Microbiology is the science that deal with the study of microorganisms, a large and diverse group of microscopic organisms that exist as single cells or cell clusters e.g, Bacteria, protozoa and fungi

- It also includes viruses, which are microscopic but not cellular.

The two oral infections caused by oral M.O are dental caries and periodontal disease.

Prokaryotic and Eukaryotic cells

A prokaryote is a unicellular organism that lacks a membrane bound nucleus, mitochondria, or any other membrane-bound organelle.

Prokaryotes are divided into two domains Archaea and Bacteria.

In the prokaryotes, all the intracellular components (proteins, DNA and metabolites) are located together in the cytoplasm enclosed by the cell membrane.

Eukaryotes are organisms, including humans, whose cells have a well defined membrane-bound nucleus (containing chromosomal DNA) and organelles.

Unlike unicellular archaea and bacteria, eukaryotes may also be multicellular and include organisms consisting of many cell types forming different kinds of tissue. Animals and plants are the most familiar eukaryotes.

Eukaryote

1- have true nucleus

2- DNA is complex with histone proteins ,have nuclear membrane

3- peptidoglycan is not present in the cell wall

4- divided by mitosis and meiosis

5- 80S ribosomes

6- have mitochondria and chloroplasts

Prokaryote

1- don't have nucleus

2-chromosome, is a single, circular molecule of double-stranded DNA, lacking a nuclear membrane

3-peptidoglycan is present in the cell wall

4- divided by binary fission

5-70S ribosomes

6- not have mitochondria and chloroplasts

Bacteria

1. Bacteria (common noun **bacteria**, singular **bacterium**) are a type of biological cell. They constitute a large domain of prokaryotic microorganisms, range in size from about 0.2 to 5 µm. The smallest bacteria (*Mycoplasma*) .The longest bacteria rods has the size of some yeasts and human red blood cells (7 µm).

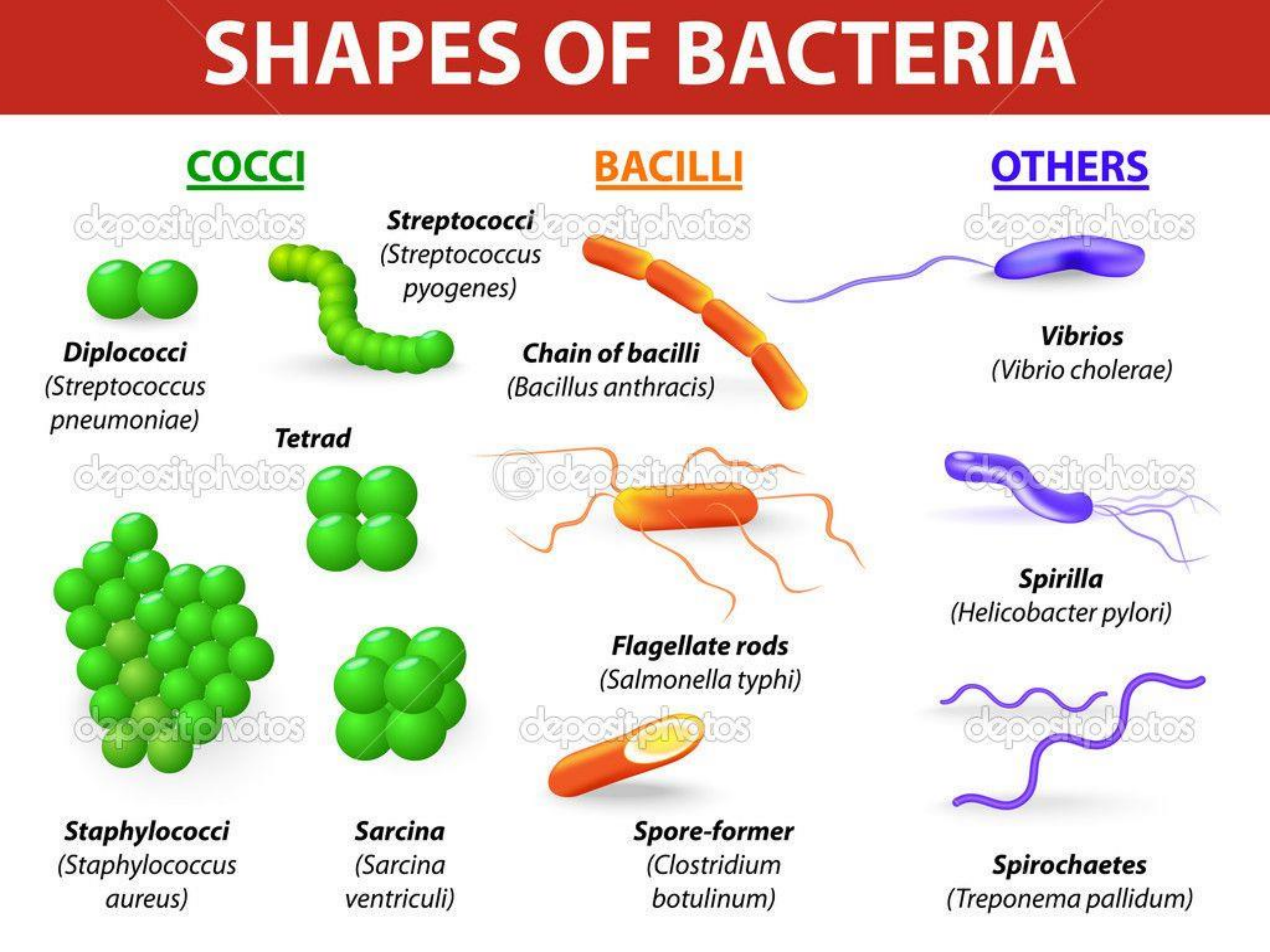
2. Shape into three basic groups: cocci, bacilli, and spirochetes . The cocci are round, the bacilli are rods, and the spirochetes are spiral-shaped. Some bacteria are variable in shape and are said to be pleomorphic (many-shaped). The shape of a bacterium is determined by its rigid cell wall.

