MICROBIOLOGY

بسم الله الرحمن الرحيم

MID – Lecture 2

Bacterial Structure (Pt.1)

﴿ وَإِن تَتَوَلَّوْا يَسْتَبْدِلْ قَوْمًا غَيْرَكُمْ ثُمَّ لَا يَكُونُوا أَمْثَالَكُم ﴾

اللهم استعملنا ولا تستبدلنا

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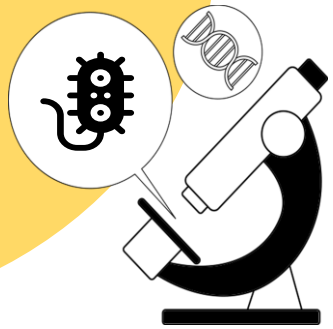


LECTURE 2

Bacterial structure

- Intracytoplasmic structure
- Cell wall
- Structures outside the cell wall

LECTURE 2

Intracytoplasmic Structures

1) Nucleoid
2) Ribosome
3) Inclusion granules Or **Inclusion bodies**
4) Cell membrane
5) Plasmid

Bacterial structure

Some bacteria have:

Capsule

Cell wall

GRAM stain is to be discussed see slide 30

Some GRAM (+) bacteria have: **Spore**

Cell Membrane

Inclusion bodies

Nucleoid

Some bacteria have: **Flagellum**

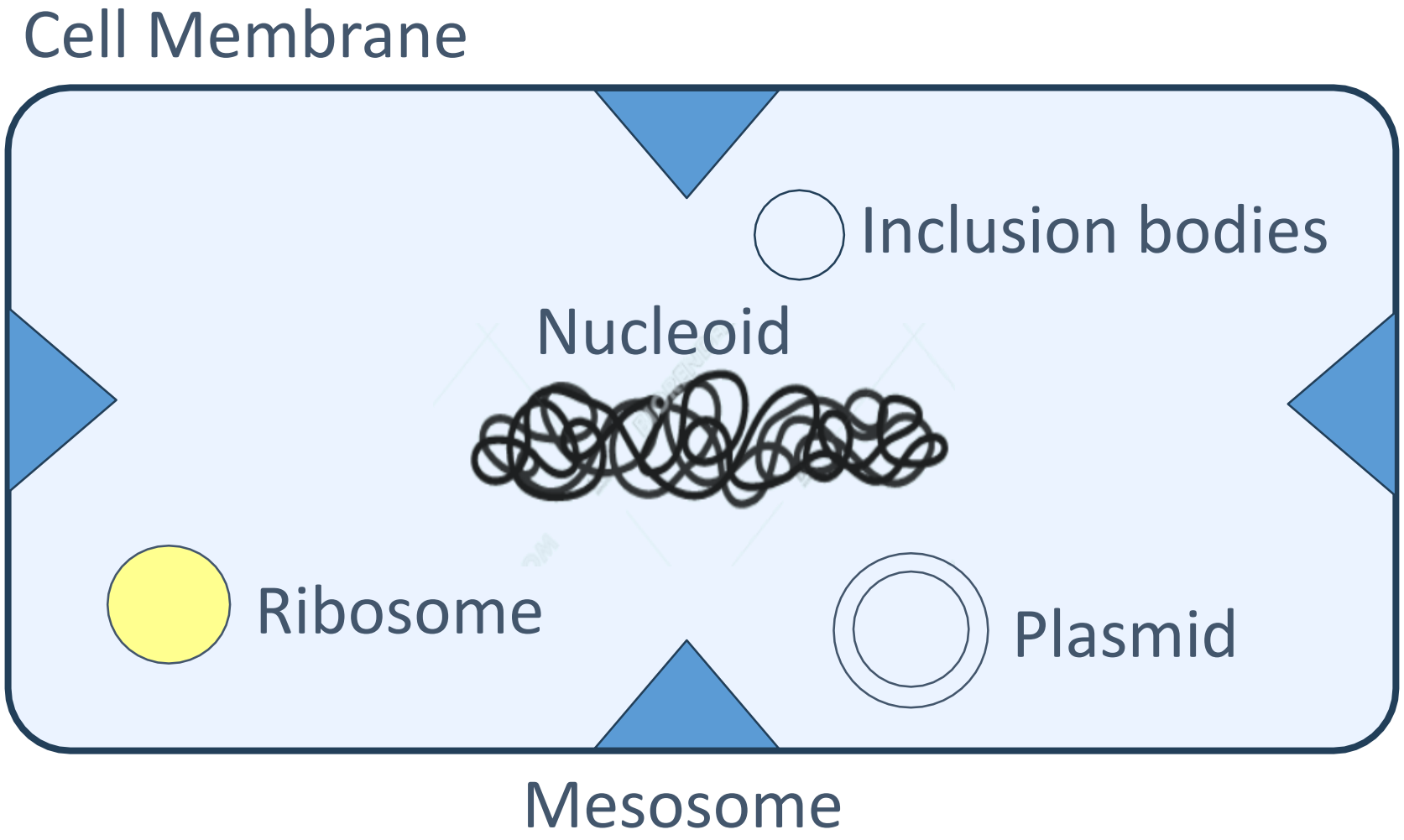
Some bacteria have: **Plasmid**

Ribosome

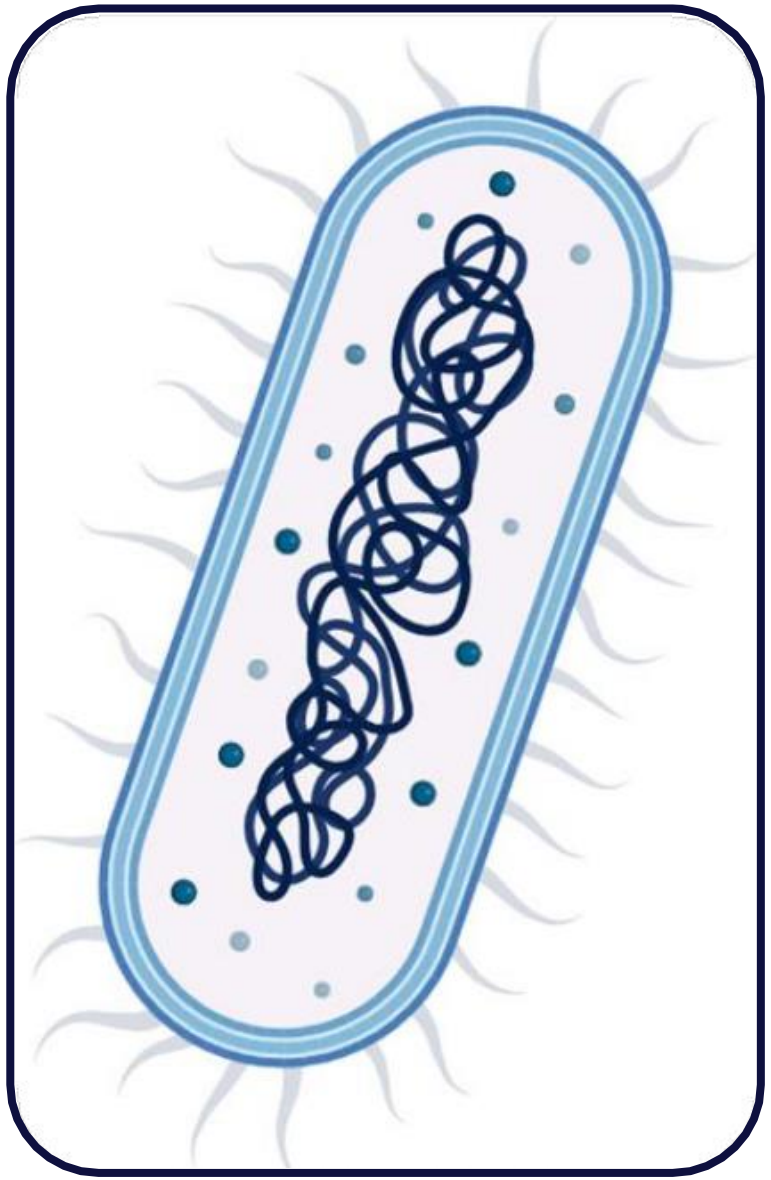
Mesosomes (the triangles): extensions in the cell membrane

Some bacteria have: **Pili**

Intracytoplasmic structure



1) Nucleoid



1. Single chromosome
   -> It is what distinguishes bacteria from eukaryotes.
   -> Bacteria doesn't have a nuclear membrane, so the nucleoid exists in the cytoplasm.
2. Circular
3. dsDNA
   ds=Double-stranded
4. 1mm in length
   Bacteria's length is measured by microns, and 1mm is 1000 microns! So, DNA must be supercoiled to fit inside the bacteria.
5. Supercoiled
6. Carry genetic information for growth & survival
   Essential means that all bacteria have it.

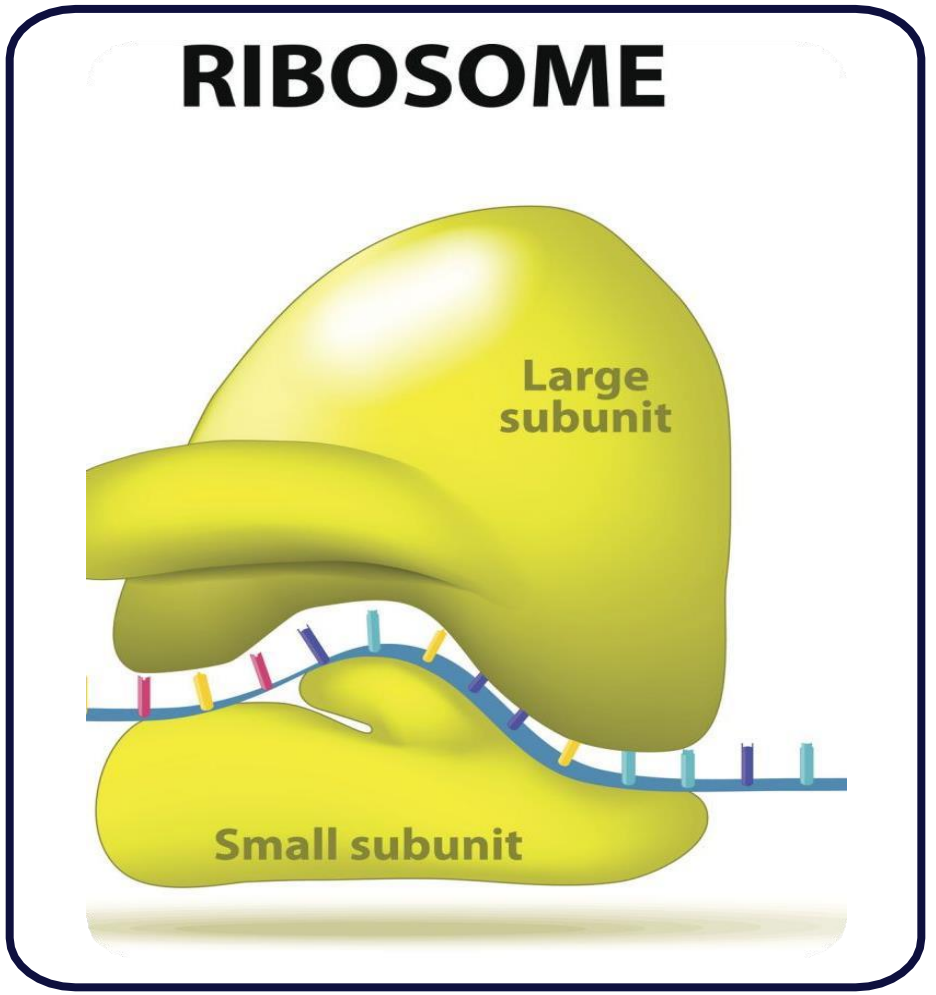
Essential

2) Ribosome

1. Ribo=RNA
2. Some=body
3. Site of Protein synthesis

Protein synthesis = mRNA + Ribosome

Essential



2) Ribosome

Bacterial ribosomes

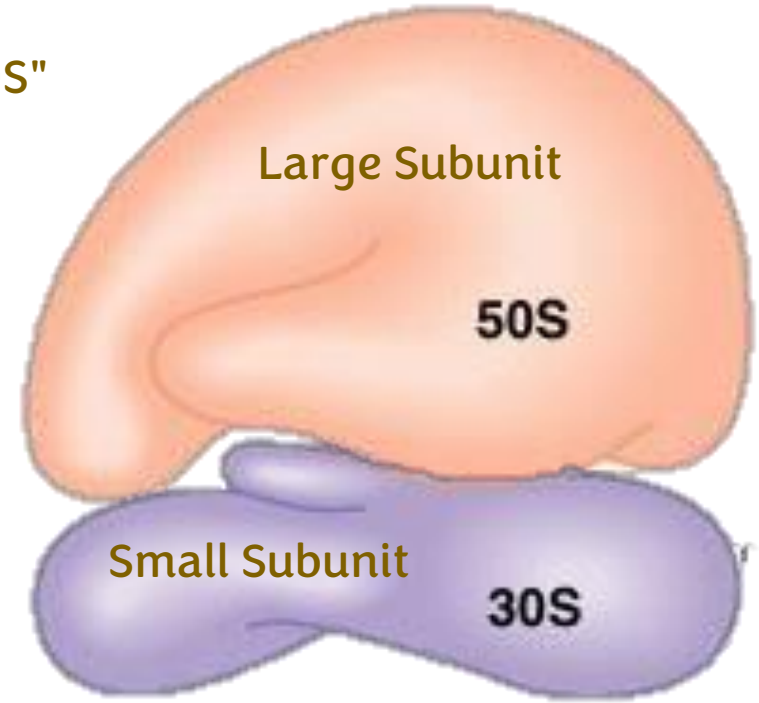
↓

(70S) → The **type of the ribosome** is "70S"

