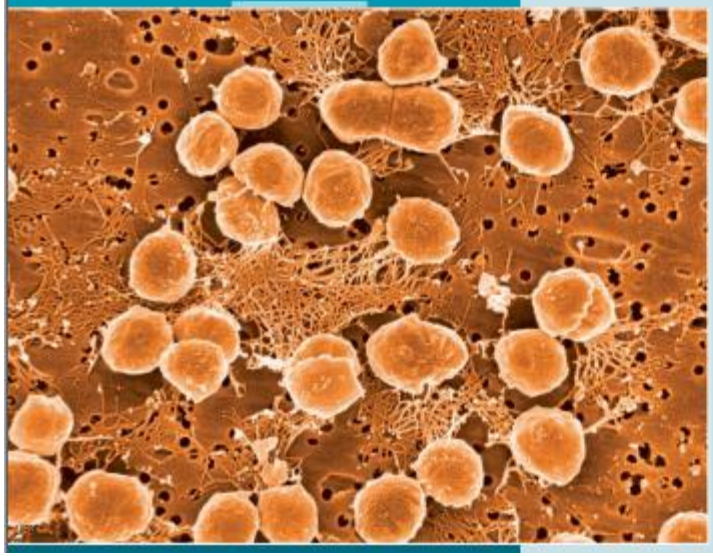

بسم الله الرحمن الرحيم

Microbial Cell Structure and Function



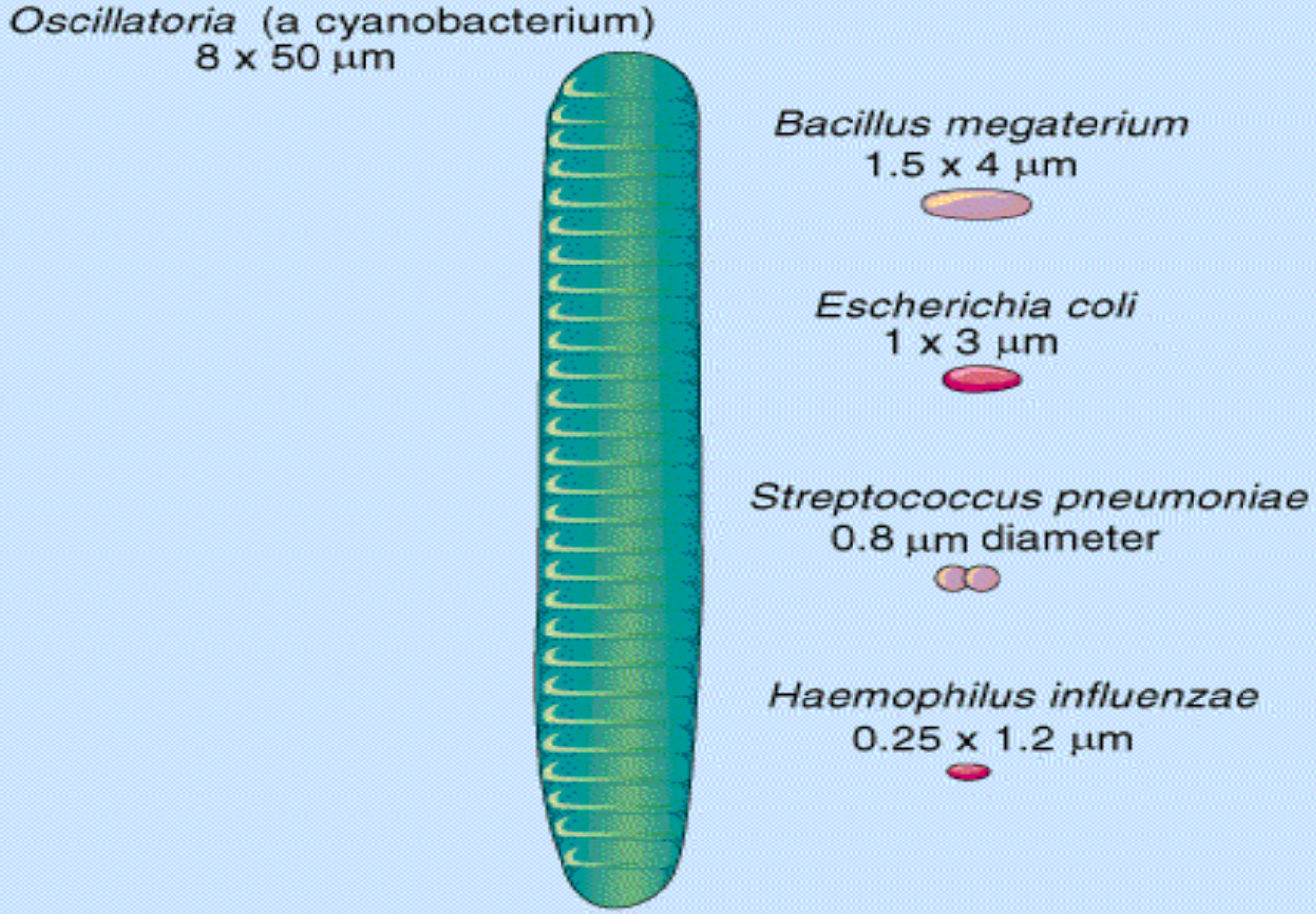
Structure of Bacteria

Size of Bacteria

Shapes of Bacteria

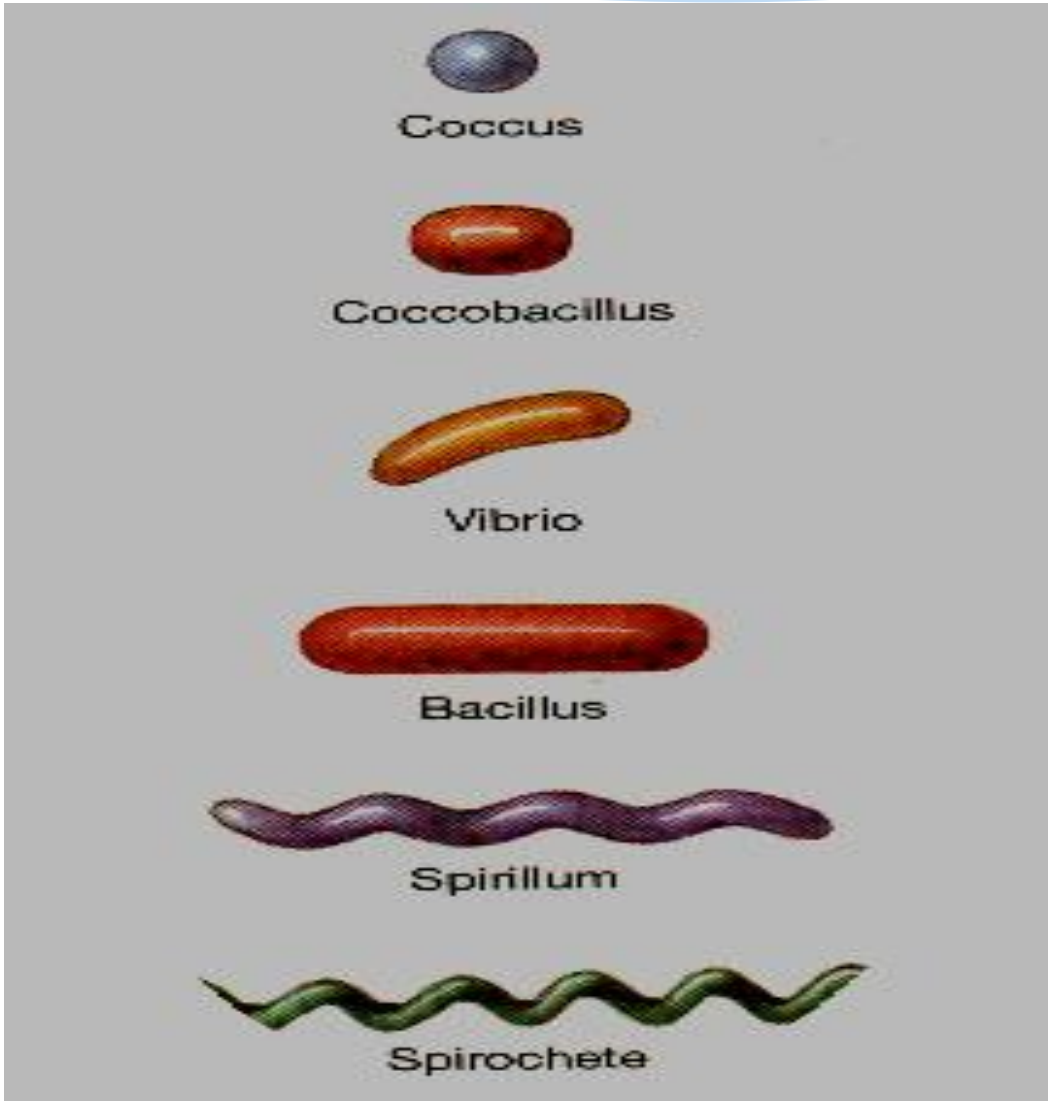
