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.

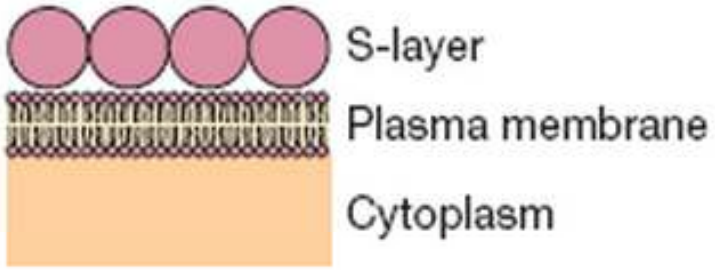
Archaebacteria

- The Archaea constitute a domain or kingdom of sing le-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.



(a)

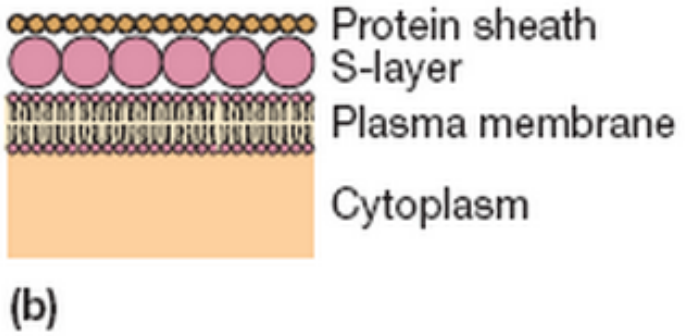
Thickness: 20-40nm thick

S-layer cell walls are present in some methanogens like *Methanococcus*, Halophiles like *Halobacterium* and extreme thermophiles like *Sulpholobus*, *Pyrodictium* etc.

Type 2:

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

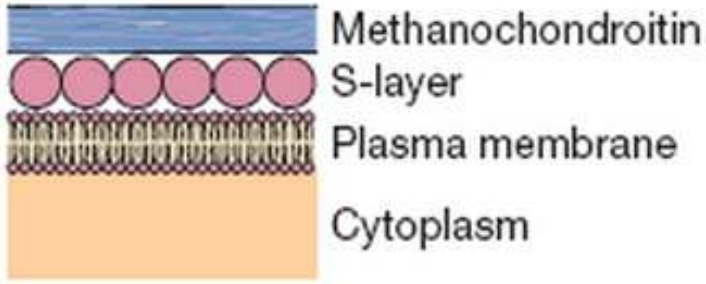
In *Methanosprillum*, There is a protein sheath external to S-layer.



(b)

Type 3:

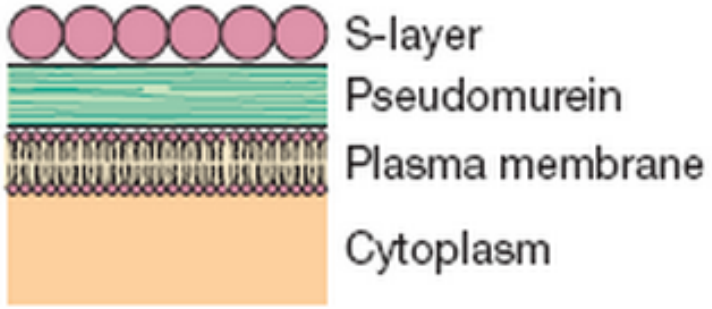
In *Methanosarcina*, S-layer is covered by a chondroitin like material called as mathanochondroitin.



(c)

Type 4:

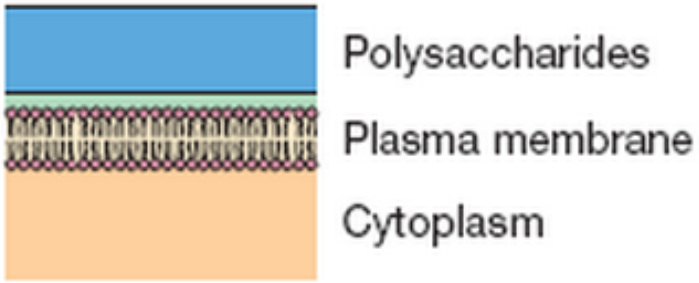
In some Archae like Methanothermus and Methanopyrus, S-layer is the outermost layer and is separated from the plasma membrane by a Peptidoglycan like molecule called psuedomurien.



(d)

Psuedomurien differ from Peptidoglycan in having N-acetyltalosaminuronic acid instead of N-acetyl muramic acid, L -amino acids instead of D-amino acids that cross links and Beta (1->3) glycosidic linkage instead of Beta (1->4) glycosidic linkage.

Type 5:

