

Bacterial Cell Wall

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Introduction

- ▶ Beneath such external structure as capsules, sheath and flagella and external to the cytoplasmic membrane is known as cell wall.
- ▶ Cell wall is very rigid structure that gives shape to cell.
- ▶ The main function of cell wall is to prevent the cell from expending and bursting because of water.
- ▶ The rigidity of cell wall prevent bacteria from high pressure or other sever physical condition.

Archaeobacteria

- ▶ The Archaea constitute a domain or kingdom of single-celled microorganisms.
- ▶ These microbes are prokaryotes, meaning that they have no cell nucleus or any other membrane-bound organelles in their cells.
- ▶ Oldest form of life on earth
- ▶ Do not contain peptidoglycan in cell wall



Major types of Archae Bacteria Cell wall

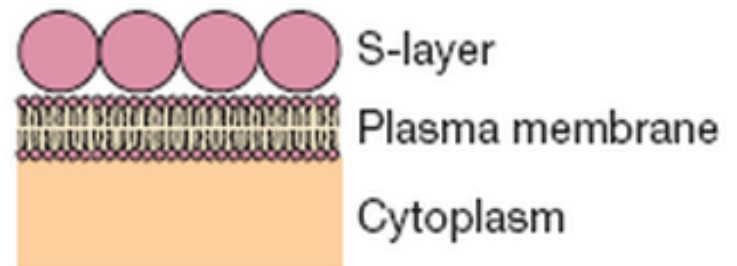
Type 1:

The most common type of archeal cell wall is an S layer composed of either protein or glycoprotein.

Thickness: 20-40nm thick

S-layer cell walls are present in

some methanogens like *Methanococcus*, Halophiles like *Halobacterium* and extreme thermophiles like *Sulpholobus*, *Pyrodictium* etc.

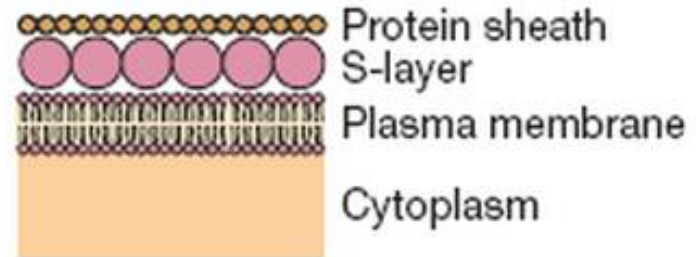


(a)

Type 2:

In this type, additional layers of material are present outside the S-layer.

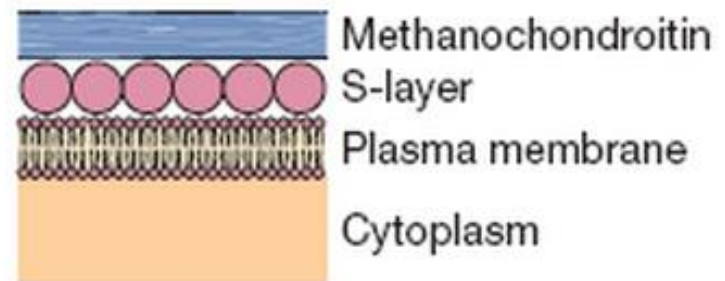
In *Methanosprillum*, There is a protein sheath external to S-layer.



(b)

Type 3:

In *Methanosarcina*, S-layer is covered by a chondroitin like material called as methanochondroitin.

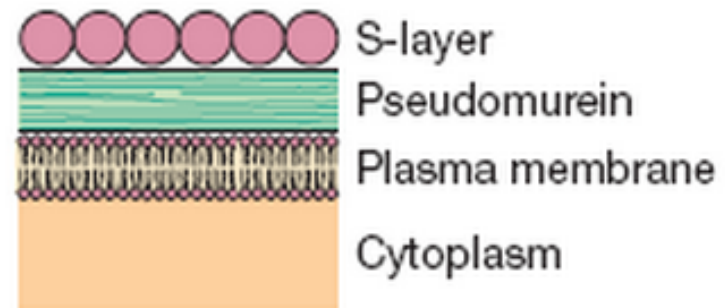


(c)

Type 4:

In some Archaea like *Methanothermus* and *Methanopyrus*, S-layer is the outermost layer and is separated from the plasma membrane by a Peptidoglycan like molecule called pseudomurein.

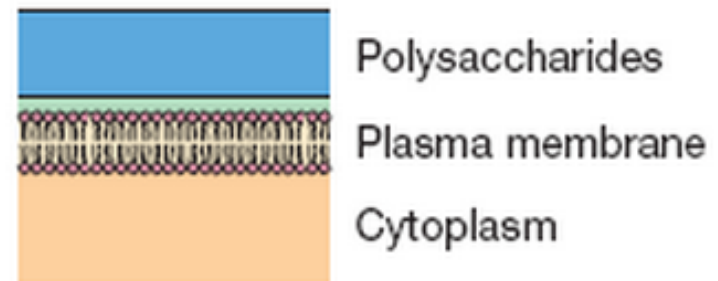
Pseudomurein differs from Peptidoglycan in having N-acetyltalosaminuronic acid instead of N-acetylmuramic acid, L-amino acids instead of D-amino acids that cross link and Beta (1→3) glycosidic linkage instead of Beta (1→4) glycosidic linkage.



(d)

Type 5:

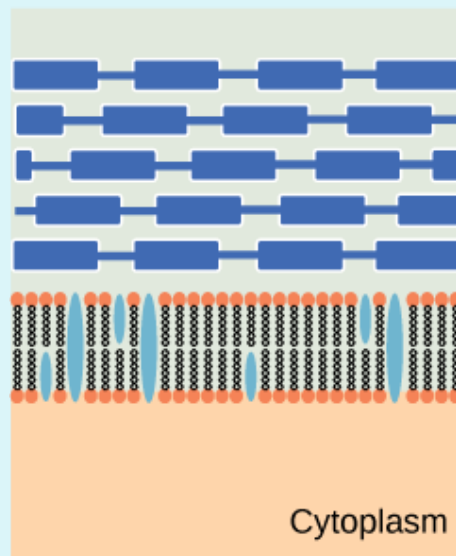
In this type, S layer is absent. Instead archeal cell wall is single thick, homogenous layer resembling Gram positive bacteria. These archaee often stain gram positive. This type is present in *Methanobacterium*, *Halococcus* etc.