↓

Svedberg unit

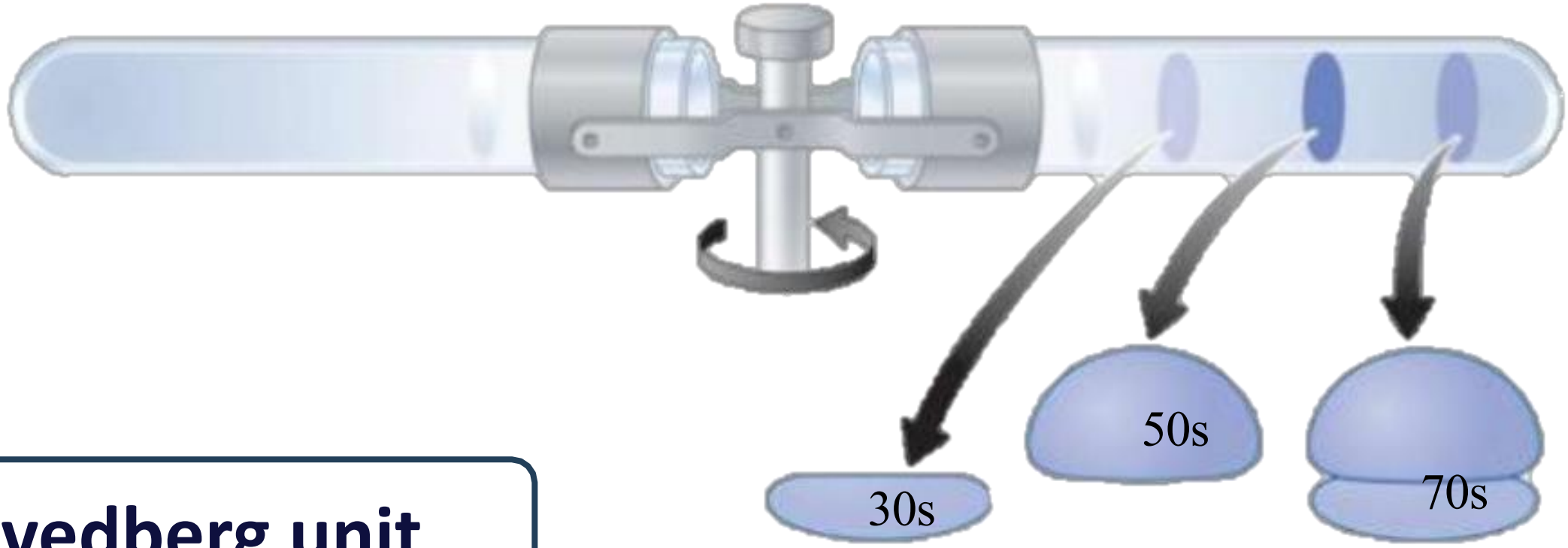
The unit "Svedberg" is named according to the scientist "Svedberg", and it measures the **density** of them.



2) Ribosome

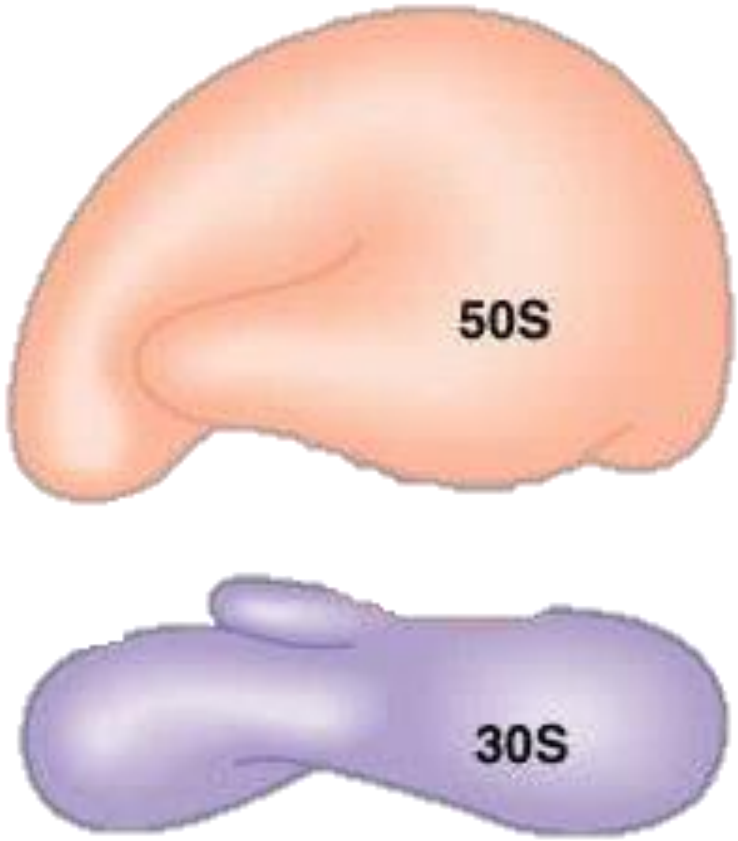
Small & large subunits binds together when they bind with mRNA

Small subunit's density is 3Os
Large subunit's density is 5Os
Their density when together is 7Os



Svedberg unit

2) Ribosome



Scientists used this difference in density to develop antibiotics that specifically attack bacterial ribosomes, without damaging our ribosomes.

50S	**60S**
Target of antibiotics	**Human**
30S	**40S**

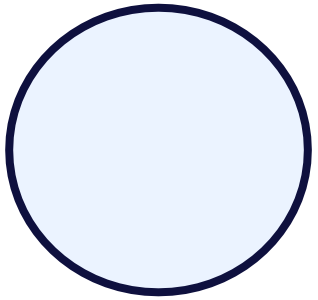
3) Inclusion granules

Its main function is

Store of nutrient

Glycogen
Starch
Phosphate

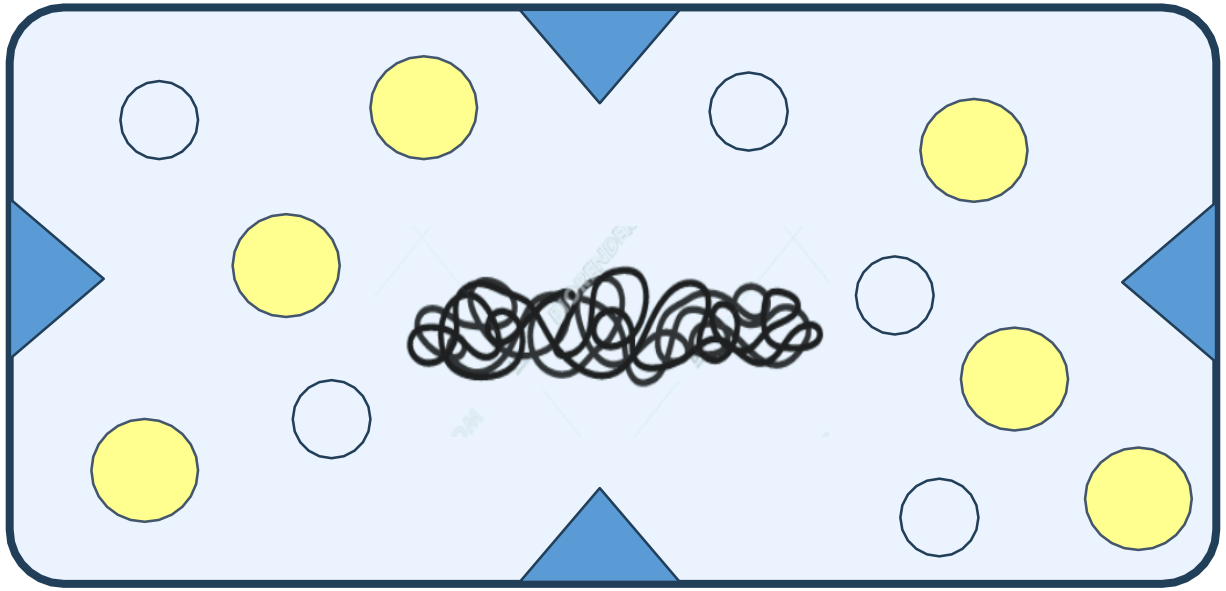
Some type of bacteria mainly stores phosphate in its inclusion bodies, that's why we call its granules as:



Volutin granule (Metachromatic granules)

Definition of the cell membrane

Thin, fragile membrane located just inside the cell wall

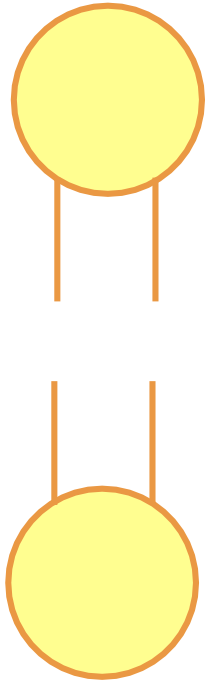


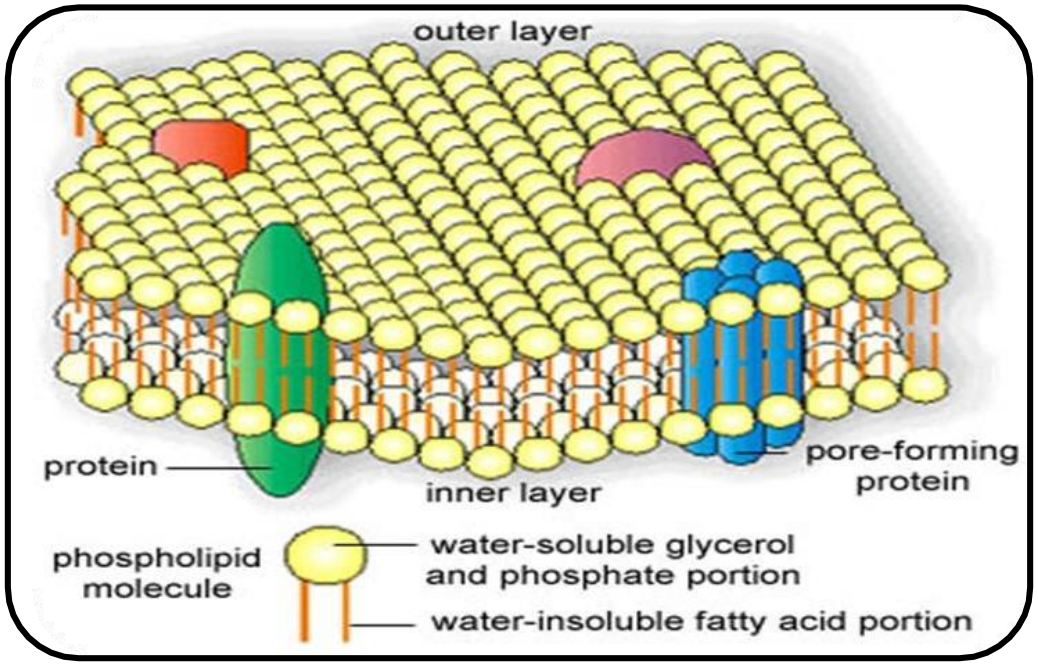
Essential

Composition of cell membrane

Phospholipid bilayer
+ Protein
(No sterols)

