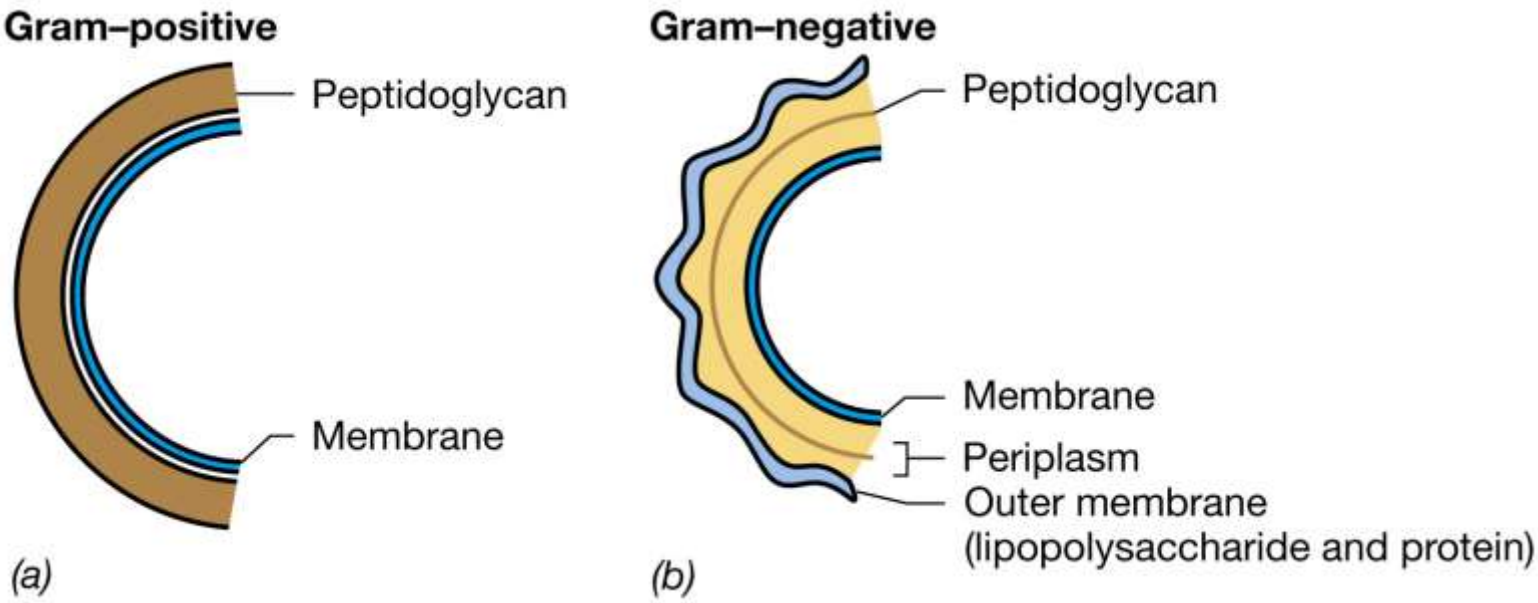
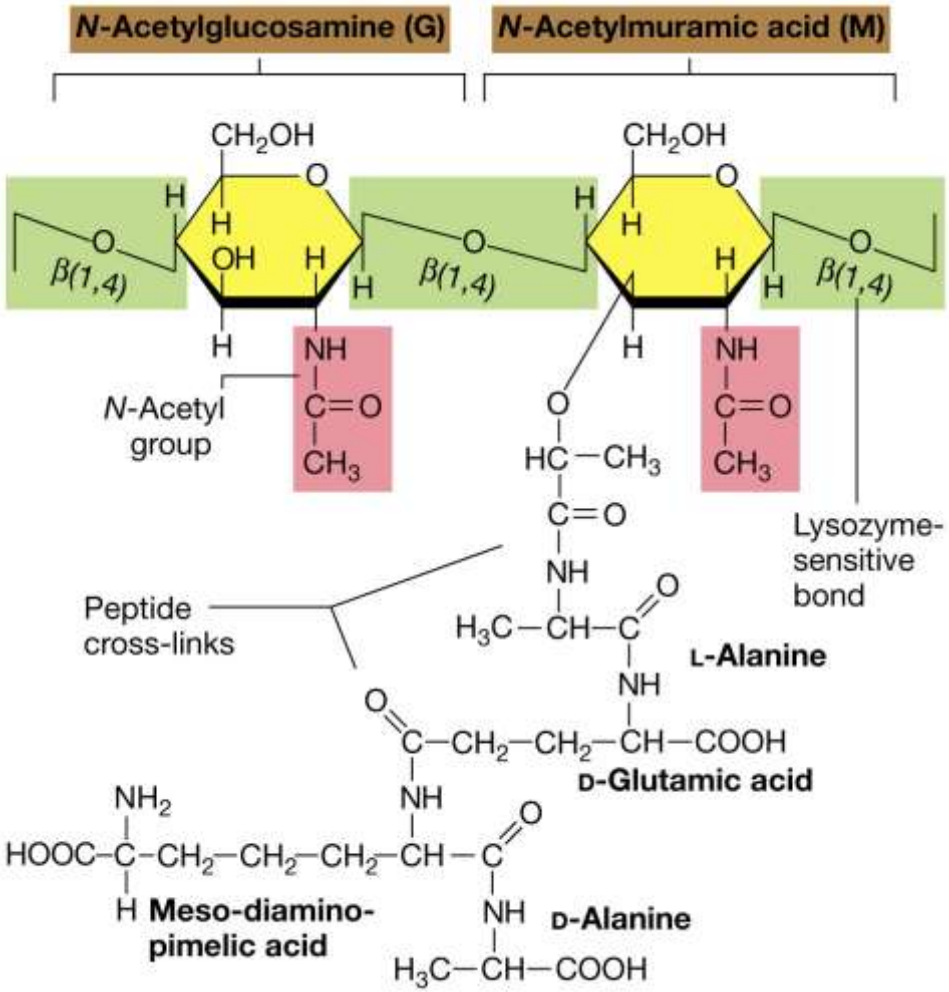
Pared celular

Bacterias

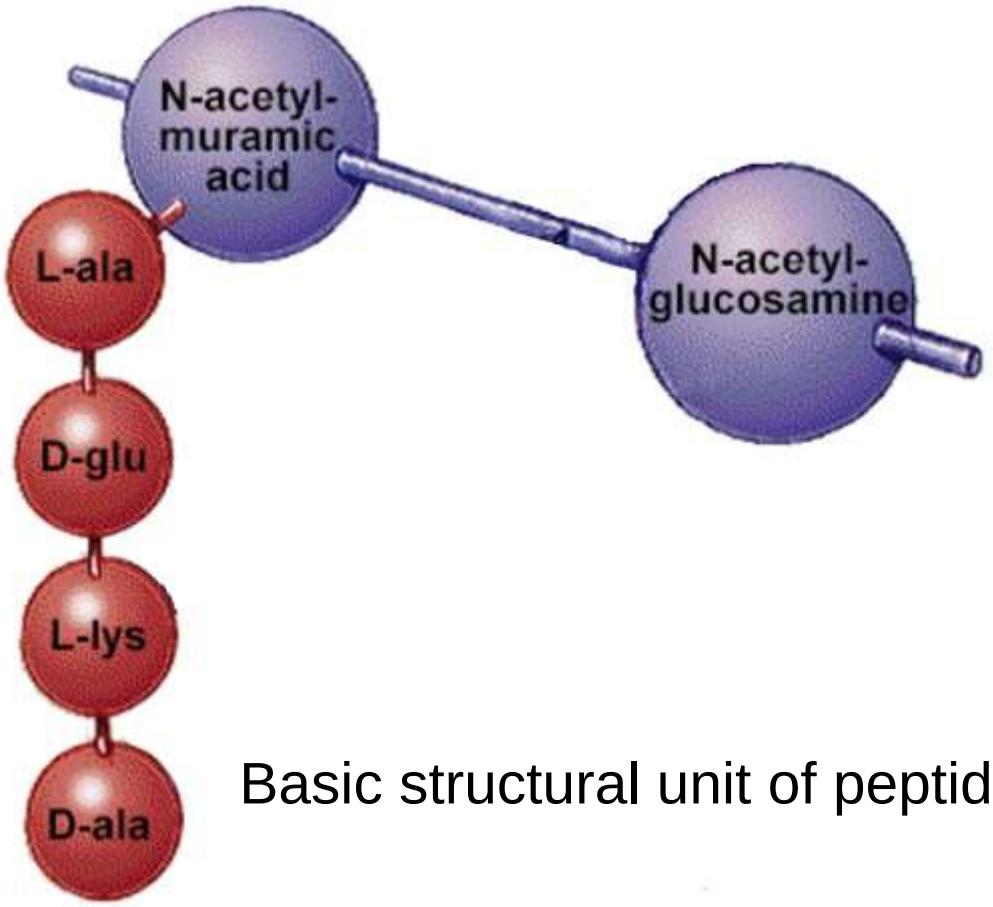
- La concentración de solutos que se alcanza en el interior de la bacteria, crea una presión osmótica significativa: aproximadamente 2 atm.
- Para resistir estas presiones la mayoría de Bacteria y Archaea tienen una pared celular.
- Además de proteger contra la lisis osmótica, las paredes celulares también confieren forma y rigidez a la célula.