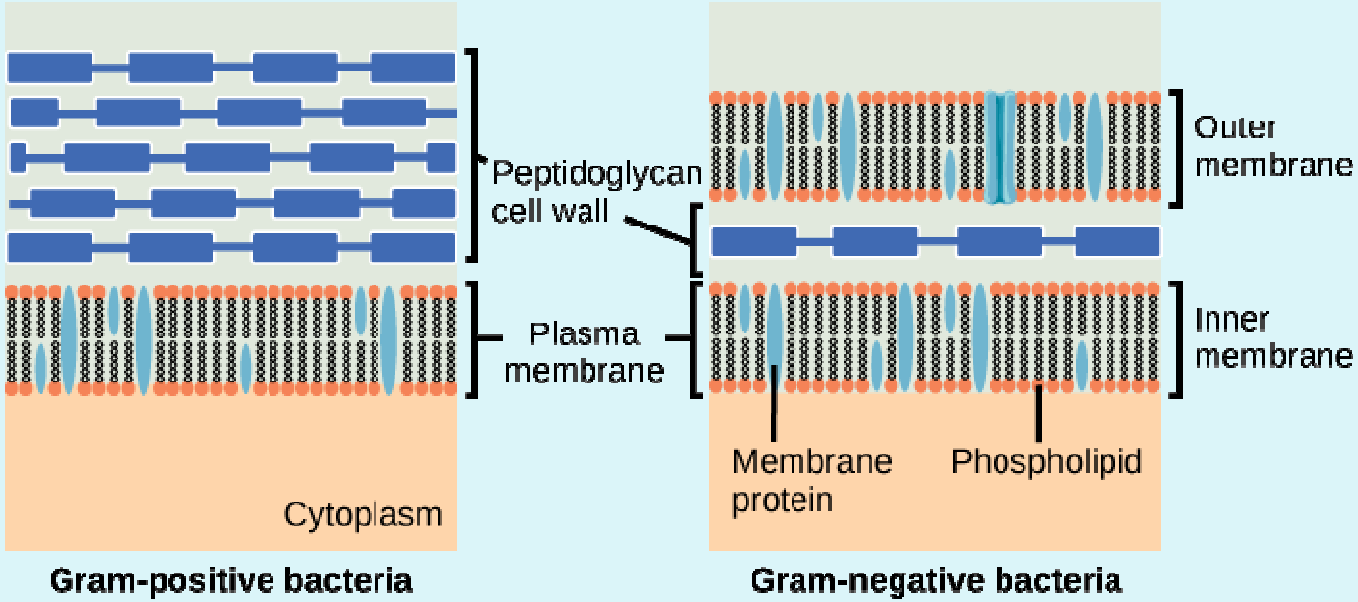


(e)

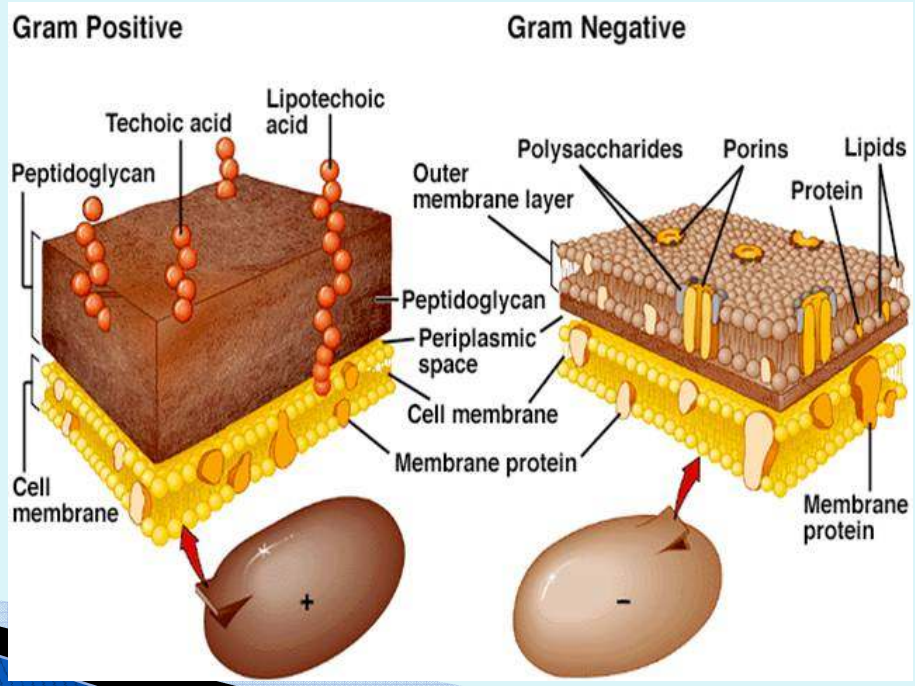
In this type, S layer is absent. Instead archeal cell wall is single thick, homogenous layer resembling Gram positive bacteria. These archeae often stain gram positive. This type is present in *Methanobacterium*, *Halococcus* etc.

Cell wall of Gram Positive Bacteria

- Gram positive bacteria usually have much grater 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**

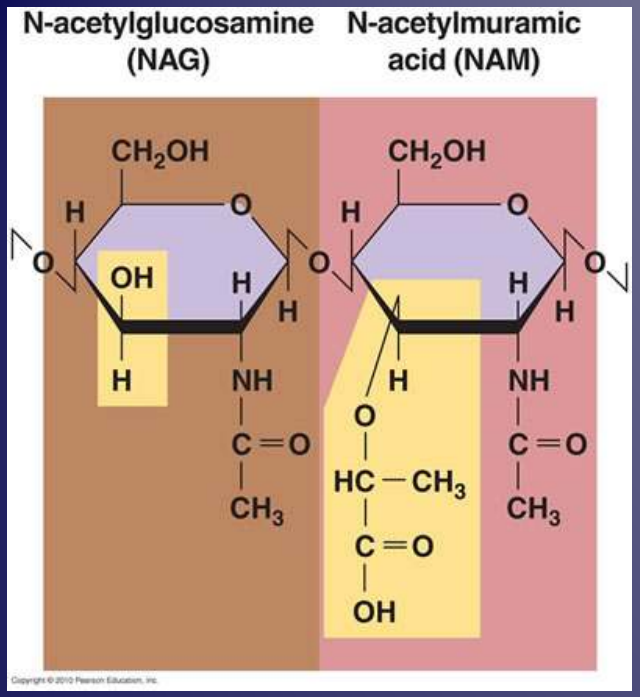


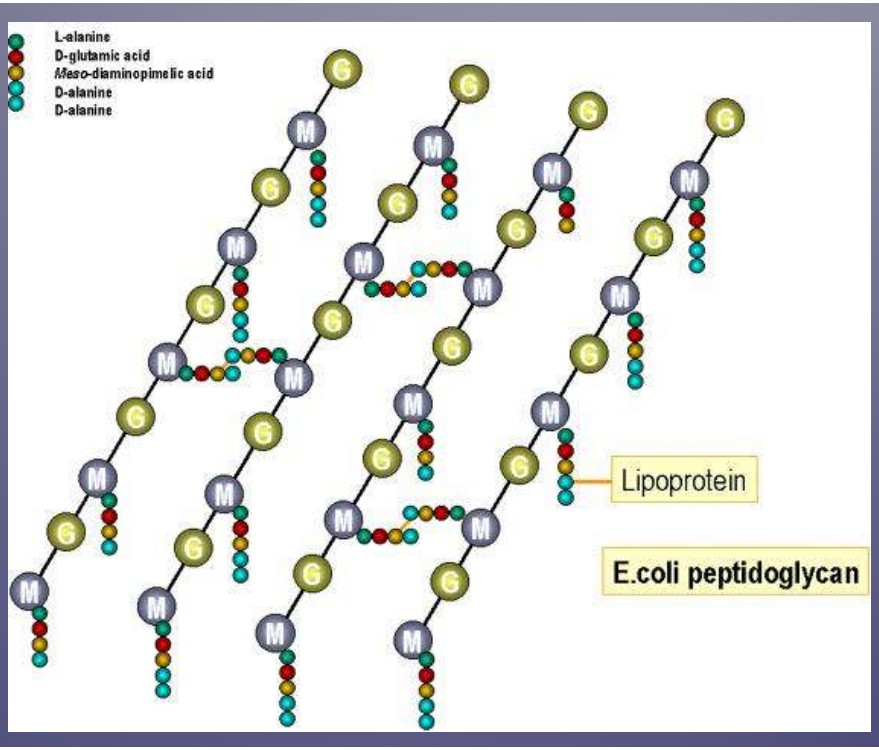
Special component of Gram Positive Cell Wall