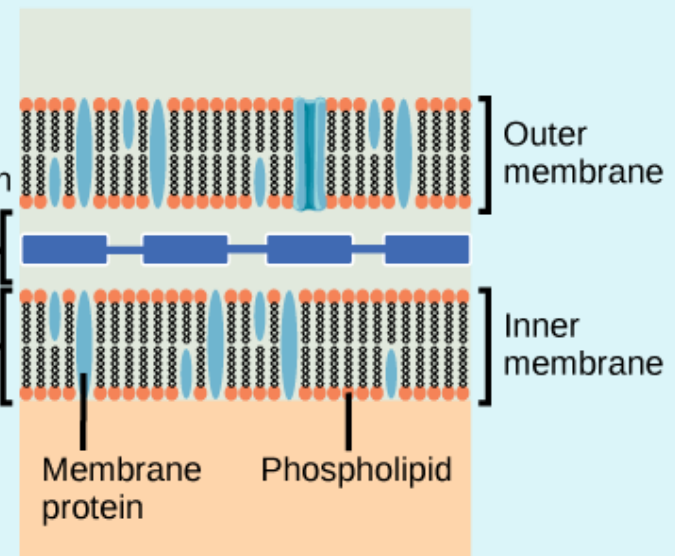
(e)

Cell wall of Gram Positive Bacteria

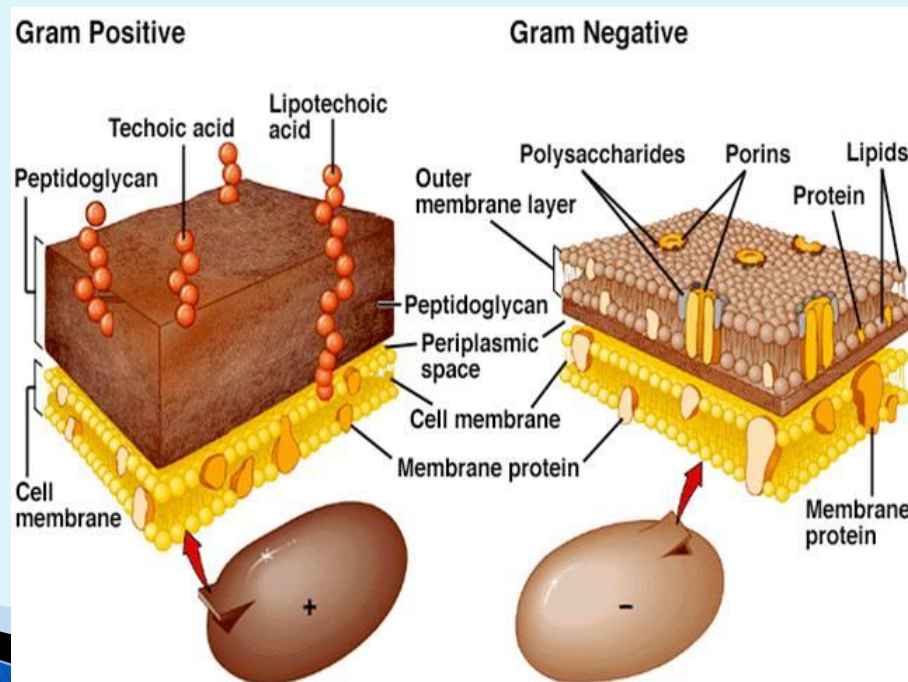
- ▶ Gram positive bacteria usually have much greater amount of peptidoglycan in their cell wall than do gram negative bacteria.
- ▶ It may account for 50% or more of the dry weight of the cell walls of some gram positive species, but only about 10% of the cell wall of gram negative bacteria.



Gram-positive bacteria



Gram-negative bacteria



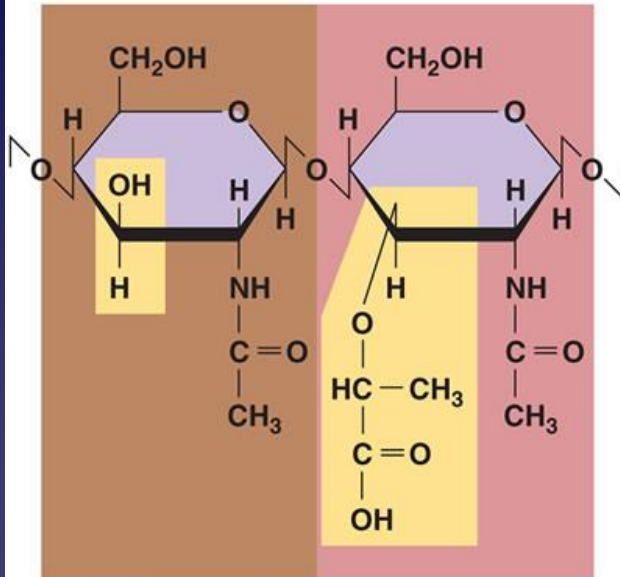
Special component of Gram Positive Cell Wall

