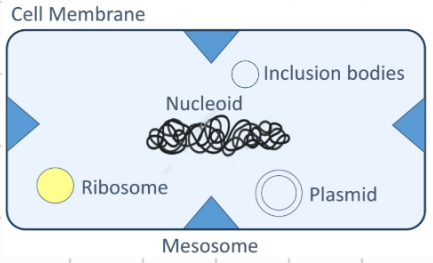
DOPAMINE
SCIENTIFIC TEAM

بسم الله الرحمن الرحيم

Bacterial Structure

① Intracytoplasmic structure

Essential structures
- Nucleoid
- Ribosome
- Cell membrane



Non-essential structures
- Inclusion granules
- plasmid
- Mesosomes

a- Nucleoid

single circular supercoiled chromosome (dsDNA)

CARRY GENETIC INFO. for GROWTH & SURVIVAL

* Bacteria don't have nuclear membrane, so the nucleoid exists in the cytoplasm.

b- Ribosome

site of protein synthesis

bacterial ribosome's type is 70S according to density (50+30)

human ribosome's type is 80S (60+40)

Scientists used this density difference to develope antibiotics

c- Inclusion granules

Store of nutrients (glycogen, starch, ...)

- Volutin (Metachromatic) granule mainly stores phosphate in its inclusion bodies

d- Mesomes

part of the plasma membrane, can perform many functions:

- contain respiratory enzymes responsible for making energy (as mitochondria)
- Septal mesosomes participate in cell devision.

e- Cell wall

Thin, fragile membrane (phospholipid bilayer + proteins), located just inside the cell wall. contains NO Sterols except Mycoplasma.

Functions

- Selective transport (passive active)
- Making energy via mesosomes
- Cell devision with septal mesosomes
- Biosynthesis of the cell wall
- Excretion of hydrolytic enzymes for digestion
- Excretion of extracellular enzymes (penicillinase) to defend themselves against some antibiotics
- Chemotactic system.

f- plasmid

EXTRA circular chromosomal dsDNA

↳ is NOT a part of bacterial chromosome

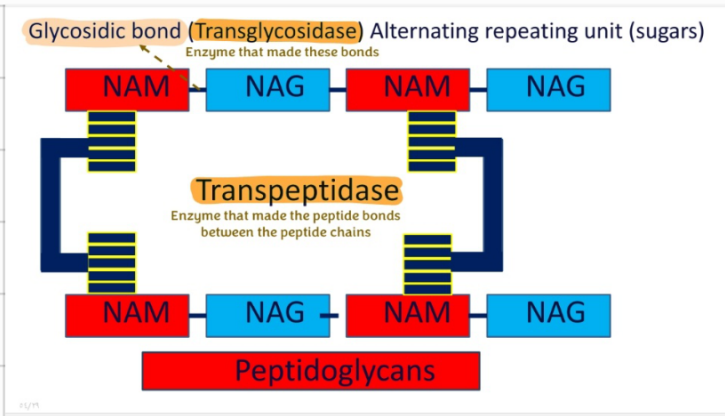
WHY ? 

Because it replicates independently on the bacterial chromosome (autonomously)

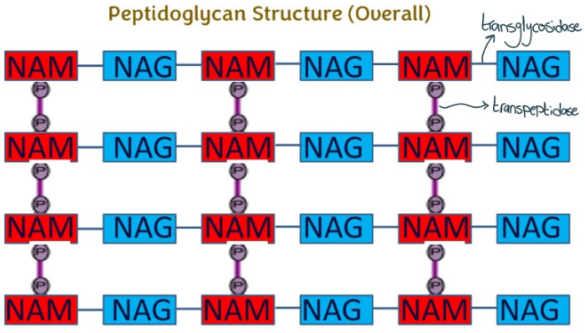
Its genetic function is toxin production for drug resistance.