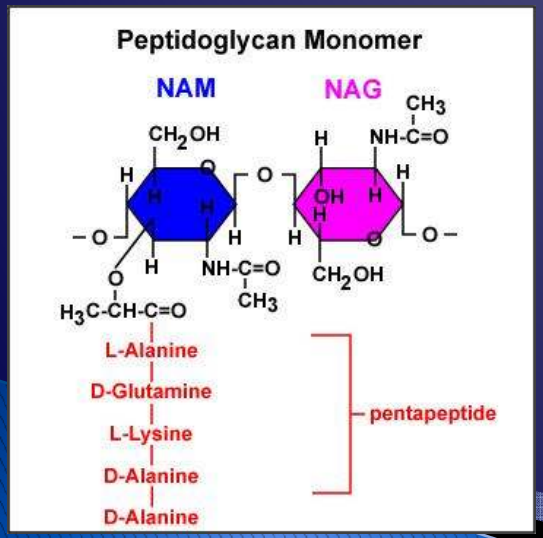
- Peptidoglycan
- Teichoic acid
- Teichuronic acid
- Polysachharides

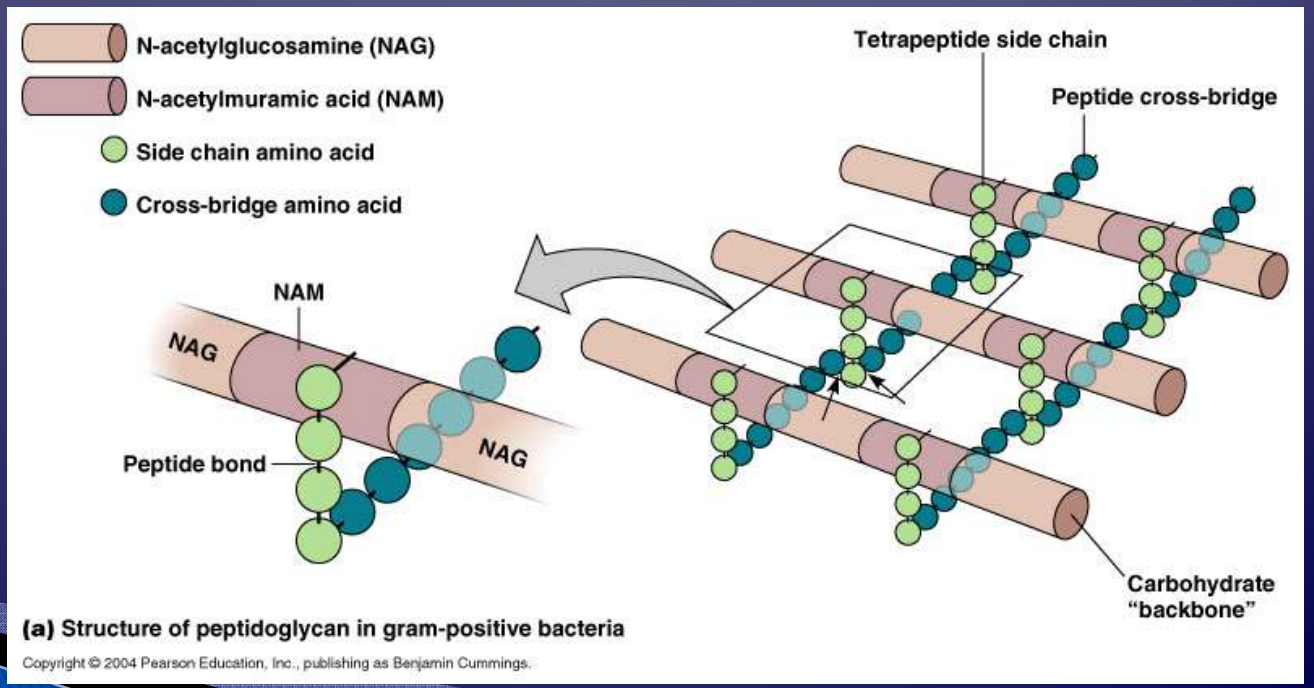
Peptidoglycan

- 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)
CH2OH
OH
NH
C=O
CH3
HC—CH3
OH


L-alanine
D-glutamic acid
Meso-diaminopimelic acid
D-alanine
D-alanine
Lipoprotein
E.coli peptidoglycan


Peptidoglycan Monomer
NAM
NAG
CH2OH
NH-C=O
CH3
H3C-CH-C=O
L-Alanine
D-Glutamine
L-Lysine
D-Alanine
D-Alanine
pentapeptide


