The prokaryotic cell

Bacterial cell

Bacteria are prokaryotic, unicellular microorganisms, they lack membrane-bound organelles like those found in eukaryotes, and much smaller than eukaryotic cells; In general, bacteria are between 0.2 and 2.0 um - the average size of most bacteria. Mycoplasma is a type of bacteria which is considered as the smallest organism, measures a size of 0.25 µm.

Research studies have shown their size to play **an important role in survival over time** (Bacteria have a high surface area to volume ratio that allows them to take up as many nutrients as possible for survival. In the process, they are able to continue growing and reproducing at a steady rate). The small size of bacteria is also **beneficial for parasitism and oligotrophy** (Bacteria can continue relying on a range of hosts for their nutrition. In addition, they can also live and survive in environments that contain a low concentration of nutrients; for instance, a group of bacteria known as oligotrophic bacteria).

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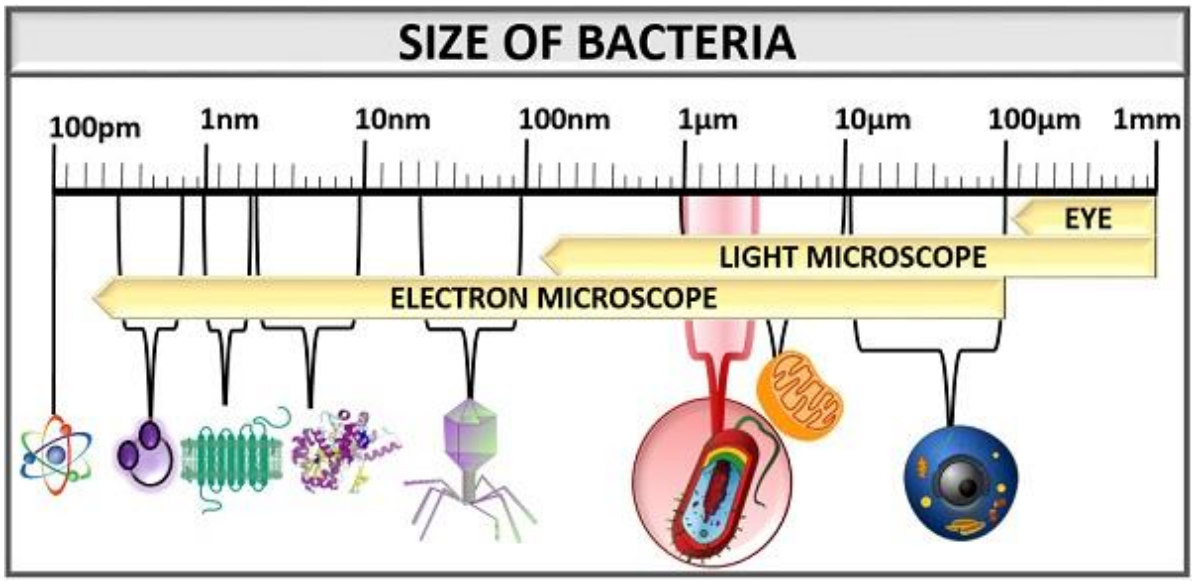


Shapes of bacteria

Typically bacteria come in three basic shapes: **spherical (Cocci), rod-shaped (Bacilli), and spiral**, however pleomorphic bacteria can assume several shapes.

- **Cocci** (or coccus for a single cell) are round cells, sometimes slightly flattened when they are adjacent to one another.
- **Bacilli** (or bacillus for a single cell) are rod-shaped bacteria.
- **Spirilla** (or spirillum for a single cell) are curved bacteria which can range from a gently curved shape to a corkscrew-like spiral.

Pleomorphism

Bacteria appear in number of different forms. Environmental conditions are affecting the size and shape of bacteria which is seen obviously in bacilli forms other than cocci forms.

Arrangement

(ملاحظة: الامثلة غير مطلوبة)

In addition to characteristic shapes, many bacteria also are found in distinctive arrangements of groups of cells.

