Chapter 1: **PROKARYOTE CELL**

I. DEFINITION

Prokaryotes are generally unicellular microorganisms, except for a majority of Cyanobacteria (multicellular microorganisms). They are subdivided into two domains, the eubacteria(*Eubacteria*) and the archaea (*archaea*). The latter differ from Eubacteria by certain characteristics. Both domains have the characteristicto reproduce by scissiparity (absence of mitosis and meiosis).

II. STRUCTURE AND ULTRASTRUCTURE

1. At the Photonic Microscope (Light microscope: LM):

Prokaryotes come in a variety of shapes (**Figure 1)**: cylindrical, pedunculated, spiral or filamentous, although two forms predominate: spherical (or cocci) and rod-shaped (or bacilli). Archaea are larger than eubacteria.

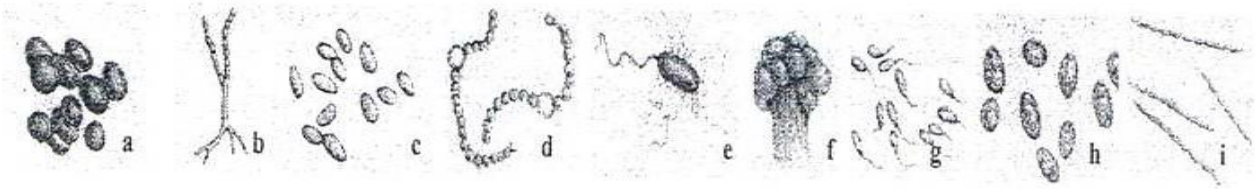


Figure 1: Different forms of bacteria.

2. Transmission electron microscope (TEM)

They have both essential and optional elements (**Figure 2**) and are characterized by the absence of the nuclear envelope, the endomembrane system (endoplasmic reticulum, Golgi apparatus, etc.), and mitochondria. Recently, a cytoskeleton-like structure has been revealed in certain prokaryotic cells, by a British researcher, in these prokaryotes.

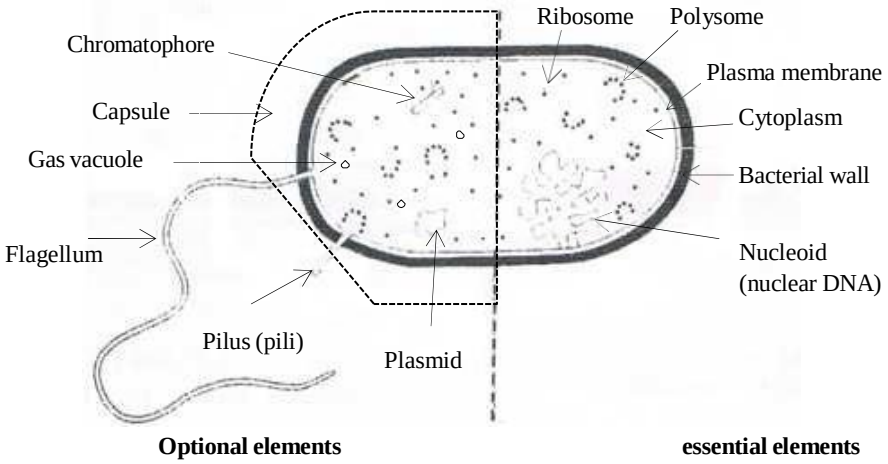


Figure 2: Organization of the prokaryotic cell.

2.1. Essential elements

The essential elements are common to all prokaryotic cells: the bacterial wall, the plasma membrane, the nuclear apparatus (nucleoid) and the cytoplasm rich in ribosomes and polyribosomes.