N-acetylglucosamine (NAG)
N-acetylmuramic acid (NAM)
Side chain amino acid
Cross-bridge amino acid
Tetrapeptide side chain
Peptide cross-bridge
NAM
NAG
NAG
Peptide bond
Carbohydrate "backbone"
(a) Structure of peptidoglycan in gram-positive bacteria
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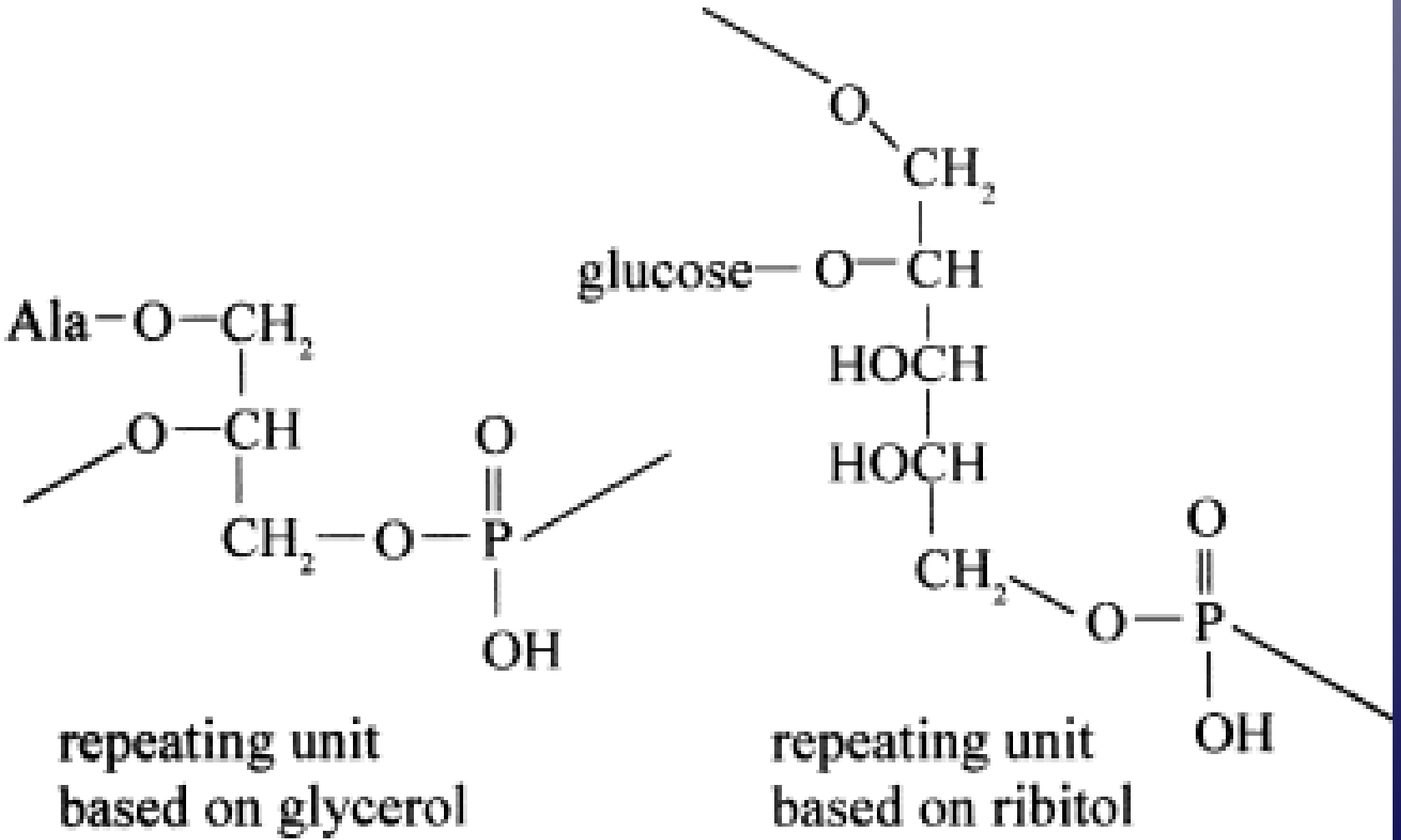
Techoic acid

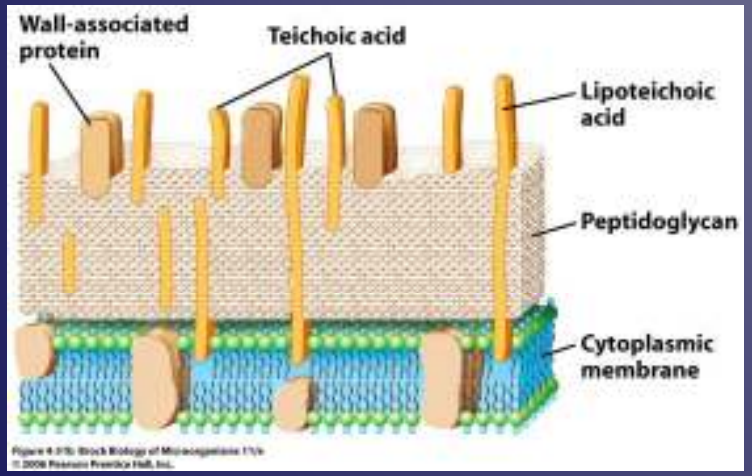
- It is a polymer containing Glycerophosphate or ribitol phosphate residue.
-
- Techoic acid are negative charged, and responsible for negative charge in cell surface.

