COURSE- B.SC. PART-II BOTANY HONOURS

PAPER – III

Topic – Cell structure of Bacteria and their Cell Wall (MICROBIOLOGY)

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Bacteria are unicellular minute organisms with typical prokaryotic structure. Bacterial cells range in size from being large with a size of 1.0 to 1.3 µm X 3 to 10 µm to very small cells with a size of 0.2 X 0.2 to 0.7 µm.

Shape: Bacteria have different characteristic shapes. They are cocci (round or ellipsoidal cells); rods; long, filamentous branched cells as in *Actinomyces* species; and comma-shaped and spiral cells as in *Vibrio cholerae*. The arrangement of cells is typical of various species or groups. Some rods or cocci grow in chains; some form grapelike clusters of spherical cells and some round cocci form cubic packets. Bacterial cells of different species grow in aggregated form or separately.

Cytoplasmic Structure

Plasma Membrane: The bacterial plasma membrane is composed primarily of proteins and phospholipids with a ratio of about 3:1. It performs several functions, including transport, biosynthesis, and energy transduction.

Organelles: The bacterial cytoplasm is densely packed with 70S ribosomes. Other granules represent metabolic reserves e.g., poly-β-hydroxybutyrate, polysaccharide, polymetaphosphate, and metachromatic granules.

Nucleoid: The bacterial nucleoid, which contains the DNA fibrils, lacks a limiting membrane. So, it differs from a true nucleus. Under light microscope, it can be seen with the aid of DNA stain Feulgen.

DNA in the nucleoid is a single, continuous, large circular molecule with a molecular weight of approximately 3×10^9. The unfolded nuclear DNA is about 1 mm long that is logistically packaged into small 1 to 2 µm bacterial cells. The extra number of this bacterial chromosome may be present in a cell but it depends on the stage of the cell cycle.

Bacterial chromatin does not contain basic histone proteins but there are low-molecular-weight polyamines and magnesium ions.

Surface Structures

Flagella: The flagella of motile bacteria differ in structure from eukaryotic flagella. In a flagellum, a basal body anchored in the plasma membrane and cell wall gives rise to a cylindrical protein filament. The flagellum moves by whirling about its long axis. The number and arrangement of flagella vary and are of diagnostical significance.

Flagella are long (3 to 12 µm) filamentous surface appendages about 12 to 30 nm in diameter. The protein subunits of a flagellum are assembled to form a cylindrical structure with a hollow core. A flagellum consists of three parts: (1) the long filament, which lies external to the cell surface; (2) the hook structure at the end of the filament; and (3) the basal body, to which the hook is anchored and which imparts motion to the flagellum. The basal body traverses the outer wall and membrane structures. It consists of a rod and one or two pairs of discs.

Force for movement of the bacterial cell is provided by counterclockwise rotation of the basal body. Response to chemical stimuli involves a sophisticated sensory system of receptors located in the cell surface and/or periplasm. They transmit information to methyl-accepting chemotactic proteins that control the flagellar motor mechanism. Genetic studies reveal the existence of mutants with altered biochemical pathways for flagellar motility and chemotaxis.

Flagella are composed of special proteins called flagellins. The hook and basal-body structures consist of numerous proteins.

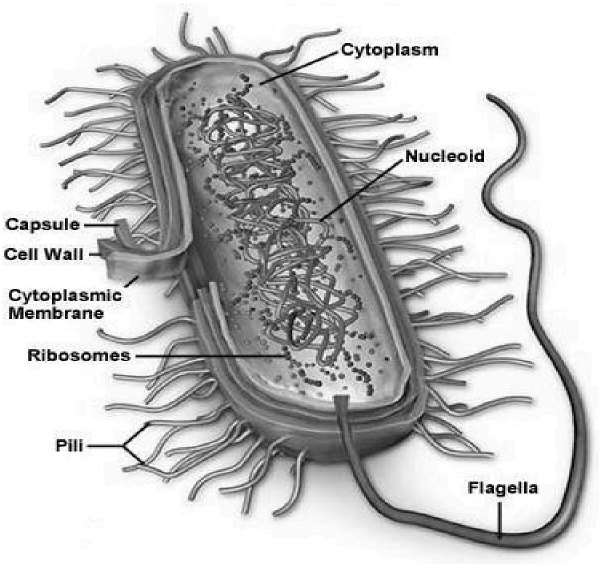
Flagellins are immunogenic and constitute a group of protein antigens called the H antigens which are characteristic of a species or a strain.

Pili (Fimbriae): Pili are slender, hair-like, proteinaceous appendages on the surface of many (Gram-negative) bacteria. They are important in adhesion to host surfaces. They are composed of the proteins referred to as pilins. Pili are more rigid in appearance than flagella. They are of two types: short, abundant common pili, and a small number (one to six) of very long pili known as sex pili. The sex pili are used for male to female bacterial attachment during conjugation. Pili in many enteric bacteria confer adhesive properties yo the bacterial cells. These adhesive properties of such cells play an important role in bacterial colonization of epithelial surfaces.