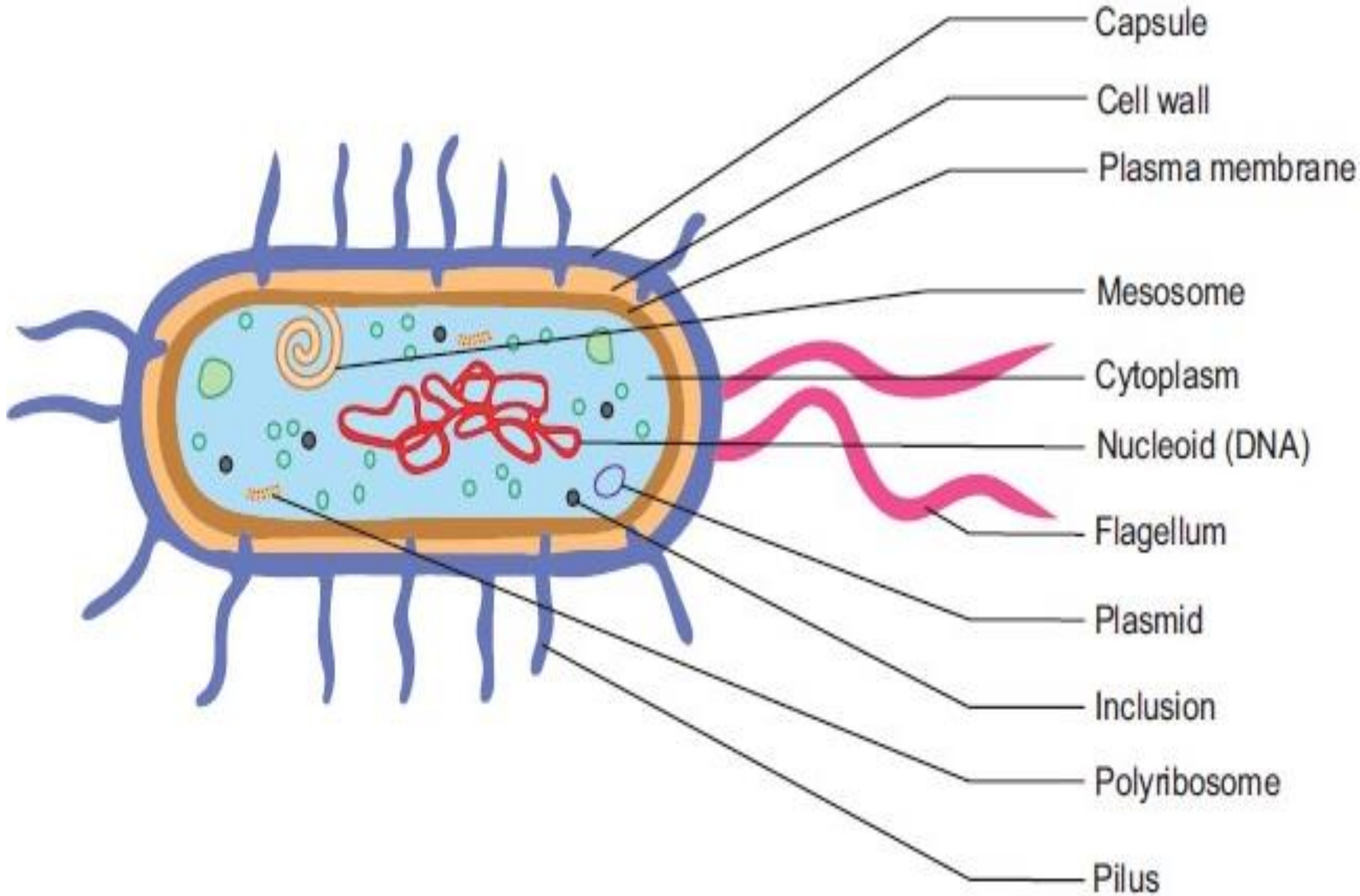
The arrangement of bacteria is important. For example, certain cocci occur in pairs (diplococci),

some in chains (streptococci),

and others in grapelike clusters (staphylococci).

These arrangements are determined by the orientation and degree of attachment of the bacteria at the time of cell division.


SHAPES OF BACTERIA
COCCI
BACILLI
OTHERS
Streptococci
(Streptococcus pyogenes)
Diplococci
(Streptococcus pneumoniae)
Tetrad
Staphylococci
(Staphylococcus aureus)
Sarcina
(Sarcina ventriculi)
Chain of bacilli
(Bacillus anthracis)
Flagellate rods
(Salmonella typhi)
Spore-former
(Clostridium botulinum)
Vibrios
(Vibrio cholerae)
Spirilla
(Helicobacter pylori)
Spirochaetes
(Treponema pallidum)


Capsule
Cell wall
Plasma membrane
Mesosome
Cytoplasm
Nucleoid (DNA)
Flagellum
Plasmid
Inclusion
Polyribosome
Pilus

Bacterial Structure

Cell Wall

- The cell wall is the outer most component common to all bacteria (except *Mycoplasma* species.
- The cell wall is a multilayered structure located external to the cytoplasmic membrane. It is composed of an inner layer of peptidoglycan and an outer membrane that varies in thickness and chemical composition depending upon the bacterial type. The peptidoglycan provides structural support and maintains the characteristic shape of the cell.

Base on the cell wall ,the bacteria divided into: Gram-Positive and Gram-Negative Bacteria