- ▶ Peptidoglycan
- ▶ Teichoic acid
- ▶ Teichuronic acid
- ▶ Polysachharides

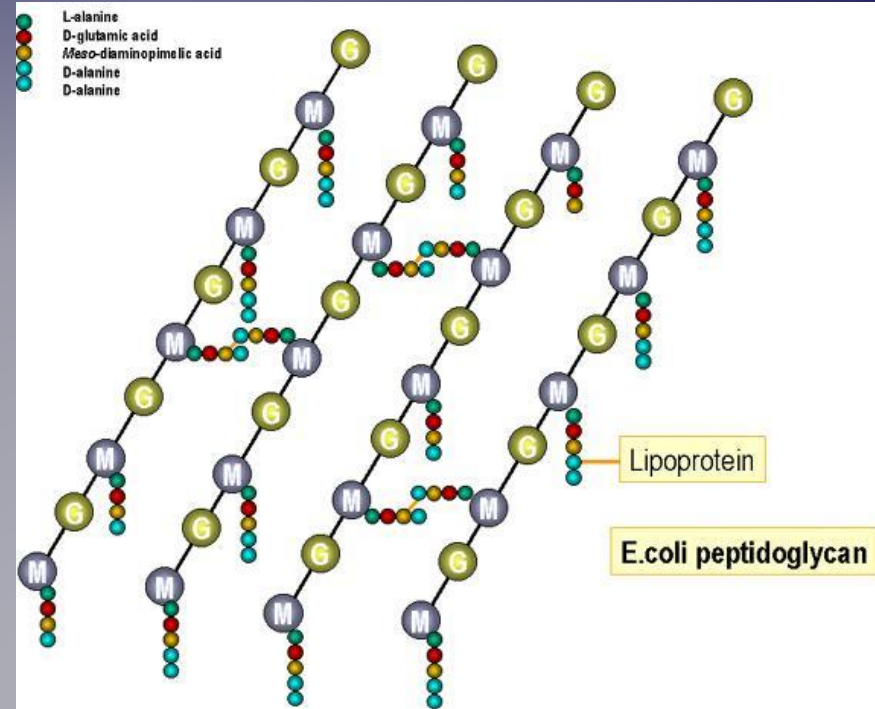
Peptidoglycan

- ▶ Peptidoglycan is a complex polymer consisting three part –
- ▶ A backbone composed of N-acetylglucosamin and N-acetylmuramic acid.
- ▶ A set of identical tetrapeptide side chain attached to N-acetylmuramic
- ▶ And A set of identical peptide cross bridge.
- ▶ The backbone is the same in all bacterial species but tetrapeptide side chains and the peptide cross bridge vary from species to species.

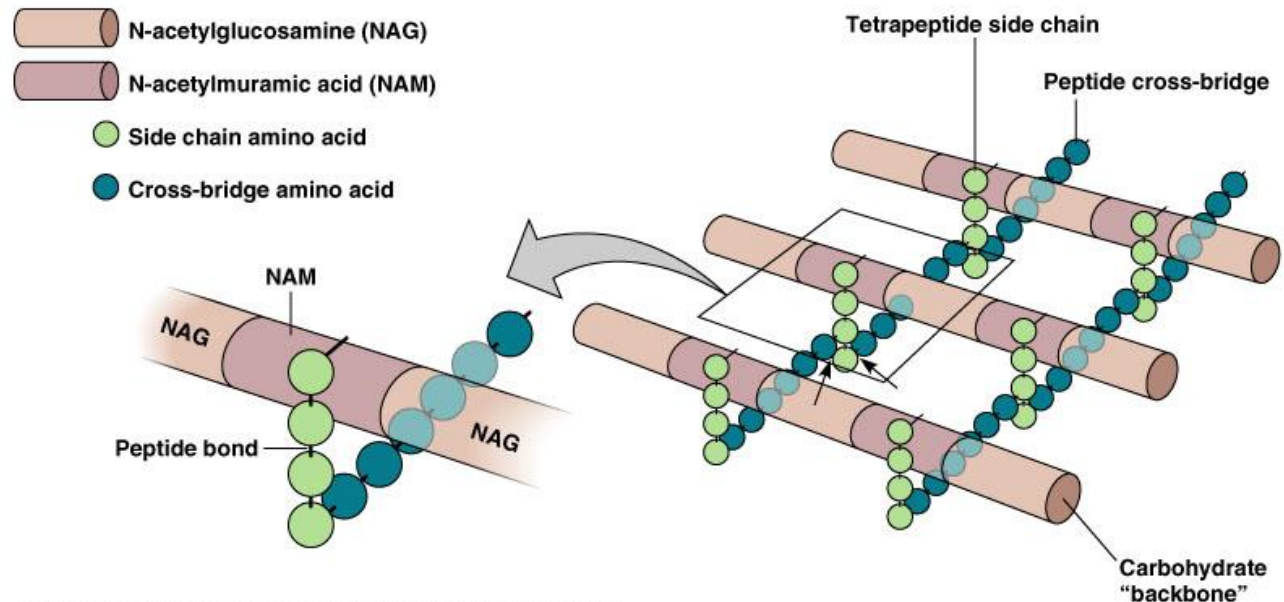
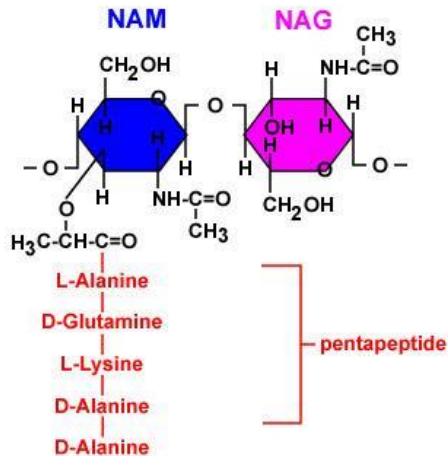
N-acetylglucosamine (NAG) N-acetylmuramic acid (NAM)