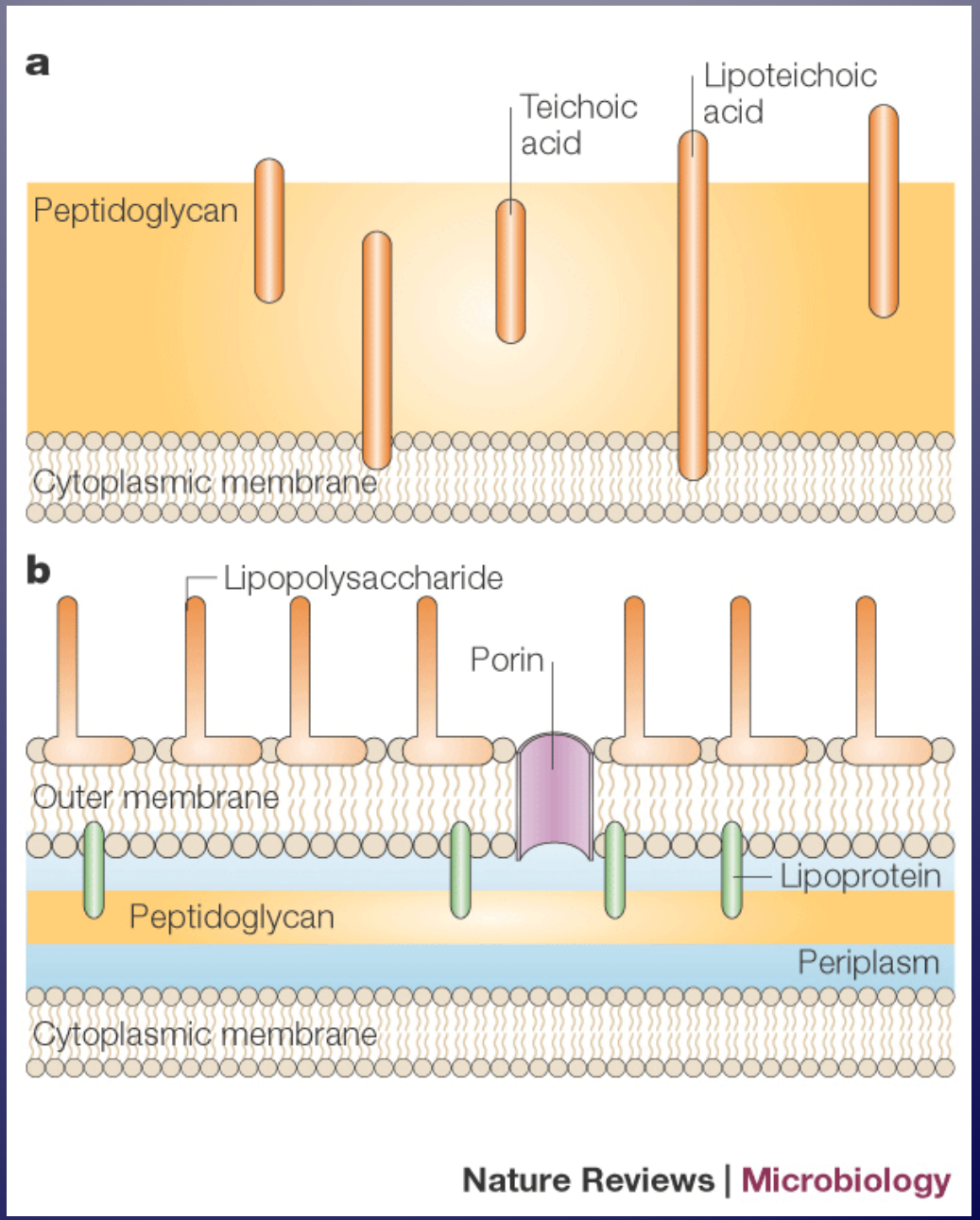
Structure of Teichoic Acid



Types of techoic acid

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


Wall-associated protein
Teichoic acid
Lipoteichoic acid
Peptidoglycan
Cytoplasmic membrane


a
Teichoic acid
Lipoteichoic acid
Peptidoglycan
Cytoplasmic membrane
b
Lipopolysaccharide
Porin
Outer membrane
Lipoprotein
Peptidoglycan
Periplasm
Cytoplasmic membrane
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- Together with peptidoglycan, WTA and LTA provide functions relating to the Elasticity, Porosity, strength, electrostatic properties.
- Most techoic 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

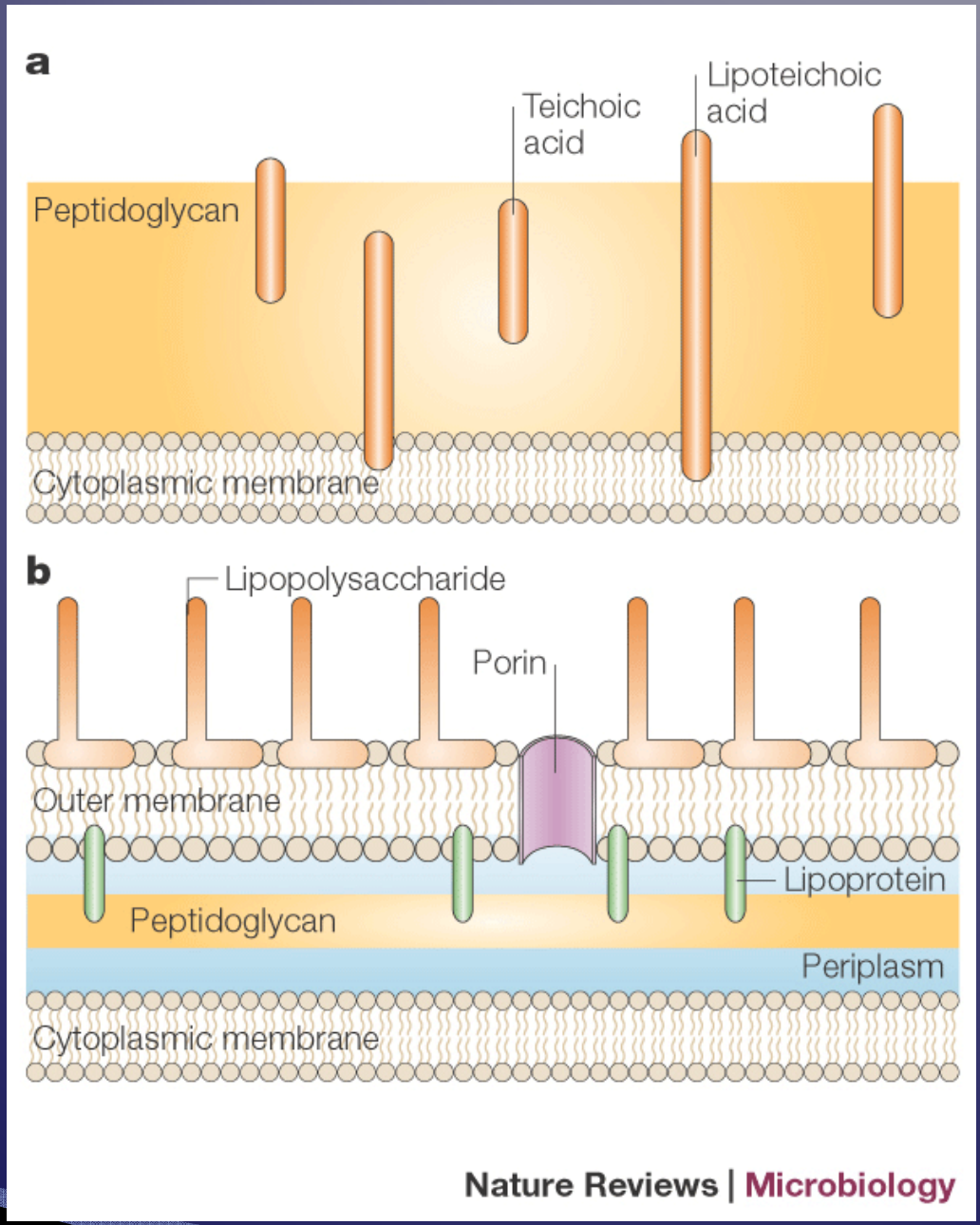
Outer Membrane of Gram Negative Bacteria