Feature	Nucleoid	Plasmid
Structure	Irregularly-shaped, dense region containing chromosomal DNA	Small, circular, double-stranded DNA molecule
Type of DNA	Chromosomal DNA (essential for cell survival)	Extrachromosomal DNA (non-essential, but advantageous)
Genetic Content	Contains most of the genes needed for cell growth, metabolism, and reproduction	Carries additional genes, such as those for antibiotic resistance or virulence
Replication	Replicates once per cell cycle during cell division	Can replicate independently of the nucleoid
Transferability	Not transferable between cells directly	Often transferred between cells via conjugation (horizontal gene transfer)
Importance	Essential for cell survival	Provides survival advantages under specific conditions

Cell Wall



A rigid layer of peptidoglycans surrounding the cell membrane



Functions

- Maintenance of cell shape
- Protection osmosis insensitive
- Target site for antibiotics (penicillin & cephalosporines)
- Cell devision
- Responsible for staining

Hans Gram

Gram stain devides bacteria into 2 main groups — purple: Gram+ / pink: Gram-

⇒ Composition of Gram (-) :

1. A thin layer of peptidoglycan (2 sheets)

2. Outer membrane :
   a) Bilayer phospholipids
   b) Lipopolysaccharides
      - Lipid A (Endotoxin)
      - polysaccharides (somatic O antigen)
      - porins (hydrophilic proteins) - for transportation

3. periplasmic space consisting of peptidoglycan layer & gel-like protein
   ↳ between cytoplasmic & outer membranes

Note

TNF-α & IL-1 are cytokines released after detecting the antigen in immunogenic respones in Gram(+) stain.

Feature	Gram-Positive Bacteria	Gram-Negative Bacteria
Cell Wall Composition	Thick peptidoglycan layer (20-80 nm)	Thin peptidoglycan layer (2-7 nm)
Outer Membrane	Absent	Present, containing lipopolysaccharides (LPS)
Teichoic Acids	Present (in peptidoglycan and membrane)	Absent
Staining Reaction	Retains crystal violet dye (appears purple)	Does not retain crystal violet (appears pink/red with safranin)
Periplasmic Space	Usually absent or very small	Present between outer and inner membranes
Sensitivity to Antibiotics	More sensitive to penicillin and lysozyme	Less sensitive due to outer membrane
Toxins Produced	Mostly exotoxins	Primarily endotoxins (LPS) and some exotoxins
Examples	*Staphylococcus*, *Streptococcus*	*Escherichia coli*, *Pseudomonas*
Pathogenicity Factors	Exotoxins cause damage TSS - Toxic shock syndrome	Endotoxins contribute to severe immune responses (e.g., septic shock)
Flagella Structure	2 basal body rings	4 basal body rings
Lipid Content	Low	High, due to outer membrane

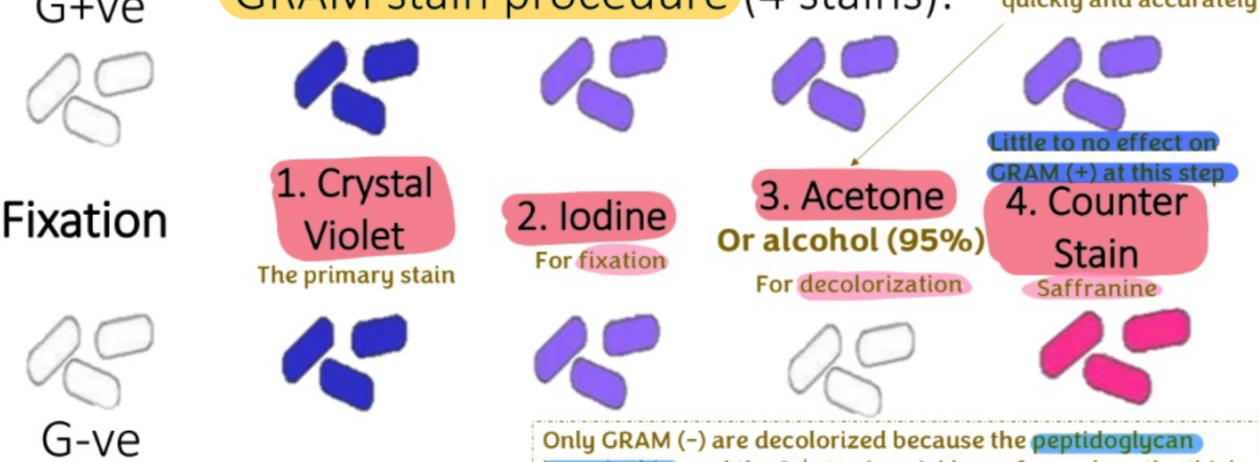
Feature	Teichoic Acid (TA) Cell wall-bound	Lipoteichoic Acid (LTA) Cell membrane-bound
Structure	Polymer of glycerol or ribitol phosphate	Polymer of glycerol or ribitol phosphate with a lipid anchor
Location	Attached to the peptidoglycan layer	Anchored to the cytoplasmic membrane
Lipid Component	Absent	Present (lipid anchor integrates into the membrane)
Function	Provides structural stability to the cell wall	Anchors the cell wall to the membrane and interacts with the environment
Role in Immune System	Can trigger immune responses (inflammatory)	Can also trigger immune responses and contribute to bacterial adhesion
Presence	Found only in Gram-positive bacteria	Found only in Gram-positive bacteria
Example Organisms	Staphylococcus aureus, Streptococcus species	Staphylococcus aureus, Streptococcus species

