called the glycocalyx. A **slime layer** consists of glycoproteins is loosely associated with the cell wall. Slime layers cause bacteria to adhere to solid surfaces.

A **capsule** is formed from polysaccharides and is firmly attached to the cell wall. The adhesive power of capsules is a major factor in the initiation of some bacterial diseases.

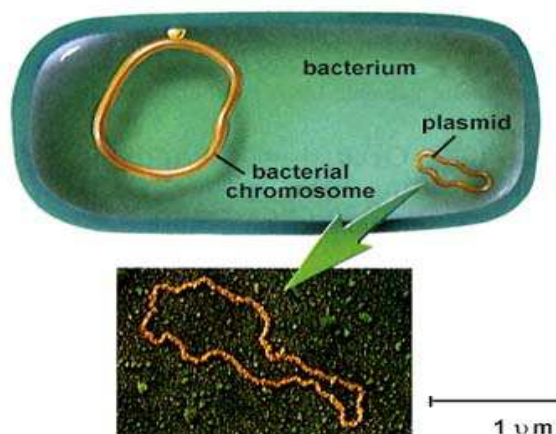


CYTOPLASM

The cytoplasm consists of water, enzymes, nutrients, such as sugars and aminoacids wastes, gases and cell structures. The cyto plasmic region contains ribosomes, DNA, Plamids and inclusions.

NUCLEOID:

Prokaryotic cell does not contain an intact nucleus. It lacks nuclear membrane. Therefore the DNA and RNA molecules and their associated proteins are in direct contact with cytoplasmic ground substance. These substances are called as Prokaryon or Nucleoid. The cell usually have single chromosome with double stranded circular DNA.



PLASMIDS:

Plasmids are extra chromosomal genetic structures; plasmids are made of a circular piece of DNA. It has genetic instructions for initiating cell division or binary fission in Bacteria. Plasmids can provide “bonus” genetic information, such as antibiotic drug resistance, resistance to heavy metals, or can promote conjugation (transfer of genetic material between bacteria).

GRANULES

The cytoplasm contains glycogen and fat granules. The stored food materials are in the form of Granulose (a polymer of Glucose) and volutin granules.

RIBOSOMES

Ribosomes are the only organelles in the prokaryotic cells. These are made of rRNA and proteins and exist either free within cytoplasm or attached to

the plasma membrane. Ribosomes translate genetic code into proteins. The Ribosomes are 70'S' type scattered freely in the cytoplasm.

CYTOSKELETON

This is the cellular "scaffolding" or "skeleton" within the cytoplasm previously thought to be a feature only of eukaryotic cells.

SURFACE APPENDAGES

Some prokaryotes have distinct appendages which includes

Flagella: long, thin extensions that allow bacteria to move about freely in aqueous environments

- **Axial filaments** or **endoflagella:** wind around bacteria causing movement in waves
- **Pili** or **fimbriae:** shorter, finer appendages that surround the cells of some gram-negative bacteria. They permit microbes to adhere to solid surfaces.

CHECK POINTS

1. The cell theory, or cell doctrine, proposed Schwann and Schleiden states that all organisms are composed of similar units of organization, called cells.
2. Rudolf Virchow (1855) first explained that cells divide and new cells are formed from pre-existing cells.
3. The cell is the unit of structure, physiology, and organization .
4. Cells that lack a membrane-bound nucleus are called prokaryotes.
5. The prokaryotic cell envelope consists of a capsule, a cell wall, and a cell membrane.

6. A cytoplasmic region that contains the cell genome (DNA), ribosomes, and various sorts of inclusions.
7. There are no chloroplasts. Photosynthesis usually takes place in infoldings or extensions derived from the cytoplasmic membrane.
8. Cell organelles such as mitochondria, endoplasmic reticulum, Golgi apparatus, vacuoles, and lysosomes are absent.
9. The appendages sometimes present are called flagella and pili.
10. In a prokaryotic cell, most of the functions of cell organelles are taken over by the prokaryotic cell membrane.
11. Instead of going through elaborate replication processes like eukaryotes, bacterial cells divide by binary fission.

Object Type Questions

1. Cell doctrine was proposed by
 - a) **Schleiden and Schwann**
 - b) Robert Hooke
 - c) Leeuwenhoek
 - d) Robert Brown
2. Who is the first to explain that cells divide and new cells are formed from pre existing cells
 - a) Schwann and Schleiden
 - b) Robert Hooke
 - c) Robert Brown
 - d) **Rudolf Virchow**
3. According to cell theory one of the following statements is not correct
 - a) All living things are made up of cells
 - b) All cells form from pre existing cells by division
 - c) The cell is the structural and functional unit of living organism
 - d) **All cells are basically not the same in chemical composition**
4. The main difference between prokaryotic and eukaryotic cells is that the former is without a

- a) Cell wall b) Genetic system **c) Nuclear membrane** d) Membrane system
5. DNA molecule of prokaryotic cell is
 a) **Double stranded circular** b) Single stranded circular c) Single stranded helix d) Double helical structure
6. The role of mesosomes in prokaryotic cell
 a) Function as mitochondria of Eukaryotes
 b) Contain respiratory enzymes
 c) They generate energy for the cell
d) All the above
7. Some prokaryotic cell have hair like pili which help in
 a) Locomotion **b) Adhesion** c) Protection d) None
8. Nucleoid is
 a) **Genetic material of prokaryotic cell**
 b) Genetic material of Eukaryotic cell
 c) Nucleus of the prokaryotic cell
 d) Nucleus without nuclear membrane
9. Type of Ribosomes in prokaryotic cell
 a) **“70 S” type** b) “80 S” type c) “50 S” type d) “30 S” type
10. Cell organelle which is absent in prokaryotic cell is
 a) Mitochondria b) Golgi apparatus c) Endoplasmic reticulum
d) All
11. The only organelle present in prokaryotic cells is
 a) **Ribosomes** b) Mitochondria c) Golgi d) Endoplasmic reticulum
12. Appendages present in prokaryotes
 a) Flagella b) Axial filaments c) Pili **d) All**
13. Extra chromosomal genetic structures present in prokaryotes
 a) Ribosomes **b) Plasmids** c) Nucleoid d) Pili

Short Answer Questions

1. What is a cell?
2. Give the salient features of cell doctrine as given by Schwann and Schleiden?
3. Where do you find prokaryotic cells?
4. Give an account of cell wall of prokaryotes.
5. What are plasmids? What is their role in biotechnology?
6. What is LPS membrane?
7. Give a brief account of cytoskeleton.
8. What is cyclosis? Explain.
9. Differentiate between flagella and pili.
10. Differentiate nucleus and nucleoid.
11. Give an account of Glycocalyx in bacteria.
12. What are the characters of Archae?
13. How archae are different from Bacteria?
14. What are the different appendages of prokaryotic cell?

Long Answer Questions

- 1) Describe the prokaryotic cell membrane and cell wall in detail
- 2) What are the features of the prokaryotic cell contents?
- 3) Draw a neat labeled diagram of prokaryotic cell and mention one important function of each part?