*Arrangement of Cocci

1. Diplococci: The cocci are arranged in pairs (Example: *Neisseria gonorrhoeae*)

2. Streptococci: The cocci are arranged in chains, as the cells divide in one plane (Example: *Streptococcus pyogenes*).

3. Tetrads: The cocci are arranged in packets of four cells, as the cells divide in two plains (Example: *Aerococcus*).

4. Sarcinae: The cocci are arranged in a cuboidal manner, as the cells are formed by regular cell divisions in three planes (Example: *Sarcina ureae*).

5. Staphylococci: The cocci are arranged in grape-like clusters formed by irregular cell divisions in three plains (Example: *Staphylococcus aureus*).

*Arrangement of Bacilli

Bacilli divide in only one level, but they can produce cells connected end-to-end (like train cars) or side-by-side.

1-Monobacillus: appear as single rods after division (Example: *Bacillus cereus*).

2. Diplobacilli: appear in pairs after division (Example: *Coxiella burnetii*).

3. Streptobacilli: The bacilli are arranged in chains, as the cells divide in one plane (Example: *Streptobacillus moniliformis*).

4. Coccobacilli: These are so short and stumpy that they appear ovoid. They look like coccus and bacillus (Example: *Haemophilus influenza*).

5. Palisades : The bacilli bend at the points of division following the cell divisions, resulting in a palisade arrangement resembling a picket fence and angular patterns that look like Chinese letters (Example: *Corynebacterium diphtheria*).

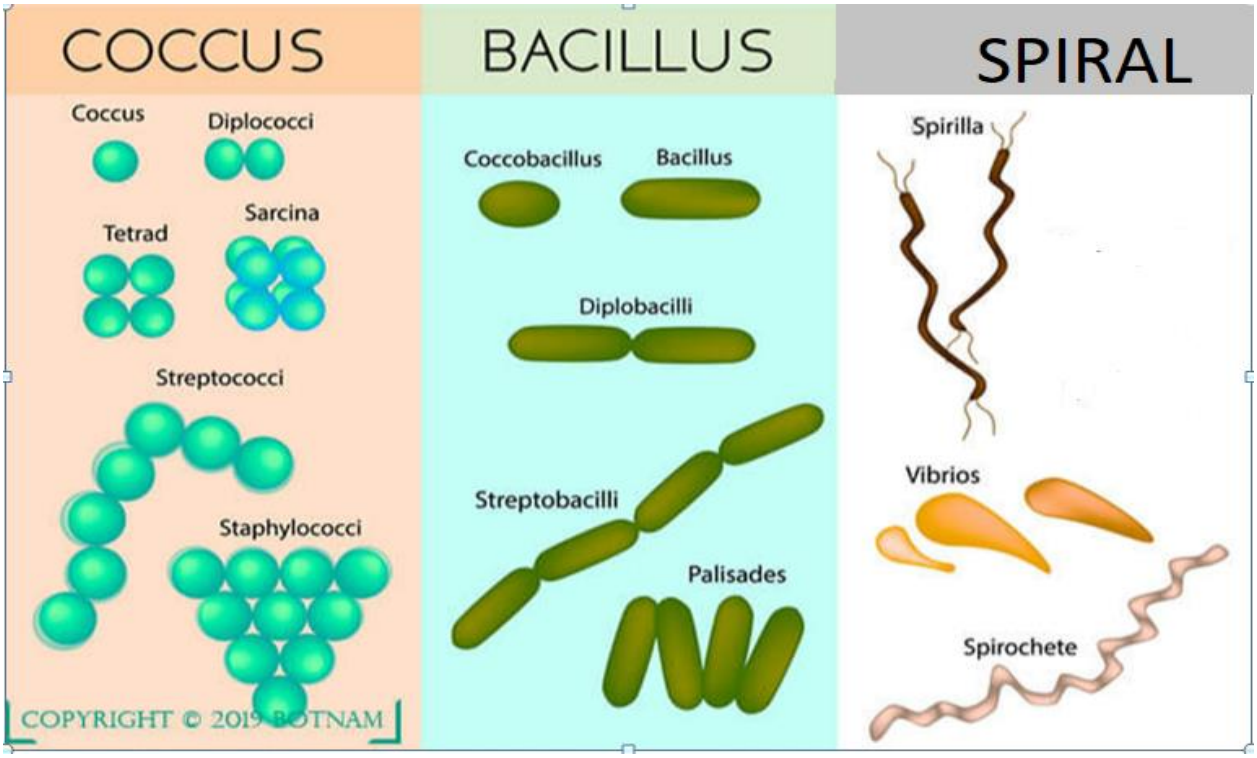
***Arrangement of Spiral Bacteria**

Spiral bacteria are not generally grouped together. But they have shapes often used to help identify certain Spiral Bacteria:-