The first step is identifying a bacterium is knowing if it is GRAM + or GRAM -

Function of cell wall

GRAM stain procedure (4 stains):

Critical step: It must be performed quickly and accurately



The steps are usually not observed in a lab. We perform all 4 steps and then look and see the final resulting color (+) or (-). We wash the sample after each stain.

Only GRAM (-) are decolorized because the peptidoglycan layer is thin, and the 3rd step is quickly performed, so the thick layer of GRAM (+) keeps the color.
The outer membrane in GRAM (-) is made of lipids, so it is dissolved in alcohol and the alcohol can perform its job then.

Cell wall deficient bacteria

a) Naturally

Mycoplasma

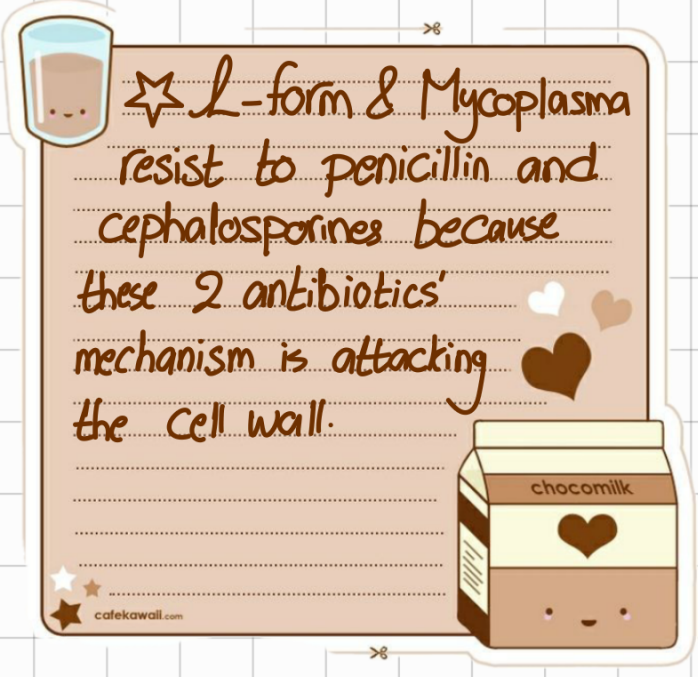
☆ Mycoplasma lacks both a cell wall and a peptidoglycan layer, meaning that they do NOT have a periplasmic space.

b) Induced

- Cell wall inhibitors
- Lyzozymes

Completely
like spheroplast and protoplast

Partially
like L-form bacteria.



Structures outside the cell wall

1. Capsule 2-Flagella 3-pilli 4-Spore

① Capsule : Extra gelatinous layer covering the cell wall of bacteria

⇒ Composition : usually polysaccharides . Exception : B. anthracis ⇝ polypeptides

* There are variations in capsules, for example. Str. pneumonia has 91 types because of capsule differences.

☆ Capules do NOT get stained by gram stain.

- Quellung reaction
When a specific antibody binds to a bacteria, its capsule (if present) will swell. This reaction is used as an identification manner to detect the presence of a capsule

	Binding	Adhering to surface organism (host cell)
Capsule	Tightly organized	Firmly adhered
Glycocalyx	Loosly Unorganized	Firmly adhered
Slime Layer	Loosly Unorganized	Loosly adhered

Glycocalyx are extending fibrils like Strept. mutans

Function

- protect the cell wall
  - Bacteriophage → a virus can infect the bacteria and has specific receptors on its surface, so the capsule protects it.
  - Complement → complement components adhere to the cell wall, so the capsule prevents them.
  - Lysosyme → breaks down the bacterial cell wall so the capsule inhibits it.

- prevent phagocytosis (virulence) كأسلحة دفاع

- Attachment of glycocalyx leads to fermintation of sugars to acids like in dental caries and prosthetic heart valves.