An exception is
Mycoplasma which have
sterols



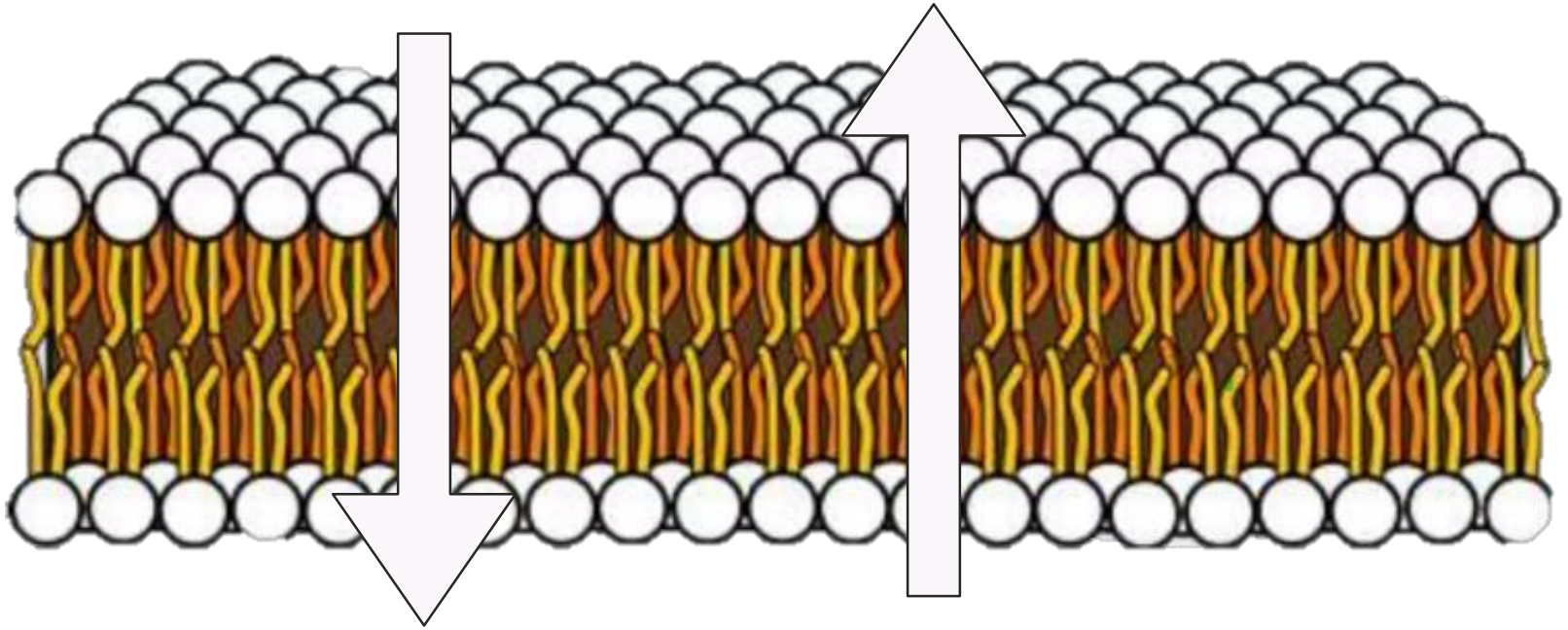


Function of the cell membrane

1

Selective transport (Passive)

Extracellular concentration is higher than intracellular concentration, so molecules get into the cell.

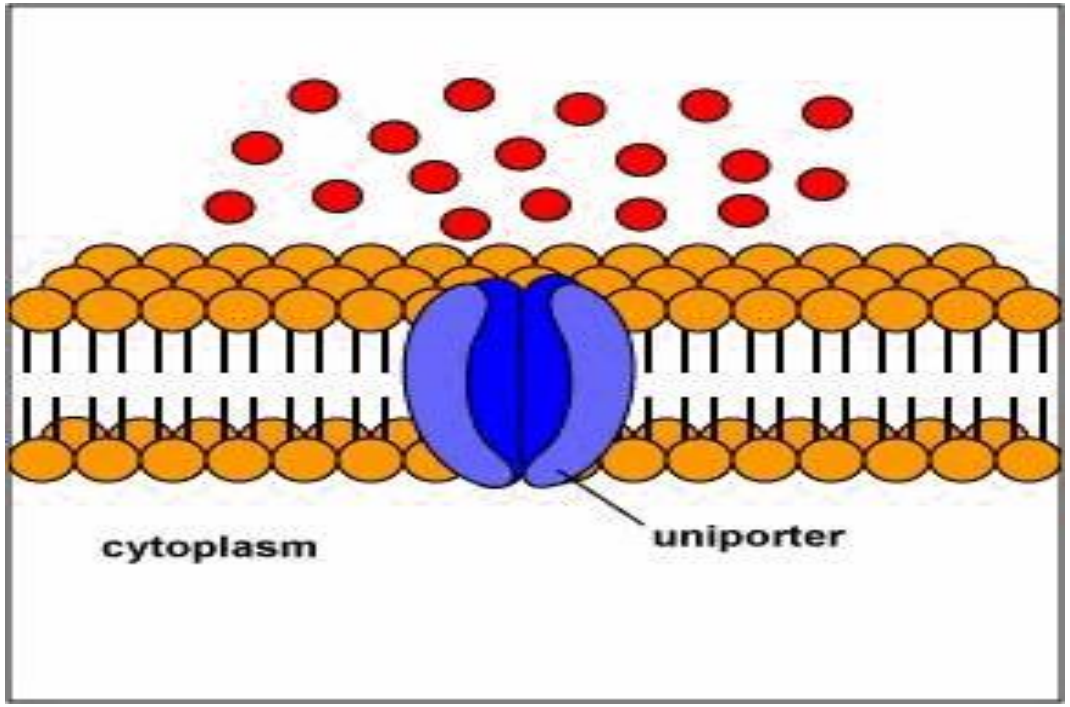


Function of the cell membrane

1

Selective transport (Active)

Extracellular concentration is lower than intracellular concentration, so molecules need **energy** to get into the cell.

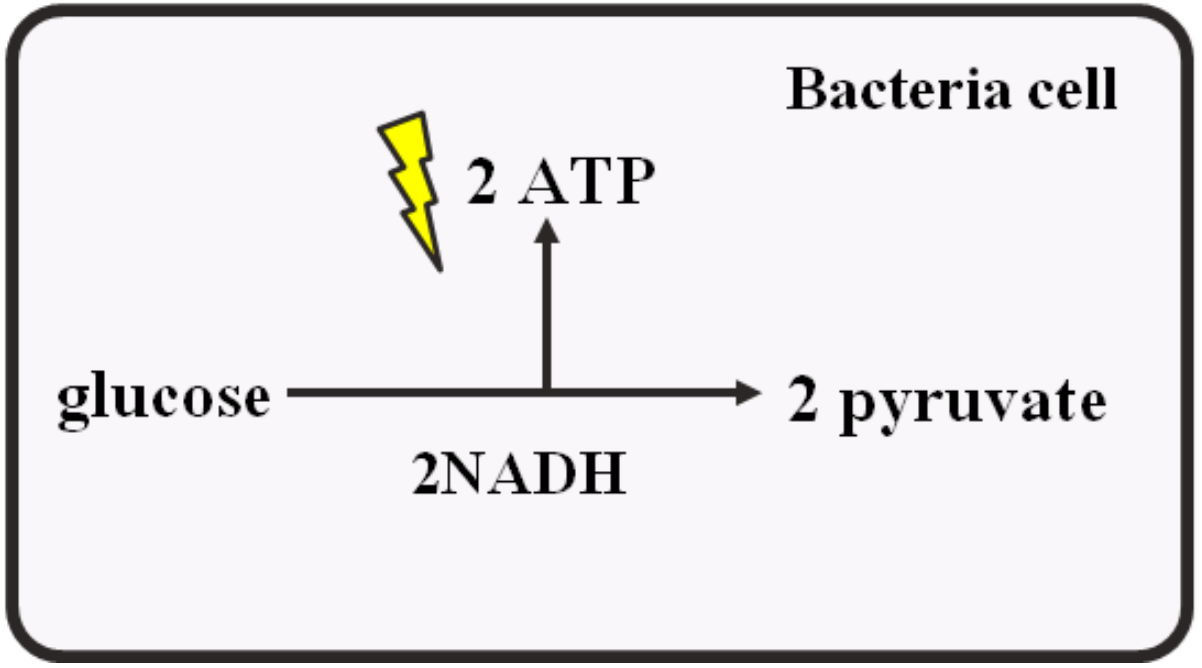


Function of the cell membrane

2

Mesosomes
Respiration enzyme
(Making energy)
(Like Mitochondria)

Mesosomes contain respiration enzymes which are responsible of making energy
(They resemble the mitochondria in eukaryotes)