Capsules:

Some bacteria form capsules as the outermost layer of the cell and surround it with a thick layer of viscous gel. Capsules may be up to 10 µm thick. Some forms lack a well-defined capsule but have loose, amorphous slime layers external to the cell wall or cell envelope. Encapsulated species are found among both Gram-positive and Gram-negative bacteria. In both groups, most capsules are composed of high

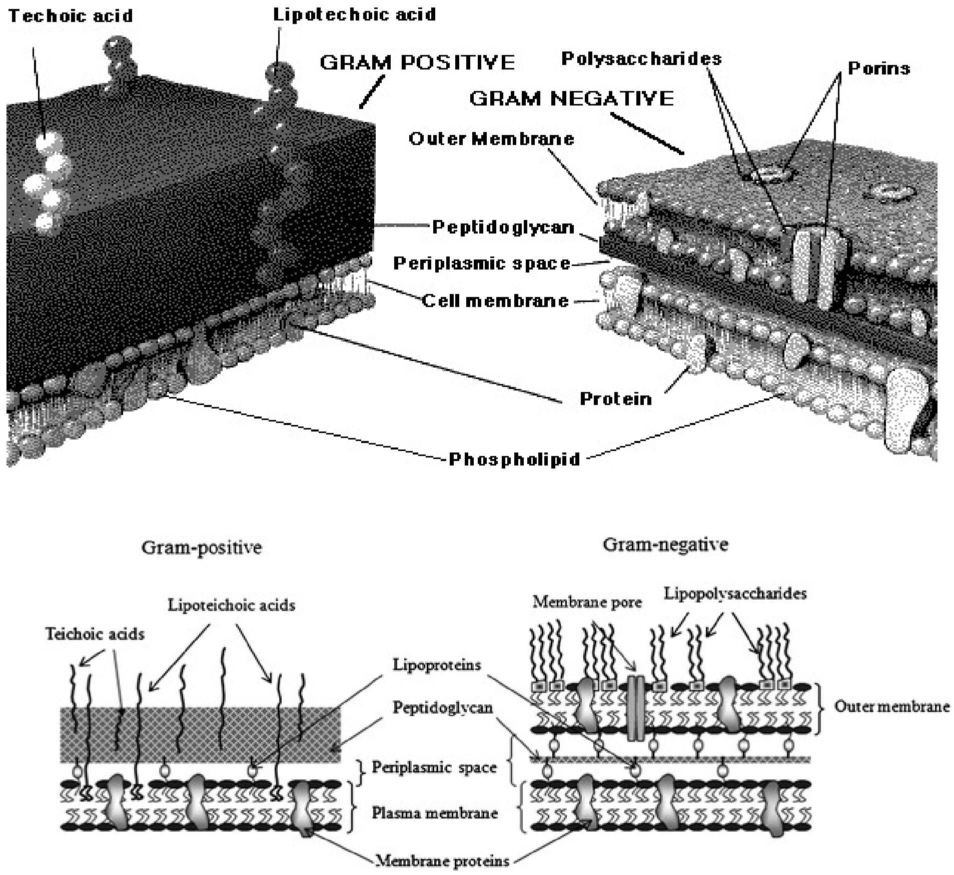
molecular-weight viscous polysaccharides that are retained as a thick gel outside the cell wall or envelope. A unique plasma membrane stage is involved in the biosynthesis and assembly of the capsular substances.
The capsule of encapsulated pathogens plays definitive role in their virulence. It is not essential for viability though.



A typical bacterial cell

Cell Wall

It lies between plasma membrane and the capsule (if present). In non-capsulated forms, it is the outermost layer. Gram-positive and Gram-negative bacteria differ drastically in the organization of the structures outside the plasma membrane but below the capsule.
Generally, in Gram-negative bacteria, these structures are referred to constitute the cell envelope while in Gram-positive bacteria, they are referred as the cell wall. This layer in both Gram-positive and Gram-negative bacteria possesses cell wall peptidoglycans which confer the characteristic cell shape and provide the cell with mechanical protection.
Gram-positive bacteria have, in general, a relatively thick (about 20 to 80 nm), and continuous cell wall which is composed largely of peptidoglycan (also called mucopeptide or murein).
Other cell wall polymers like teichoic acids, polysaccharides, and peptidoglycolipids are covalently attached to the peptidoglycan.



Structure of Gram negative and Gram positive bacterial cell wall

In contrast, the peptidoglycan layer in Gram-negative bacteria is thin being about 5 to 10 nm in thickness. Outside the peptidoglycan layer of the envelope is an outer membrane structure of about 7.5 to 10 nm thickness. In most Gram-negative bacteria, this outer membrane structure is anchored non-covalently to lipoprotein molecules (called Braun's lipoproteins). Braun's lipoproteins are covalently linked to the peptidoglycan. The lipopolysaccharides of the Gram-negative cell envelope form a part of the outer layer of the outer membrane structure.

The basic differences in the surface structures of Gram-positive and Gram-negative bacteria cause the differential Gram staining. Both types of bacteria take up crystal violet (CV) and iodine (I) stains equally but. The CV- I complex is trapped inside the Gram-positive cells due to the dehydration and lessened porosity of the thick cell wall when washed with 95% ethanol. That does not occur in the thin peptidoglycan layer of the Gram-negative cells.