Bacterial Structures

SIZE - 0.25-1 µm width
1-3 µm length

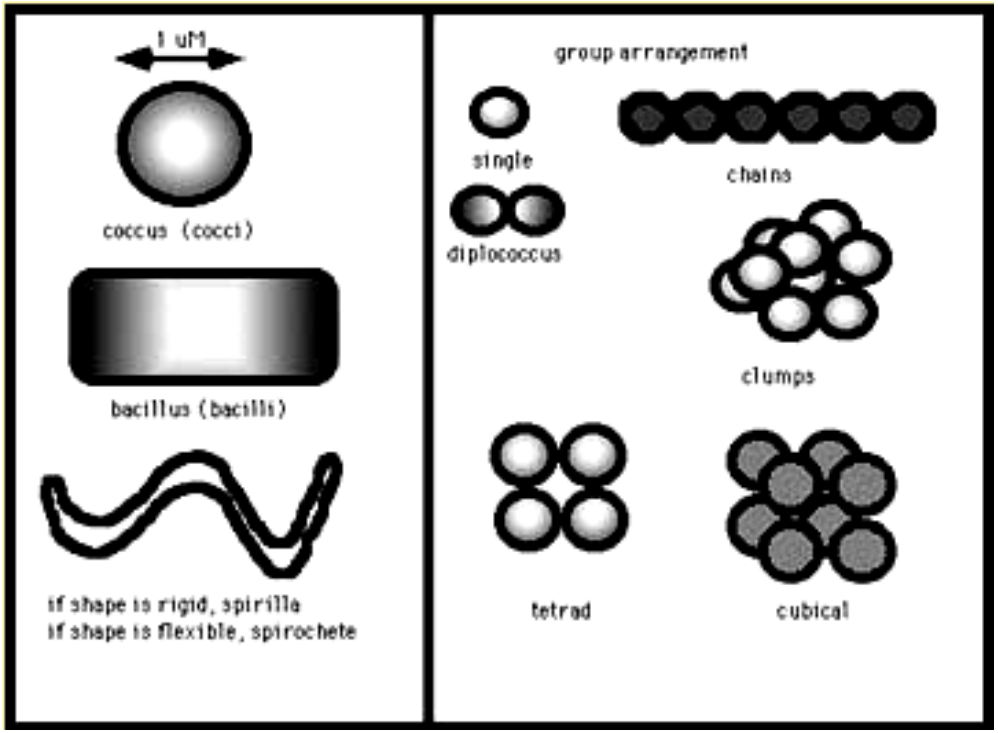


❖SHAPE

- ❖ cocci
- ❖ Bacilli
- ❖ Coccobacilli
- ❖ Vibrio = curved
- ❖ Fusiform
- ❖ Spiral
- ❖ Spirochate
- ❖ Square
- ❖ Star
- ❖ Filamentous