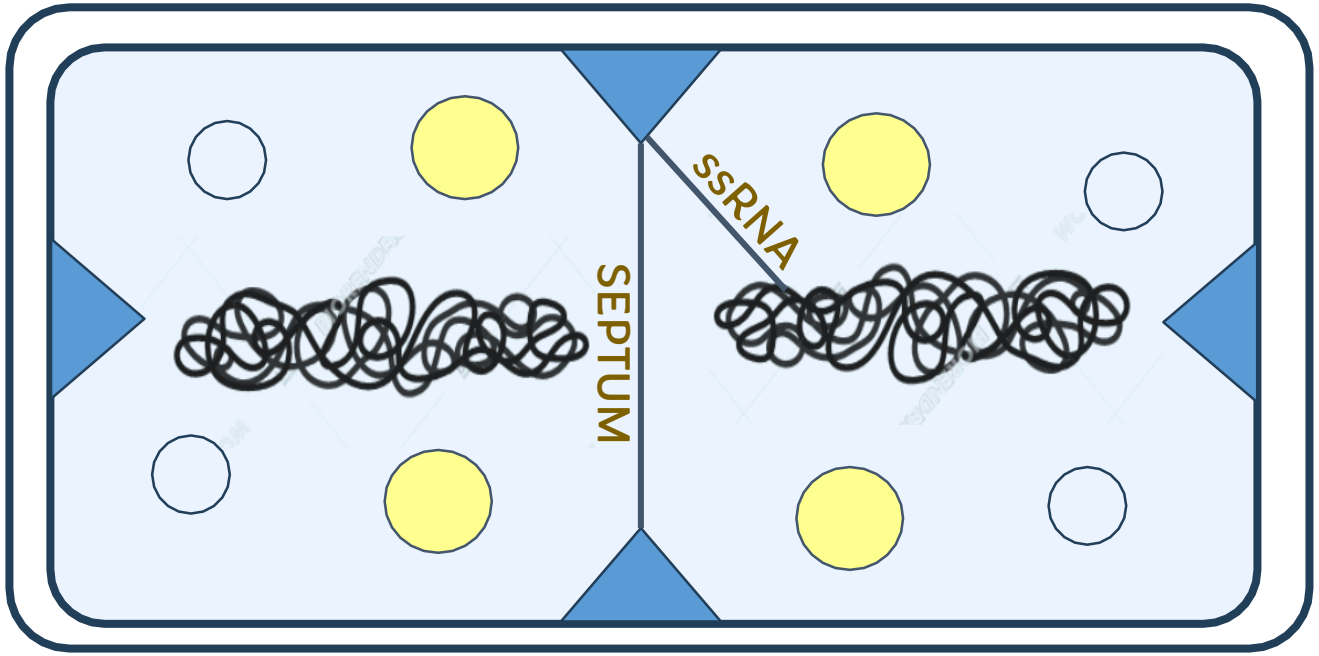


Function of the cell membrane

2

Mesosomes
Cell division
Separate DNA
Septal mesosomes

ssRNA = single-stranded RNA
It helps in DNA separation into 2 copies

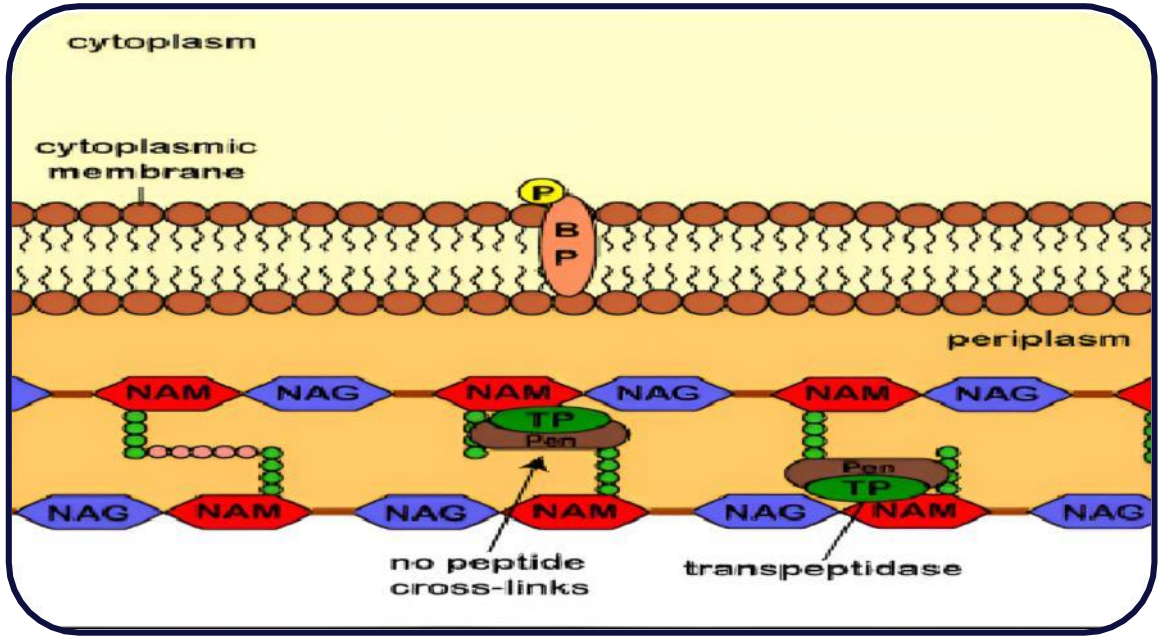


Function of the cell membrane

3

Biosynthesis of cell wall

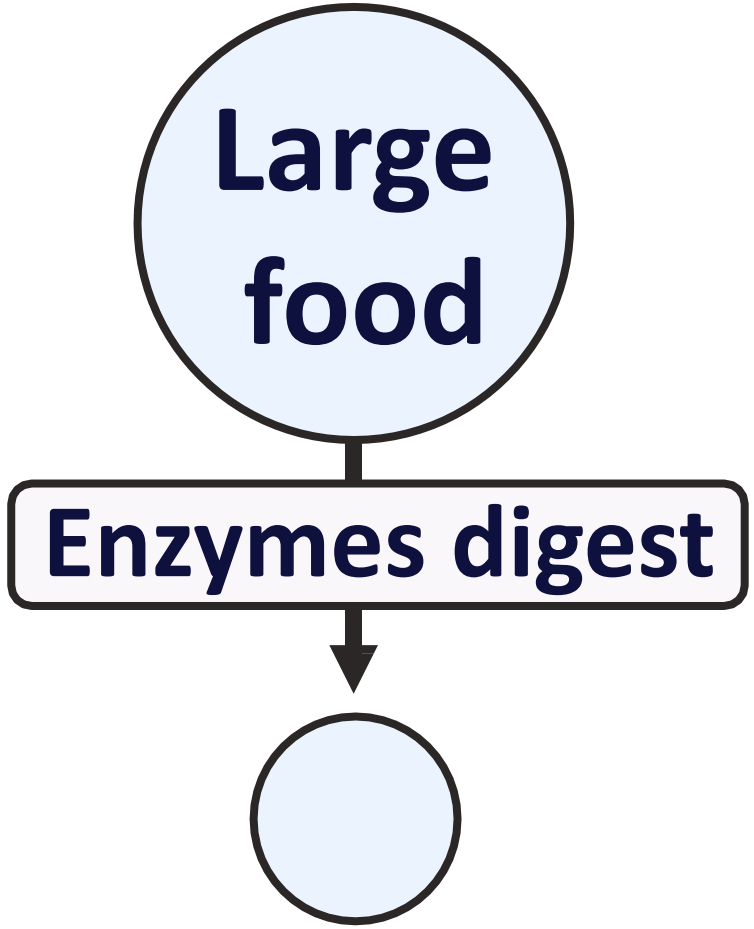
Cell membrane synthesize the building blocks "precursors" of the cell wall



4

Excretion of extracellular enzymes

(Hydrolytic enzymes)

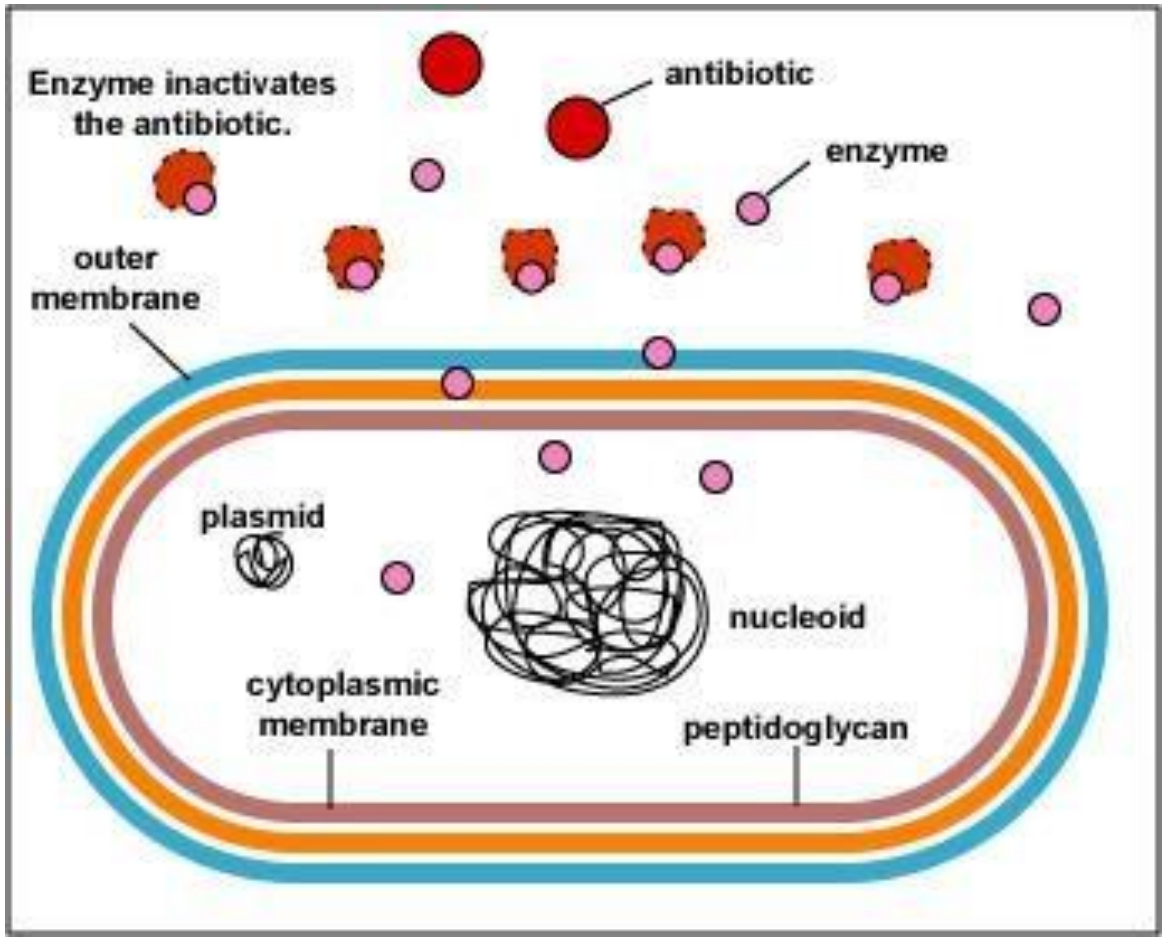


Function of the cell membrane

5

Excretion of extracellular enzymes (Penicillinase)

Some bacteria excrete these enzymes (such as Penicillinase) to defend themselves against some antibiotics (such as Penicillin)



Function of the cell membrane

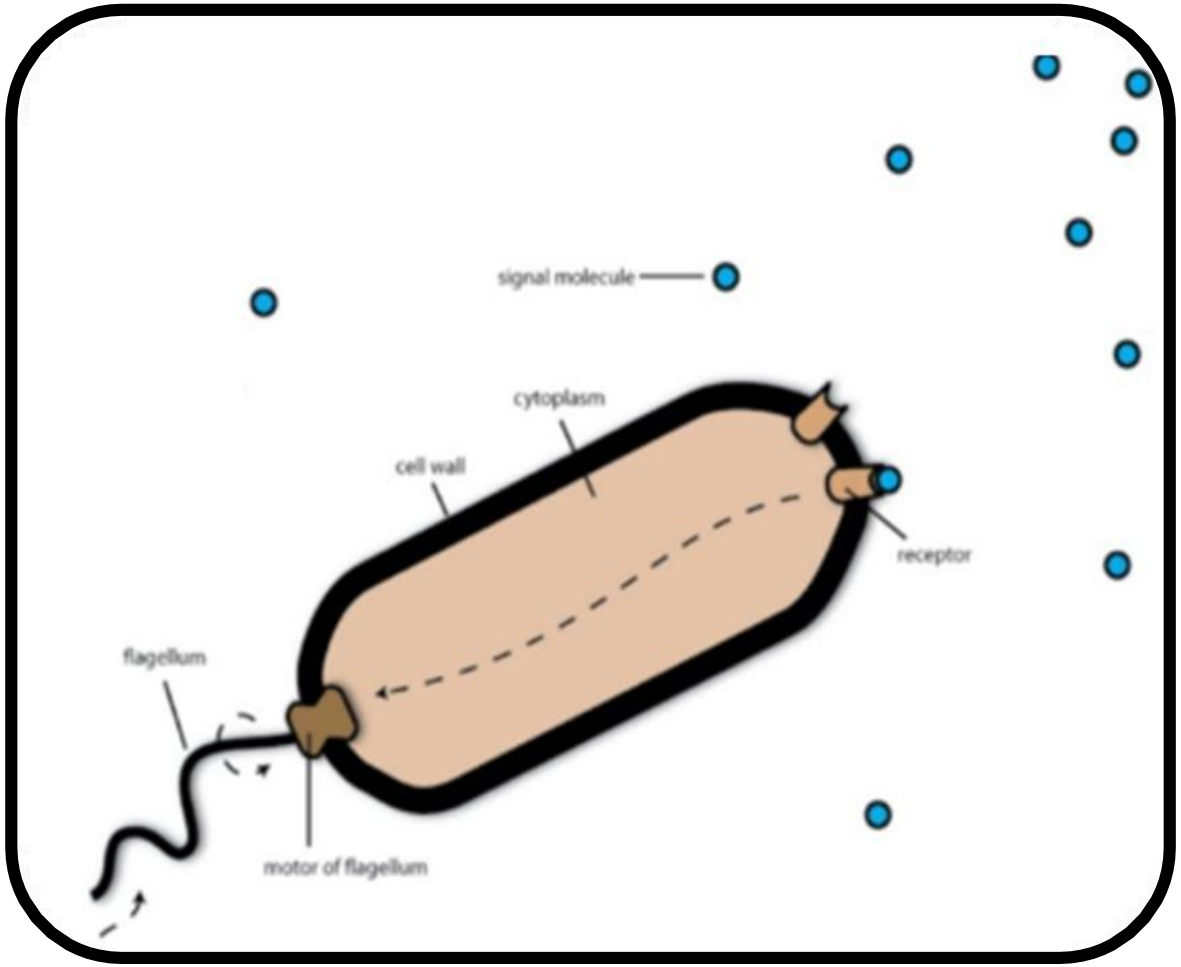
6

Chemotactic system

For bacteria that has flagella

The cell membrane has receptors for certain materials.

- When they detect a beneficial substance, they signal the flagella to propel the bacteria toward it.
- Conversely, if a harmful substance is sensed, they signal the flagella to move the bacteria away.



Plasmid

ds = Double-stranded

EXTRA circular chromosomal dsDNA

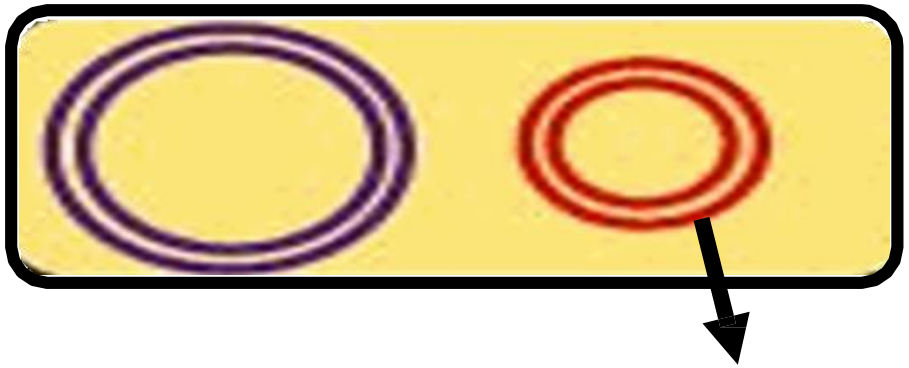
Why isn't plasmid considered a part of the bacterial chromosome?