Gram–positive
Peptidoglycan
Membrane
(a)
Gram–negative
Peptidoglycan
Membrane
Periplasm
Outer membrane
(lipopolysaccharide and protein)
(b)

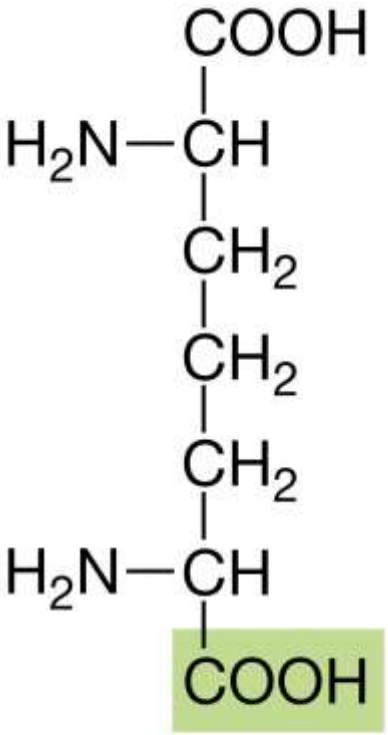


Structure of the repeating unit in peptidoglycan, the glycan tetrapeptide. The structure given is that of *Escherichia coli* and most other gramnegative *Bacteria*. In some *Bacteria*, other amino acids are present.