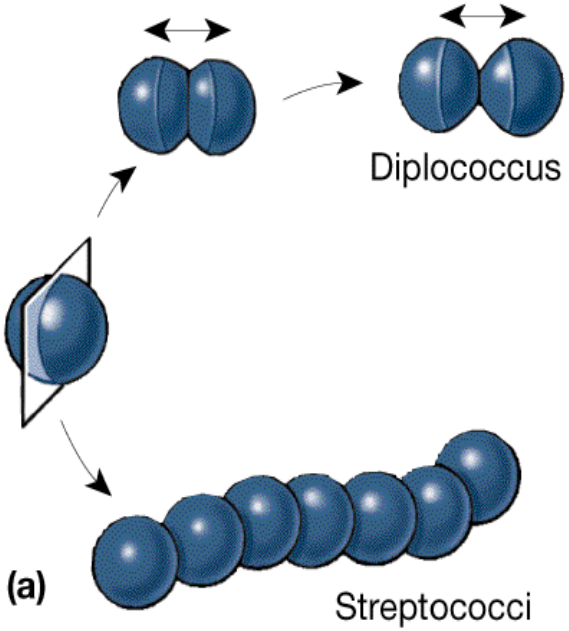


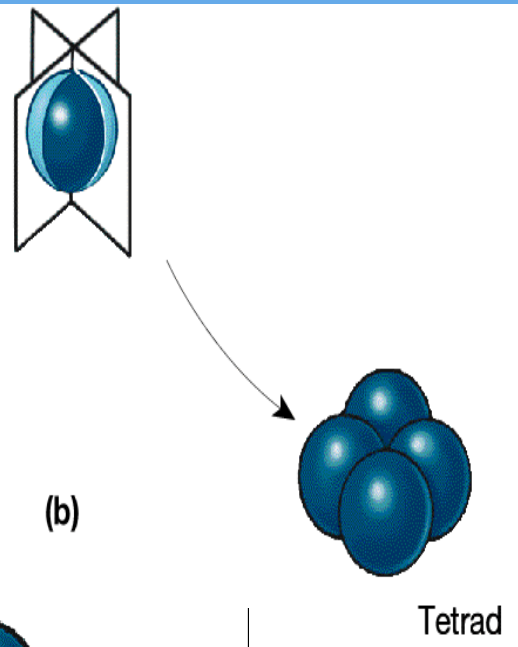
Bacterial Morphology Arrangement

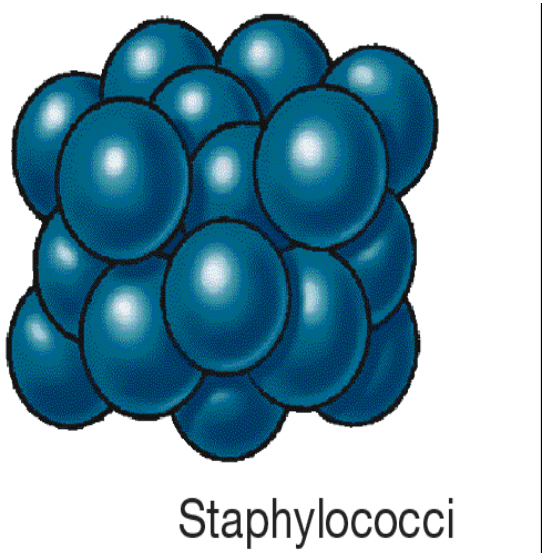


1. Bacilli
   a.Streptobacilli
   b. Bacilli

2. Cocci
   a. Cocci
   b. Doplococci
   c. Streptococci *chain
   d. Staphylococci* cluster
   e. Sarcina* packets of eight

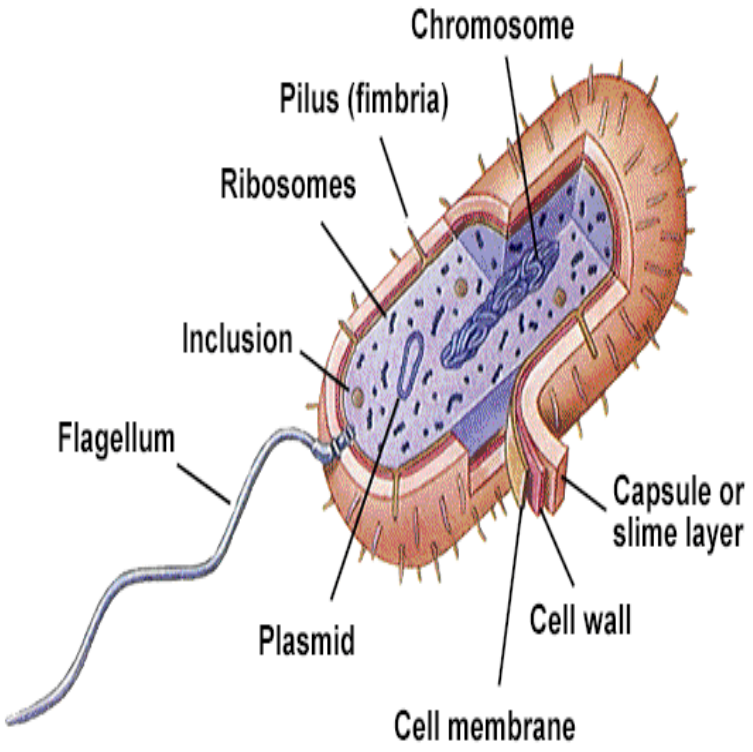

Diplococcus
(a)
Streptococci


(b)
Tetrad


(d)
Staphylococci

Bacterial Structures

- Flagella
- Pili
- Capsule
- Plasma Membrane
- Cytoplasm
- **Cell Wall**
- ***Lipopolysaccharides***
- ***Teichoic Acids***
- Inclusions
- Spores



Cell Wall

►**Determine shape of bacteria**

►**Strength prevents osmotic lysis:** **Accumulation of solutes inside the prokaryotic cell cytoplasm" 10-250atm**

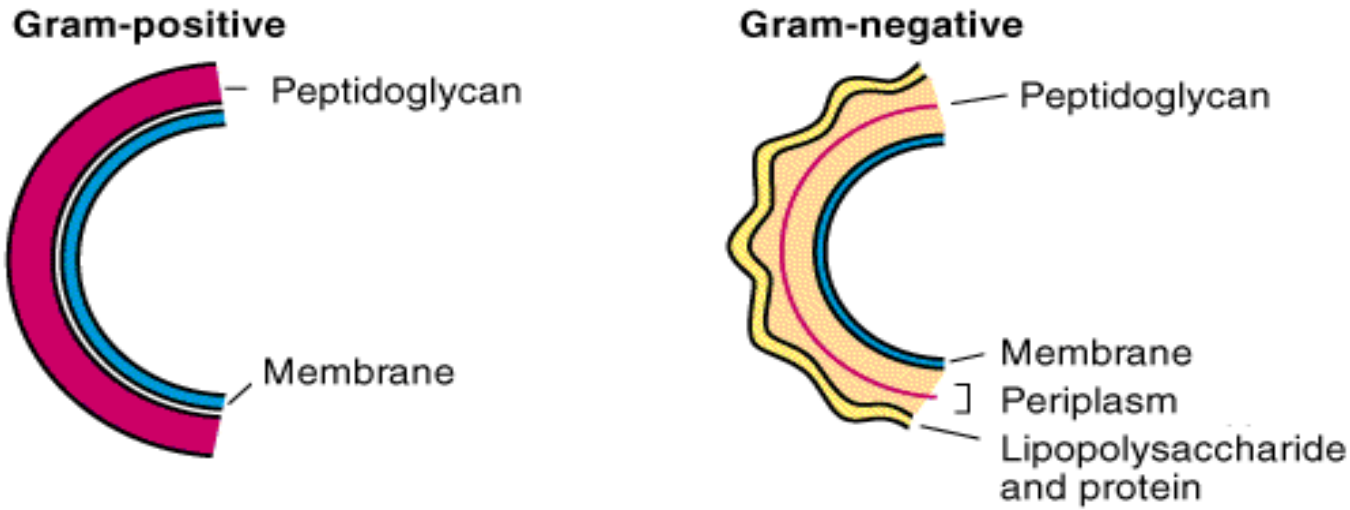
►**Unique to bacteria:** **Murine is a unique type of peptidoglycan, a polymer of disaccharides (glycan) cross-linked by short chains of amino acids (peptide): N-acetylmuramic acid**