1. **Replicate autonomously (Independent of bacterial chromosome)**

2. **Its genetic function is toxin production for drug resistance**

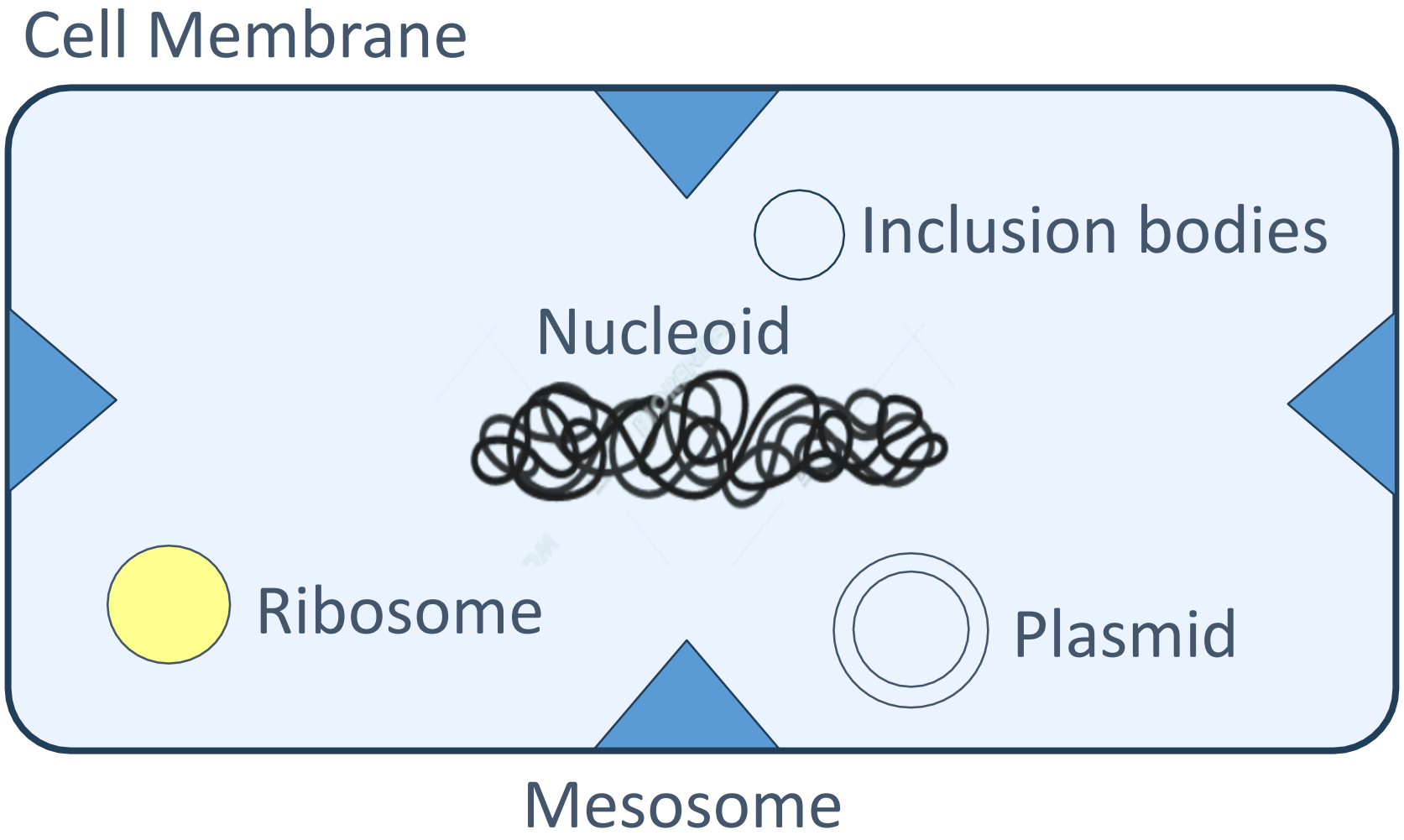
   Recall that bacterial chromosome's function is survival & growth

Not essential



Plasmid

Intracytoplasmic structure



Objectives

Cell wall

Definition

Composition

Synthesis

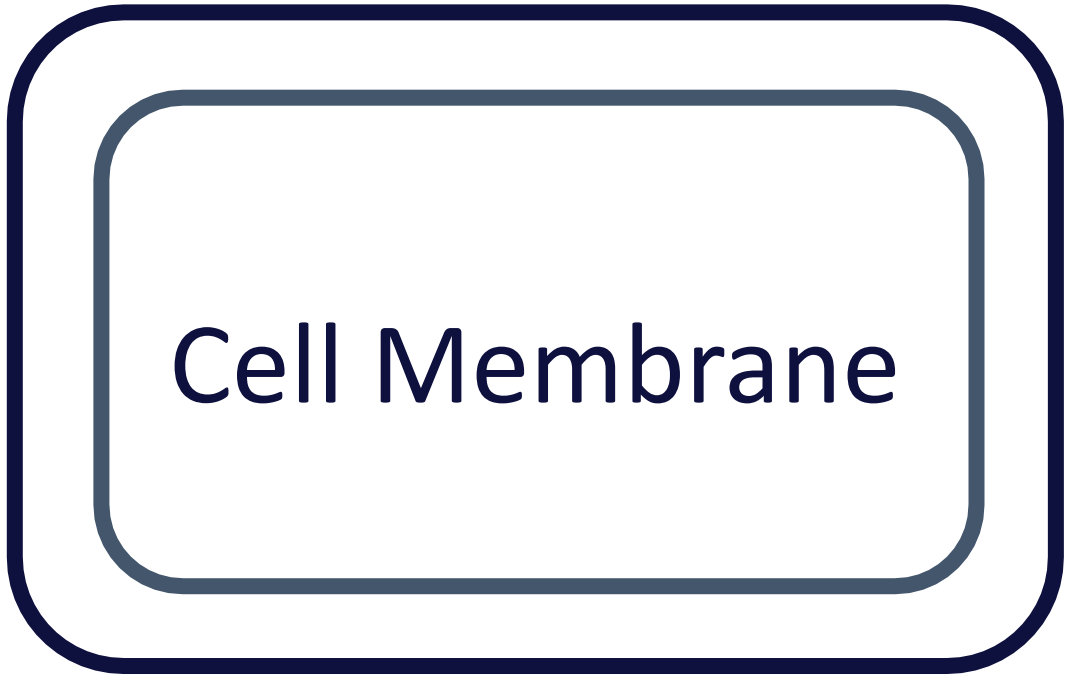
Function

Cell wall Deficient

Definition of cell wall

Not a very good definition.
Some bacteria have capsules that are external to the cell wall!

Outermost layer!!!



A more precise definition:

Surrounds the cell membrane

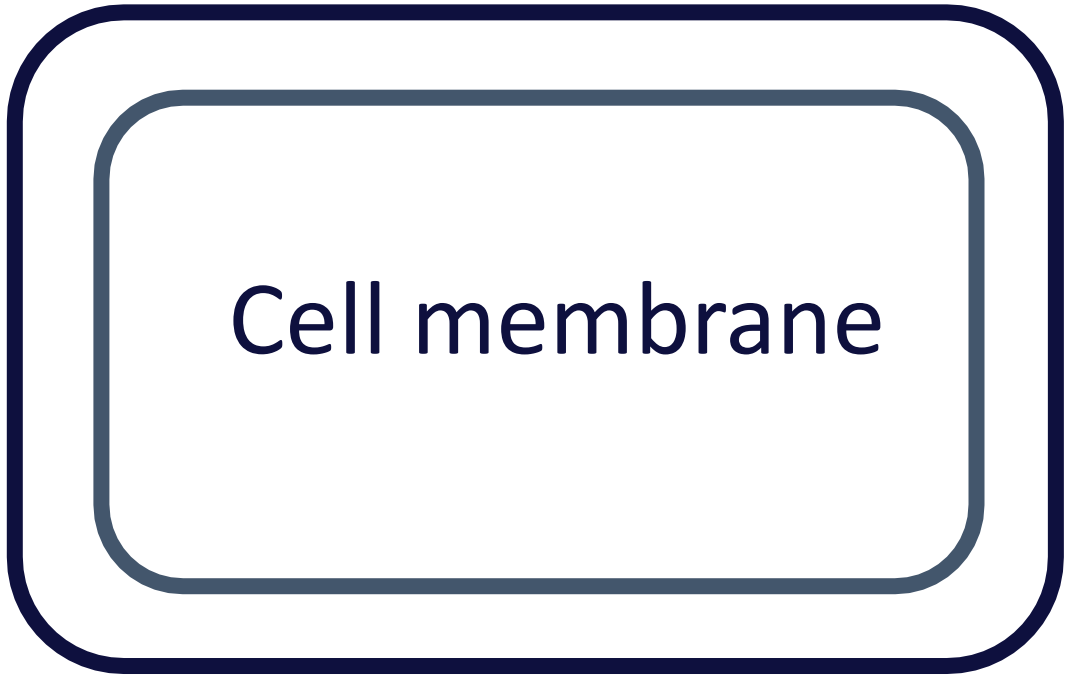
Rigid

Due to its composition and the presence of peptidoglycans

Composition of cell wall

Rigidity

(Peptidoglycan)