2.1.1. Bacterial wall

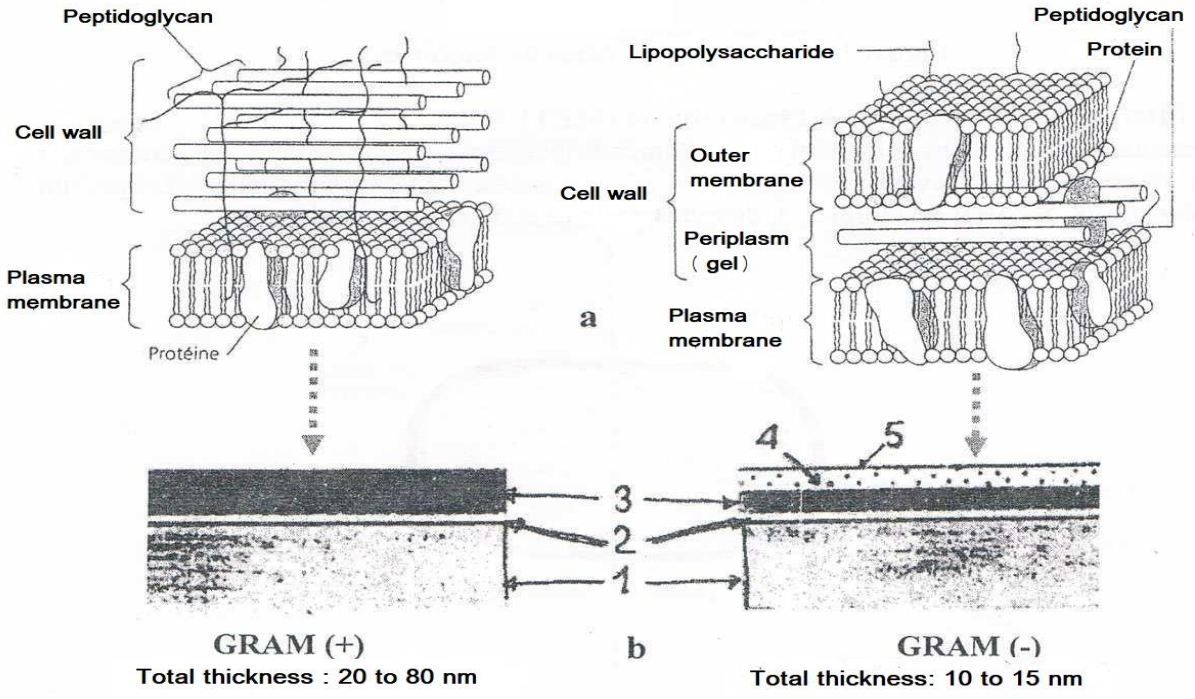
It's an external, rigid and resistant structure that determines shape and provides protection.
In eubacteria, it generally consists of sugar polymers (essentially

N-acetyl muranic acid and N-acetyl glucosamine) linked by peptide bridges: peptidoglycans (PG). The Gram staining technique, based on the chemical composition of the cell wall, has revealed the existence of 2 types of bacteria:

- Gram-positive (+) bacteria, with a thick wall consisting mainly of PG (20 to 80nm) and few lipids (lipoteichoic acid bound to PG and plasma membrane lipids).

- Gram-negative (-) bacteria have a wall consisting of a thin layer of PG (1 to 3nm) associated with an abundant lipoprotein. This lipoprotein is also linked to an additional outer membrane, rich in lipopolysaccharides (LPS). The space between the 2 membranes, in which the PG bathe, is an aqueous gel called periplasm.

Figure 3a shows proposed molecular architecture models for these two walls types, highly schematized in **Figure 3b**. The walls of archaea do not contain PG, and have a different organization and chemical composition from those of eubacteria.



1- cytoplasm, 2- plasma membrane, 3- peptidoglycans (PG), 4- PG-associated lipoproteins, 5- outer membrane, 3 and 4- (Gram -) periplasm.

Figure 3: Molecular architecture (**a**) and schematic representation (**b)** of the walls of Gram (+) and Gram (-) eubacteria.

2.1.2. Plasma membrane

In TEM, the plasma membrane of prokaryotes is similar to that of eukaryotic cells; it is trilamellar, asymmetrical, 7.5 nm thick and has a fluid mosaic molecular architecture. However, its chemical composition is different, containing 70% proteins, 30% lipids (without cholesterol) and rare carbohydrates.

In archaea, lipids are branched and made up of longer chains, and are also linked together by ether bonds. Whereas in eubacteria, as in eukaryotic cells, lipids are unbranched, consisting of shorter chains linked by ester bonds.

The plasma membrane performs several functions, some of which are specific to the cell (respiration and biosynthesis), while others are common to those of eukaryotic cells (exchanges with the external environment, without membrane deformation).

2.1.3. Cytoplasm

It is an aqueous gel with a cytoskeleton-like, whose proteins are homologous to those of Eukaryotic cells,
it contains ribosomes and polyribosomes characterizedby a sedimentation coefficient of 70S. It is the site of all metabolic activities, but also of transcription and translation, which take place simultaneously, as is characteristic of prokaryotes.The tRNA that initiates translation is f-methionine in eubacteria and methionine in archaea as well as in eukaryotes.