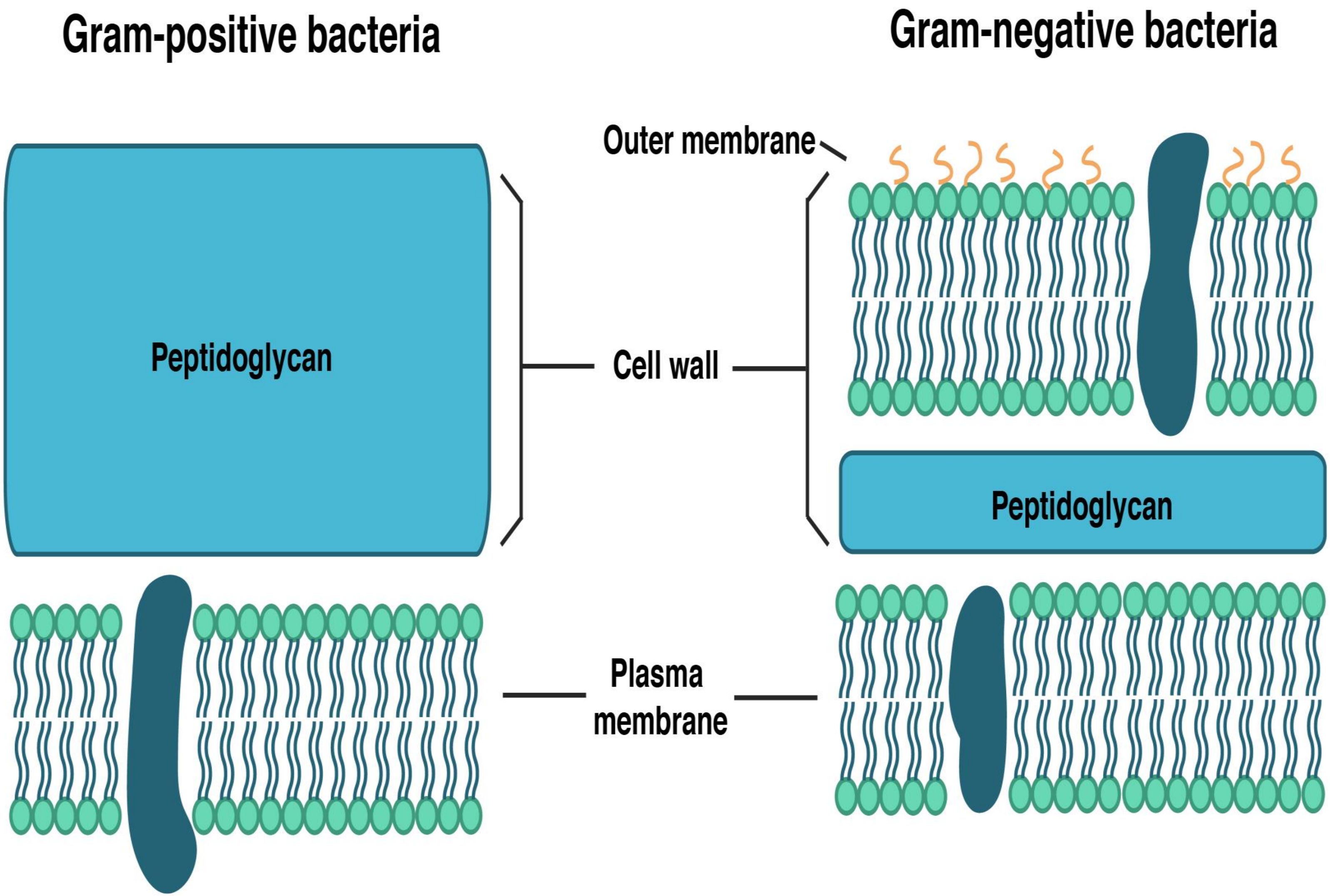
- **The structure, chemical composition, and thickness of the cell wall differ in Gram-positive and Gram-negative bacteria .**

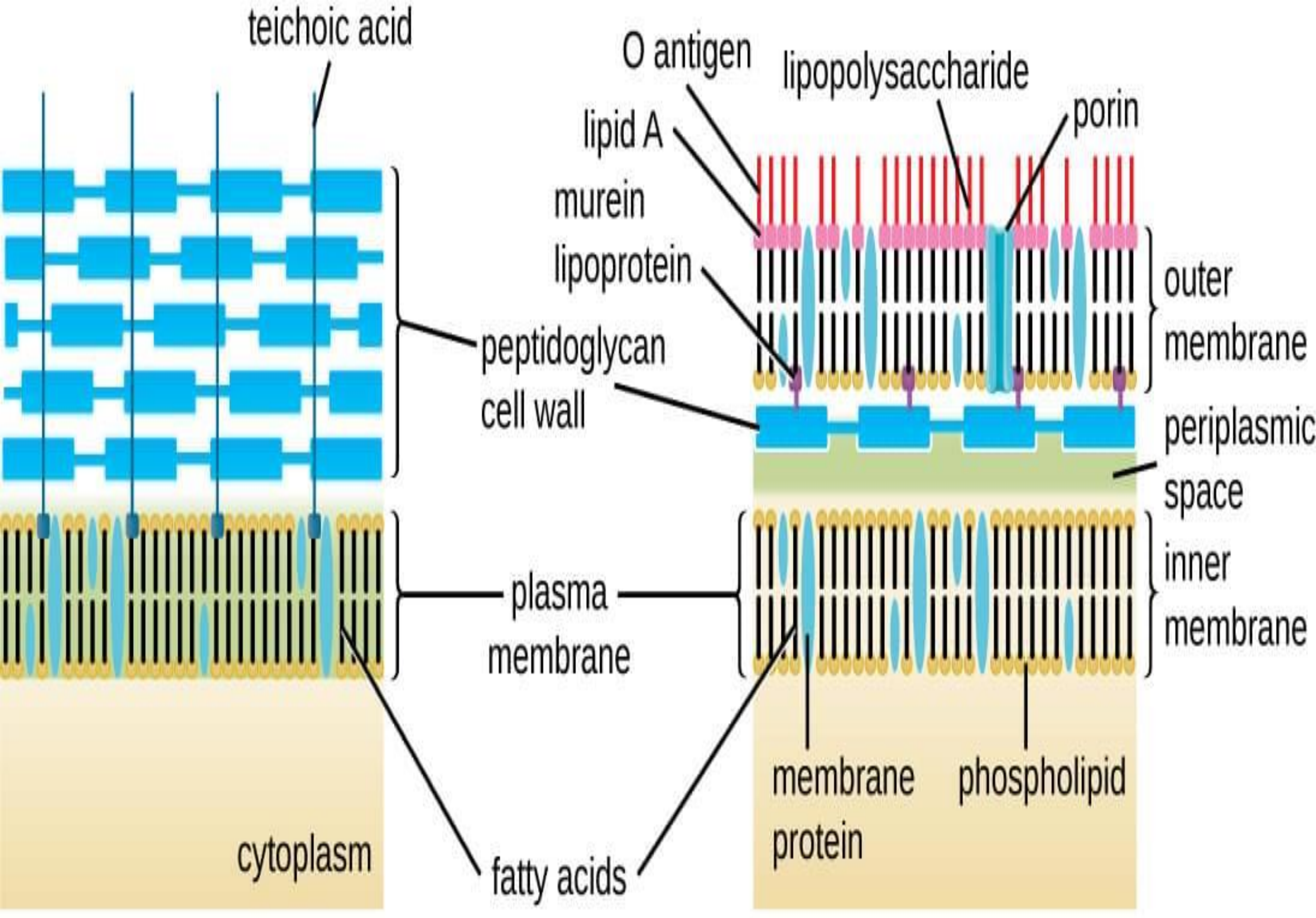
- **The peptidoglycan layer is much thicker (multilayer) in Gram-positive than in Gram-negative bacteria (Thinner; single layer). Gram's-positive bacteria also have fibers of teichoic acid, which protrude outside the peptidoglycan, whereas Gram-negative bacteria do not.**