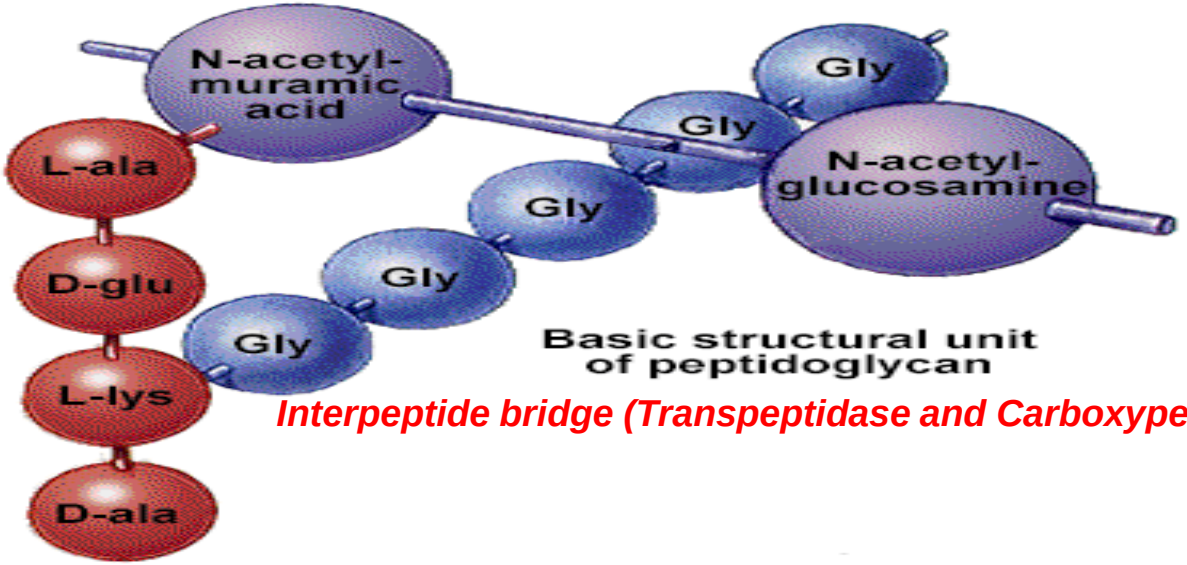
►**Important sites for attack by antibiotics**

►**Ligands for adherence and receptor sites for drug or viruses**

►**Immunological distinction and immunological variation among strains of bacteria**