2.1.4. Nucleoid or nuclear apparatus

Also known as a chromosome (**Figure 4**), it is diffused in the cytoplasm and is made up of a single double-stranded DNA molecule, circular, supercoiled and forming several loops due to the action of enzymes and to its association with histone-like proteins, similar to the histones of eukaryotic cells.

The fully unrolled nucleoid is about 1.4mm long, while the prokaryotic cell varies in size from 0.lµm to l0µm, depending on the species. Prokaryotic genes have no introns (with the exception of certain archaeal genes), unlike eukaryotic cell genes.

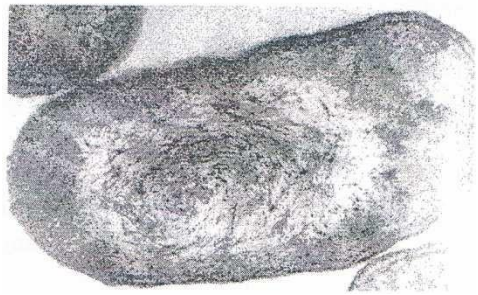


Figure 4: Organization of the prokaryotic cell.

2.2. Optional elements

Optional elements are specific to certain prokaryotic species and absent in others: plasmids, capsule, flagella, pilus, chromatophore and gas vacuole.

2.2.1. Plasmid

It's a very small molecule of extranuclear, double-stranded, circular DNA, located in the cytoplasm. Their number varies from 1 to several depending on the species. Plasmids carry genesthat are useful but not essential to the normal growth and division of prokaryotic cells. They duplicate independently of the nucleoid; some have the ability to transfer from one bacterium to another, in which case they are called fertility plasmids (F) if they carry fertility genes, or resistance plasmids (R) if they carry antibiotic resistance genes.

2.2.2. Capsule

This is the outermost structure. Layers of polysaccharide or protein-aqueous material, called a thin layer if it is diffuse and easily destroyed, or a capsule if well organized. They ensure the protection and/or adhesion of prokaryotes to surfaces.

2.2.3. Flagellum

A rigid, cylindrical appendage extending outside the plasma membrane and cell wall, of variable length up to 20µm. Its organization, chemical composition and operating mechanism are very different from those of the eukaryotic flagellum. It is made up of a specific protein: flagellin. Variable in number and position, it enables mobile bacteria to move rapidly (**figure 5**).

2.2.4. Pilus

Pili (in the plural), are extensions of the plasma membrane (**figure 5**). There are two types, somatic pili and sexual pili. The first ones serve for the adhesion of bacteria to different surfaces and the latter are of genetic material (e.g., copy of the plasmid) from one bacterium to another.

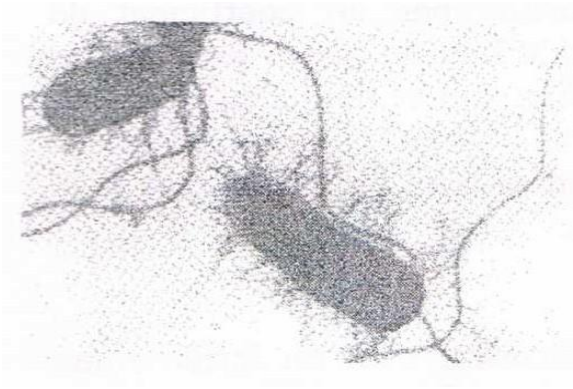


Figure 5: Flagella and pili of a prokaryotic cell.

2.2.5. Chromatophores

These are membrane systems or thylakoids diffused throughout the cytoplasm, rich in specific pigments. They are found only in photosynthetic eubacteria (**Figure 6**).

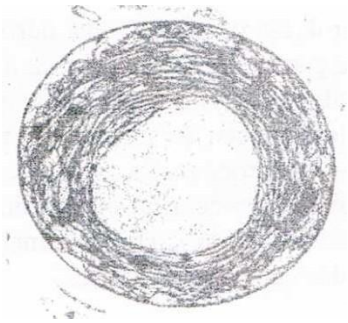


Figure 6: Ultrastructure of a photosynthetic bacterium, a cyanobacterium.

2.2.6. Gas Vacuoles

These are small vacuoles containing only air, found in the cytoplasm of photosynthetic bacteria living in aquatic environments. They enable these bacteria to move vertically and float.

Find out more

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