1. Vibrio: They are comma-shaped bacteria with less than one complete turn or twist in the cell (Example: *Vibrio cholerae*).

2. Spirilla: They have rigid spiral structure (Example: *Helicobacter pylori*).

3. Spirochetes: have a helical shape and flexible bodies. Spirochetes move by means of axial filaments (Example: Leptospira species).



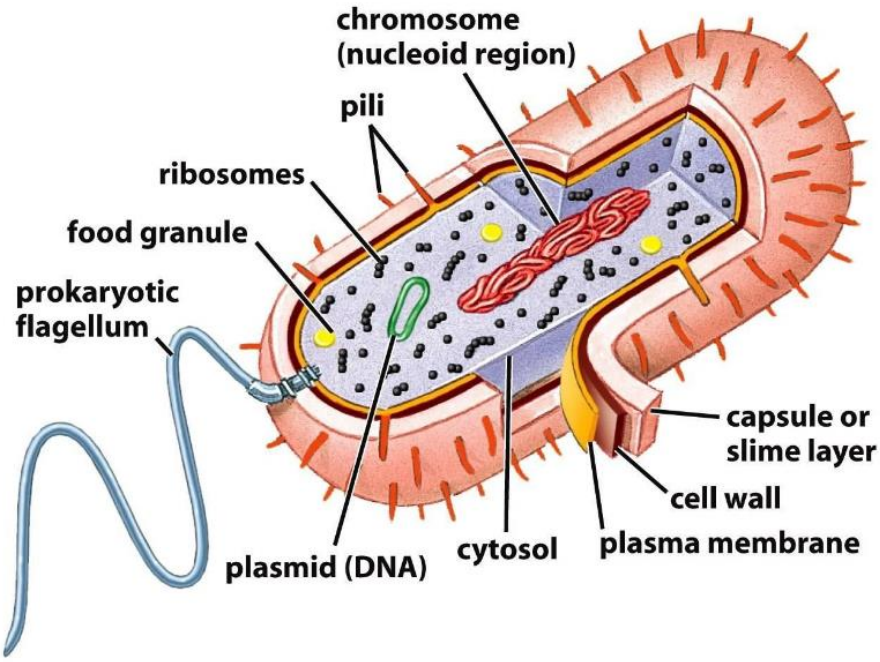
Structure of bacteria

Structurally, bacterial cells consist of the following regions:

1- Appendages (attachments to the cell surface) in the form of flagella and pili (or fimbriae).

2- Cell envelope consisting of cell wall and plasma membrane. Some bacteria may even have a protective layer called the capsule.

3- Cytoplasmic region that contains the cell chromosome (DNA) and ribosomes and various sorts of inclusions.



Common structures bacteria cell

	Function	Kemisk opbygning
Flagel	movement	protein
Pili	attachment, protection	protein
F or sex pili	transfer DNA under conjugation	protein
Capsule	attachment to surfaces, protection against phagocytosis	polysaccharides
Cell wall	protect, give form, stability	peptidoglycan
Cytoplasmic membrane	permeabilitets barriere, transport, energy, enzymes	
Ribosomes	make synthesis of proteins	RNA, protein
Inclusions	reservelager for nærings-stoffer	carbohydrate, lipid, protein, salts
Chromosomes	genetic material	DNA
Plasmids	extrachromosomal DNA	DNA

The Cell Wall

Most bacterial cells are surrounded by a rigid wall that has been thought to determine the shape of the cells. In both Gram-negative and –positive cells, the cell wall is located on the outside of the inner membrane, but is further surrounded by the outer membrane in Gram-negative bacteria. It performs two important functions:

1- It maintains the characteristic shape of the cell. If the cell wall is digested away by enzymes, the cell takes on a spherical shape.