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Peptidoglycan Monomer



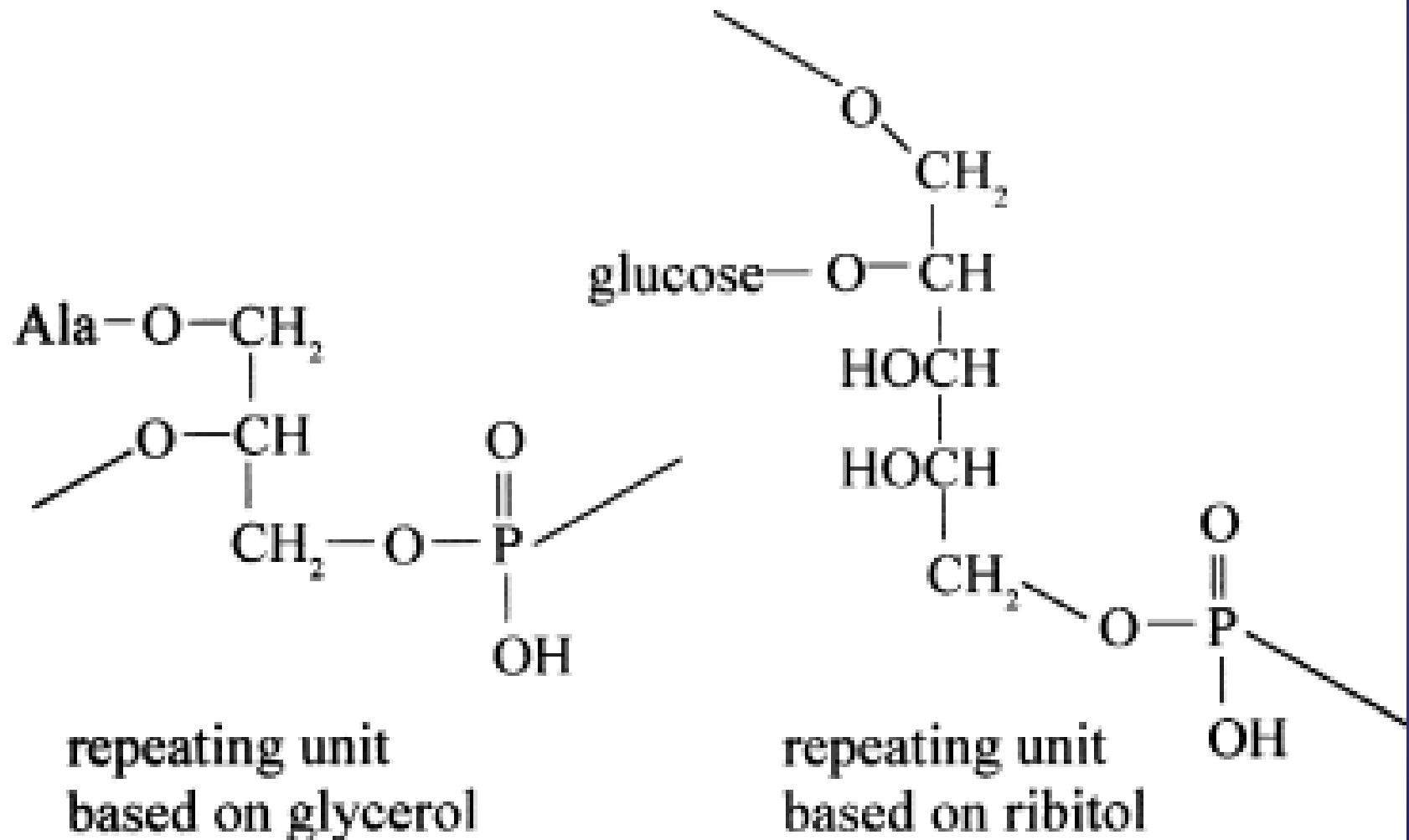
(a) Structure of peptidoglycan in gram-positive bacteria

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Teichoic acid

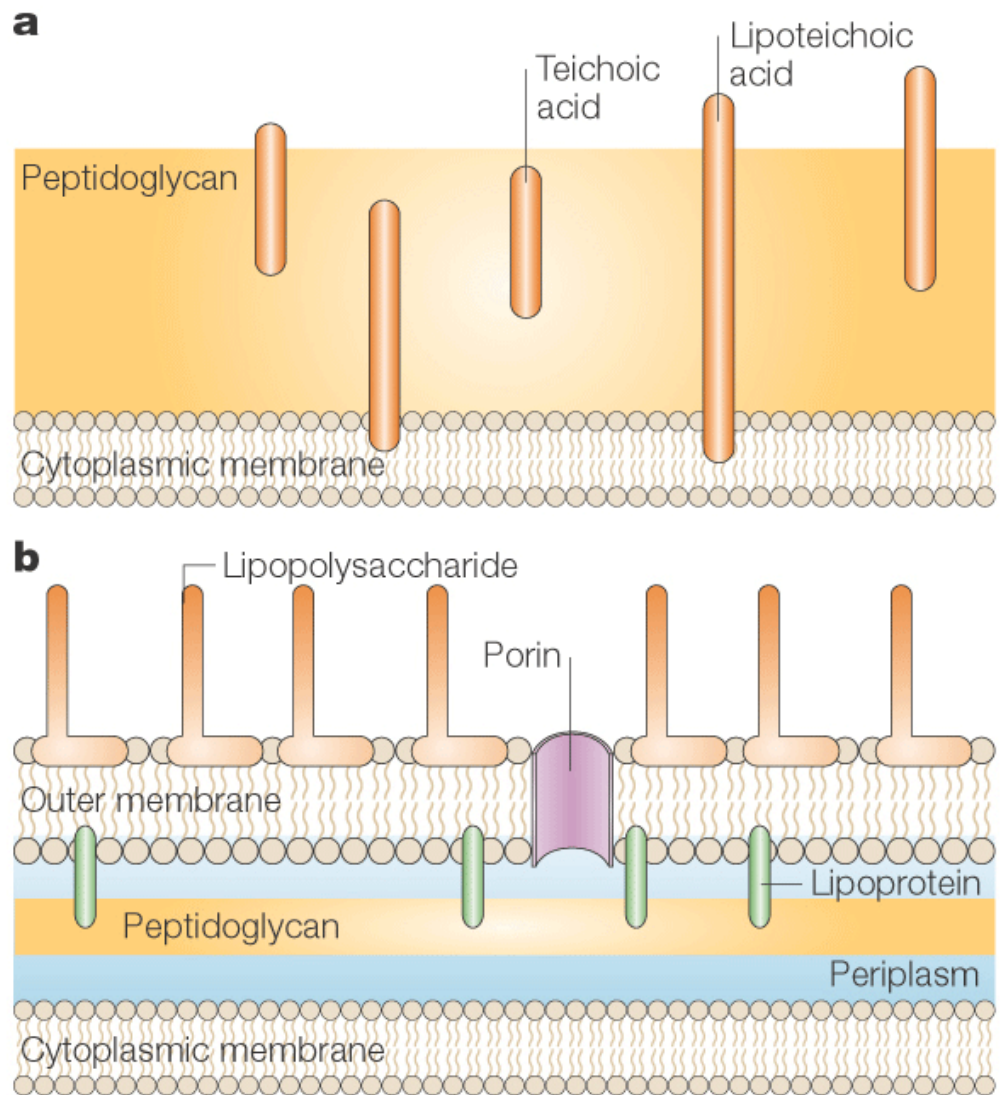
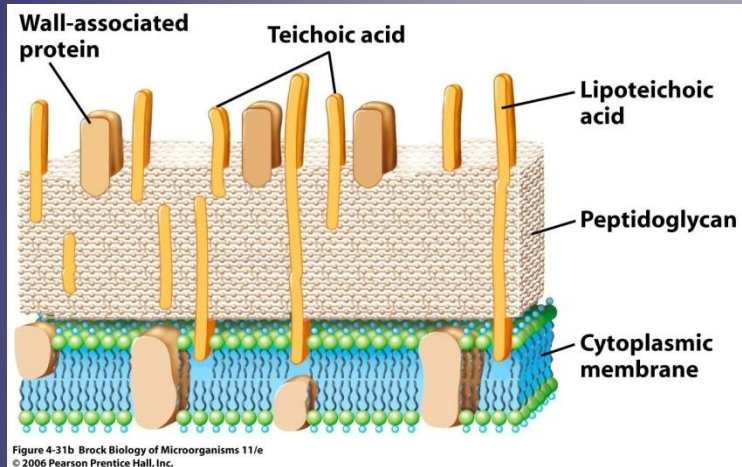
- ▶ It is a polymer containing Glycerophosphate or ribitol phosphate residue.
- ▶
- ▶ Teichoic acid are negative charged, and responsible for negative charge in cell surface.