Cell Wall of Gram-Positive and Gram-Negative Bacteria

- **In contrast, the Gram-negative bacteria have a complex outer layer consisting of lipopolysaccharide, lipoprotein, and phospholipid.**

- **Lying between the outer-membrane layer and the cytoplasmic membrane in gram-negative bacteria is the periplasmic space, which is the site, in some species, of enzymes called β –lactamase that degrade penicillins and other β -lactam drugs.**


Gram-positive bacteria
Gram-negative bacteria
Outer membrane
Peptidoglycan
Cell wall
Peptidoglycan
Plasma
membrane



gram-positive bacteria

gram-negative bacteria

Important of the cell wall

1. Is important in maintaining the characteristic shape of the cell,
2. Allows the cell to withstand media of low osmotic pressure, such as water.
3. Its polysaccharides and proteins are antigens that are useful in laboratory identification.
4. Its porin proteins play a role in facilitating the passage of small, hydrophilic molecules into the cell. Porin proteins in the outer membrane of gram-negative bacteria act as a channel to allow the entry of essential substances such as sugars, amino acids, vitamins, and metals as well as many antimicrobial drugs such as penicillins. The other important It provides rigid support for the cell,

5.In gram-negative bacteria, it contains endotoxin, a lipopolysaccharide.

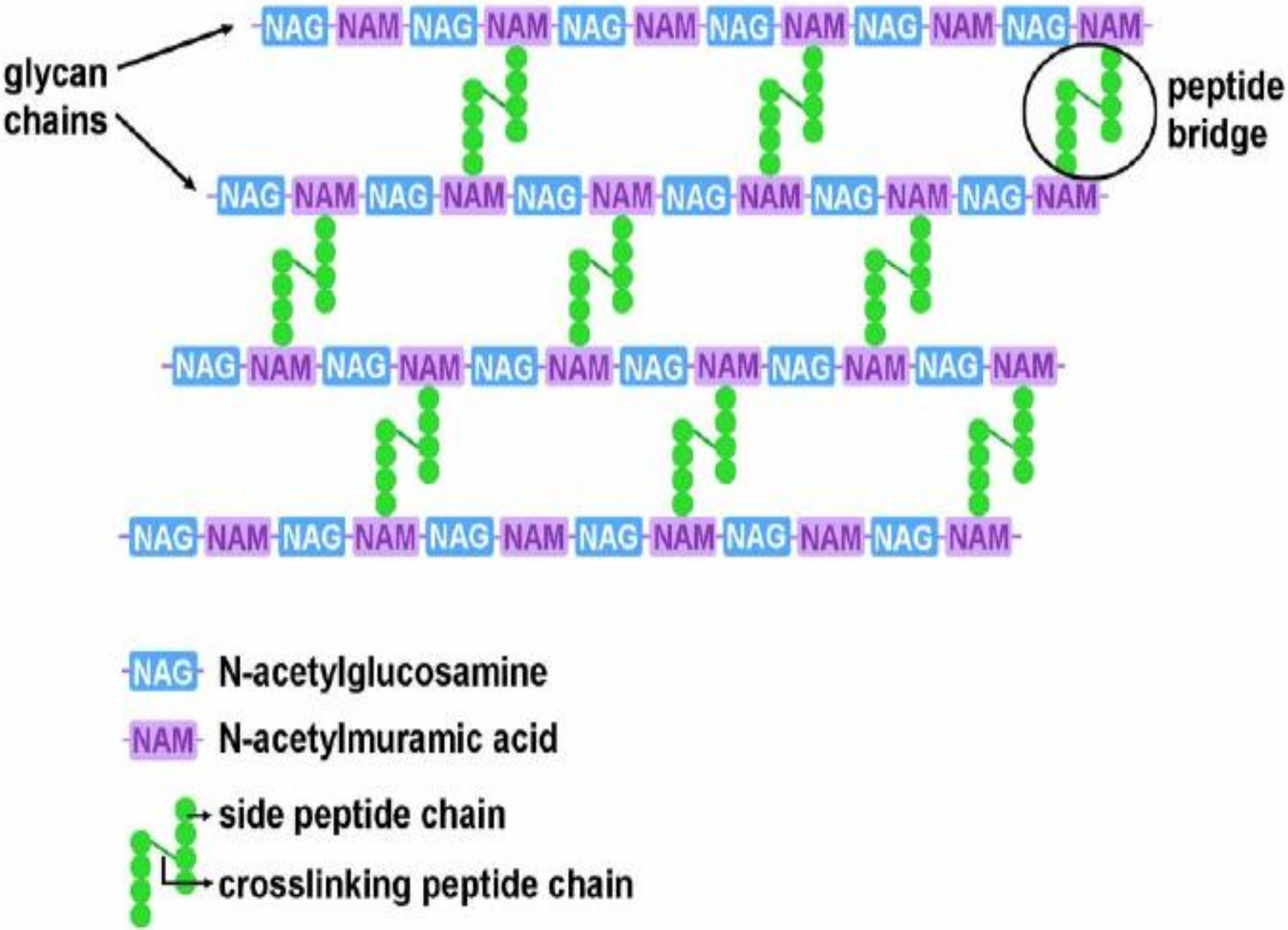
Essential components of bacterial cell wall

A. Peptidoglycan

The term "peptidoglycan" is derived from the peptides and the sugars (glycan) that make up the molecule. Synonyms for peptidoglycan are murein and mucopeptide. Peptidoglycan is a complex, interwoven network that surrounds the entire cell and is composed of a single covalently linked macromolecule. It is found only in bacterial cell walls. The carbohydrate backbone, which is composed of alternating N-acetylmuramic acid and N-acetylglucosamine molecules attached to each of the muramic acid molecules is a tetrapeptide consisting of both D- and L-amino acids, Two of these amino acids are : diaminopimelic acid, which is unique to bacterial cell walls.

