AL-Anbar University

Medicine College

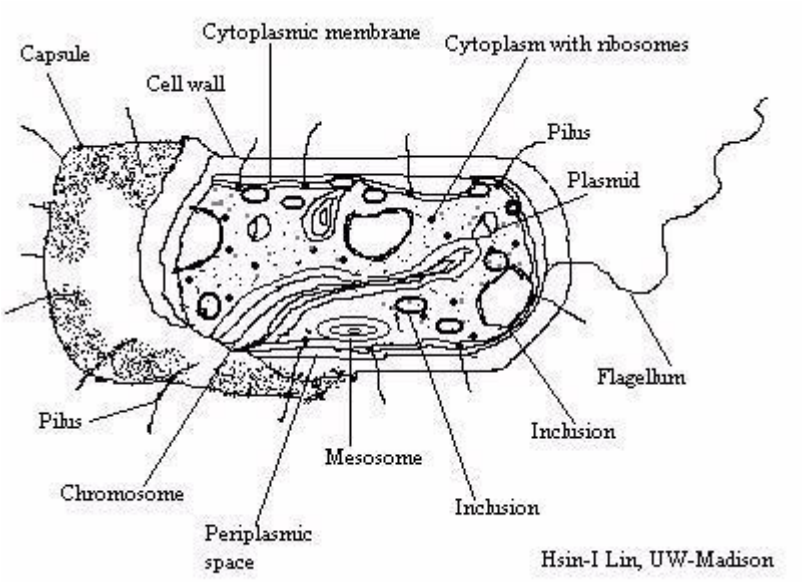
Microbiology Department

An Introduction to Bacteriology

The **Bacteria** are a group of single-cell microorganisms with **procaryotic** cellular configuration. The genetic material (DNA) of procaryotic cells exists unbound in the cytoplasm of the cells. There is **no nuclear membrane**, which is the definitive characteristic of eucaryotic cells such as those that make up, fungi, protista, plants and animals.

Structure and function of prokaryotic cells

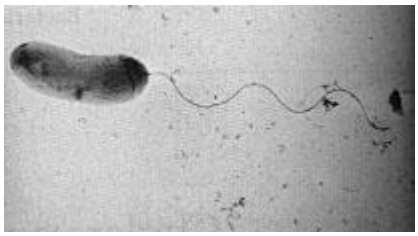
Prokaryotic cells have (proteins attached to the cell surface) in the form of **flagella** and **pili**; a **cell envelope** consisting of a **capsule**, **cell wall** and **plasma membrane**; and a **cytoplasmic region** that contains the cell genome (**DNA**) and **ribosomes** and various sorts of **inclusions**.



Schematic drawing of typical bacterial cell

Bacterial cell struture

Flagella are filamentous protein structures attached to the cell surface that provide swimming movement for most motile prokaryotic cells. The flagellar filament is rotated by a motor apparatus in the plasma membrane allowing the cell to swim in fluid environments.



The distribution of flagella are:

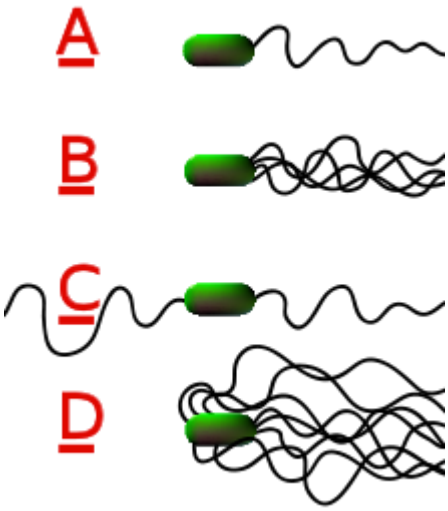
A-Polar distribution into:

1-Monotrichous

2-Amphitrichous

3-Lophtrichous

B-Peritrichous distribution



Examples of bacterial flagella arrangement schemes. A-Monotrichous; B-Lophotrichous; C-Amphitrichous; D-Peritrichous.