Composition

The one that links with peptides is NAM and **not** NAG

N-acetylmuramic acid

Glycans

Sugars

NAM

NAG

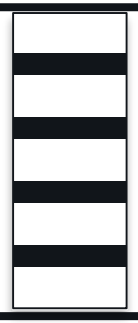
N-acetylglucosamine

Peptido

Protein

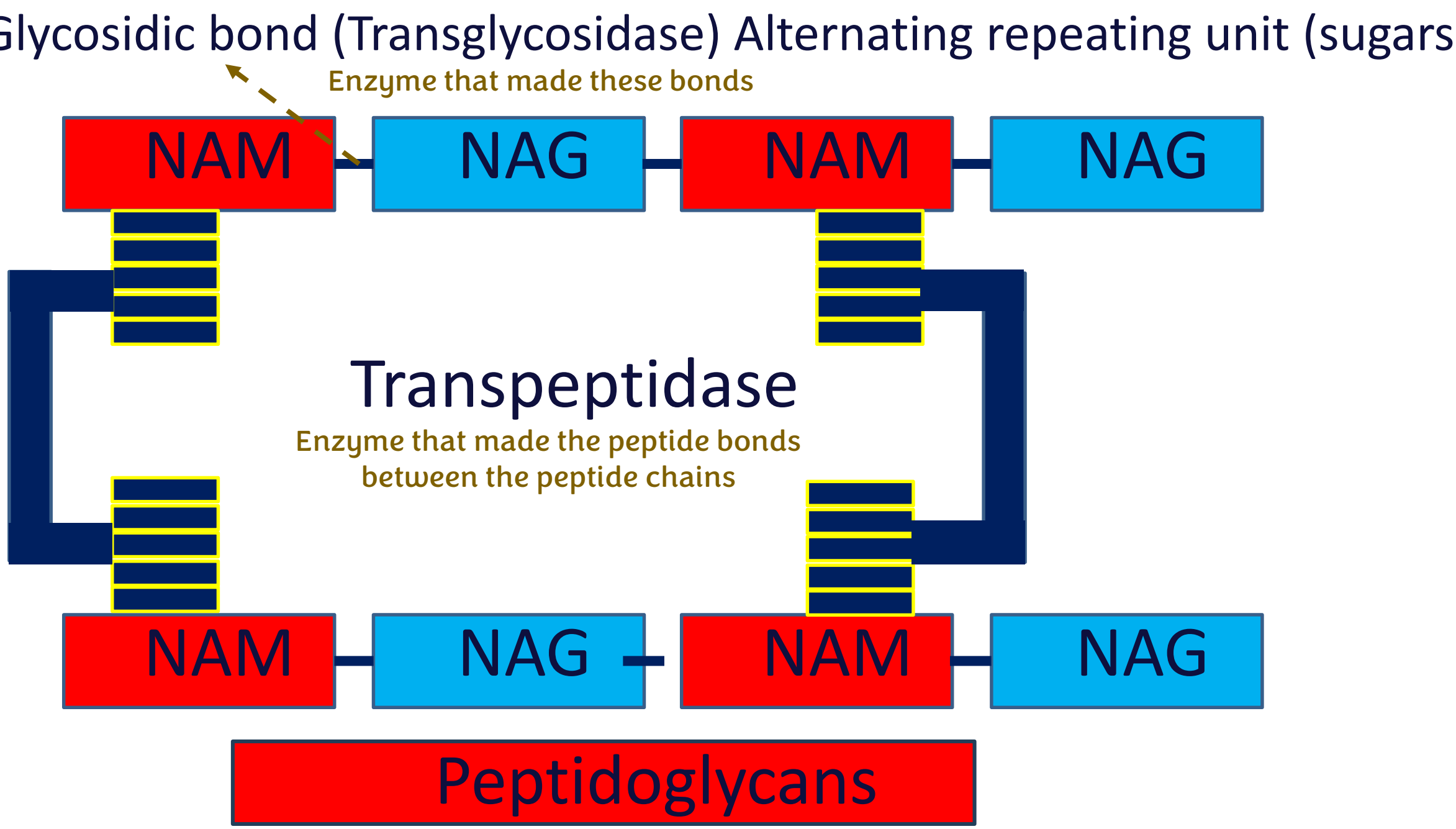
Actually, amino acids

4 or 5 Amino Acids

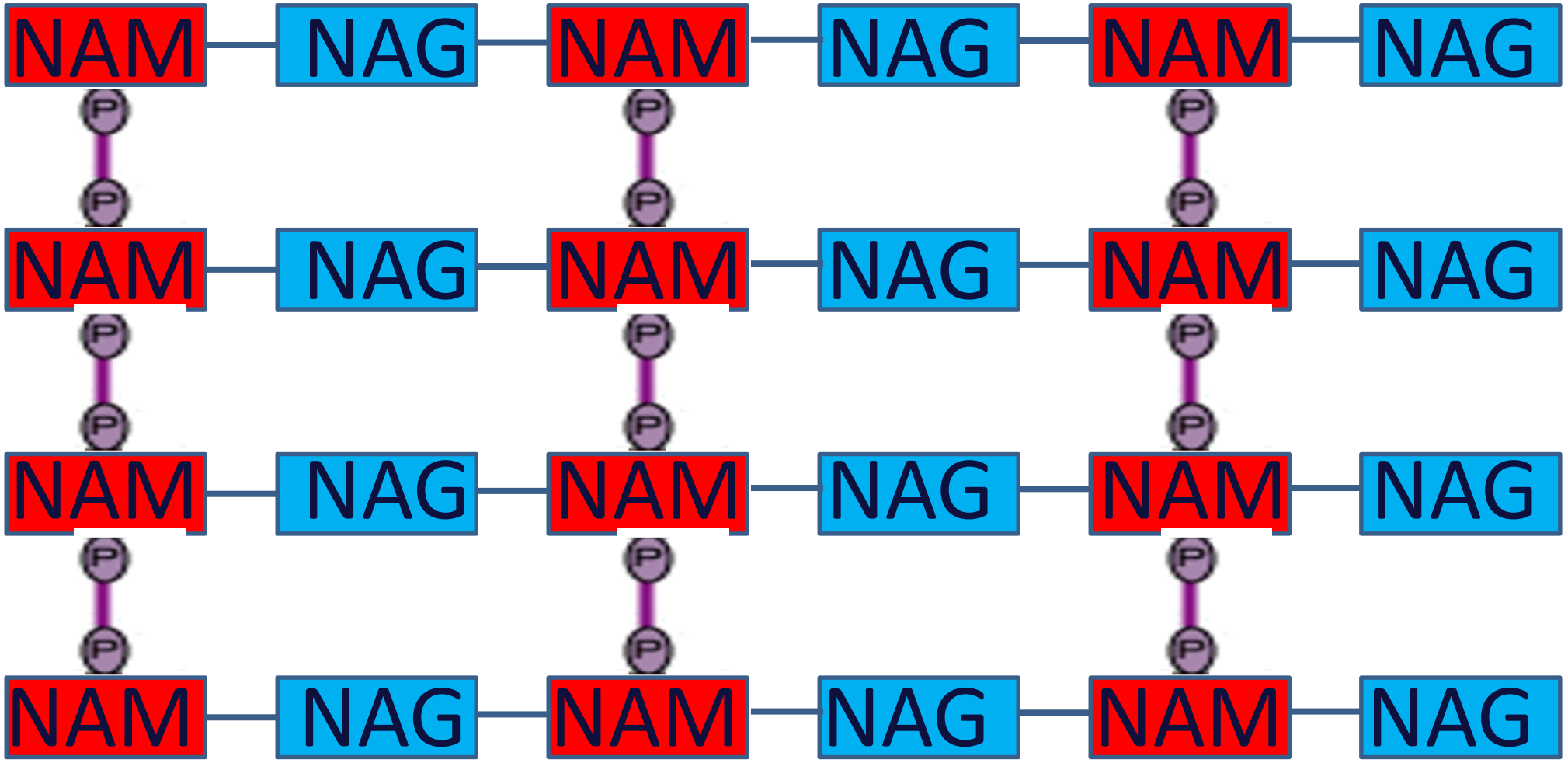


Peptide chain

Peptidoglycans

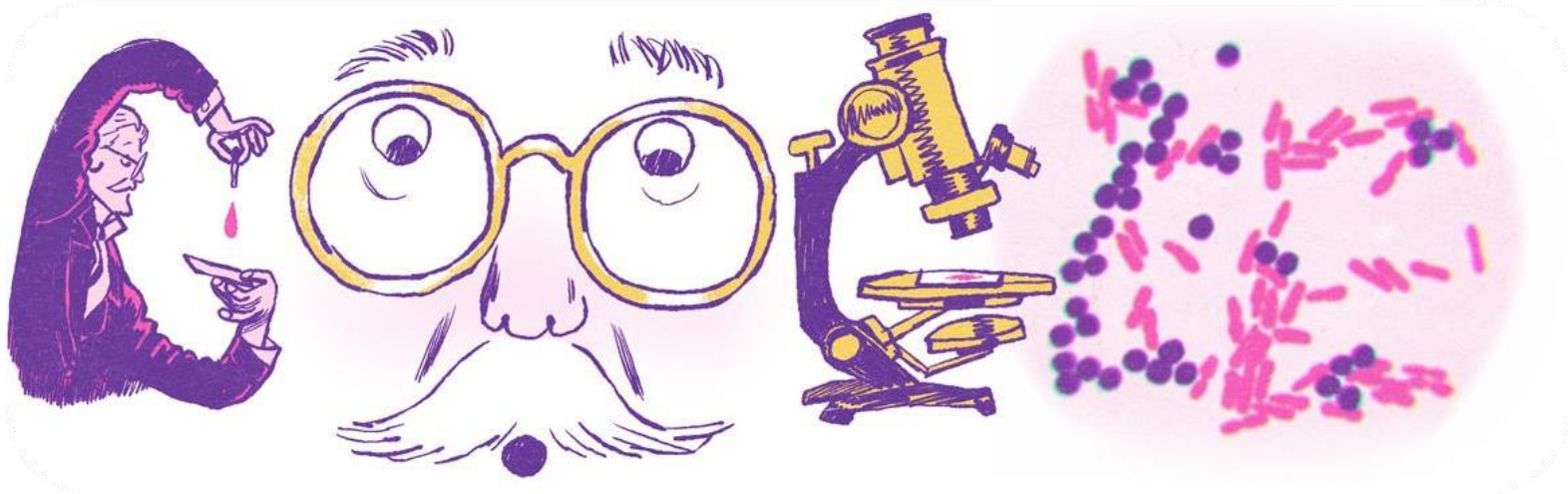

Glycosidic bond (Transglycosidase) Alternating repeating unit (sugars)
Enzyme that made these bonds
NAM
NAG
NAM
NAG
Transpeptidase
Enzyme that made the peptide bonds
between the peptide chains
NAM
NAG
NAM
NAG
Peptidoglycans

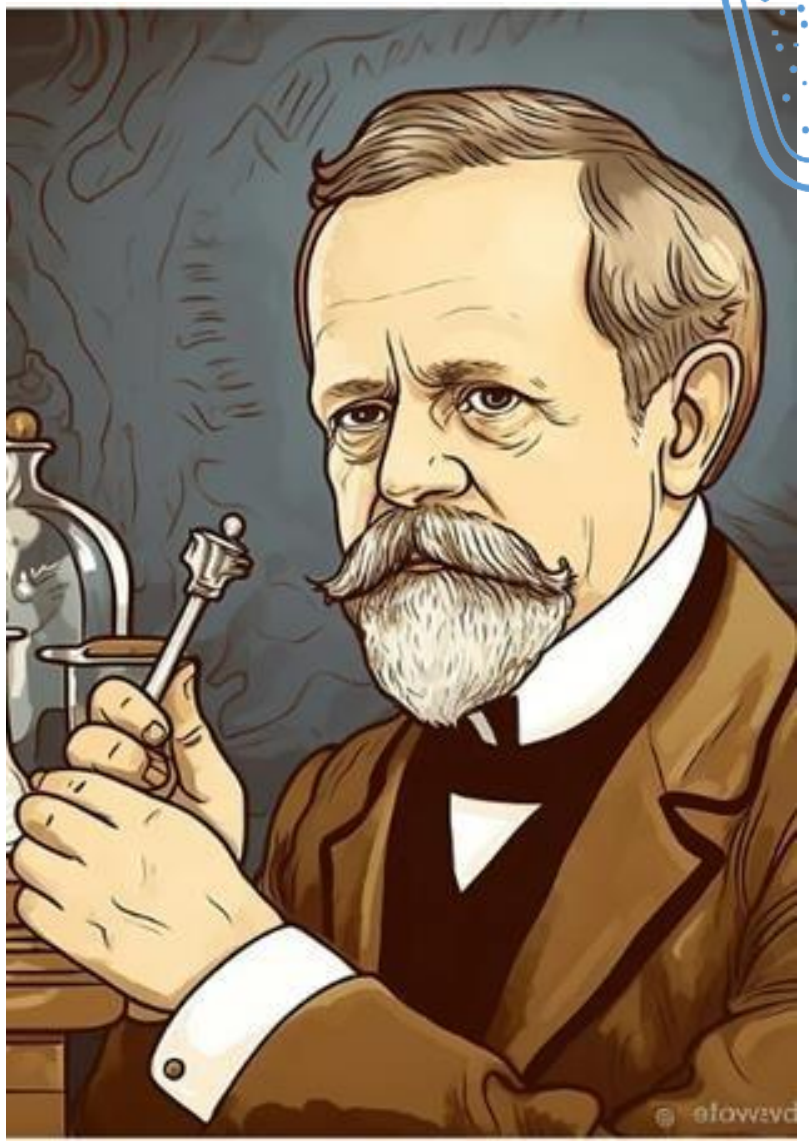
Peptidoglycan Structure (Overall)



Created the GRAM stain

Hans Gram





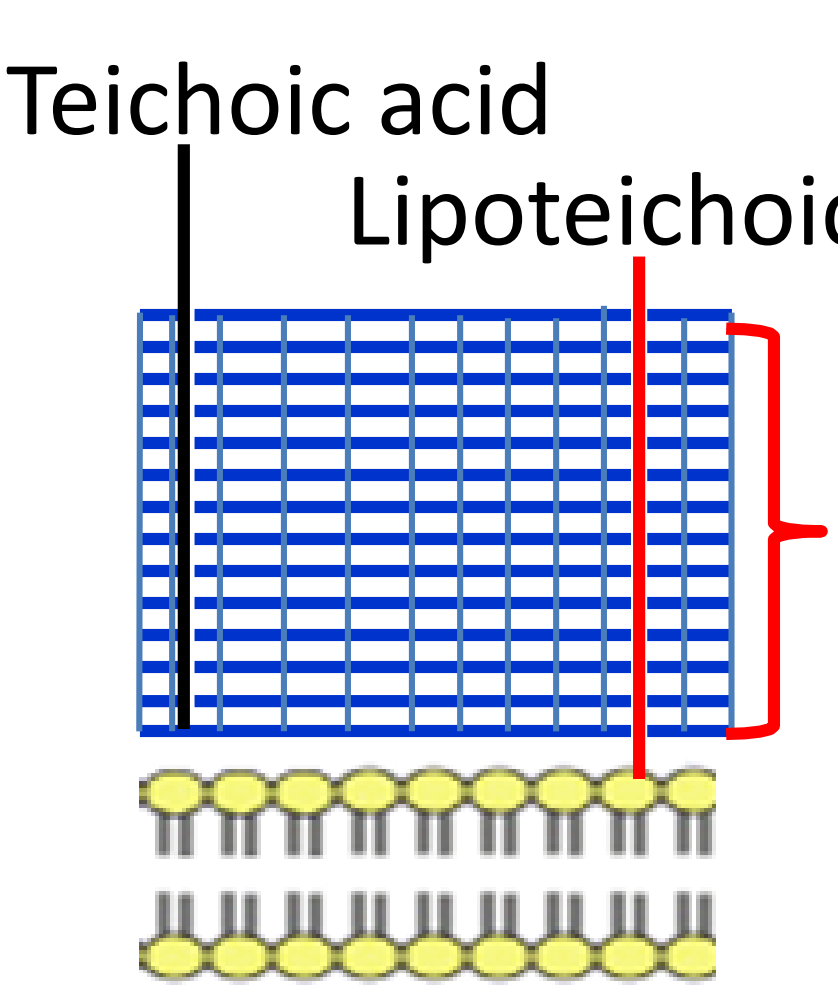
Bacteria are (mainly)
either GRAM + or GRAM –

2 Colors in this stain:

Purple	Pink
GRAM +	GRAM –

The GRAM stain divides bacteria into two main groups; each has its own characteristics (see next slides).