Important note :

* **Because peptidoglycan is present in bacteria but not in human cells, it is a good target for antibacterial drugs. Several of these drugs, such as penicillins, cephalosporins, and vancomycin, inhibit the synthesis of peptidoglycan by inhibiting the transpeptidase that makes the cross-links between the two adjacent tetrapeptides .**


glycan
chains
peptide
bridge
NAG
NAM
NAG N-acetylglucosamine
NAM N-acetylmuramic acid
side peptide chain
crosslinking peptide chain

Lipopolysaccharide

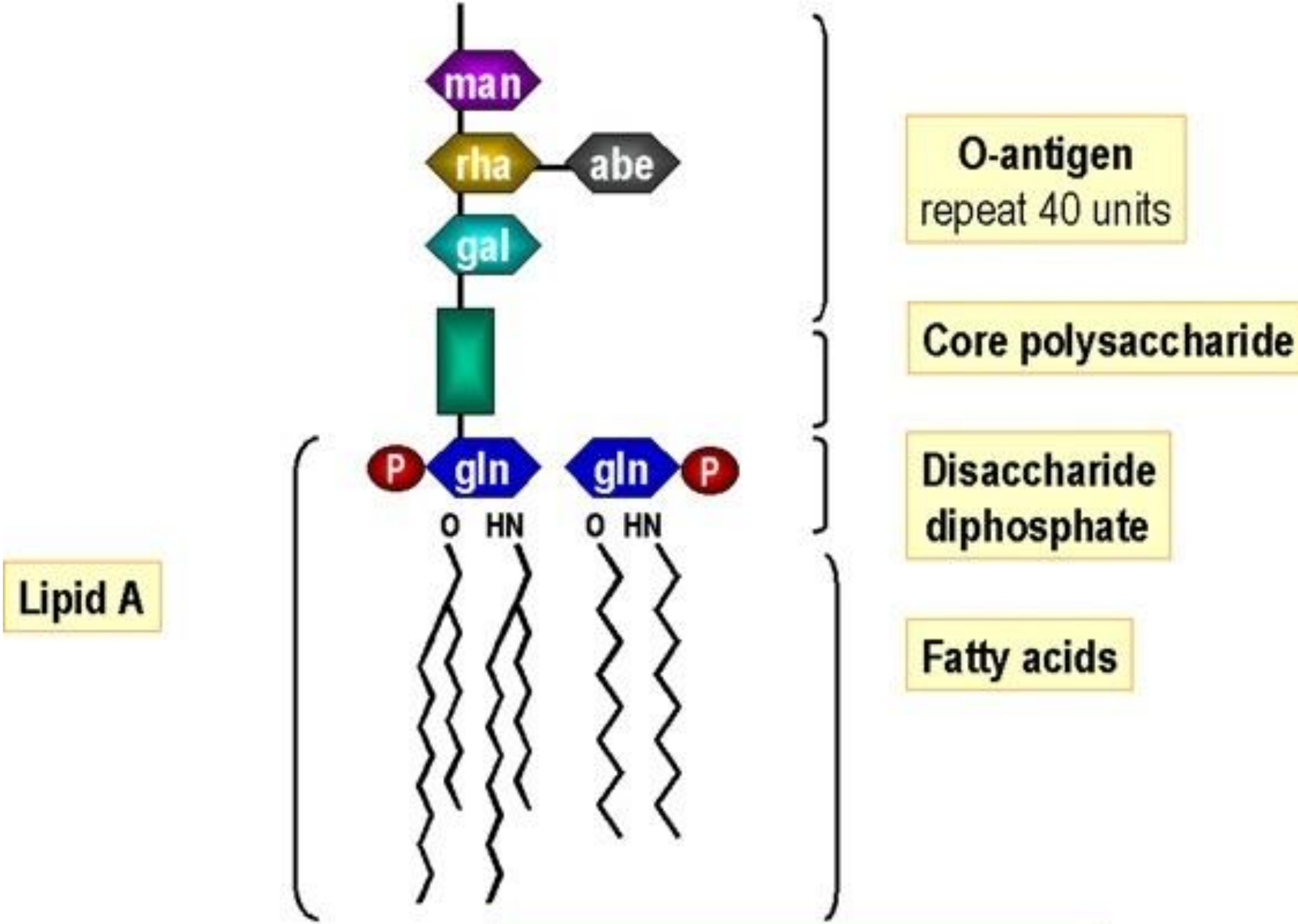
- **The lipopolysaccharide (LPS) of the outer membrane of the cell wall of gram-negative bacteria is endotoxin. It is responsible for many of the features of disease, such as fever and shock (especially hypotension), caused by these organisms. It is called endotoxin because it is an integral part of the cell wall. The symptoms caused by the endotoxin of one gram-negative bacteria is similar to another but the severity of the symptoms can differ greatly.**

The LPS is composed of three distinct units:

1. **A phospholipid called lipid A, which is responsible for the toxic effects(Toxic component of endotoxin).**

2. **A core polysaccharide of five sugars linked through 2-keto-3-deoxyoctonate (KDO) to lipid A.**

3. **An outer polysaccharide consisting of three to five sugars. This outer polymer is the important somatic, or O, antigen of several gram-negative bacteria that is used to identify certain organisms in the clinical laboratory.**