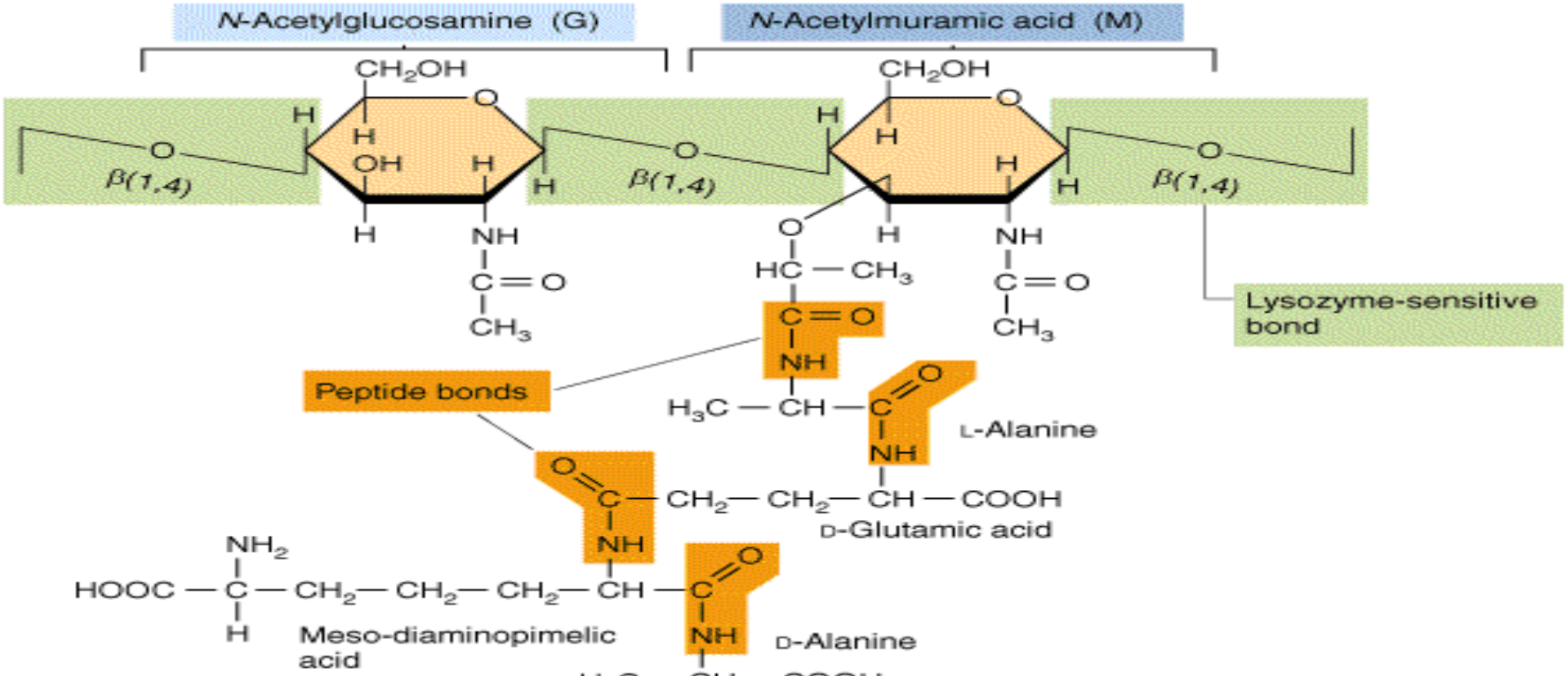
Cell walls of bacteria



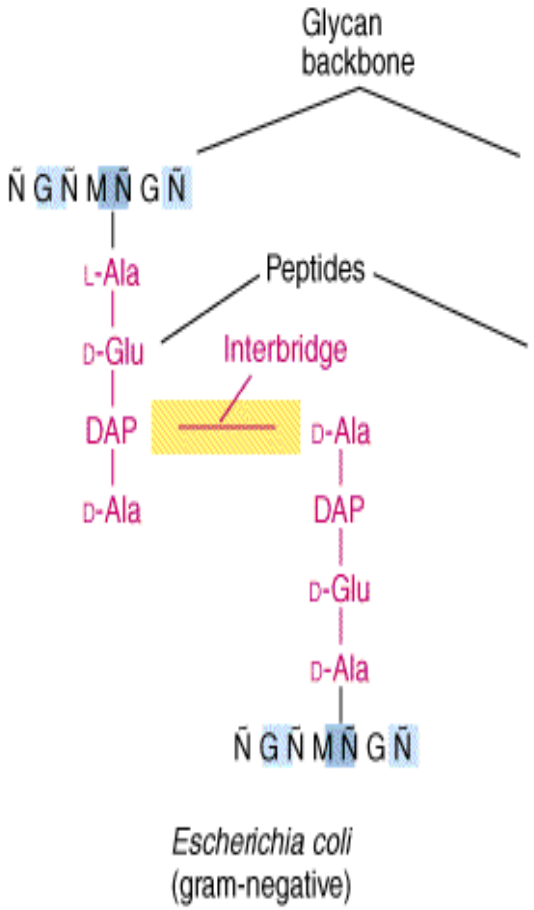


Basic structural unit of peptidoglycan

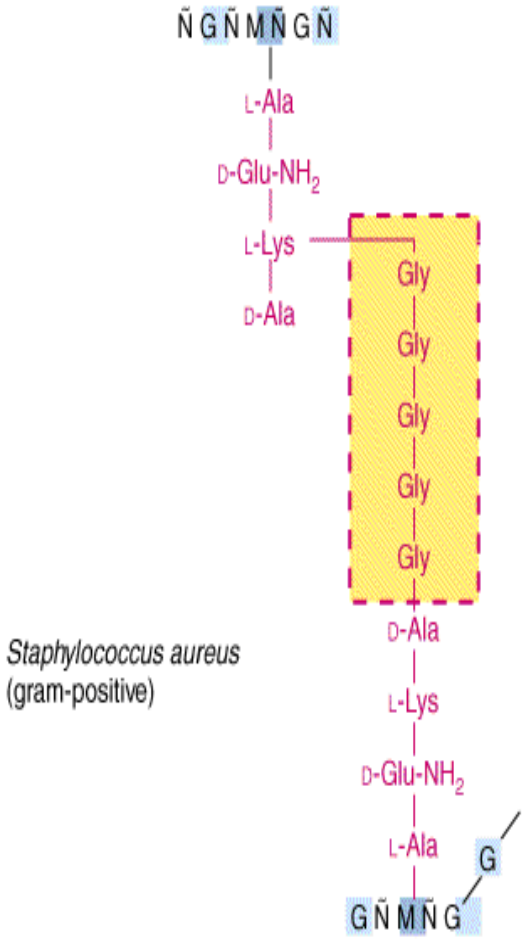
Interpeptide bridge (Transpeptidase and Carboxypeptidase)



Structure of peptidoglycan



Escherichia coli
(gram-negative)



Staphylococcus aureus
(gram-positive)

Gram positive bacterial cell wall

Thick peptidoglycan layer

pentaglycin cross linkage.

Teichoic acid: ribitol TA & glycerol TA

Some have peptioglycan

teichoic acid.

All have lipoteichoic acid.

Function of TA:

* Antigenic determinant

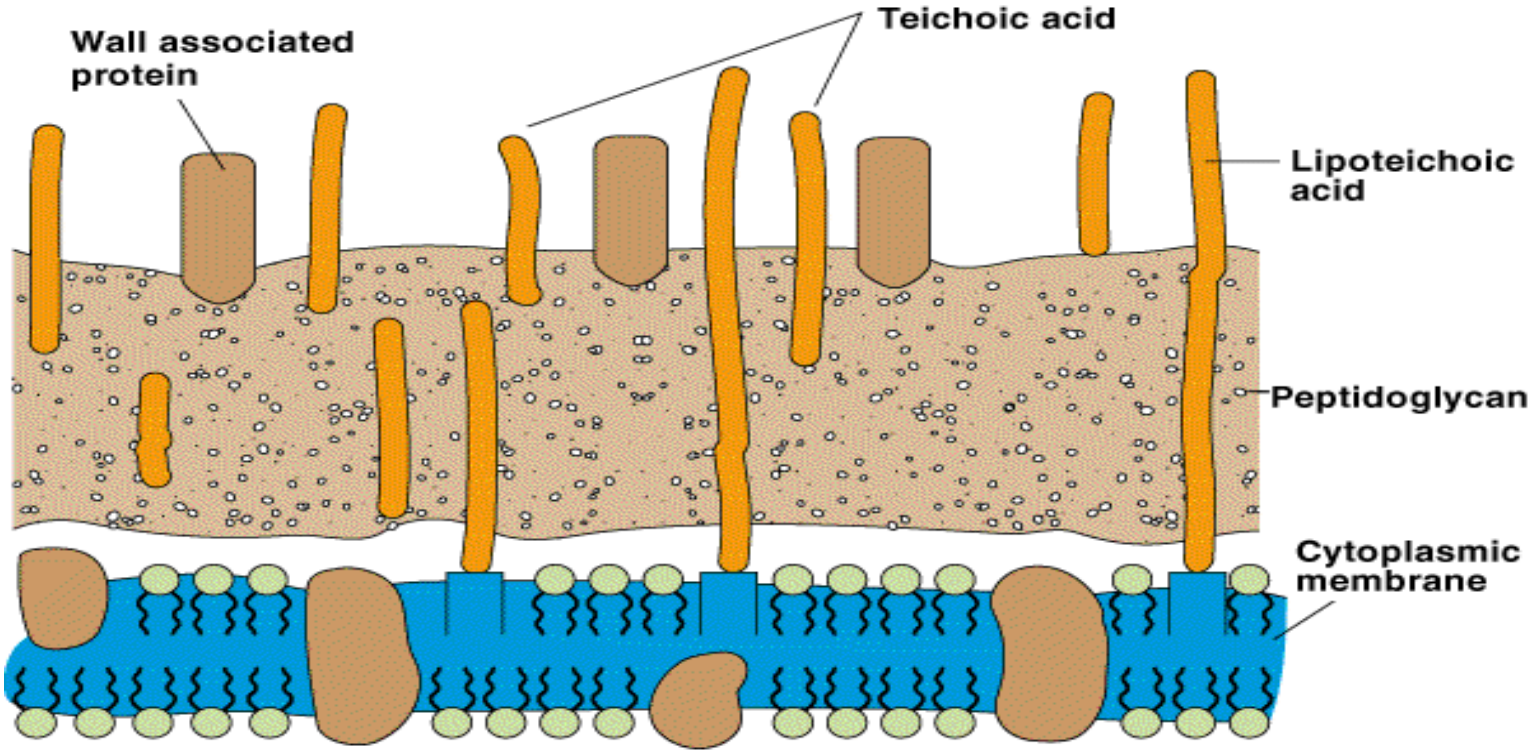
* Participate in the supply of Mg to the cell by binding Mg**++**