- It contains –
  - Lipoprotein
  - Outer Membrame
  - 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
Teichoic acid
Lipoteichoic acid
Peptidoglycan
Cytoplasmic membrane
b
Lipopolysaccharide
Porin
Outer membrane
Lipoprotein
Peptidoglycan
Periplasm
Cytoplasmic membrane
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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 liner trischharides

- LPS are extreamly toxic to animals has been called endotoxin
- O-antigen is highly immunogenic in vertibrate animals
- Over 1000 endotoxin have been recognized in salmonella alone

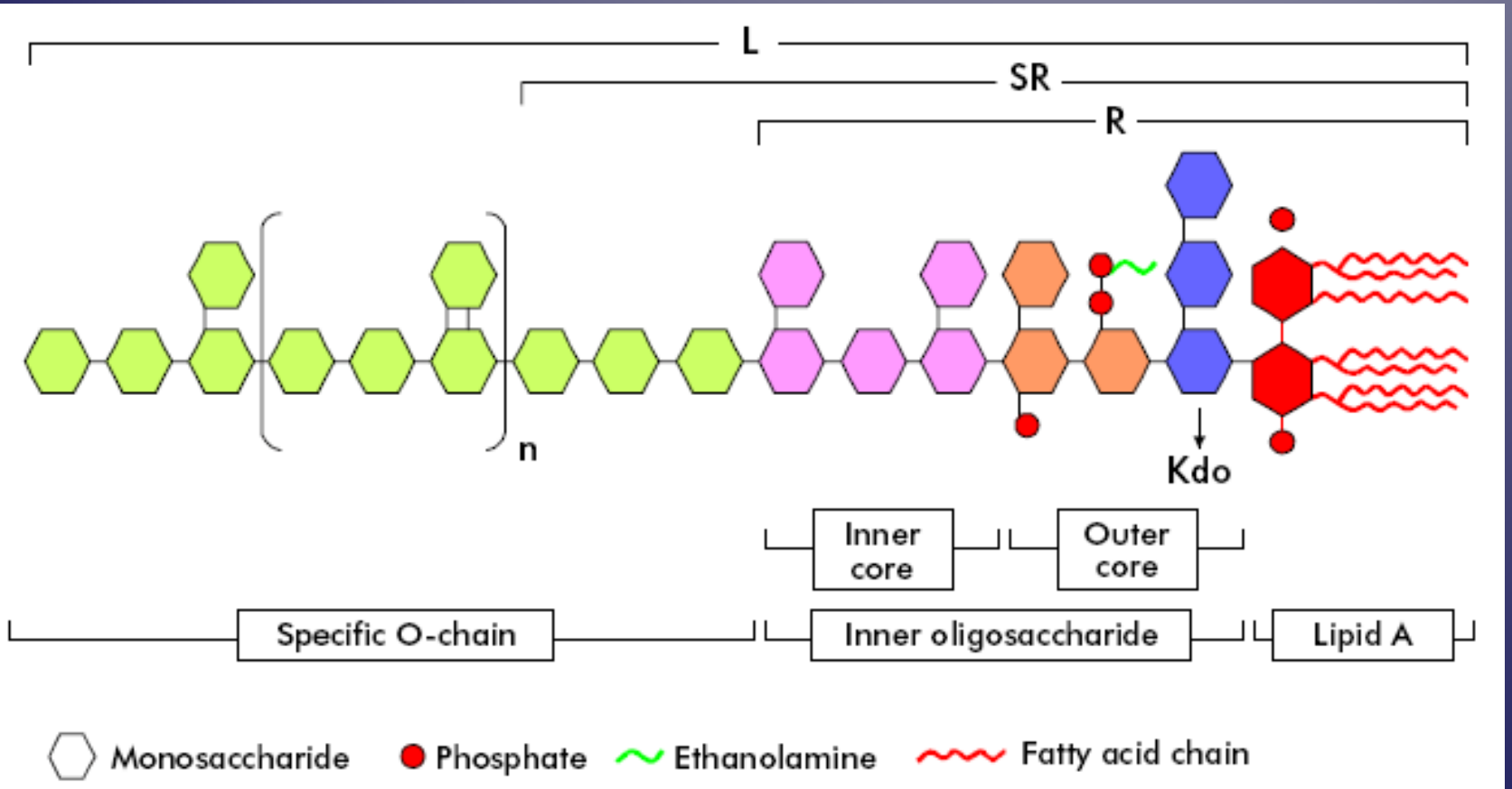
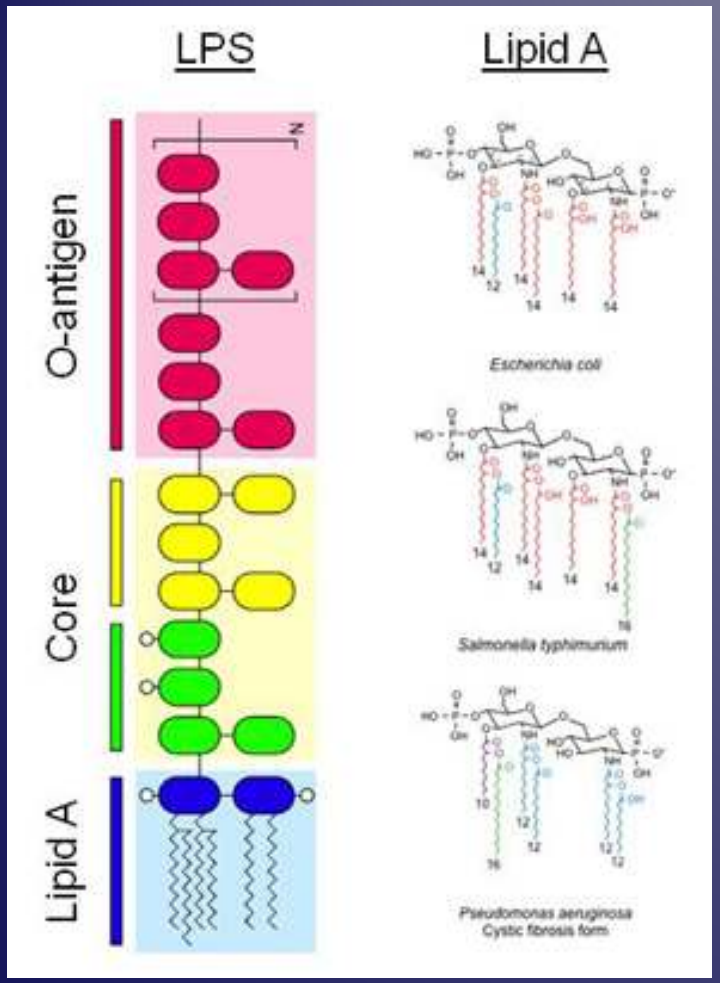
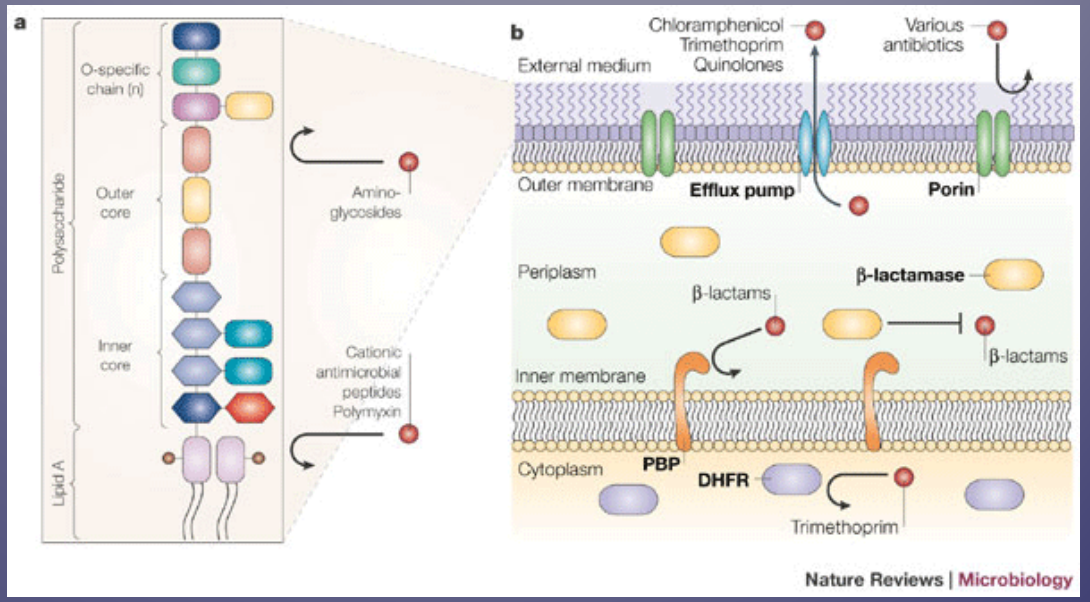