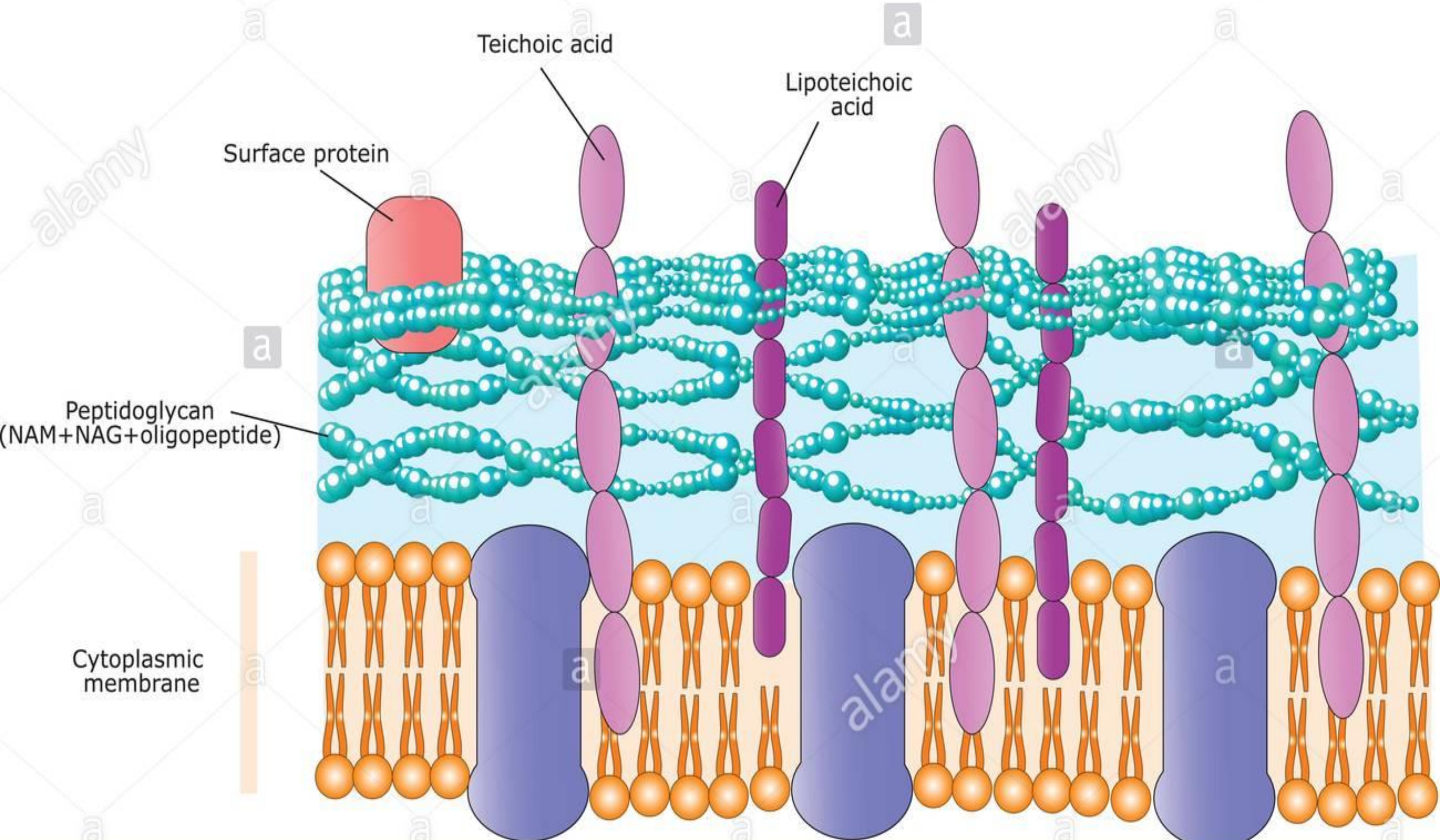
Structure of Lipopolysaccharide

Teichoic Acid

- **These fibers of glycerol phosphate or ribitol phosphate are located in the outer layer of the gram-positive cell wall and extend from it. Some polymers of glycerol teichoic acid penetrate the peptidoglycan layer and are covalently linked to the lipid in the cytoplasmic membrane, called lipoteichoic acid; others anchor to the muramic acid of the peptidoglycan.**

- **The medical importance of teichoic acids lies in their ability to induce septic shock when caused by certain gram-positive bacteria. Gram-negative bacteria do not have teichoic acids.**

cell wall of Gram + bacteria



Cytoplasmic Membrane

- **Just inside the peptidoglycan layer of the cell wall lies the cytoplasmic membrane, which is composed of a phospholipid bilayer similar in to that in eukaryotic cells. They are chemically similar *but* eukaryotic membranes contain sterols, whereas prokaryotes generally do not. The only prokaryotes that have sterols in their membranes are members of the genus Mycoplasma.**