Bacterial species differ in the number and arrangement of flagella on their surface; some have a single flagellum (monotrichous), a flagellum at each end (amphitrichous), clusters of flagella at the poles of the cell (lophotrichous), while others have flagella distributed over the entire surface of the cell (peritrichous).

Monotrichous: having a single flagellum, usually at a polar position; applied to a bacterial cell.
Lophotrichous :bacteria that have flagella at both ends
Amphitrichous :having two or more flagella at one end or both ends (of a bacterial cell).

peritrichous
Having a **flagella**, occurring around the entire surface of a bacterial cell.

Fimbriae

In bacteriology, a **fimbria** is a proteinaceous appendage in many Gram-negative and some Gram-positive bacteria that is thinner and shorter than a flagellum. This appendage ranges from 3-10 nanometers in diameter. Fimbriae are used by bacteria to adhere to one another and to adhere to host cells. Fimbriae are shorter and stiffer than flagella, and slightly smaller in diameter. Fimbriae are only visible with the use of an electron microscope.

Fimbriae are one of the primary mechanisms of virulence for *E. coli*, *Bordetella pertussis*, *Staph* and *Strep* bacteria. Their presence greatly enhances the bacteria's ability to attach to the host and cause disease.

Pili

A **pilus** is a hair like structures on the surfaces of bacterial cells. *pilus* for the appendage required for bacterial conjugation. All pili are primarily composed of proteins.

Pili connect a bacterium to another of its species, or to another bacterium of a different species, and build a bridge between the interior of the cells. This enables the transfer of plasmids between the bacteria. An exchanged plasmid can code for new functions, e.g., antibiotic resistance. The pilus is made up of the protein pilin.

Sex pilus, have a role in the transfer of DNA between mating bacteria and usually involved in adherence (attachment) of procaryotes to surfaces in nature. In medical situations, they are major determinants of bacterial

virulence because they allow pathogens to attach to (colonize) tissues and to resist attack by phagocytic white blood cells.

Cell wall

Around the outside of the cell membrane is the bacterial cell wall. Bacterial cell walls are made of peptidoglycan (also called murein), which is made from polysaccharide chains cross-linked by unusual peptides containing D-amino acids. Bacterial cell walls are different from the cell walls of plants and fungi which are made of cellulose and chitin, respectively. The cell wall of bacteria is also distinct from that of Archaea, which do not contain peptidoglycan. The cell wall is essential to the survival of many bacteria, although L-form bacteria can be produced in the laboratory that lack a cell wall. The antibiotic penicillin is able to kill bacteria by preventing the cross-linking of peptidoglycan and this causes the cell wall to weaken and lyses. The lysozyme enzyme can also damage bacterial cell walls.

There are broadly speaking two different types of cell wall in bacteria, called Gram-positive and Gram-negative. The names originate from the reaction of cells to the Gram stain, a test long-employed for the classification of bacterial species.

Gram-positive bacteria possess a thick cell wall containing many layers of peptidoglycan and teichoic acids. In contrast, Gram-negative bacteria have a relatively thin cell wall consisting of a few layers of peptidoglycan surrounded by a second lipid membrane containing lipopolysaccharides and lipoproteins.

So that in the **Gram-positive bacteria** (those that retain the purple crystal violet dye when subjected to the Gram-staining procedure) the cell wall is a thick layer of murein.

In the **Gram-negative bacteria** (cells which do not retain the crystal violet dye) the cell wall is relatively thin and is composed of a thin layer of murein surrounded by a membranous structure called the **outer membrane**.

Cell membrane

The **cell membrane** or **plasma membrane** is a biological membrane that separates the interior of all cells from the outside environment. The cell membrane is selectively permeable to ions and organic molecules and controls the movement of substances in and out of cells. It consists of the lipid bilayer with embedded proteins.

The cell membrane surrounds the cytoplasm of a cell and, in animal cells, physically separates the intracellular components from the extracellular environment. Fungi, bacteria and plants also have the cell wall which provides a mechanical support for the cell and precludes the passage of larger molecules. The cell membrane also plays a role in anchoring the cytoskeleton to provide shape to the cell, and in attaching to the extracellular matrix and other cells to help group cells together to form tissues.