Structure of Teichoic Acid



Types of teichoic acid

- ▶ 1 wall teichoic acid (WTA) – it attach to peptidoglycan
- ▶ 2 Membrane Techoic acid – it attach glycolipids of membrane, so called as Lipotechoic acid (LTA)



- ▶ Together with peptidoglycan, WTA and LTA provide functions relating to the Elasticity, Porosity, strength, electrostatic properties.
- ▶ Most teichoic acid contain large amount of D-alanine, usually attached to position 2 or 3 of glycerol or position of 3 or 4 of ribitol.
- ▶ In addition to D-alanine, other substitutes may be attached to free hydroxyl groups of glycerol and ribitol e.g. Glucose, galactose, NAG, NAM.

Polysachharides

- ▶ The hydrolysis of certain species of gram positive walls has yielded polysaccharides. It includes –
 - ▶ Mannose,
 - ▶ Arabinose,
 - ▶ Rhamnose,
 - ▶ Glucosamine

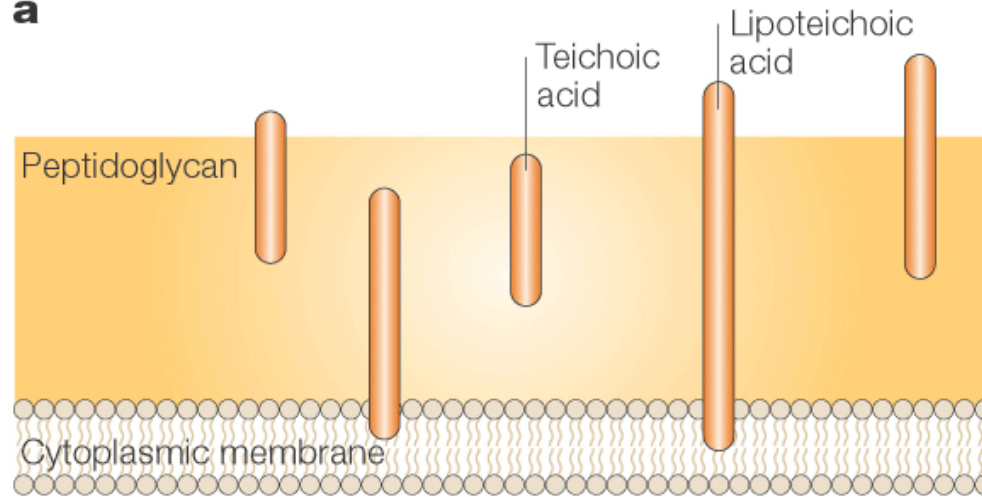
Outer Membrane of Gram Negative Bacteria