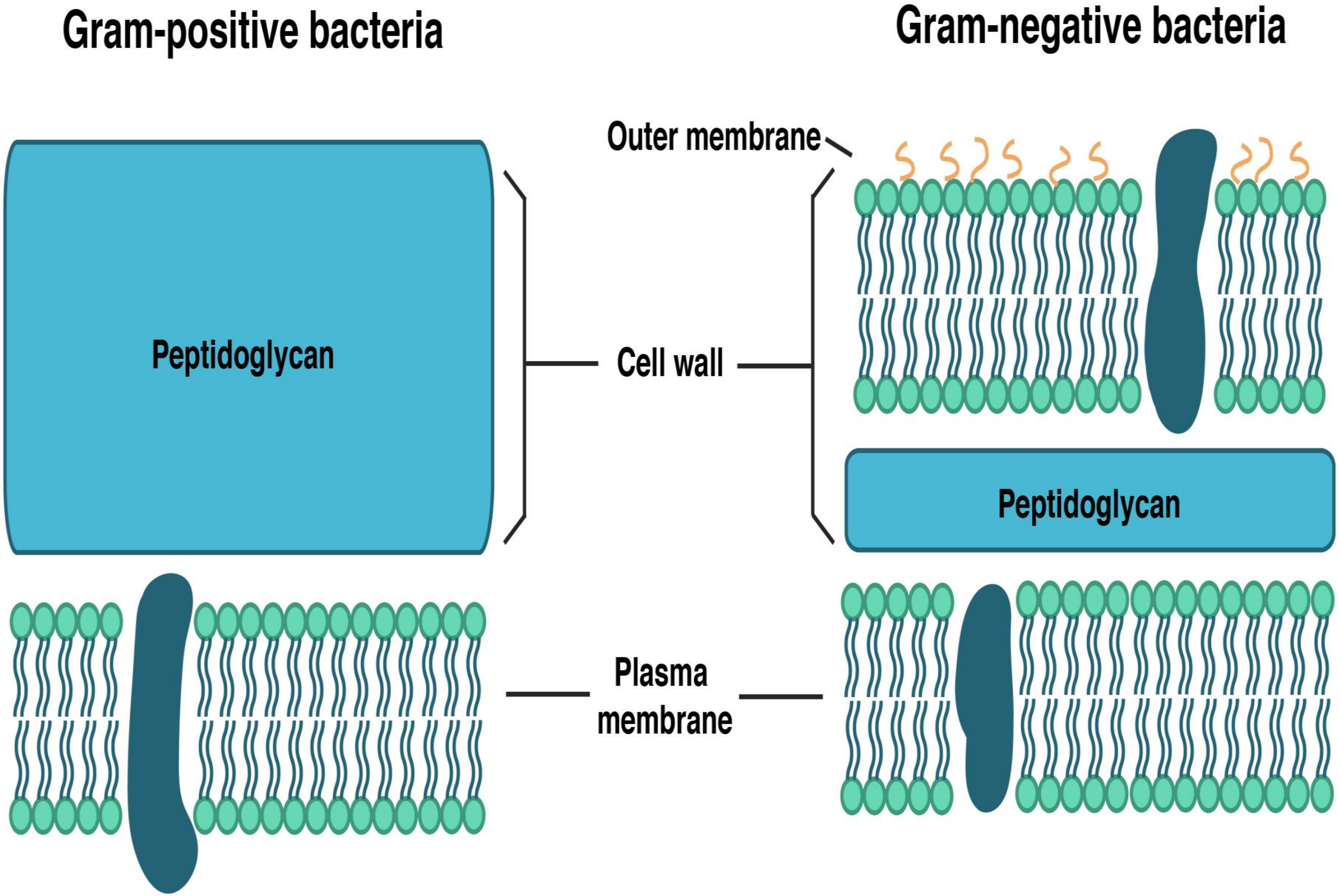
The membrane has four important functions:

(1) Active transport of molecules into the cell.

(2) Energy generation by oxidative phosphorylation.

(3) Synthesis of precursors of the cell wall.

(4) Secretion of enzymes and toxins.


Gram-positive bacteria
Gram-negative bacteria
Outer membrane
Peptidoglycan
Cell wall
Peptidoglycan
Plasma
membrane

Cytoplasm

- **The cytoplasm has two distinct areas when seen in the electron microscope:**

1. **An amorphous matrix that contains ribosomes, nutrient granules, metabolites, and plasmids.**

2. **An inner, nucleoid region composed of DNA.**

Ribosomes

Bacterial ribosomes are the site of protein synthesis as in eukaryotic cells, but they differ from eukaryotic ribosomes in size and chemical composition. Bacterial ribosomes are 70S in size, with 50S and 30S subunits, whereas eukaryotic ribosomes are 80S in size, with 60S and 40S subunits. The differences in both the ribosomal RNAs and proteins constitute the basis of the selective action of several antibiotics that inhibit bacterial, but not human, protein synthesis.

Nucleoid

- The nucleoid is the area of the cytoplasm in which DNA is located. The DNA of prokaryotes is a single, circular molecule that has a molecular weight (MW) of approximately 2×10^9 and contains about 2000 genes. Because the nucleoid contains no nuclear membrane, no nucleolus, no mitotic spindle, and no histones, there is little resemblance to the eukaryotic nucleus. One major difference between bacterial DNA and eukaryotic DNA is that bacterial DNA has no introns, whereas eukaryotic DNA does.

Specialized Structures Outside the Cell Wall

A. Capsule

- **The capsule is a gelatinous layer covering the entire bacterium. It is composed of polysaccharide. The sugar components of the polysaccharide vary from one species of bacteria to another and frequently determine the serologic type within a species. For example, there are 84 different serologic types of *Streptococcus pneumoniae*, which are distinguished by the antigenic differences of the sugars in the polysaccharide capsule.**

The important of capsule

1. **It is a determinant of virulence of many bacteria since it limits the ability of phagocytes to engulf the bacteria. Also Negative charges on the capsular polysaccharide repel the negatively charged cell membrane of the neutrophil and prevent it from ingesting the bacteria.**

2. **Specific identification of an organism can be made by using antiserum against the capsular polysaccharide. In the presence of the homologous antibody, the capsule will swell greatly. This swelling phenomenon, which is used in the clinical laboratory to identify certain organisms, is called the quellung reaction.**

3. **Capsular polysaccharides are used as the antigens in certain vaccines because they are capable of eliciting protective antibodies. For example, the purified capsular polysaccharides of 23 types of *S. pneumoniae* are present in the current vaccine.**

4. **The capsule may play a role in the adherence of bacteria to human tissues, which is an important initial step in causing infection.**