The membrane is differentially permeable and able to regulate what enters and exits the cell, thus facilitating the transport of materials needed for survival. The movement of substances across the membrane can be either *passive*, occurring without the input of cellular energy, or active, requiring the cell to expend energy in transporting it. The membrane also maintains the cell potential. The cell membrane thus works as a selective filter that allows only certain things to come inside or go outside the cell. To do so, the membrane employs a number of transport mechanisms.

Function of cell membrane

1. Diffusion : Some substances (small molecules, ions) such as carbon dioxide (CO2), oxygen (O2), and water, can move across the plasma membrane by diffusion, which is a passive transport process.

2. Osmosis : Because the membrane acts as a barrier for certain molecules and ions, they can occur in different concentrations on the two sides of the membrane. Such a concentration difference across a semipermeable membrane can set up a osmotic flow for the solvent, in this case water. Water can thus be transported across the membrane by osmosis.

3. **Mediated Transport** : Nutrients such as sugars and materials of growth such as amino acid must enter the cell, and the waste of metabolism must leave. Such molecules are moved across the membrane by special proteins called transport proteins.

4. **Endocytosis** : Endocytosis is the process in which cells absorb molecules by engulfing them. Endocytosis requires energy for active transport.

5. **Exocytosis** : Just as material can be brought into the cell by invagination and formation of a vesicle, the membrane of a vesicle can be fuse with the plasma membrane and extrude its contents to the surrounding medium. This is the process of exocytosis. Exocytosis occurs in various cells to remove undigested residues of substances brought in by endocytosis, to secrete substances such as hormones and enzymes, and to transport a substance completely across a cellular barrier. In the process of exocytosis, the undigested waste-containing food vacuole or the secretory vesicle budded from Golgi apparatus, is first moved by cytoskeleton from the interior of the cell to the surface. The vesicle membrane comes in contact with the plasma membrane. The lipid molecules of the two bilayers rearrange themselves and the two membranes are, thus, fused. A passage is formed in the fused membrane and the vesicles discharges its contents outside the cell.

Capsule

The **cell capsule** is a very large structure of some prokaryotic cells, such as bacterial cells. It is a layer that lies outside the cell wall of bacteria. It is a well organized layer, not easily washed off, and it can be the cause of various diseases.

Composition

It usually consists of polysaccharides, most capsules are water soluble, and they are difficult to stain using standard stains because most stains do not adhere to the capsule. For examination under the microscope, the bacteria and their background are stained darker than the capsule, which doesn't stain. When viewed, bacterial cells as well as the surface they are on, are stained dark, while the capsule remains pale or colorless and appears as a ring around the cell.

Function

The capsule is considered a virulence factor because it enhances the ability of bacteria to cause disease (i.e. prevents phagocytosis). The capsule is slippery and fragile, so when a phagocyte tries to phagocytose the bacteria, it can slip away. A capsule-specific antibody may be required for phagocytosis to occur. Capsules also contain water which

protects bacteria against desiccation. Capsules also help cells adhere to surfaces.

The capsule is found most commonly among Gram-negative bacteria:

- *Klebsiella pneumoniae*
- *Haemophilus influenzae*[

However, some Gram-positive bacteria may also have a capsule:

- *Bacillus megaterium* for example, synthesizes a capsule composed of polypeptide and polysaccharides.
- *Streptococcus pyogenes* synthesizes a hyaluronic acid capsule.

Capsules too small to be seen with an ordinary microscope, such as the M protein of *Streptococcus pyogenes*, are called microcapsules.

Cytoplasmic membrane

The bacterial cytoplasmic membrane is composed of a phospholipid bilayer and thus has all of the general functions of a cell membrane such as acting as a permeability barrier for most molecules and serving as the location for the transport of molecules into the cell. In addition to these functions, prokaryotic membranes also function in energy conservation as the location about which a proton motive force is generated.