- ▶ It contains –
 - Lipoprotein
 - Outer Membrane
 - Lipopolysaccharides

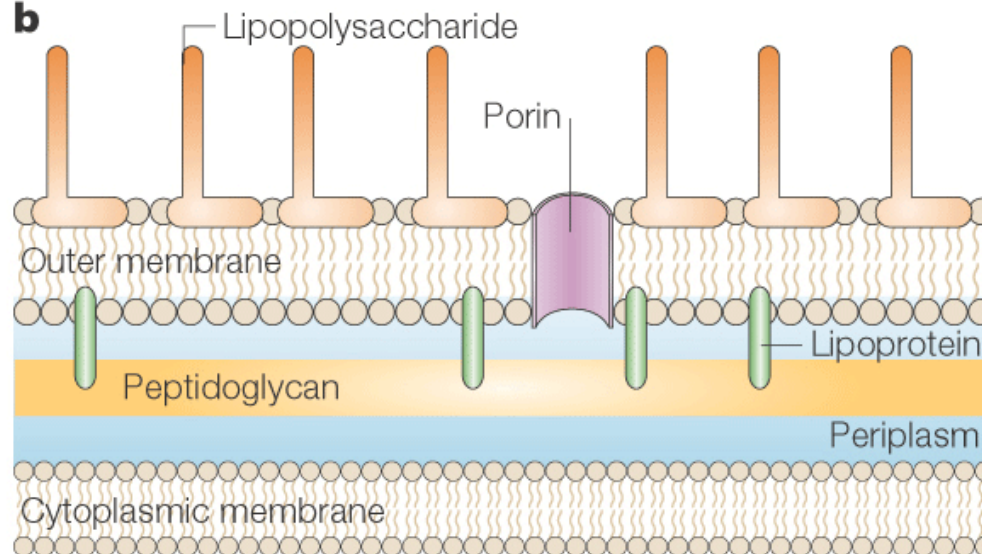
Outer Membrane

- ▶ Outer Leaflets Contain – Lipopolysaccharides
- ▶ Inner Leaflets Contain – Lipoprotein
- ▶ Outer Membrane Contain – special Channel called Porins
- ▶ It Permits passive diffusion of sugar, amino acids, ions etc.
- ▶ OmpA Protein is an abundant protein in the outer membrane

a



b



Lipopolysachharides

- ▶ LPS of gram negative cell wall consists – complex glycolipids called lipid A
- ▶ Lipid A is embedded in the outer leaflet of the membrane
- ▶ Lipid A consists – Phosphorylated glucosamine disachharides unit to which long chain fatty acid attached
- ▶ Beta-hydroxymyristic acid attached to disachharide unit.

▶ Polysaccharide Core

- Similar in all gram negative bacteria
- It contain two sugars
- Ketodeoxyoctanoic acid (KDO) and Heptose

- ▶ O-antigen
- ▶ Each gram negative bacteria contain unique repeating unit. Repeating units are linear trisaccharides

- ▶ LPS are extremely toxic to animals has been called endotoxin
- ▶ O-antigen is highly immunogenic in vertebrate animals
- ▶ Over 1000 endotoxins have been recognized in salmonella alone