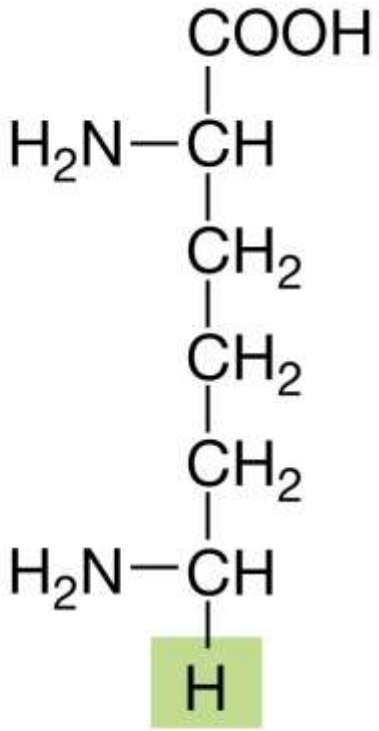
The glycan tetrapeptide



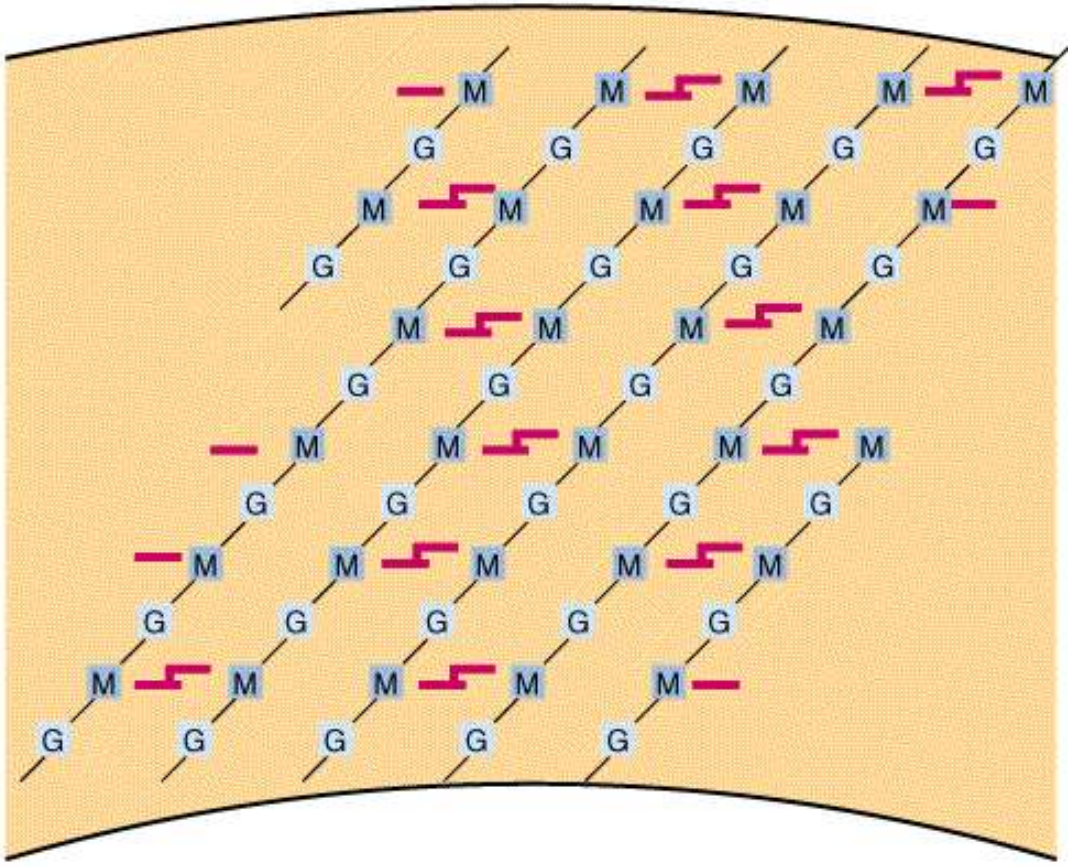
Basic structural unit of peptidoglycan

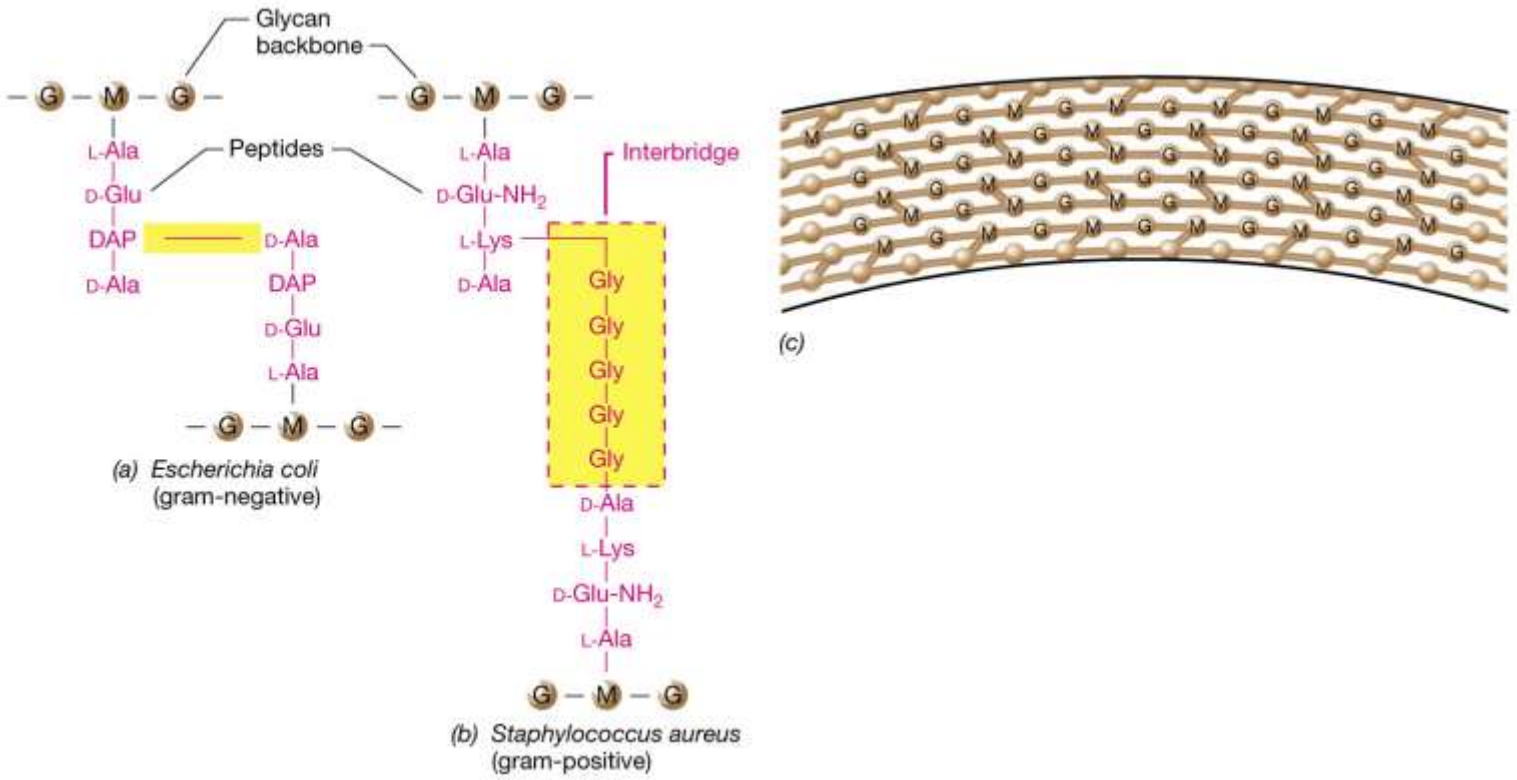

COOH
H2N—CH
CH2
CH2
CH2
H2N—CH
COOH

(a) **m-DAP**

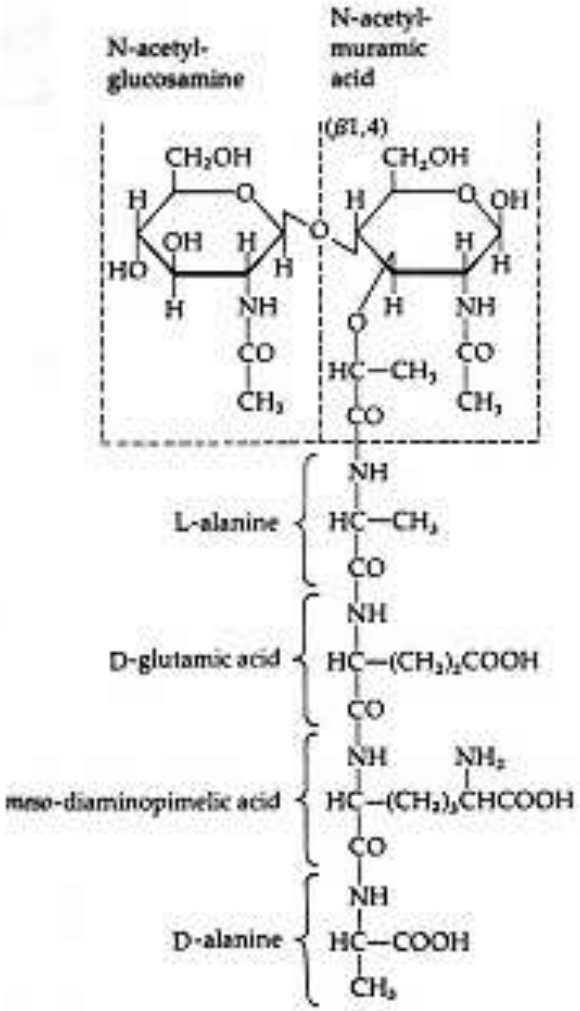

COOH
H2N—CH
CH2
CH2
CH2
H2N—CH
H

(b) **L-lys**

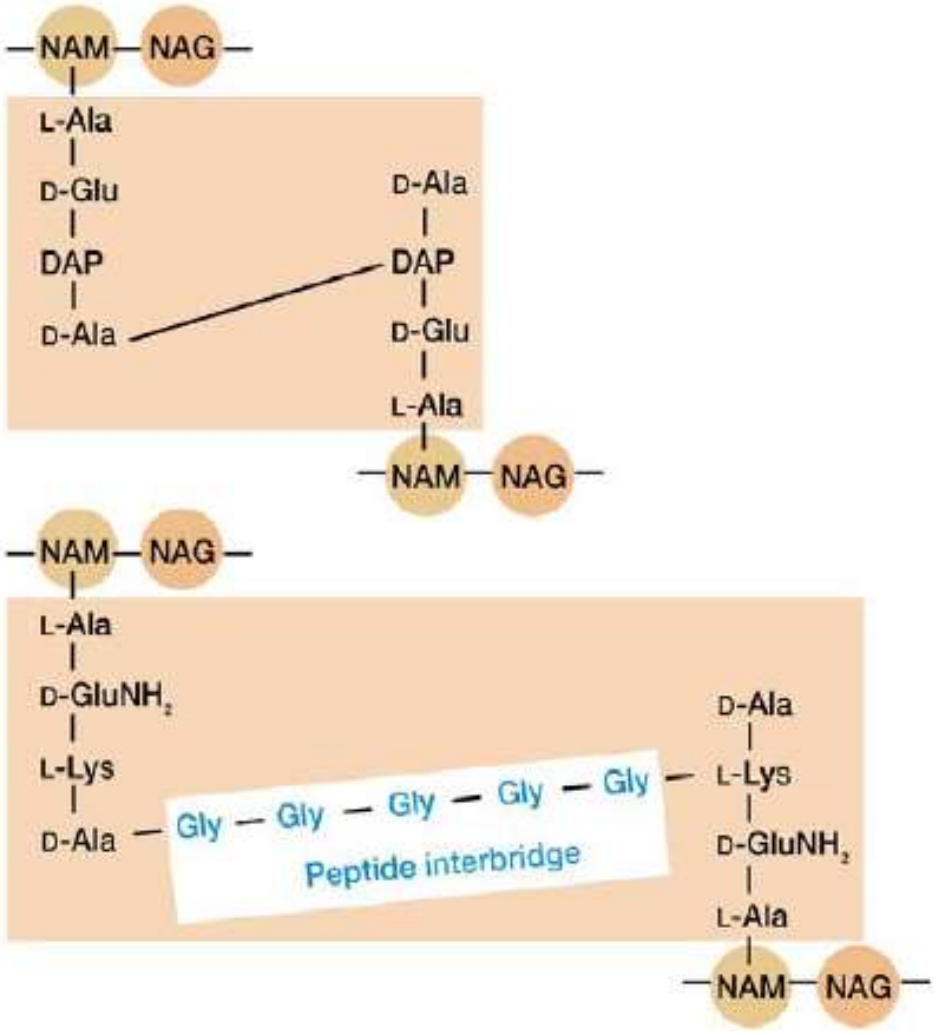

M
G



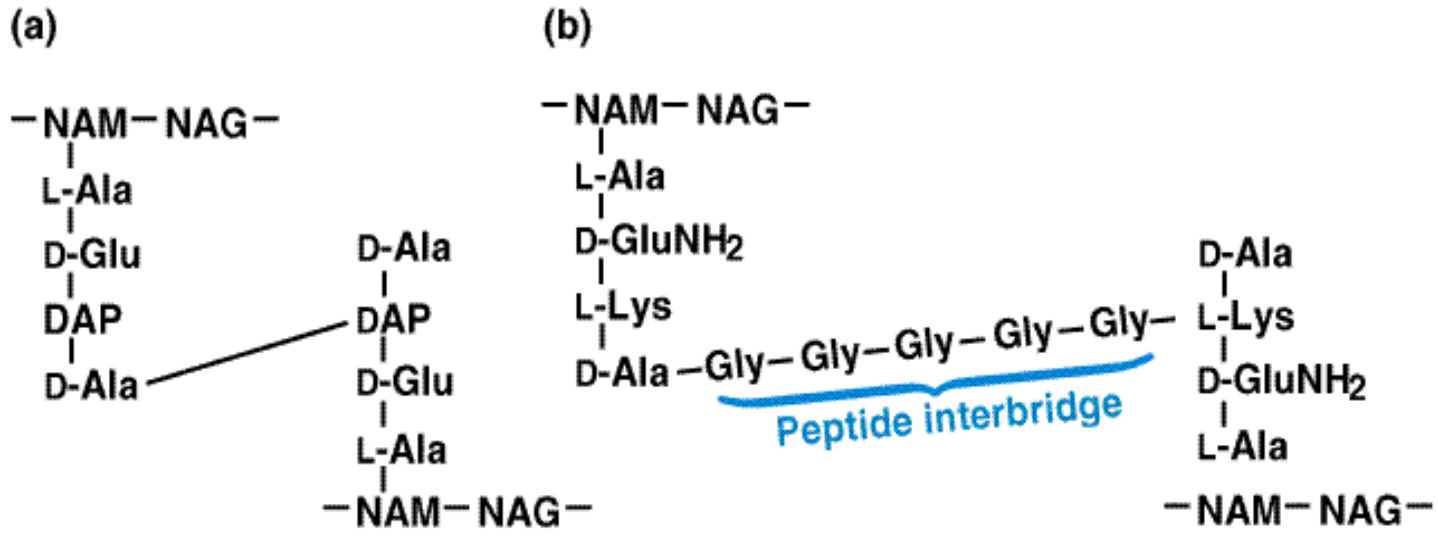
Peptidoglycan in *Escherichia coli* and *Staphylococcus aureus*.
(a) No interbridge is present in *E. coli* peptidoglycan nor in that of other gram-negative *Bacteria*.
(b) The glycine interbridge in the gram-positive bacterium *S. aureus*.
(c) Overall structure of peptidoglycan. G, *N*-acetylglucosamine; M, *N*-acetylmuramic acid



The vegetative cell wall of almost all *Bacillus* species is made up of a peptidoglycan containing meso-diaminopimelic acid (DAP). (The cell walls of *Sporosarcina pasteurii* and *S. globisporus,* contain lysine in the place of DAP.) This is the same type of cell wall polymer that is nearly universal in Gram-negative bacteria, i.e., containing DAP as the diamino acid in position 3 of the tetrapeptide


NAM
NAG
L-Ala
D-Glu
DAP
D-Ala
D-Ala
DAP
D-Glu
L-Ala
NAM
NAG
NAM
NAG
L-Ala
D-GluNH2
L-Lys
D-Ala
Gly
Gly
Gly
Gly
Gly
Peptide interbridge
D-Ala
L-Lys
D-GluNH2
L-Ala
NAM
NAG