- Development of vaccines

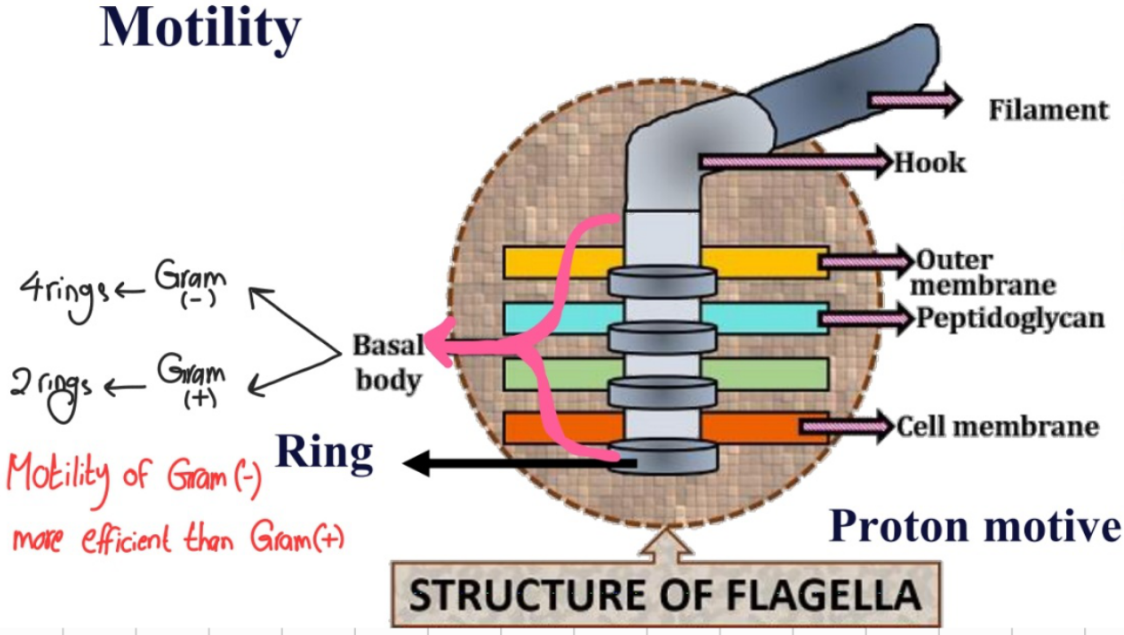
☆ Capsules get synthesized when the bacteria enters the host cell
- in VIVO ONLY -

Flagella : long thick threads (20nm)(filamentous) formed from protein (flagellin)= H Ag ← seen in EM

- Spiral → monotrichous / amphitrichous / lophotrichous
- peritrichous → Example : Salmonella typhi

Flagella - Function

Motility



For flagella to move, rings in the basal body also must move, so there is a type of energy called Proton motive force leads to motility of the rings and therefore the flagella → bacteria

Function

The organ of motility.

Tactic response

↓

- The stimulus may be light or chemical

☆ Sometimes the flagella is inside the bacteria (Endoflagella) → In spirochetes

pilli

→ seen in EM

: Short and thin hair like structure, formed from a protein (pilin)

- → Ordinary pilli — virulance factor - adhesive
- → Sex pilli — longer - so attaches well

Spore

vegetative bacteria —Unfavourable Condition→ spore formation in VITRO - Resting phase -

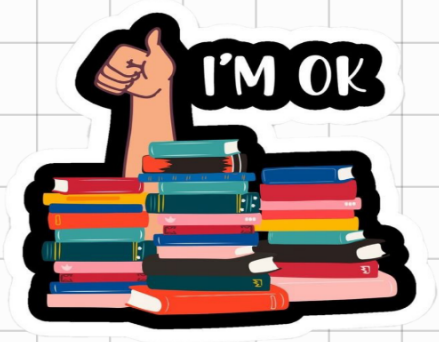
↓

may be : High temp. , Drying , Depletion of nutrition

Examples : Bacillus , Clostridium

☆ Can NOT be stained by ordinary stain.

☆ Highly resistant to dryness, heat and disinfectant.



Spoile Formation

1- DNA replication

2- Formation of multiple membranes :

- Cortex (Ca^{+2} + Diplconic acid)
- Spore coat (more than 80 types of proteins)
- Exosporium (Collagen like glycoprotein)

- After sporulation, if the bacteria entered a host cell ⟶ Germination ⇝ gets rid from all previous layers in order to return to normal vegetative bacterium phase