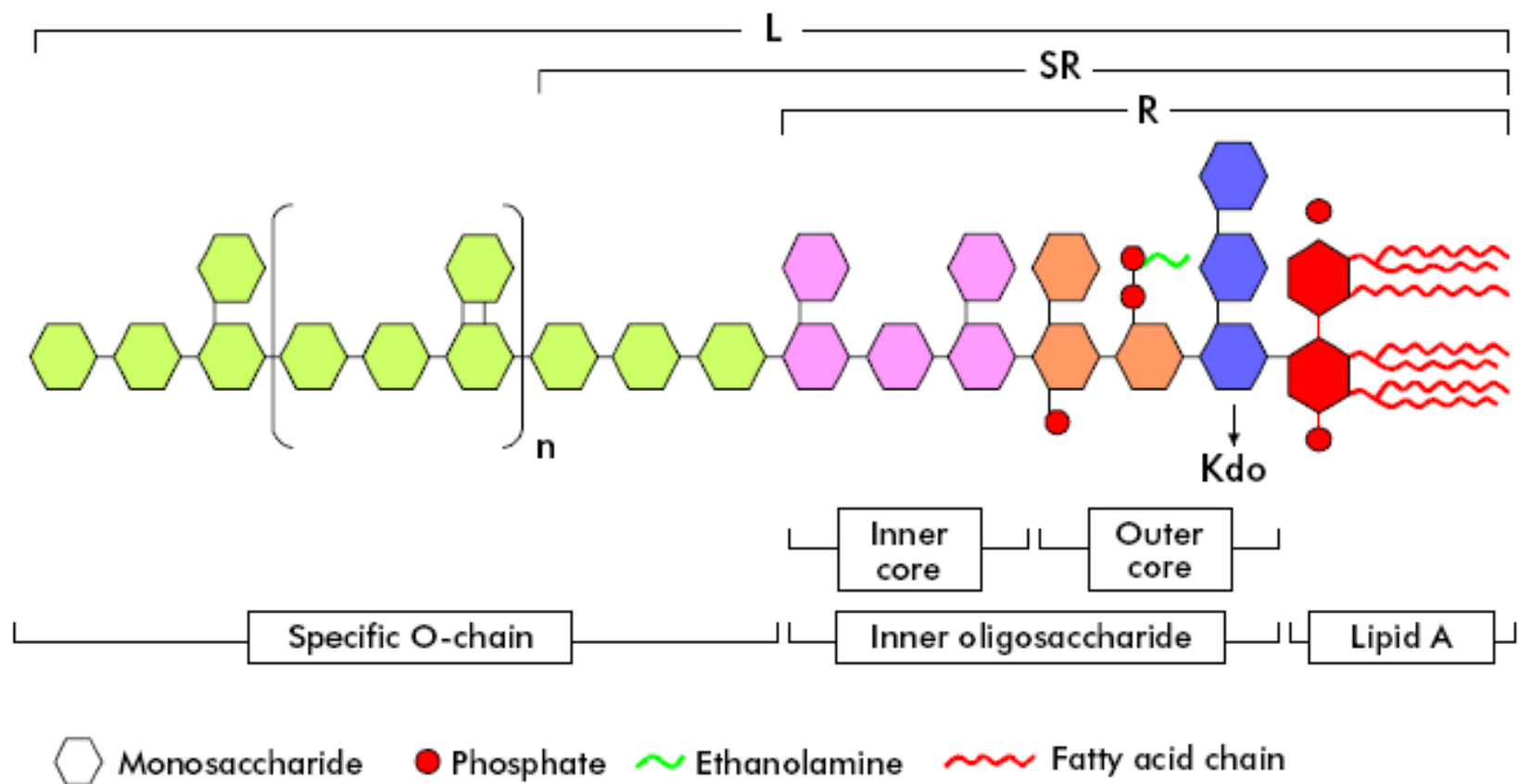
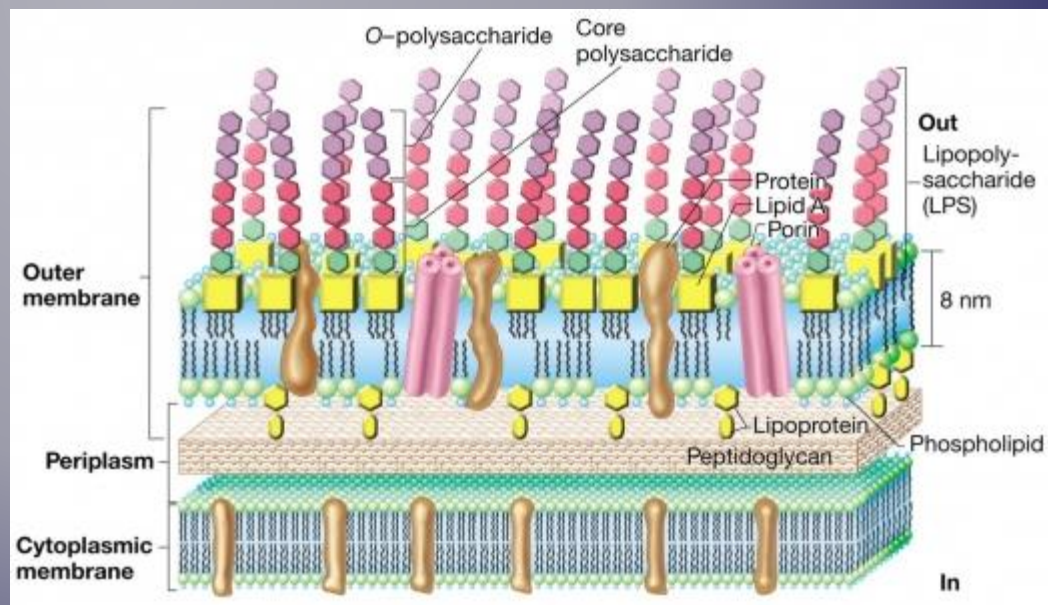
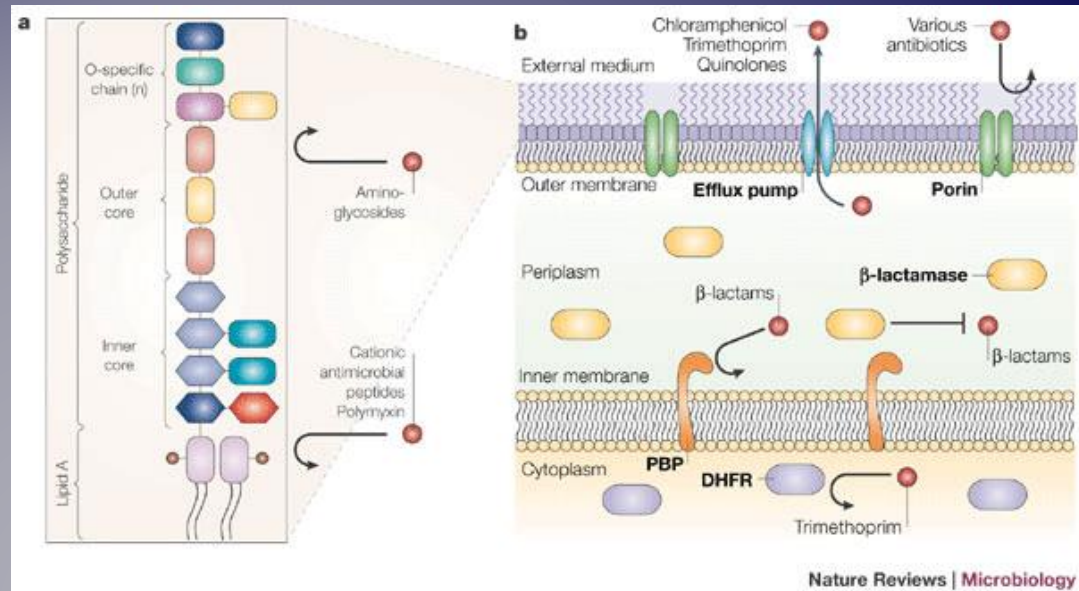
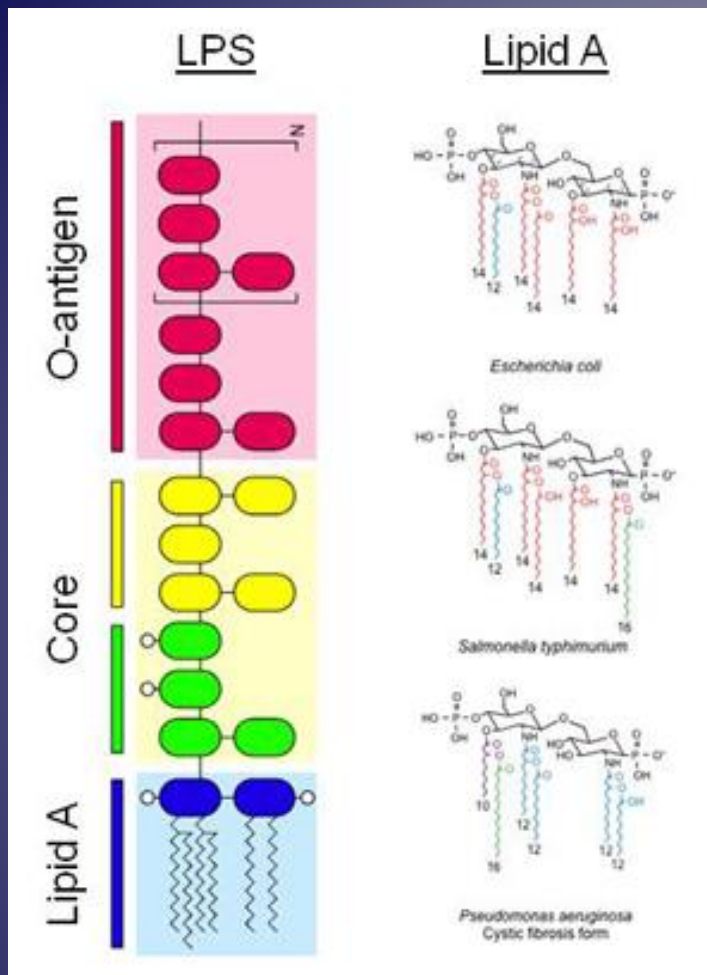
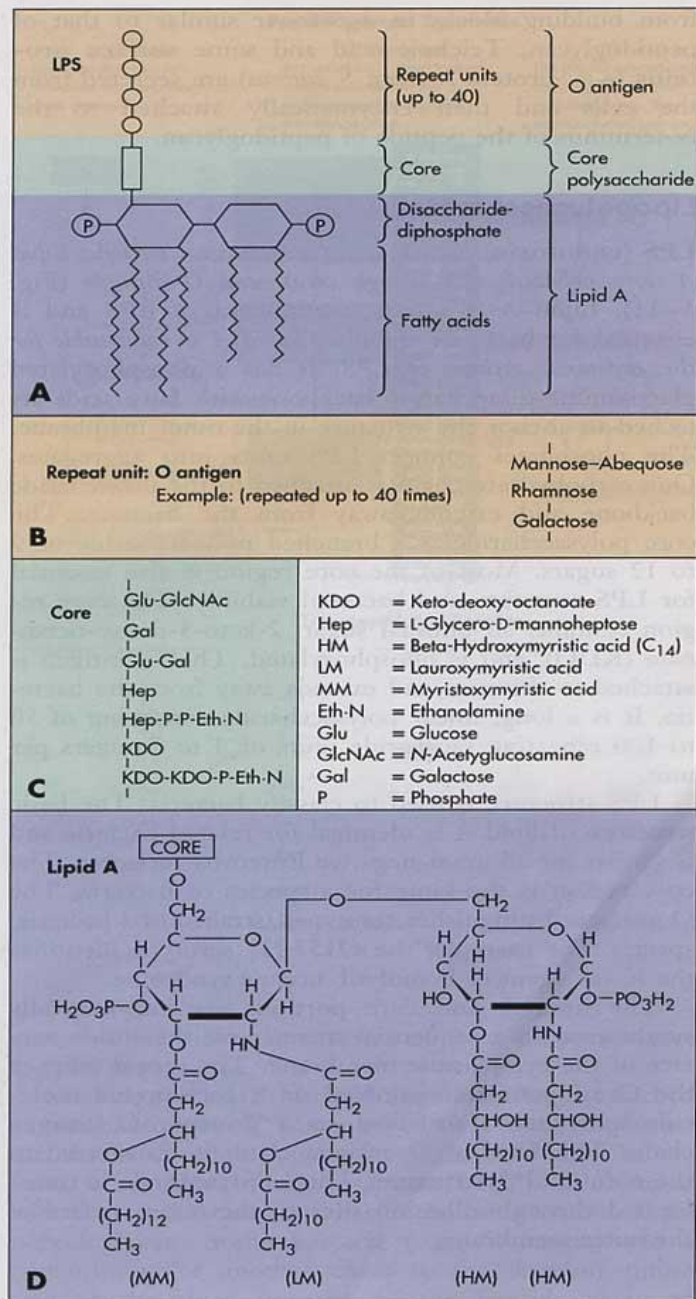