Peptiodoglycan Cross-Links

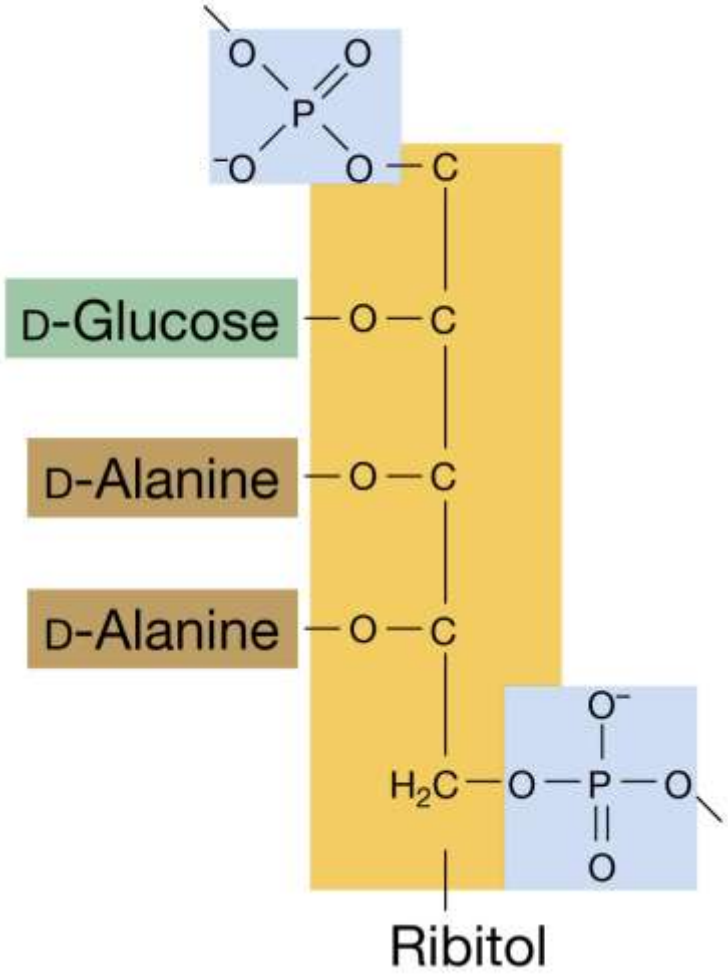


Diversidad del péptidoglucano

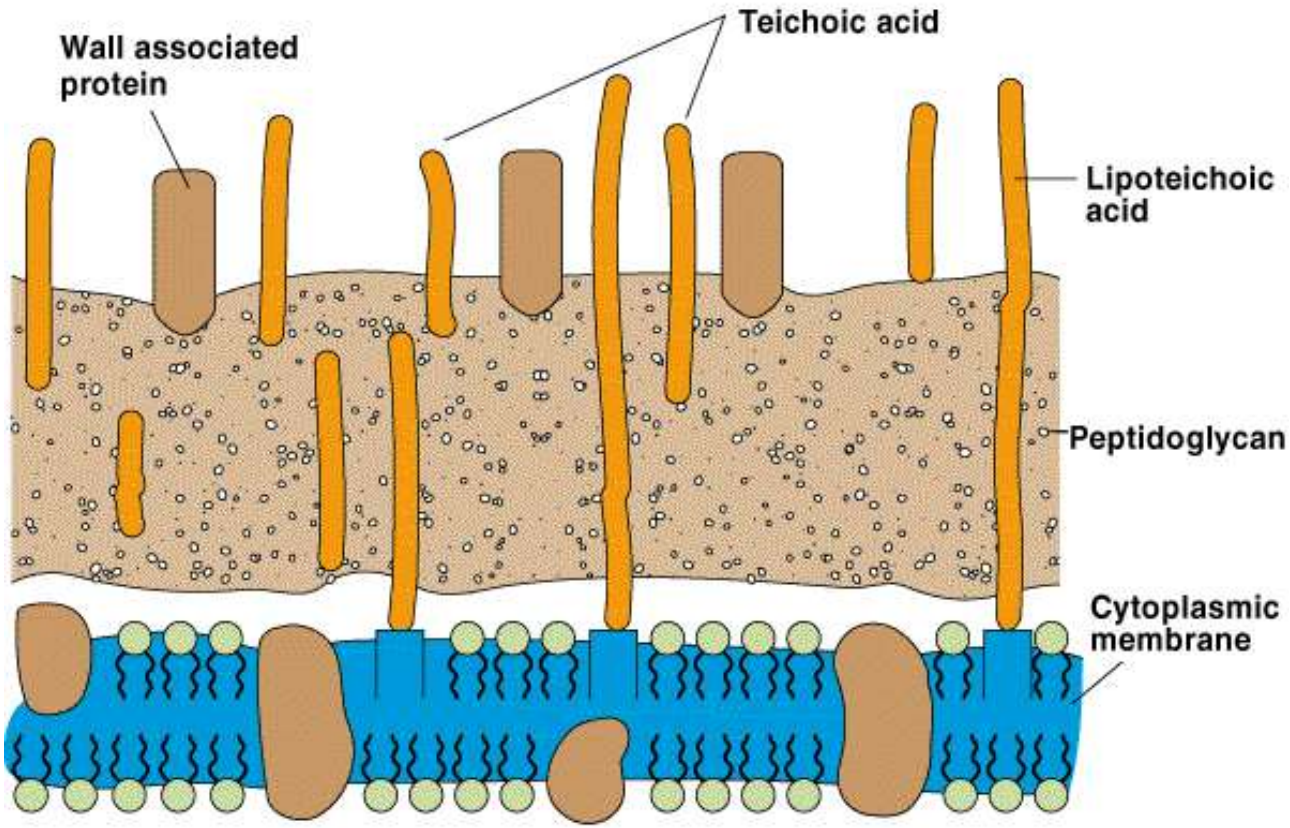
- Sólo existe péptidoglucano en Bacteria
- No todas las bacterias poseen DAP en su péptidoglucano
- Presencia de dos aminoácidos que presentan configuración D: D-alanina y D-glutámico
- La porción del glucano es uniforme: N-Acetilglucosamina y N-Acetilmurámico

Ácido teicoico

- Gram + → polímero formado por glicerol fosfato o ribitol fosfato.
- Polialcoholes unidos por enlaces ésteres fosfato y generalmente se les une otros azúcares y D-alanina.
- Dos clases de ácidos teicoicos: ácido lipoteicoico y ácido teicoico de la pared.



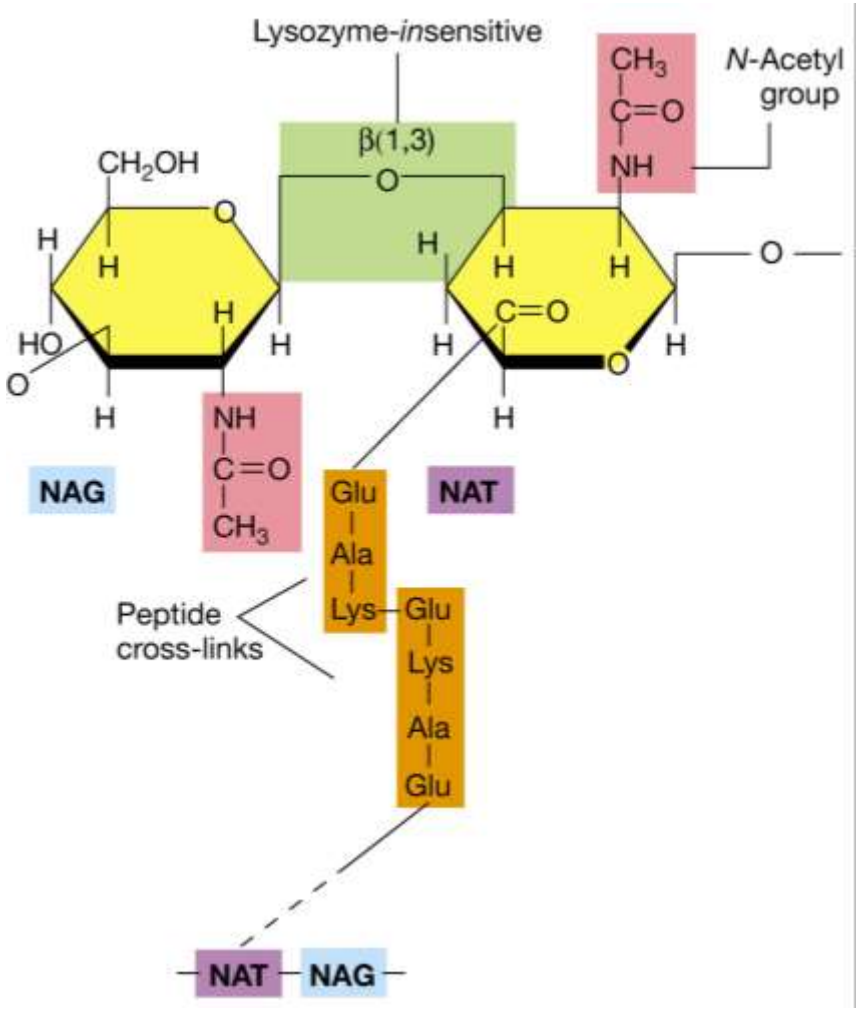
Structure of a ribitol teichoic acid. The teichoic acid is a polymer of the repeating ribitol unit shown here



Los ácidos teicoicos están unidos al péptidoglucano a nivel del ácido murámico; algunos ácidos teicoicos están unidos covalentemente a lípidos de membrana: ácido lipoteicoico

Pared celular en Archaea

- La pared de ciertas Archaea metanógenas presentan polisacáridos muy parecido al péptidoglucano llamado pseudopéptidoglucano: N-acetilglucosamina y N-acetiltalosaminurónico
- *Methanosarcina*, tiene una pared gruesa de polisacárido formado por glucosa, ácido glucurónico, galactosamina y acetato
- *Halococcus*, pared similar a *Methanosarcina* con abundantes residuos de sulfatos (SO^{-2}_4)