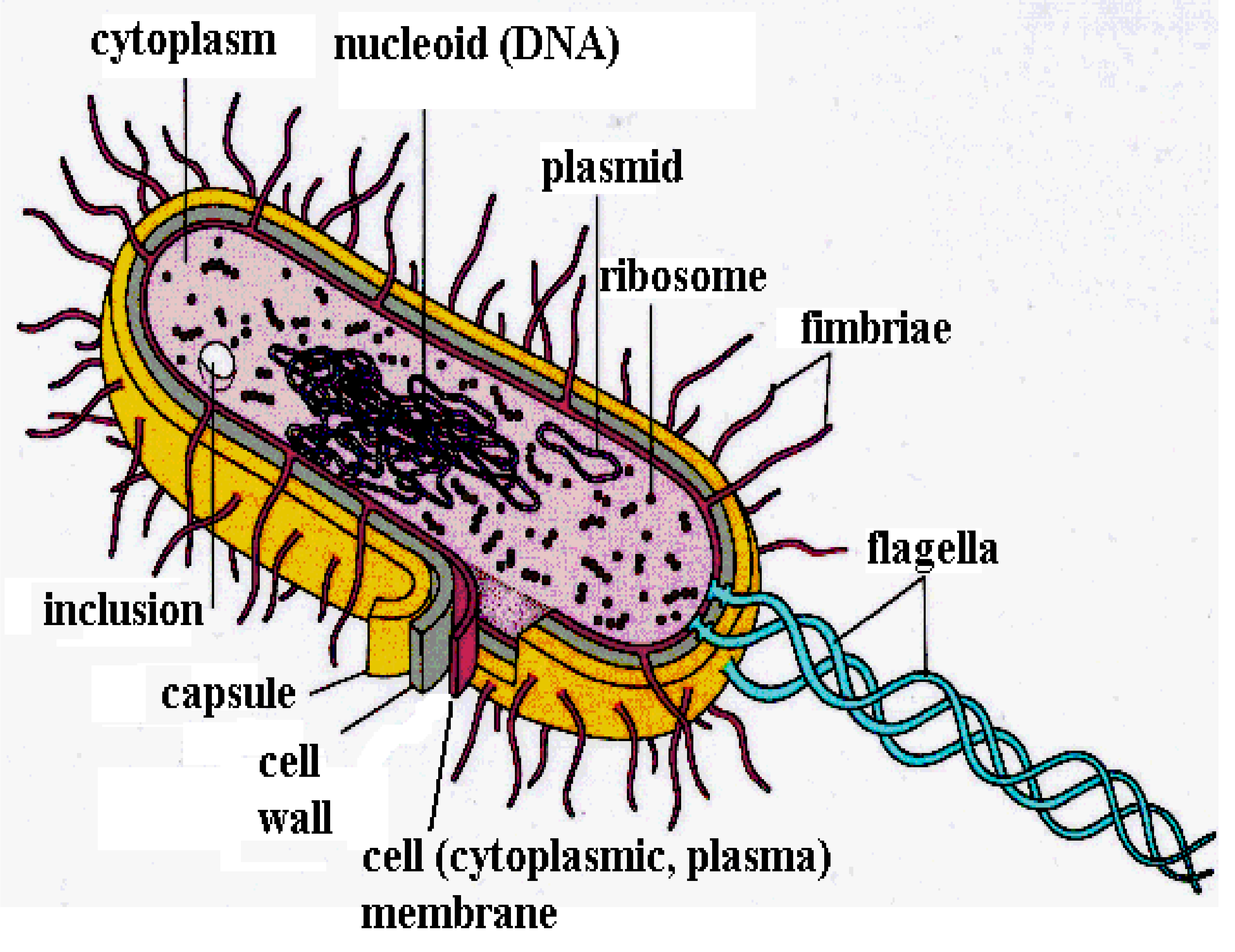
Flagella

- **Flagella are long, whiplike appendages that move the bacteria toward nutrients and other attractants, a process called chemotaxis. The long filament, which acts as a propeller, is composed of many subunits of a single protein, flagellin, arranged in several intertwined chains. The energy for movement, the proton motive force, is provided by adenosine triphosphate (ATP), derived from the passage of ions across the membrane.**
- **Flagellated bacteria have a characteristic number and location of flagella: some bacteria have one, and others have many; in some, the flagella are located at one end, and in others, they are all over the outer surface. Spirochetes move by using a flagellumlike structure called the axial filament, which wraps around the spiral-shaped cell to produce an undulating motion.**

- **Flagella are medically important for two reasons:**

1. Some species of motile bacteria, e.g., *E. coli* and *Proteus* species, are common causes of urinary tract infections. Flagella may play a role in pathogenesis by propelling the bacteria up the urethra into the bladder.

2. Some species of bacteria, e.g., *Salmonella* species, are identified in the clinical laboratory by the use of specific antibodies against flagellar proteins.


cytoplasm
nucleoid (DNA)
plasmid
ribosome
fimbriae
flagella
inclusion
capsule
cell
wall
cell (cytoplasmic, plasma)
membrane

Pili (Fimbriae)

- **Pili are hairlike filaments that extend from the cell surface. They are shorter and straighter than flagella and are composed of subunits of pilin, a protein arranged in helical strands. They are found mainly on gram-negative organisms.**

Pili have two important roles:

1. **They mediate the attachment of bacteria to specific receptors on the human cell surface, which is a necessary step in the initiation of infection for some organisms. Mutants of *Neisseria gonorrhoeae* that do not form pili are nonpathogens.**

2. **A specialized kind of pilus, the sex pilus, forms the attachment between the male (donor) and the female (recipient) bacteria during conjugation.**

Spores

- **These highly resistant structures are formed in response to adverse conditions by two genera of medically important gram-positive rods: the genus Bacillus, which includes the agent of anthrax, and the genus Clostridium, which includes the agents of tetanus and botulism. Spore formation (sporulation) occurs when nutrients, such as sources of carbon and nitrogen, are depleted. The spore forms inside the cell and contains bacterial DNA, a small amount of cytoplasm, cell membrane, peptidoglycan, very little water, and most importantly, a thick, keratin like coat that is responsible for the remarkable resistance of the spore to heat, dehydration, radiation, and chemicals. This resistance may be mediated by dipicolinic acid, a calcium ion chelator found only in spores.**

- **Once formed, the spore has no metabolic activity and can remain dormant for many years. Upon exposure to water and the appropriate nutrients, specific enzymes degrade the coat, water and nutrients enter, and germination into a potentially pathogenic bacterial cell occurs. Note that this differentiation process is *not* a means of reproduction since one cell produces one spore that germinates into one cell.**

- **The medical importance of spores lies in their extraordinary resistance to heat and chemicals. As a result of their resistance to heat, sterilization cannot be achieved by boiling. Steam heating under pressure (autoclaving) at 121°C, usually for 30 minutes, is required to ensure the sterility of products for medical use. Spores are often not seen in clinical specimens recovered from patients infected by spore-forming organisms because the supply of nutrients is adequate.**