As a phospholipid bilayer, the lipid portion of the outer membrane is impermeable to charged molecules. However, channels called porins are present in the outer membrane that allow for passive transport of many ions, sugars and amino acids across the outer membrane. These molecules are therefore present in the periplasm, the region between the cytoplasmic and outer membranes. The periplasm contains the peptidoglycan layer and many proteins responsible for substrate binding or hydrolysis and reception of extracellular signals. The periplasm it is thought to exist as a gel-like state rather than a liquid due to the high concentration of proteins and peptidoglycan found within it. Because of its location between the cytoplasmic and outer membranes, signals received and substrates bound are available to be transported across the cytoplasmic membrane using transport and signalling proteins imbedded there.

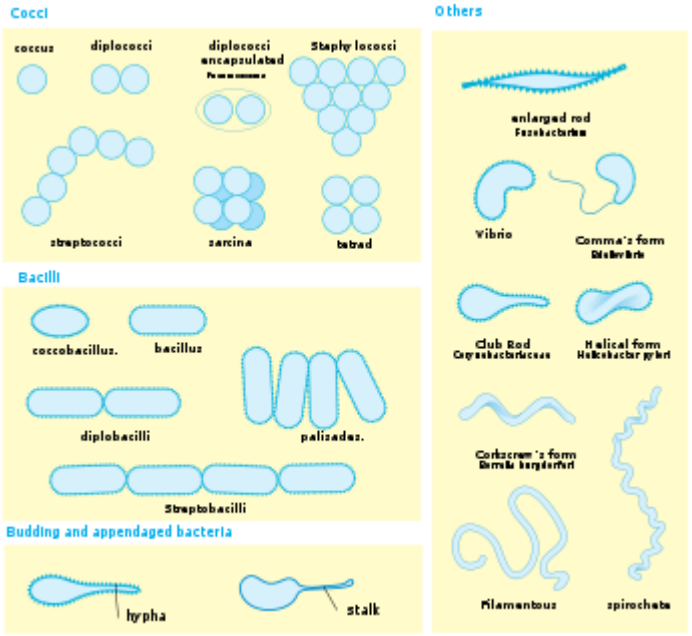
The different between Prokaryotic and Eukaryotic

No.	Prokaryotic	Eukaryotic
1-	Prokaryotic cell are a group of organisms that lack a cell nucles.	Eukaryotic cell are a group of organisms have cell nucles.
2-	Most prokaryotic are unicellular .	Eukaryotic may be unicellular , as in amoebae or multicellular ,as in plants and animals.
3-	The size of Ribosomes in prokaryotes is smaller than that in eukaryotes,	The size of Ribosomes in Eucaryotic is larger than that in Procaroytic,
4-	Prokaryotic do not have a nucleus , mitochondria and chloroplasts.	Eucaryotic cell contains a nucleus , mitochondria and chloroplasts.
5-	Lack of a nuclear membrane	Have a nuclear membrane
6-	absent	Cell membrane contains sterols
7-	Prokaryotes contain only a single loop of stable chromosomal DNA stored in an area named the nucleoid,	Whereas eukaryote DNA is found on tightly bound and organized chromosomes.

Morphology of bacterial cells

Prokaryotic cells have various shapes; the four basic shapes are:

1- Cocci – spherical
2- Bacilli - rod-shaped
3- Spirochaete - spiral-shaped
4- Vibrio - comma-shaped



Bacteria display a wide diversity of shapes and sizes, called *morphologies*.

Most bacterial species are either spherical, called cocci, or rod-shaped, called bacilli Elongation is associated with swimming. Some rod-shaped bacteria, called vibrio, are slightly curved or comma-shaped; others, can be spiral-shaped, called spirilla, or tightly coiled, called spirochaetes.

Many bacterial species exist simply as single cells, others associate in characteristic patterns: *Neisseria* form diploids (pairs), *Streptococcus* form chains, and *Staphylococcus* group together in "bunch of grapes" clusters.