- regulate normal cell division.
- **Attachment for Phages**

Gram Positive Bacteria

PG + Teichoic Acids

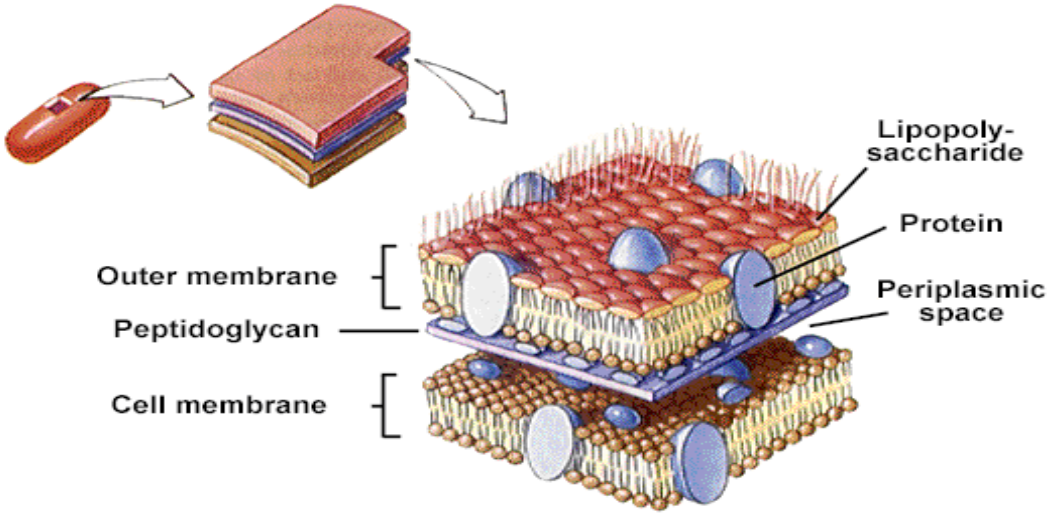
- Gram + only
- Glycerol, Phosphates, & Ribitol
- Attachment for Phages



Gram Negative Bacteria

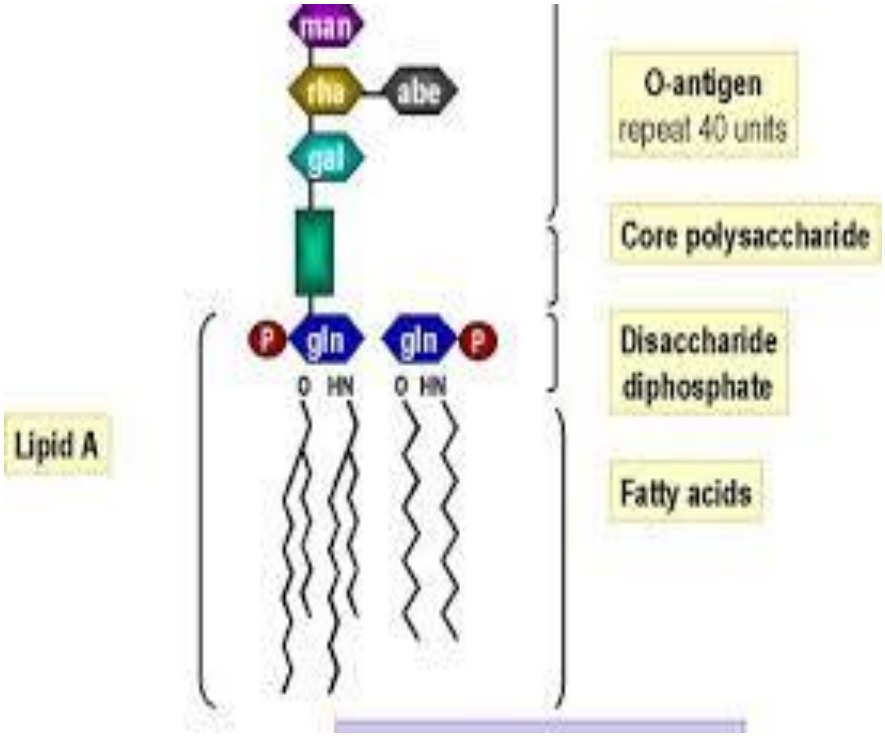
PG + Lipopolysaccharide (LPS) + Lipoprotein + Periplasmic Space+ Outer Membrane

- **Endotoxin or Pyrogen**
  - **Fever causing**
  - **Toxin nomenclature**
- **Structure**
  - **Lipid A**
  - **Polysaccharide**
    - **O Antigen**
- **G- bacteria only**



O antigen: An outer polysaccharide consisting of up to 25 repeating units of 3-5 sugars. These are hydrophilic in nature. O antigen is highly varied among species.

A core polysaccharide of fiver sugars linked through ketodeoxyoctulonate (KDO) to lipid A.



A phospholipid called Lipid A; It embeds Lipolysaccharide layer in the outer leaflet. Also known as endotoxin, it is responsible for toxic effects (fever and shock and coagulation). Generally it is not released until death of cell. Exception: *Neisseria meningitidis*, which over-produces outer membrane fragments.

Note: LPS is heat stable and not strongly immunogenic so it cannot be converted to a toxoid.

Mechanism of Action:

LPS activates macrophages, leading to release of TNF-alpha, IL- 1 , and IL-6. IL-1 is a major mediator of fever.

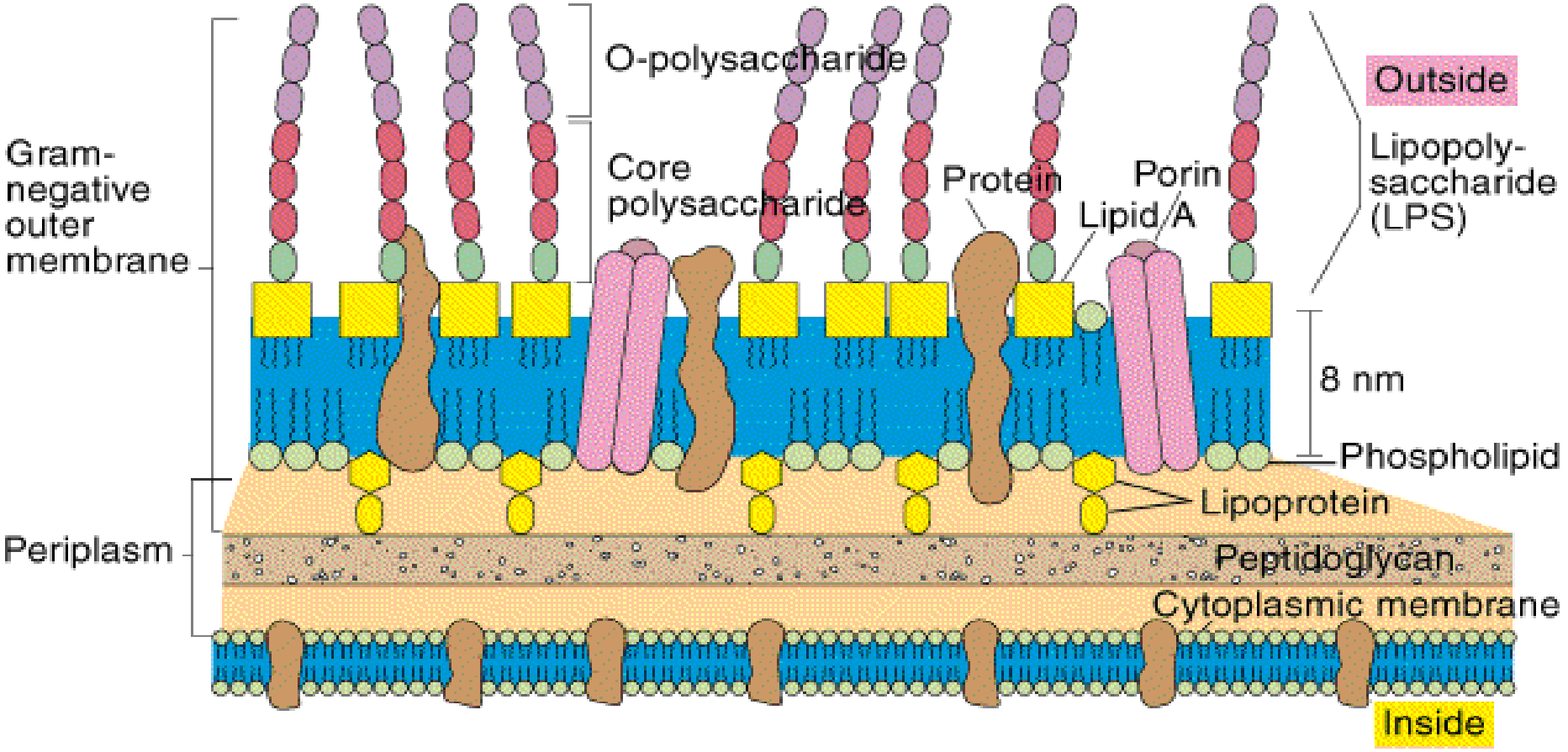
Macrophage activation and products lead to tissue damage.