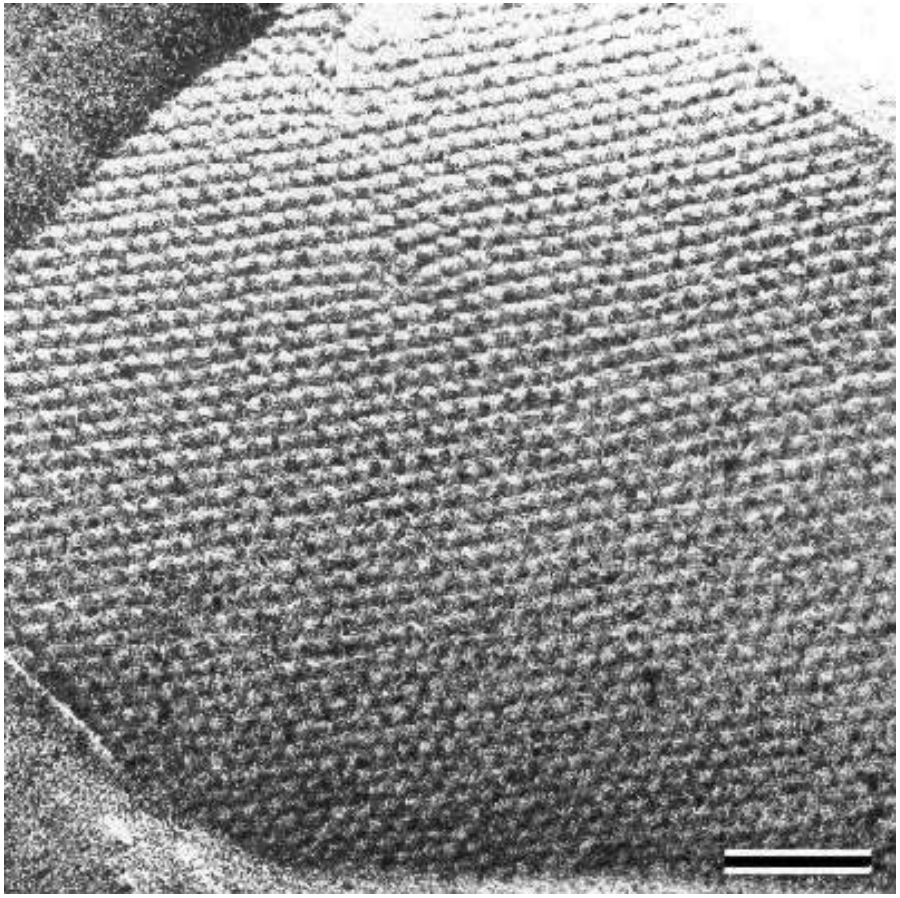


Pseudomurein. Structure of pseudomurein, the cell wall polymer of *Methanobacterium* species. Note the similarities and differences between pseudomurein and peptidoglycan

Capas S

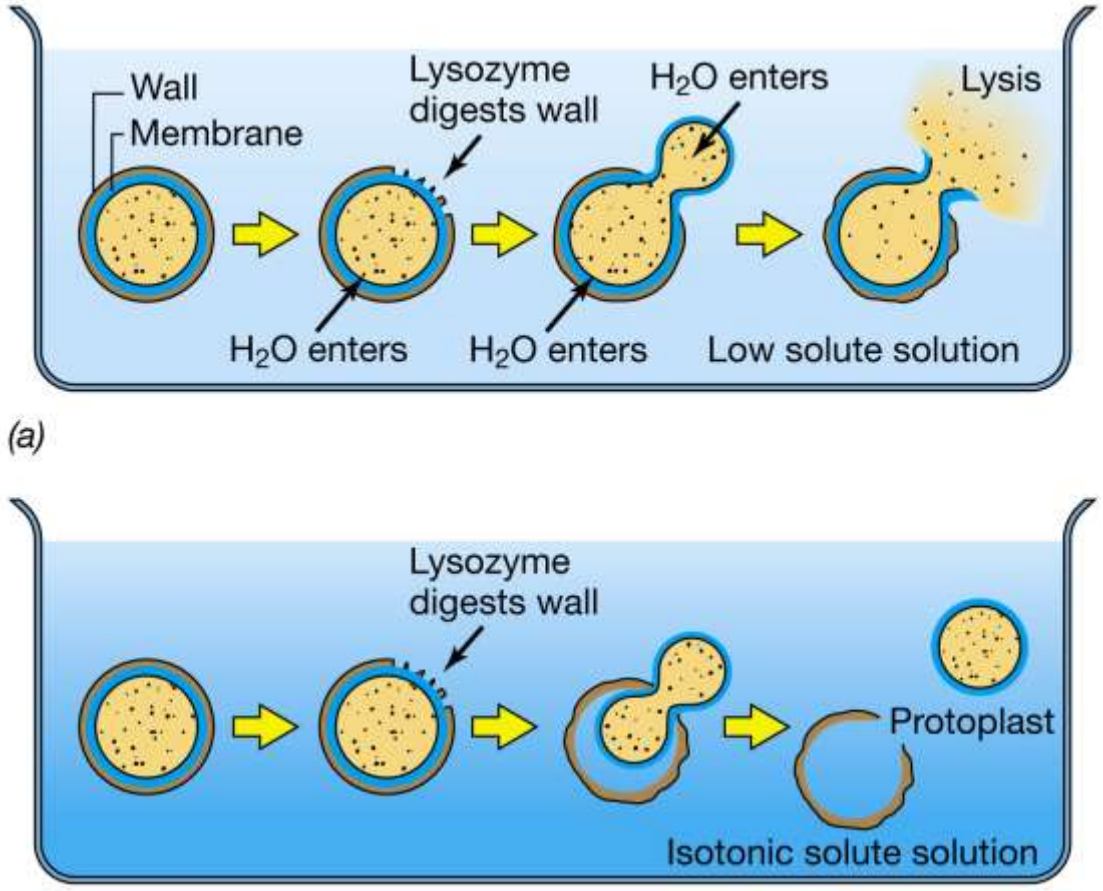
- Tipo más común de pared en Archaea: capa superficial paracristalina, formada por moléculas entrelazadas de proteínas o glicoproteínas
- Puede formar varias simetrías: hexagonal, tetragonal o triméricas
- *Methanocaldococcus jannaschii*, pared formada sólo por capa S.

S-layer with hexagonal symmetry



The S-layer. Transmission electron micrograph of an S-layer fragment showing its paracrystalline nature. Shown is the S-layer from *Aquaspirillum* (*Bacteria*); this S-layer shows hexagonal symmetry common in S-layers of *Archaea*.