Figure 1. Scheme of the general chemical structure of bacterial lipopolysaccharides: Lipid A, internal oligosaccharide and specific O-chain. Rough type LPS (R) do not contain specific O-chain, semi-rough type (SR) just contain a repetitive unit of specific O-chain, and smooth type (S) contain two or more repetitive units of specific O-chain.





The Lipopolysaccharide Complex

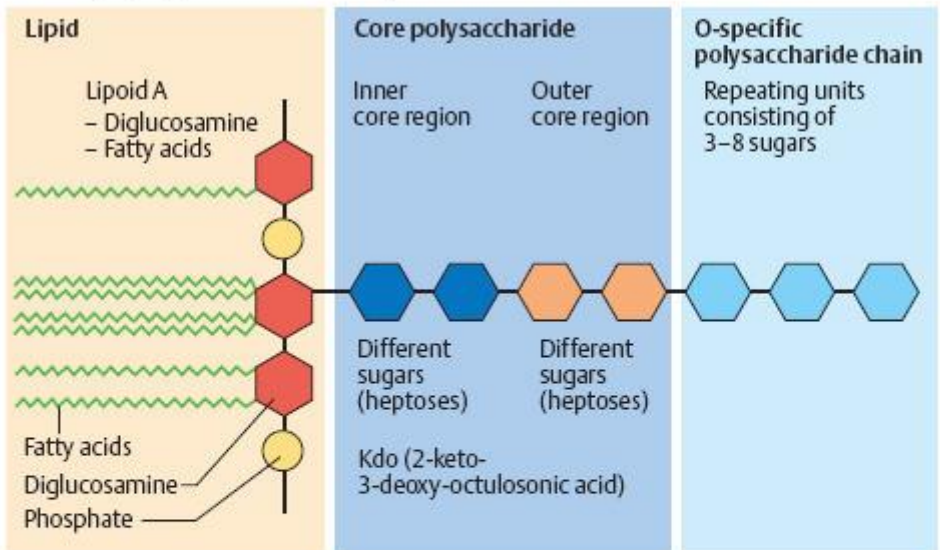


Fig.3.12 The three-part lipopolysaccharide complex (LPS) of Gram-negative bacteria is anchored in the outer membrane by means of its lipid moiety. LPS is also known as endotoxin.

Lipoprotein

- ▶ Lipoprotein crosslink between outer membrane and Peptidoglycan
- ▶ It contain 57 amino acids
- ▶ Functions –
- ▶ Stabilized outer membrane and anchored into the peptidoglycan layer.



Thankyou