Damage to the endothelium from bradykinin-induced vasodilation leads to septic shock.

Coagulation (DIC) is mediated through the activation of Hageman factor (Factor 12).



Limulus amebocyte lysate (LAL) is an aqueous extract of blood cells (amoebocytes) from the blue-blooded horseshoe crab, Limulus polyphemus. LAL is being used for endotoxin detection.


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

Periplasmic space

The area between the external surface of rhe cytoplasmic membrane and the internal surface of the outher membrane

A variety of hydrolytic enzymes
Breakdown of large macromolecules for metabolism
Lytic virulence factors (collagenases, hyalurodidases, proteases, beta-lactamases)
Components of sugar transport system

Outer membrane

- Unique to gram-negative-bacteria
- Maintains the bacterial structure
- Permeability barrier to large molecules and hydrophobic molecules
- Provides protection from adverse environmental conditions

Lipopolysaccaride

Porins: transmembrane proteins they form pores allow diffusion of hydrophilic molecules

Structural proteins and receptor molecules for bacteriophages

Disruption of the outher membrane

- Weakens the bacteria
- +lysozyme
- Spheroplasts (osmotically sensitive) are formed

- Protoplast.

Property	Gram-positive	Gram-negative
Thickness of wall	thick (20-80 nm)	thin (10 nm)
Number of layers	1	2
Peptidoglycan (murein) content	>50%	10-20%
Teichoic acids in wall	present	absent
Lipid and lipoprotein content	0-3%	58%
Protein content	0	9%
Lipopolysaccharide content	0	13%
Sensitivity to Penicillin G	yes	no (1)
Sensitivity to lysozyme	yes	no (2)

Bacterial exceptions

- Mycobacteria
- Corynebacterium
- Nocardia
- Mycoplasmas

Cord factor
Wax D
Sulfolipids
Acid-fast staining

- Corynebacterium
- Nocardia

Produce mycolic acid lipids.

How Do Bacteria Grow?

Stationary phase is entered when nutrient levels are too low to sustain growth.

Some cells dividing some cells multiplying. How? Living off the dead cell



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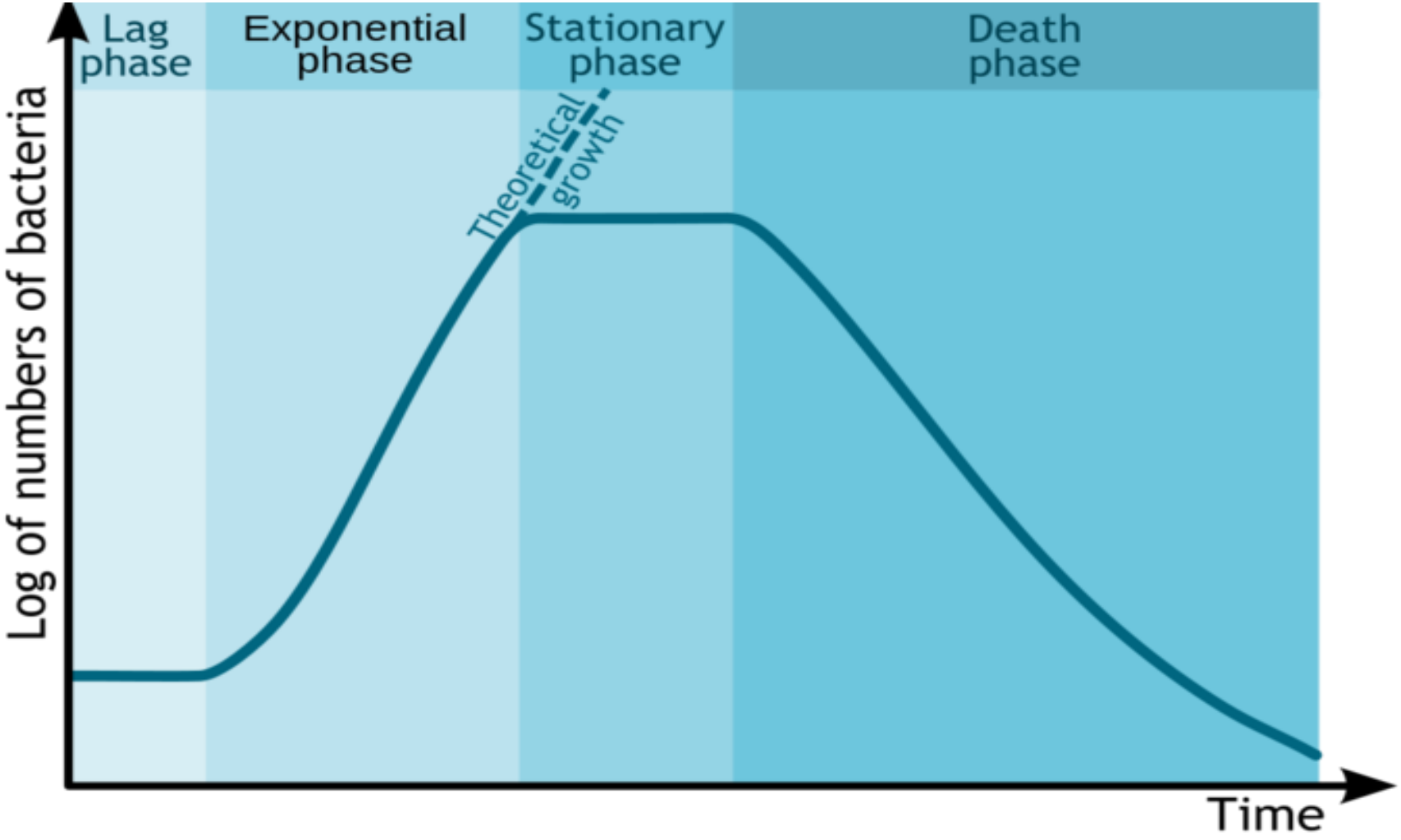
Phase 3: **Stationary phase** -number of living cells stays relatively constant as the level of nutrients declines and waste products increase