Figure 1. Scheme of the general chemical structure of bacterial lipopolysaccharides: Lipid A, internal oligosaccharide and specific O-chain. Rough type LPS (R) do not contain specific O-chain, semi-rough type (SR) just contain a repetitive unit of specific O-chain, and smooth type (S) contain two or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


LPS
Lipid A
O-antigen
Core
Lipid A
Escherichia coli
Salmonella typhimurium
Pseudomonas aeruginosa
Cystic fibrosis form


a
O-specific chain (n)
Outer core
Inner core
Lipid A
Polysaccharide
Amino-glycosides
Cationic antimicrobial peptides Polymyxin
b
External medium
Chloramphenicol Trimethoprim Quinolones
Various antibiotics
Outer membrane
Efflux pump
Porin
Periplasm
β-lactamase
β-lactams
β-lactams
Inner membrane
Cytoplasm
PBP
DHFR
Trimethoprim
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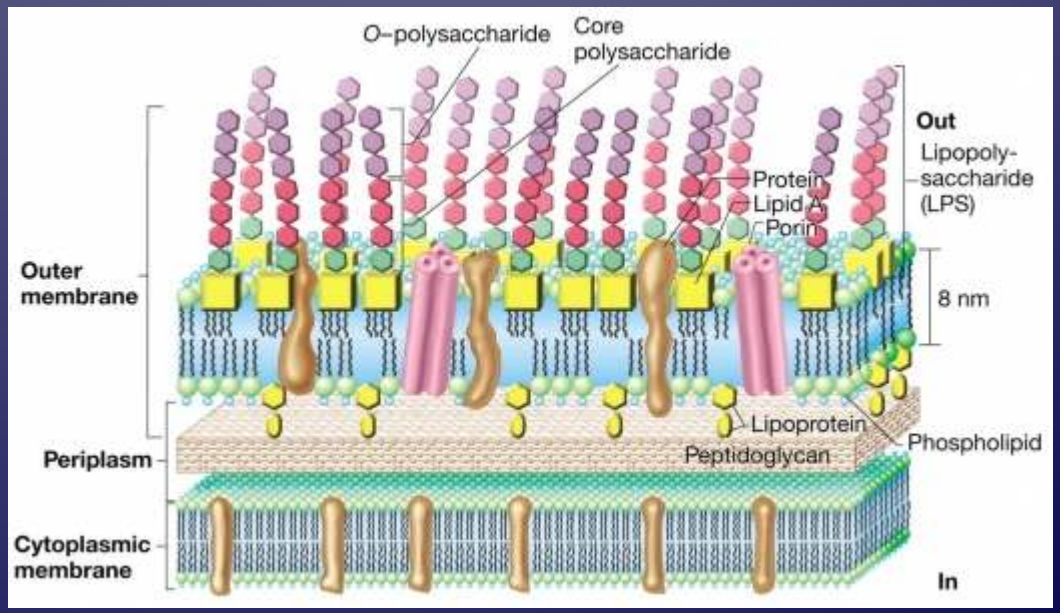
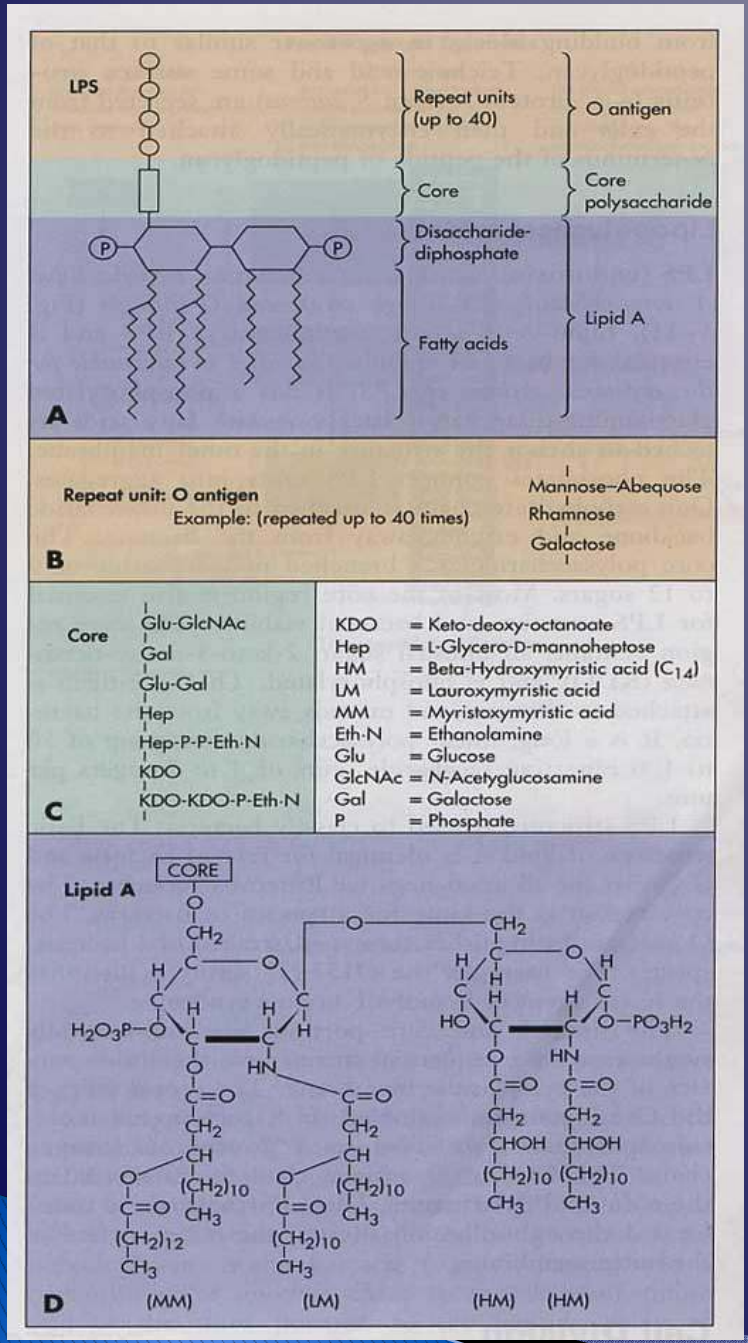