Formación de protoplastos



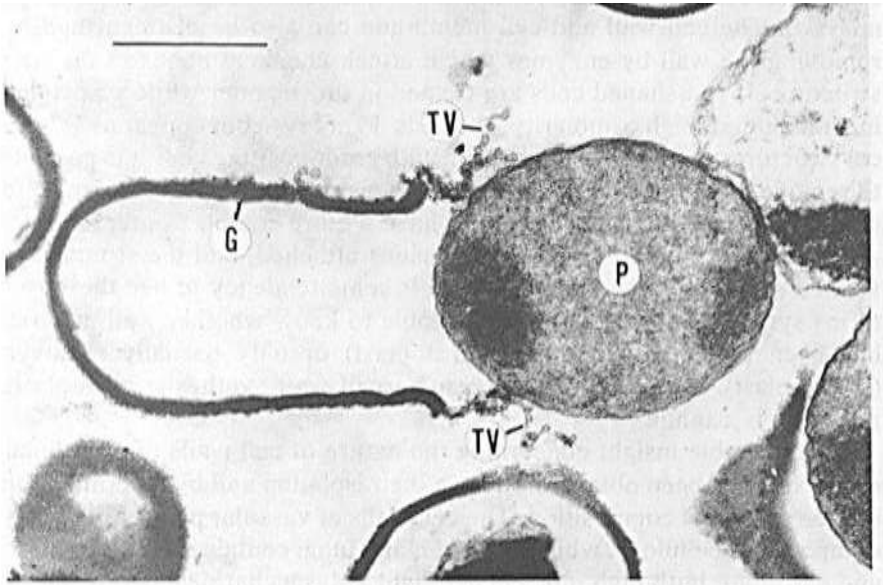


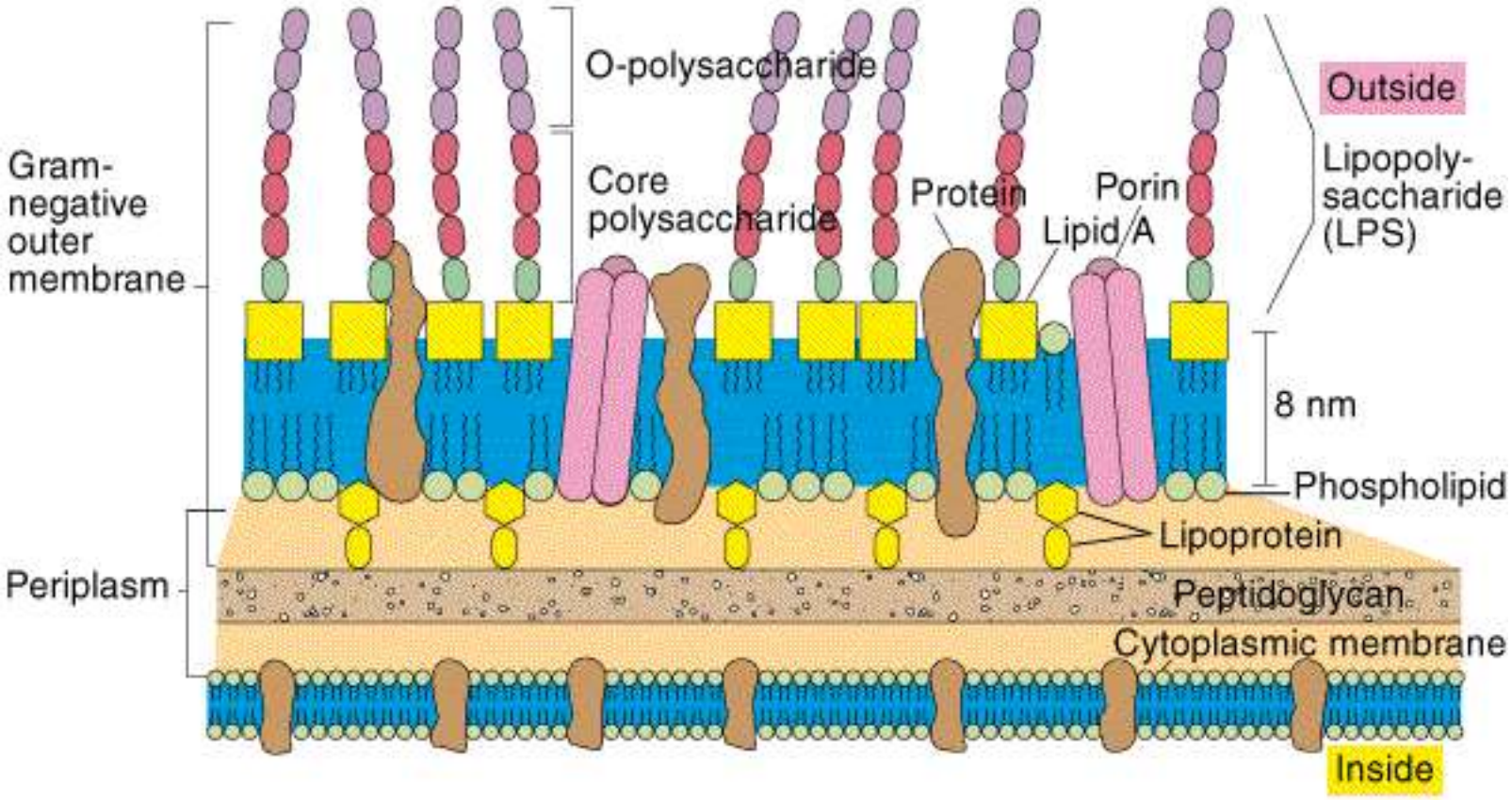
Fig. 2–10. Comparison of cells of *Lactobacillus casei* in the normal state, and after treatment with EDTA followed by treatment with lysozyme in the presence of sucrose and 10 mM $MgCl_2$. Normal cells (upper photograph)

Membrana externa de las bacterias Gram (-)

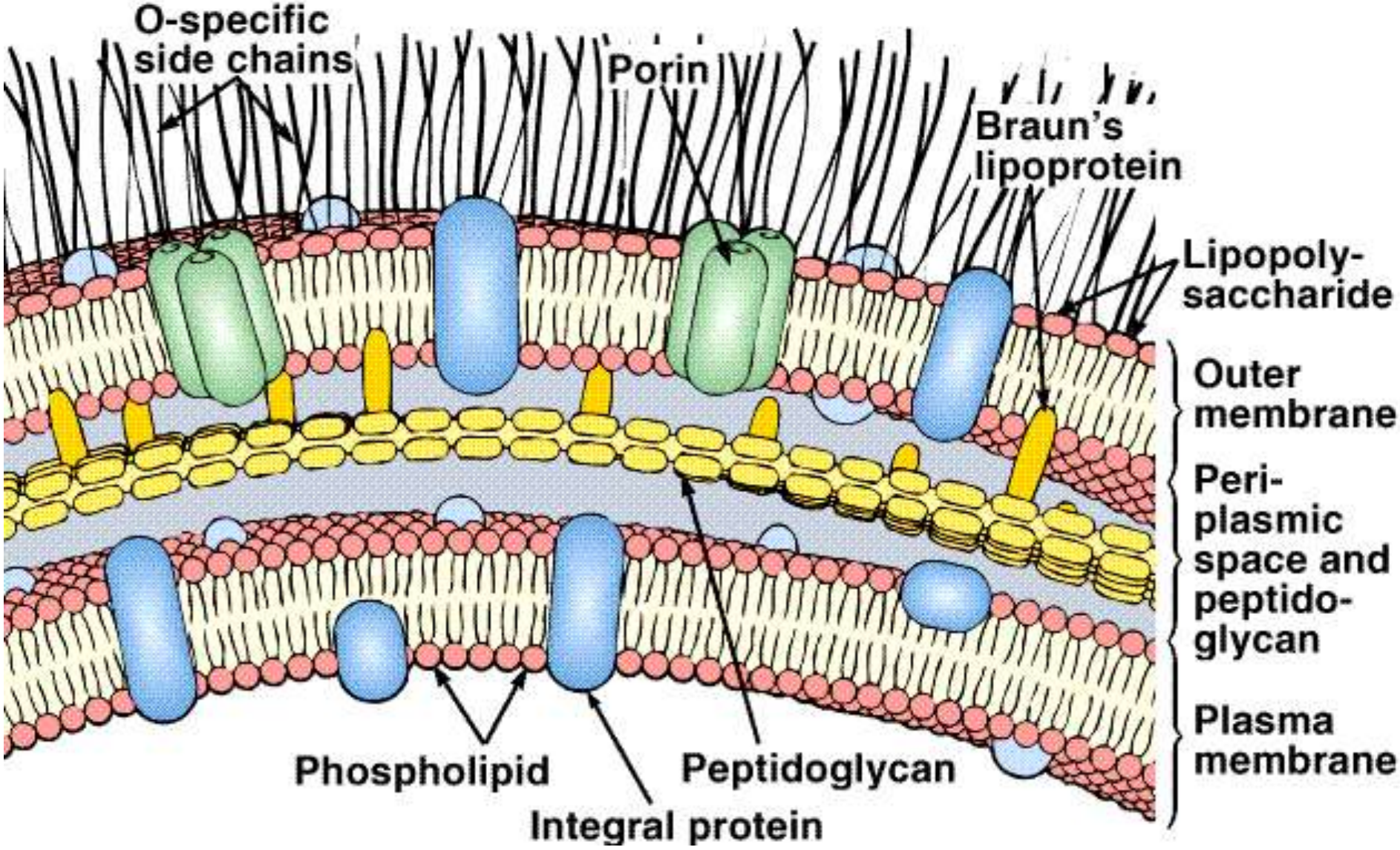
- Además del péptidoglucano presentan una capa adicional en su pared que está compuesta de lipopolisacárido
- Representa una segunda bicapa lipídica, contiene además polisacáridos y proteínas
- La presencia del lipopolisacárido justifica que la membrana externa se denomine generalmente capa de lipopolisacárido o LPS

Composición química del LPS

1. Núcleo polisacárido: Cetodesoxioctonato (KDO), heptosas, glucosa, galactosa y N-acetilglucosamina
2. Polisacárido O: galactosa, glucosa, ramnosa y manosa, además dideoxiazúcares como abecuosa, colitosa, paratosa o tivelosa

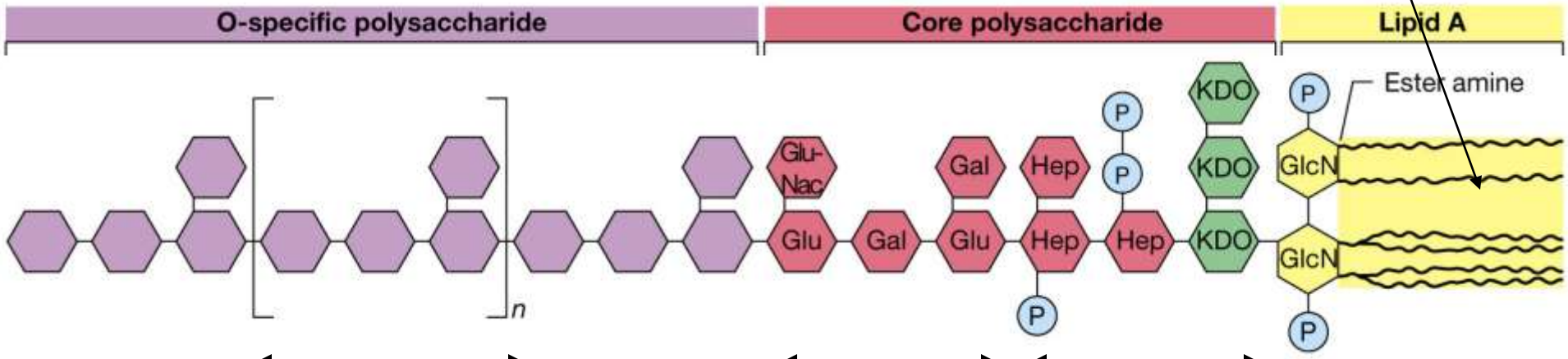

O-polysaccharide
Core polysaccharide
Gram-negative outer membrane
Protein
Porin
Lipid A
Outside
Lipopoly-saccharide (LPS)
8 nm
Phospholipid
Lipoprotein
Periplasm
Peptidoglycan
Cytoplasmic membrane
Inside