Lag phase
Exponential phase
Stationary phase
Death phase
Theoretical growth
Log of numbers of bacteria
Time

Factors affecting bacterial growth are:

1. Oxygen requirement.
2. Temperature requirement.
3. PH
4. Osmotic pressure (salt tolerance).

1) Oxygen requirement:

Aerotolerant anaerobes

Capnophiles

Bacteria are divided into four groups according to oxygen requirement:

1. Bacteria grow only in the presence of oxygen, called: **strict aerobes.**
2. Bacteria grow only in the absence of oxygen, called: **strict anaerobe**.
3. Bacteria grow in the presence or absence of oxygen, called: **facultative anaerobe**.
4. Bacteria grow in a little amount of oxygen, called: **micro aerophilic**

Bacteria can be classified by their optimal growth temperature. The following are the five classifications:

►*Hyperthermophile* (60 degrees C and upwards)
Thermodesulfobacterium, Aquifex, Pyrolobus fumari, Thermotoga

►*Thermophile* (optimal growth between 45 and 122 degrees)
Streptococcus thermophiles, Bacillus stearothermophilus, Thermus aquaticus

► *Mesophile* (20 and 45 degrees C)
coli, Salmonella, Klebsiella, Staphulococci

► *Psychrotrophs* (will survive at 0 degrees C, but prefer mesophilic temperature
Vibrio psychroerythrus, vibrio marinus, Polaromonas vaculata, Psychroflexus

Classification of bacteria on the basis of optimum pH of growth

1. Acidophiles: Those bacteria that grow best at acidic pH The cytoplasm of these bacteria are acidic in nature. Some acidopiles are thermophilic in nature, such bacteria are called Thermoacidophiles. Examples: Thiobacillus thioxidans, Thiobacillus, ferroxidans, Thermoplasma, Sulfolobus

2. Alkaliphiles:Those bacteria that grow best at alkaline pH Example: vibrio cholerae: oprimum pH of growth is 8.2

3. Neutriphiles: Those bacteria that grow best at neutral pH (6.5-7.5)
   Most of the bacteria grow at neutral pH Example: E. coli

Classification of bacteria on the basis of salt requirement

Halophiles:

Halotolerant

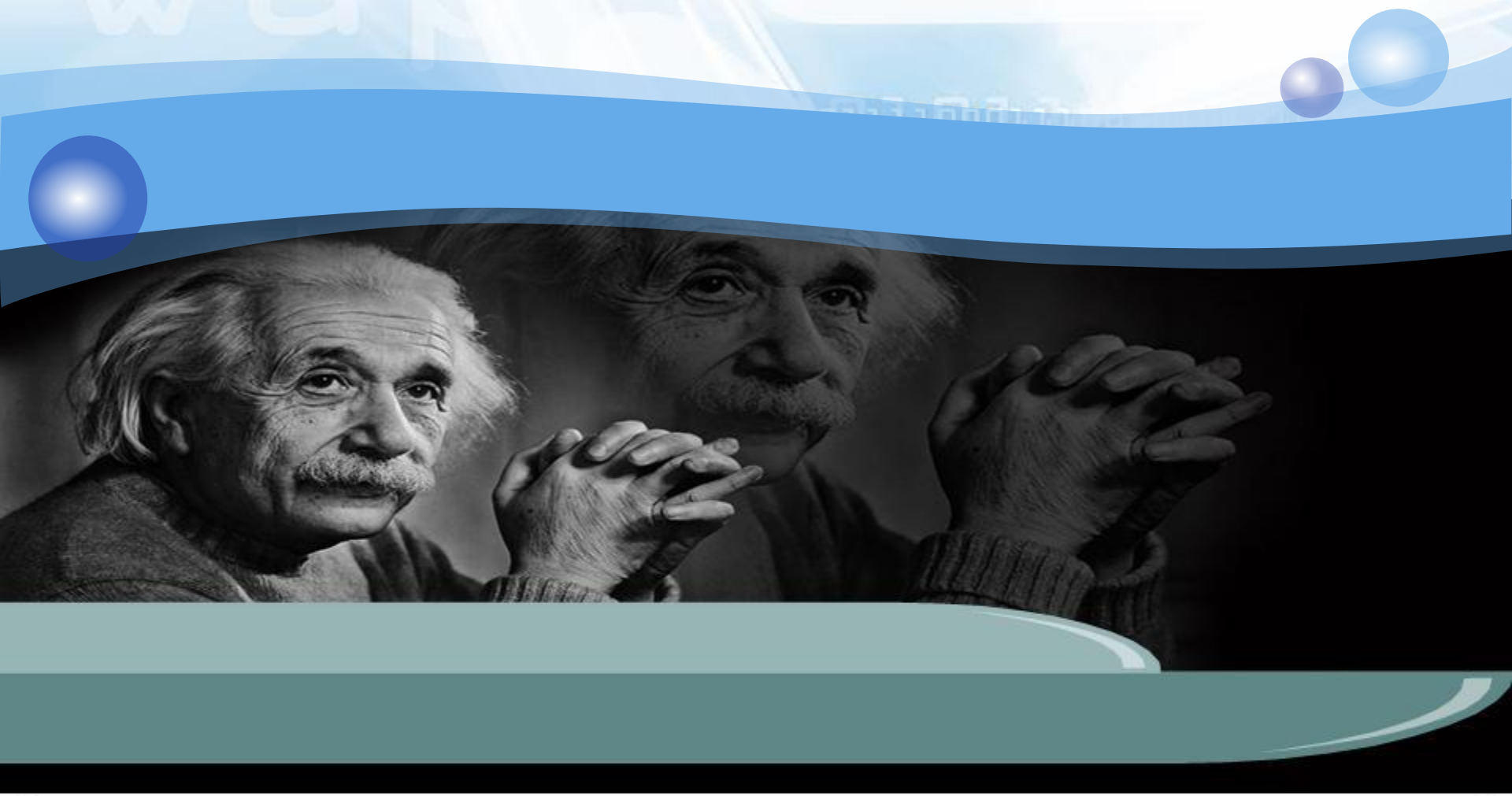
External structures

- Capsule
- Pili
- Flagellum

Spores

Prokaryotes vs. Eukaryotes

- ***Cell Wall***
- ***Teichoic Acids***
- ***LPS***
- ***Endospores***
- ***Circular DNA***
- ***Plasmids***



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