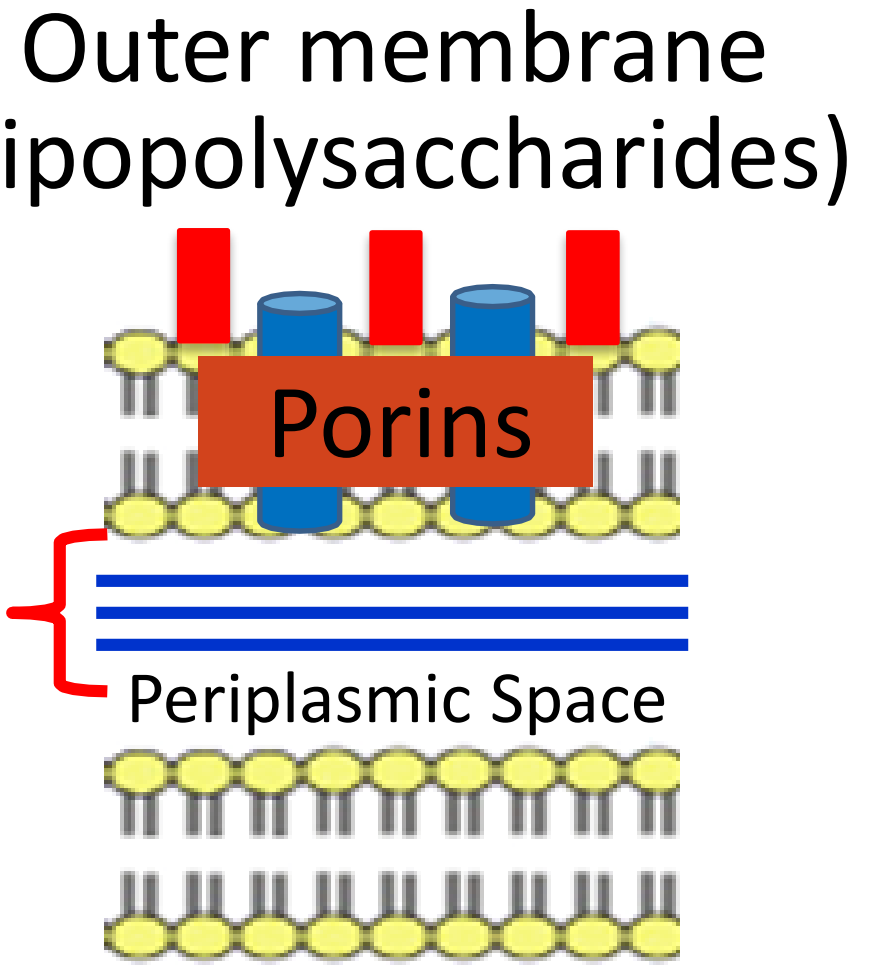
Gram (+) vs Gram (-)



Cell membrane + THICK layer of peptidoglycans

Has teichoic acid (peptidoglycan-bound)

Has lipoteichoic acid (lipid-bound [to the cell membrane])



Cell membrane + THIN layer of peptidoglycans

Has an outer membrane

Gram positive bacteria

1) Peptidoglycan
(50%)

NAM-NAG

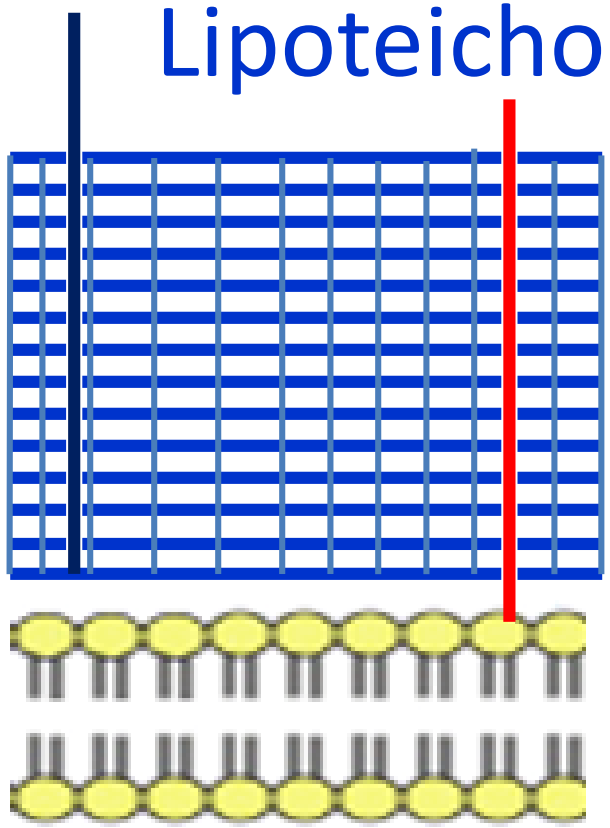
|

Peptide

(Porous)

Teichoic acid

Lipoteichoic acid



Gram (+)

Composition of Gram positive

Both TEICHOIC ACID and
LIPOTEICHOIC ACID are composed of

Polymers of Glycerol or Ribitol

Lipoteichoic acid is

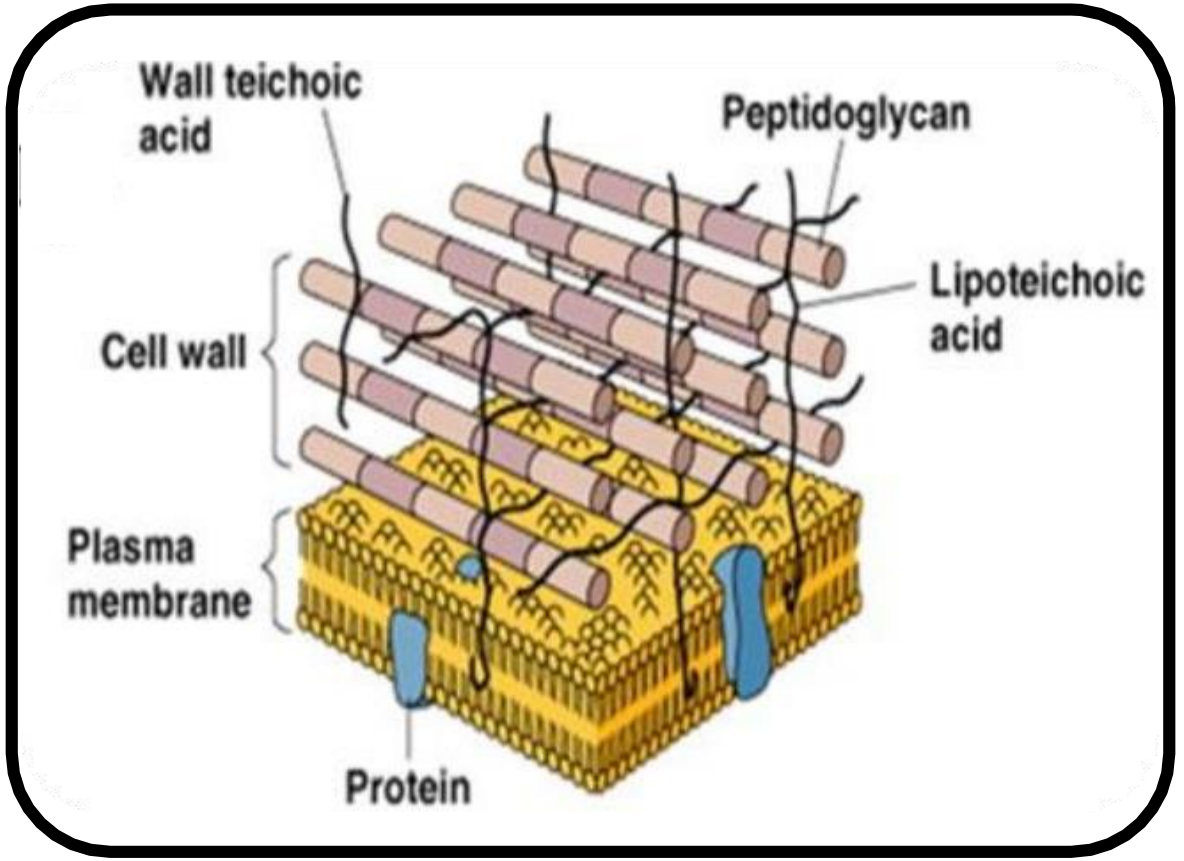
(Cell membrane-bound)

Teichoic acid is

(Cell wall-bound)

Teichoic acids that are anchored to the lipid membrane are referred to as lipoteichoic acids (LTAs), whereas teichoic acids that are covalently bound to peptidoglycan are referred to as wall teichoic acids (WTA).

2) Teichoic acid



Composition of Gram positive

Antigen

Major surface Ag of G+ve

Induces an immune response in our bodies because it is perceived as a foreign body

Highly immunogenic

Tumor Necrosis Factor – Alpha

TNF-α

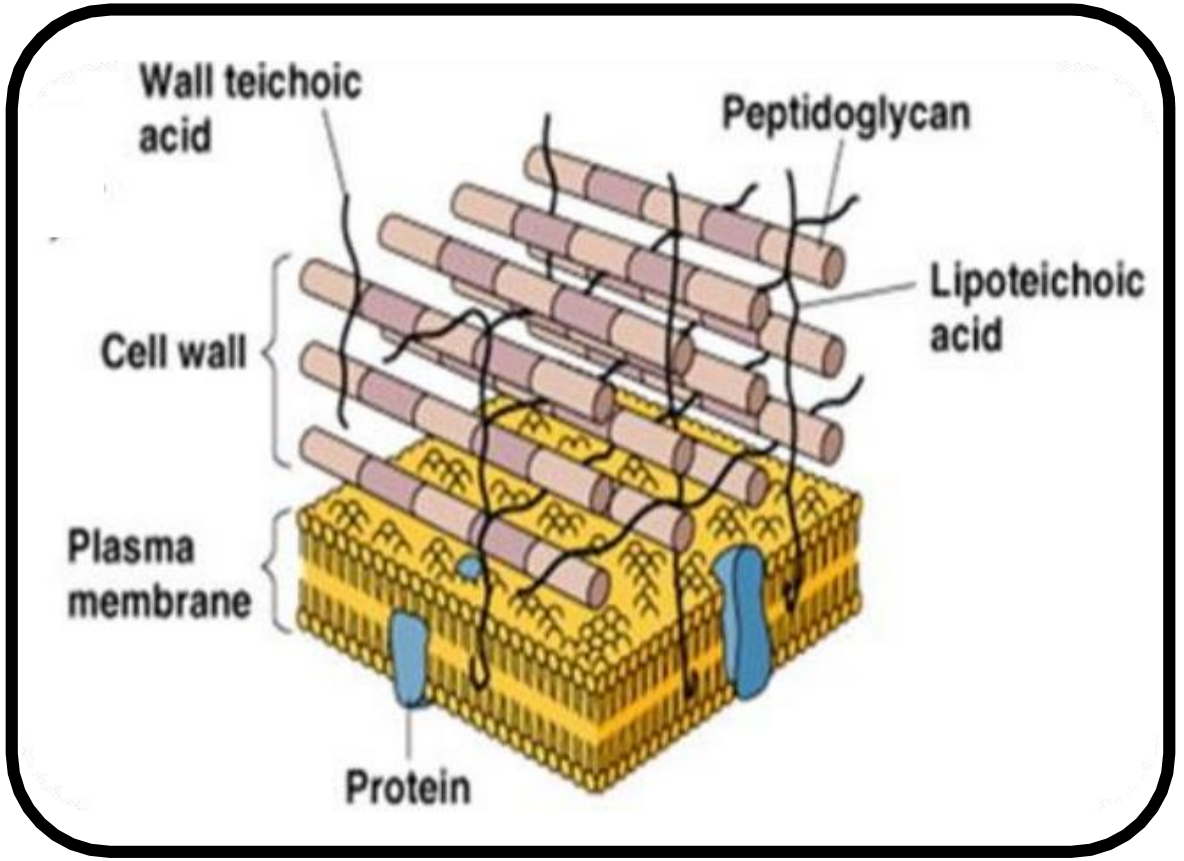
IL-1

Interleukin – 1

Cytokines
Released after detecting the antigen

Teichoic acid is responsible for the Toxic Shock Syndrome (TSS)