Gram-negative Envelope



El lipopolisacárido

A.G. saturados (C-14): beta-hidroximirístico



Unidad repetitiva de la cadena lateral

Núcleo externo

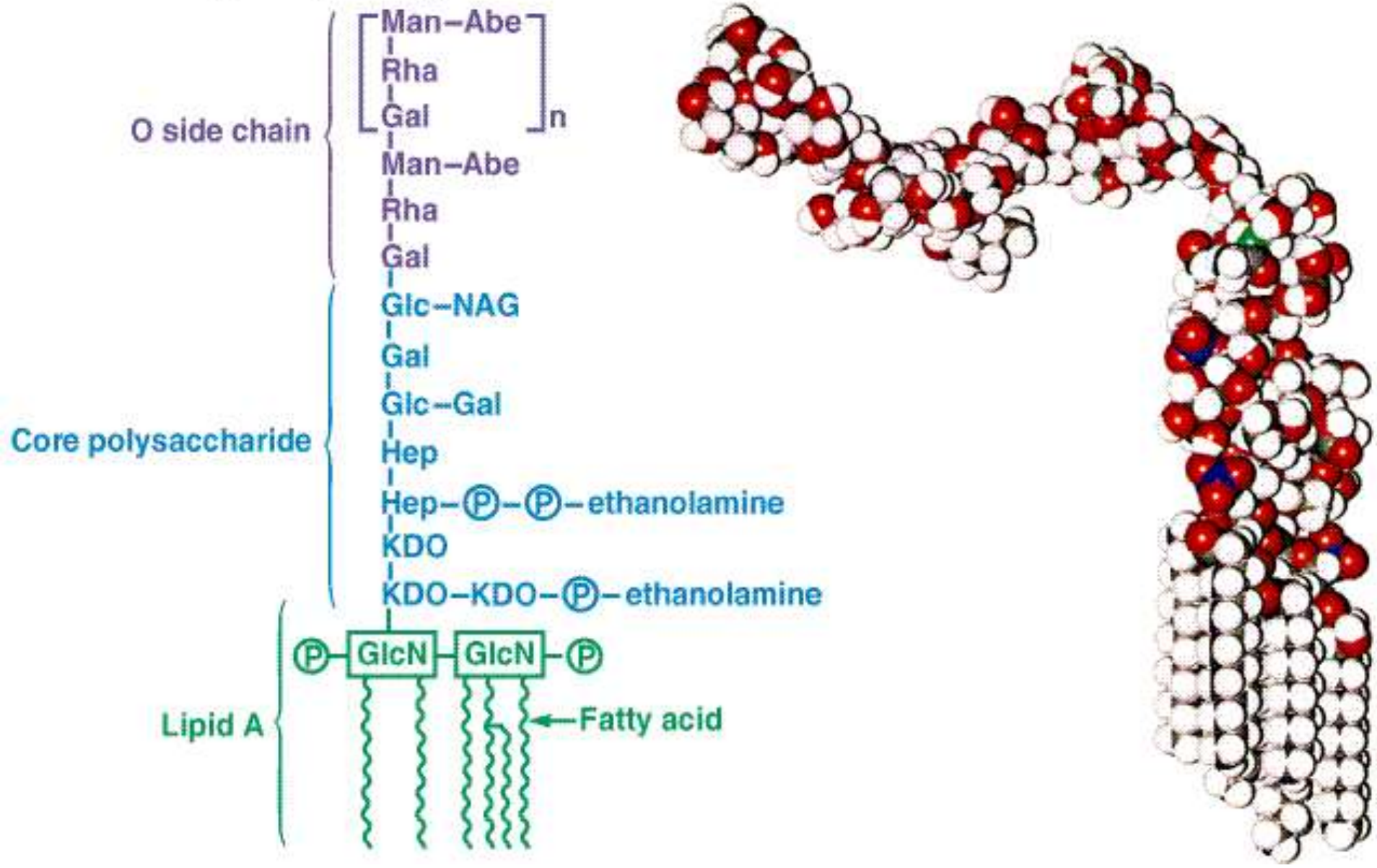
Núcleo interno

Glucosamina-ß(1→6)-glucosamina, con –OH en 1 sustituido con –P-etanolamina

Lípido A

- Es la parte lipídica del lipopolisacárido
- No es un glicerolípido: ácidos grasos se unen a un disacárido compuesto de glucosamina fosfato por enlace ester amina

Lipopolysaccharide Structure

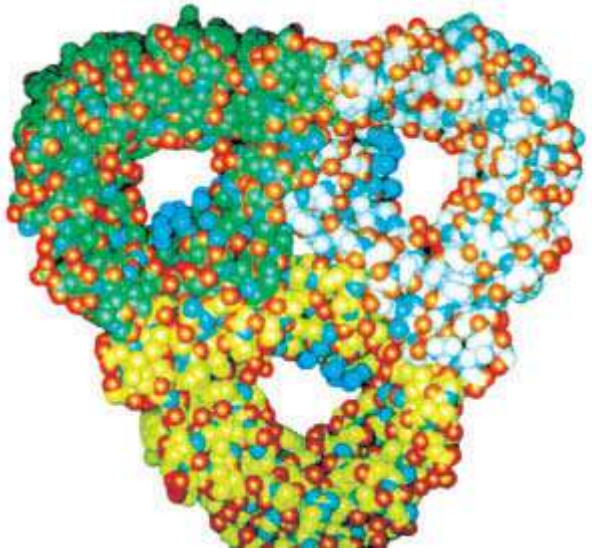


Endotoxina

- Una propiedad biológica importante de la membrana externa es que resulta habitualmente tóxica para animales
- *Salmonella*, *Shiguella* y *E. coli*
- La propiedad tóxica se asocia a una parte de la capa LPS: Lípido A

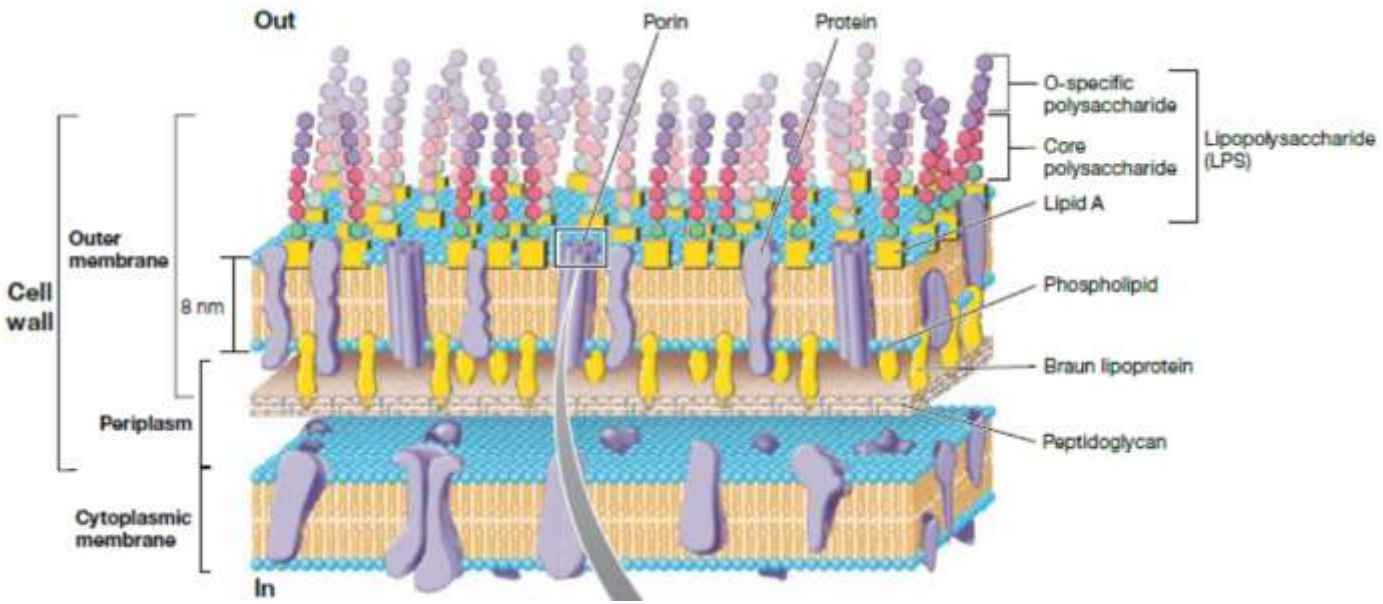
Porinas y zona periplásmica

- La membrana externa de las Gram – es relativamente permeable a pequeñas moléculas
- La membrana externa de las Gram – presenta unas proteínas llamadas Porinas



… porinas y zonas periplásmica

- Actúan como canales de entrada y salida de sustancias hidrofílicas de bajo peso molecular
- Porinas inespecíficas y porinas específicas