2- It prevents the cell from bursting when fluids flow into the cell by ***osmosis***.

Although the cell wall surrounds the cell membrane, in many cases it is extremely porous and does not play a major role in regulating the entry of materials into the cell.

Components of cell wall

The bacterial cell wall differs from that of all other organisms by the presence of peptidoglycan which is located immediately outside of the cytoplasmic membrane. **Peptidoglycan (also known as murein)** is a polymer consisting of sugars (polysaccharide) and amino acids. The sugar component consists of alternating residues of N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM). Attached to the N-acetylmuramic acid is a peptide chain of three to five amino acids. The peptide chain can be cross-linked to the peptide chain of another strand forming the 3D mesh-like layer. Peptidoglycan serves a structural role in the bacterial cell wall, giving structural strength, as well as counteracting the osmotic pressure of the cytoplasm. Peptidoglycan is also involved in binary fission during bacterial cell reproduction.

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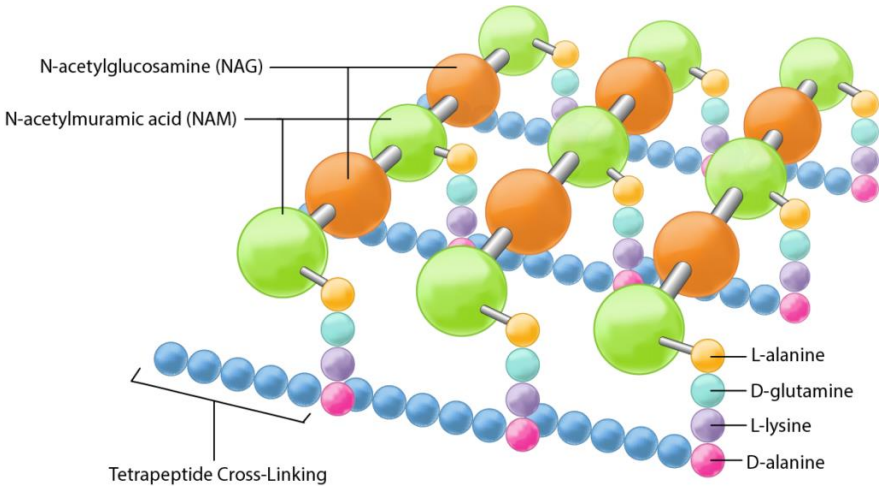

In the Gram-positive Bacteria (those that retain the purple crystal violet dye when subjected to the Gram-staining procedure), the cell wall consists of several layers of peptidoglycan (20 - 80 nanometers) with an additional molecule, **teichoic acid**.

Teichoic acid consists of glycerol, phosphates, and the sugar alcohol ribitol, occurs in polymers up to 30 units long. These polymers extend beyond the rest of the cell wall, even beyond the capsule in encapsulated bacteria. Although its exact function is unclear, teichoic acid furnishes attachment sites for bacteriophages (viruses that infect bacteria) and probably serves as a passageway for movement of ions into and out of the cell.

In the Gram-negative Bacteria (which do not retain the crystal violet), the cell wall is composed of a single layer of peptidoglycan (7 - 8 nanometers) surrounded by a membranous structure called the **outer membrane**. The outer membrane of Gram-negative bacteria invariably contains a unique component, **lipopolysaccharide (LPS**

or endotoxin), which is toxic to animals. In Gram-negative bacteria the outer membrane is usually thought of as part of the cell wall.