O–polysaccharide
Core polysaccharide
Out
Lipopoly-saccharide (LPS)
Protein
Lipid A
Porin
Outer membrane
8 nm
Lipoprotein
Peptidoglycan
Phospholipid
Periplasm
Cytoplasmic membrane
In



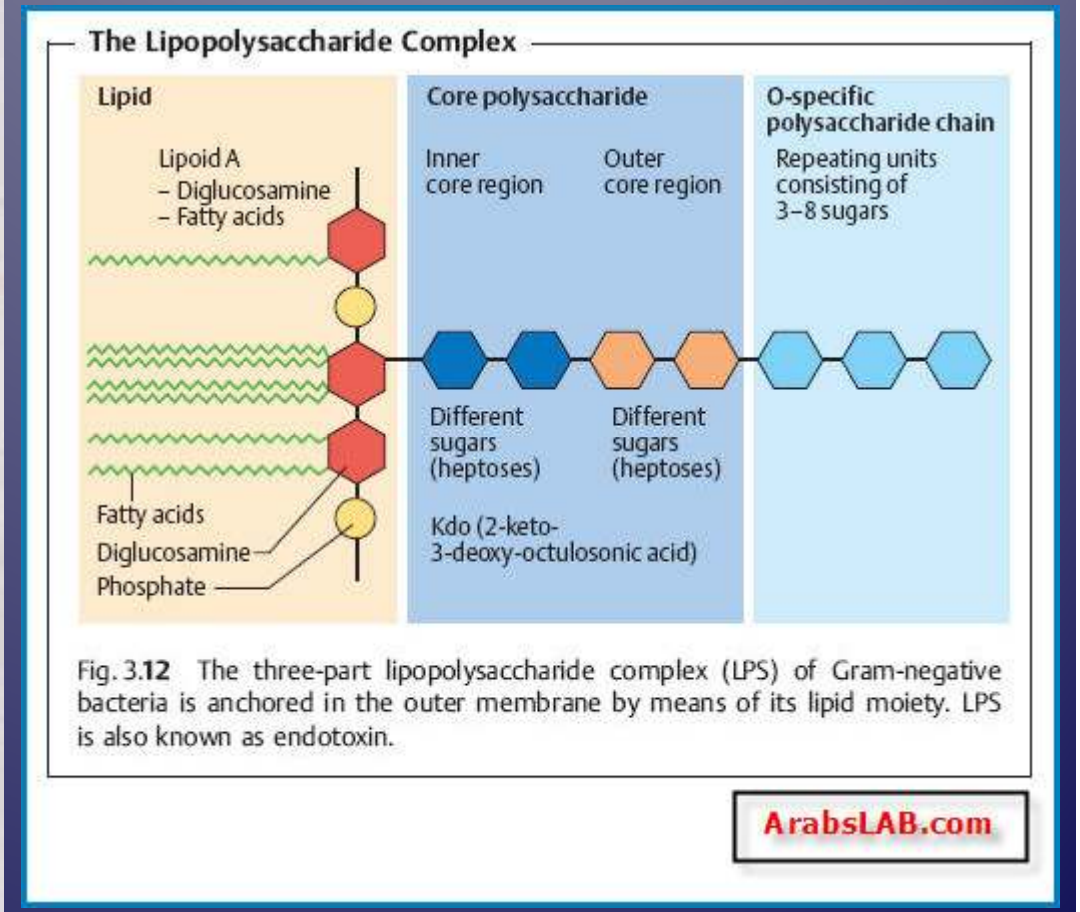


Fig. 3.12 The three-part lipopolysaccharide complex (LPS) of Gram-negative bacteria is anchored in the outer membrane by means of its lipid moiety. LPS is also known as endotoxin.

Lipoprotein

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

Thankyou