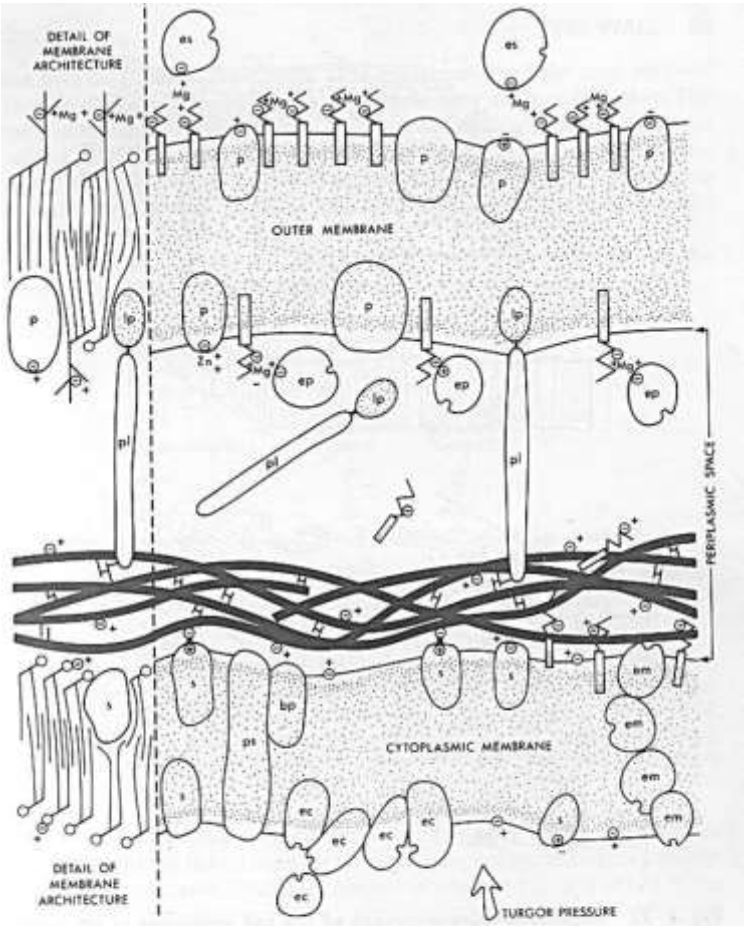


Capa externa, función

- Mantener determinadas enzimas que se hallan fuera de la membrana plasmática evitando su difusión hacia el entorno
- Esta enzimas se encuentran en una zona denominada periplasma, *E*. *coli*: 12 – 15 nm
- Periplasma de Gram – tres tipos de proteínas: enzimas hidrolíticas, proteínas de unión, quimiorreceptores

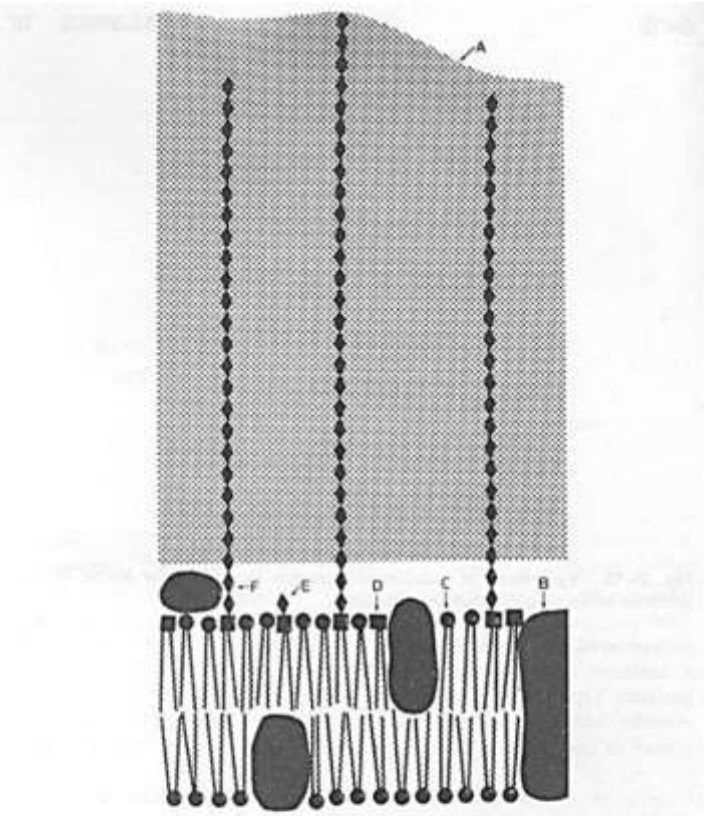
Pared celular y tinción Gram

- Mecanismo de Gram está basado en las diferencias estructurales de las paredes de Gram + y Gram –
- Complejo CV-I_2 que en caso de las Gram – puede extraerse con alcohol pero, no en Gram +
- El alcohol deshidrata la pared de las Gram + que tiene una gruesa capa de péptidoglucano
- Gram – el alcohol penetra rápidamente en la capa externa, la fina capa de péptidoglucano no evita el paso del solvente permitiendo de este modo la eliminación del complejo CV-I_2.



B. GRAM-NEGATIVE

enzymes associated with the cytoplasmic membrane whose function is directed to the cytoplasm; em, enzymes associated with the cytoplasmic membrane which synthesize macromolecular components of the cell wall; ep, enzymes localized in the periplasmic zone; es, enzymes localized at the cell surface; lp, lipid portion of Braun's lipoprotein; p, structural and enzymatic proteins of the outer membrane; pl, protein portion of Braun's lipoprotein; ps, permease; s, structural protein of cytoplasmic membrane. From Costerton, Ingram, and Cheng, 1974.



A. GRAM-POSITIVE

Fig. 2–21. Comparison of the gram-positive (A) and gram-negative (B) cell surfaces. A: Gram-positive cell surface consists of (A) the cell wall, and these membrane components: (B) protein, (C) phospholipid, (D) glycolipid, (E) phosphatidyl glycolipid, and (F) lipoteichoic acid. Depending on the length and conformation of the glycerophosphate chains and the thickness of the wall, the lipoteichoic acid molecules may function as surface antigens. From van Driel et al., 1973. B: Gram-negative cell surface. +, free cation; −, free anion; ⊕, bound cation; ⊖, bound anion; , adhesion point produced by ionic bonding; , hydrophobic zone; , covalent bond; , cross-linking polypeptide in the peptidoglycan; , polysaccharide portion of peptidoglycan; , enzymatically active protein; , phospholipid; , lipopolysaccharide; , lipopolysaccharide (schematic); bp, binding protein; ec,

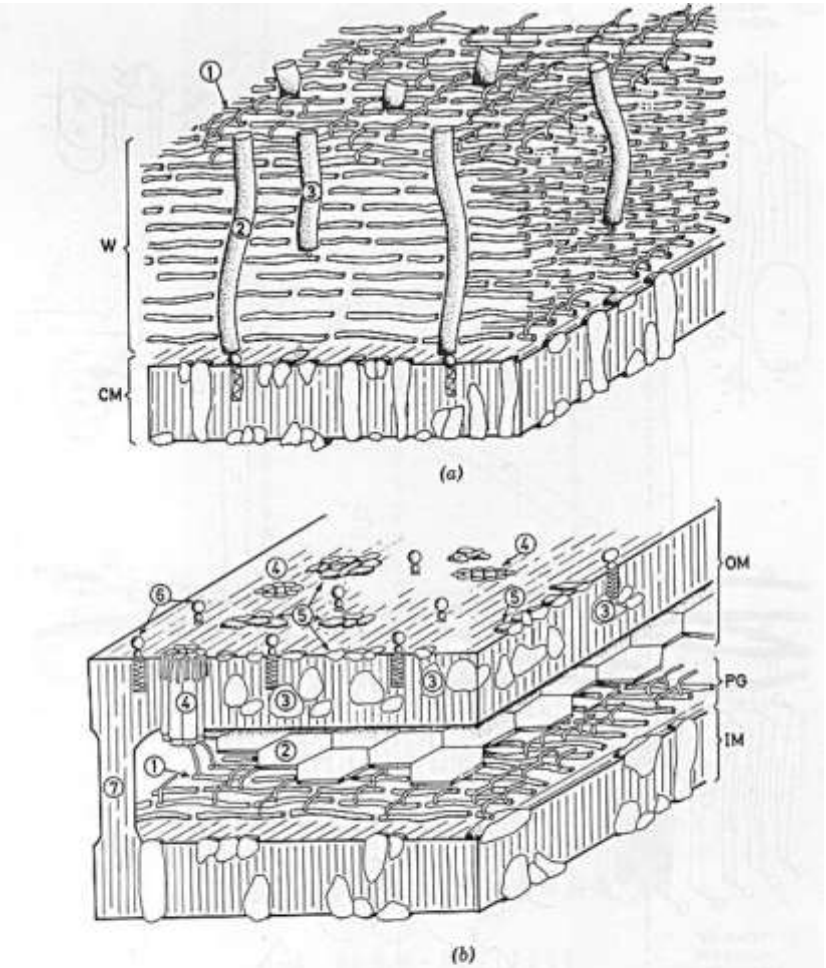


Fig. 2–22. Schematic representations of the cell envelopes of (A) gram-positive and (B) gram-negative bacteria. CM = cytoplasmic membrane; W = wall. The gram-positive wall (A) essentially consists of a thick, multilayered peptidoglycan structure (1) and of anionic polysaccharides (2) and (3). Wall teichoic acids (3) are covalently linked to glycan strands of the peptidoglycan. Lipoteichoic acids (2) are anchored in the cytoplasmic membrane. Depending upon the growth conditions, the wall teichoic acids can be replaced by other anionic polysaccharides (teichuronic acids) which are also linked to the peptidoglycan. Lipoteichoic acids are permanent constituents of the cell envelope. They are not dependent upon growth conditions. The gram-negative cell envelope contains IM, inner (cytoplasmic) membrane;