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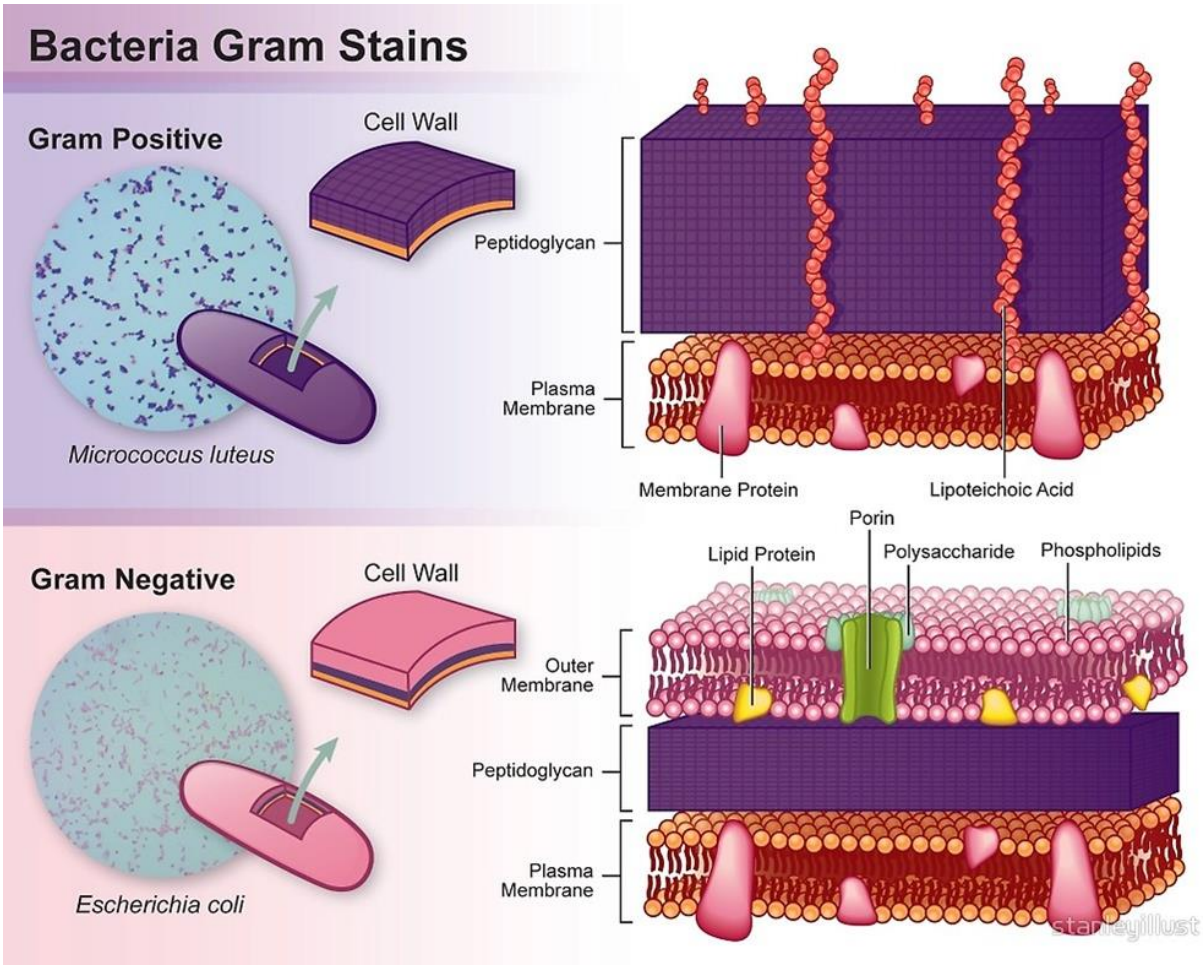

	Gram-positive cell wall	Gram-negative cell wall
Peptidoglycan	90% of cell wall, 20nm thick 2 tetrapeptides of adjacent chains of NAM, NAG are linked by peptide bridges (which contain 5 Glycine)	Thinner 2 tetrapeptides of NAM, NAG are directly linked between D-Alanine and DAG within 2 tetrapeptides
Teichoic acid	10% of cell wall Polyribitol/polyglycerol phosphate linked to peptidoglycan	None
Lipoteichoic acid	Lipid linked teichoic acid	None
Periplasmic space	Small or none	Contains enzymes for transport, degradation and synthesis
Outer membrane	None	Phospholipids with saturated fatty acids. Embedded porins, lipoproteins, transport proteins
Lipopolysaccharide	None	Lipid A (endotoxin), core polysaccharide, O antigen