2) Teichoic acid



Composition of Gram Negative

1) Peptidoglycan

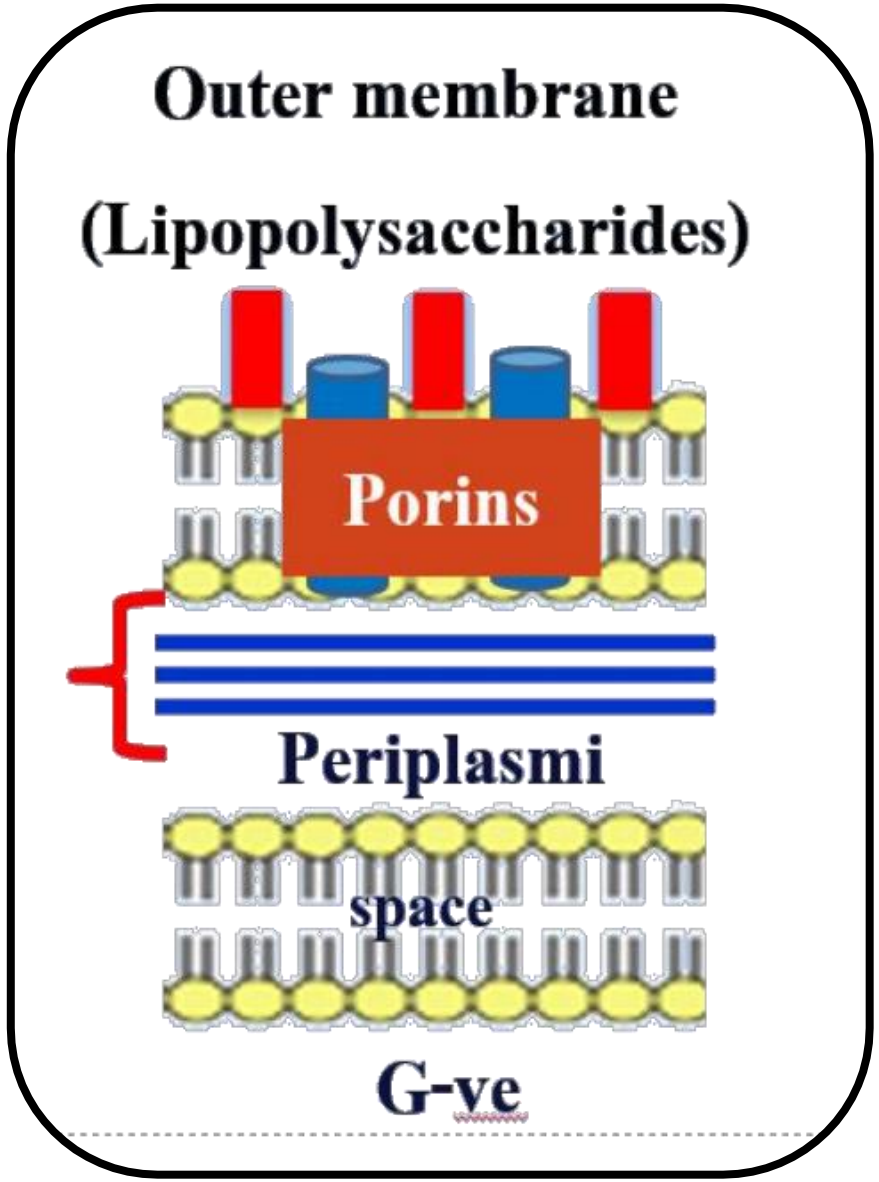
A thin layer (5%)

2 sheets of

NAM & NAG

|

Peptides



2) Outer membrane

A) Bilayer phospholipids

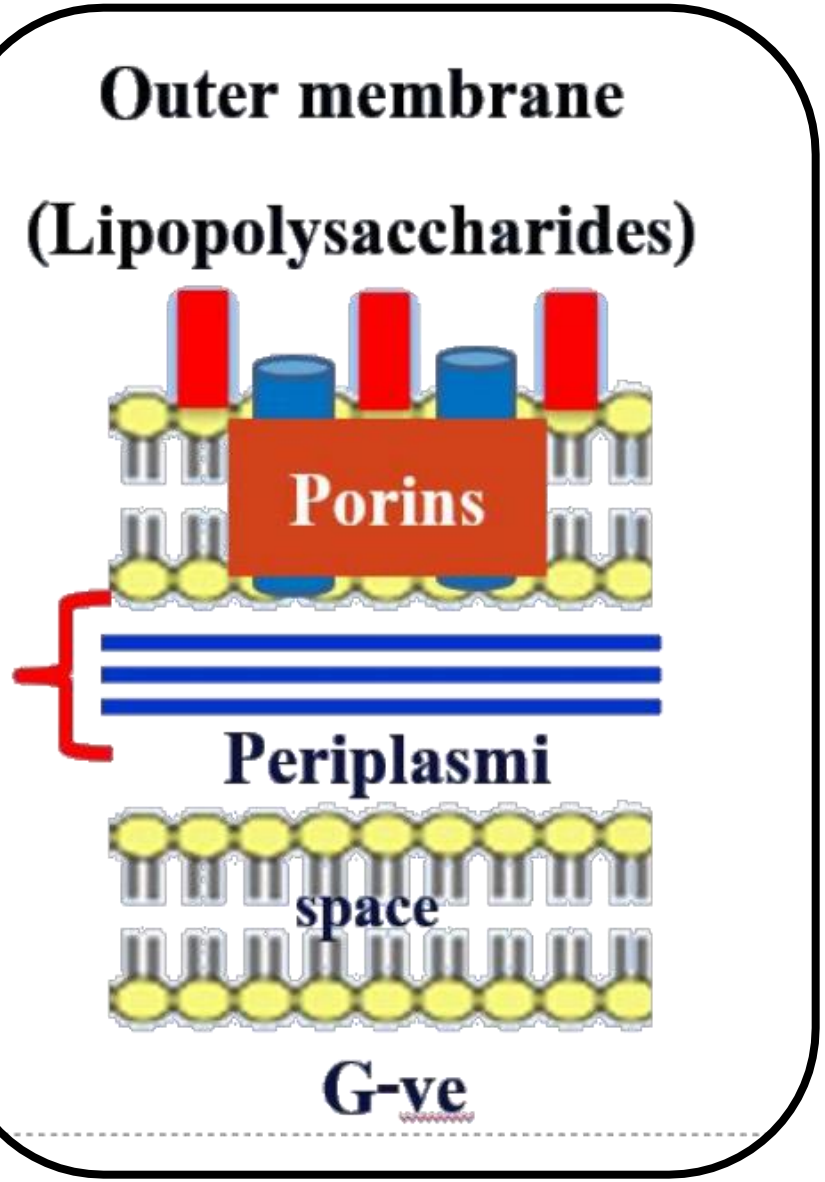
B) Lipopolysaccharides

Lipid A (Endotoxin)

Toxin inside the GRAM (-)

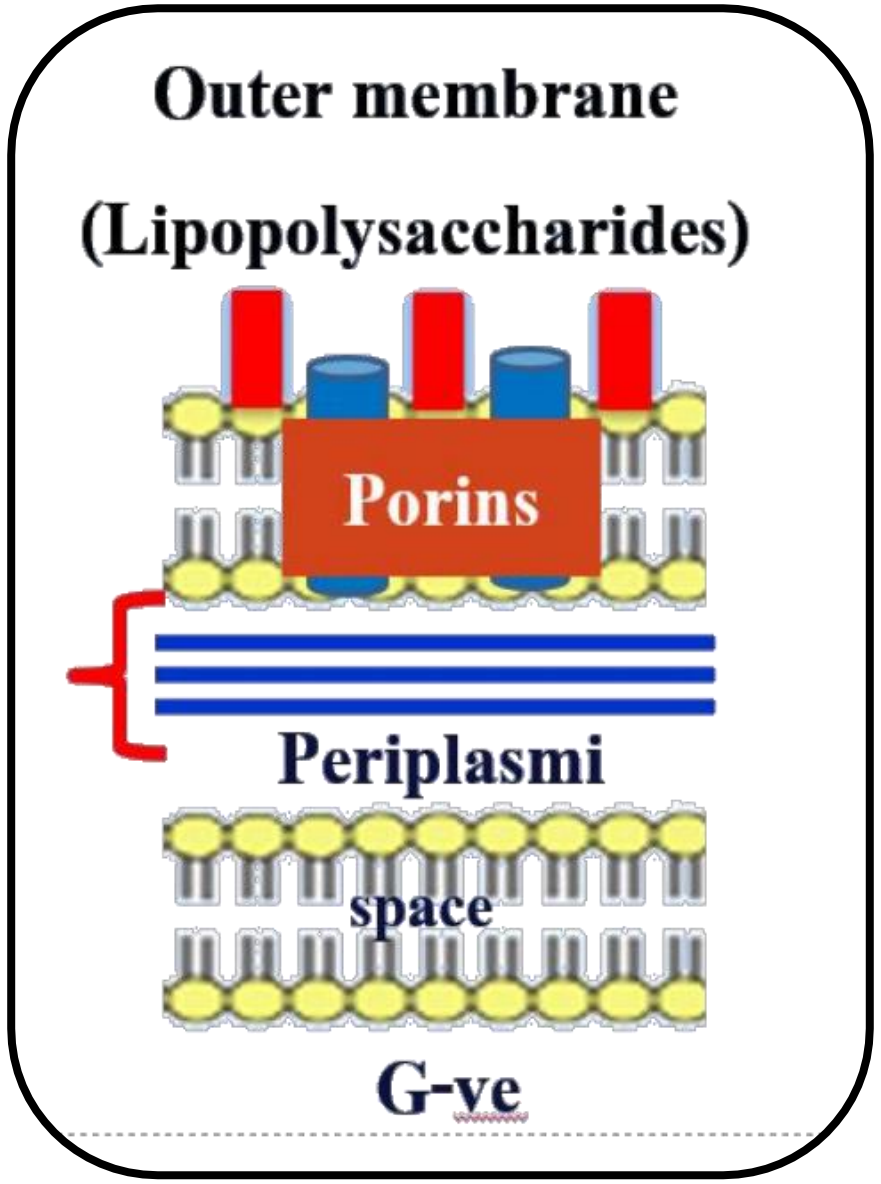
Polysaccharides (somatic O Ag)

Antigen



2) Outer membrane

C) Porins
(hydrophilic proteins)
In the outer membrane
(Transportantion)

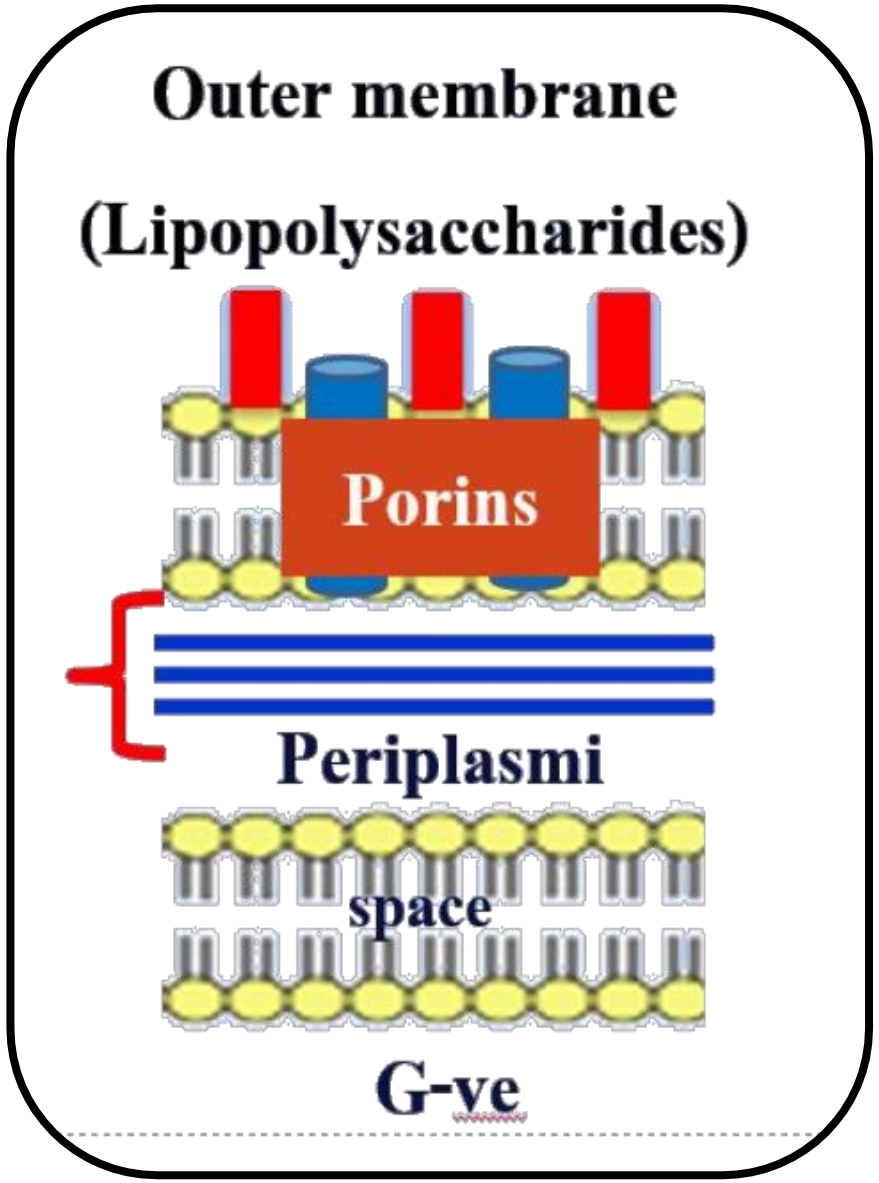


3) Periplasmic space

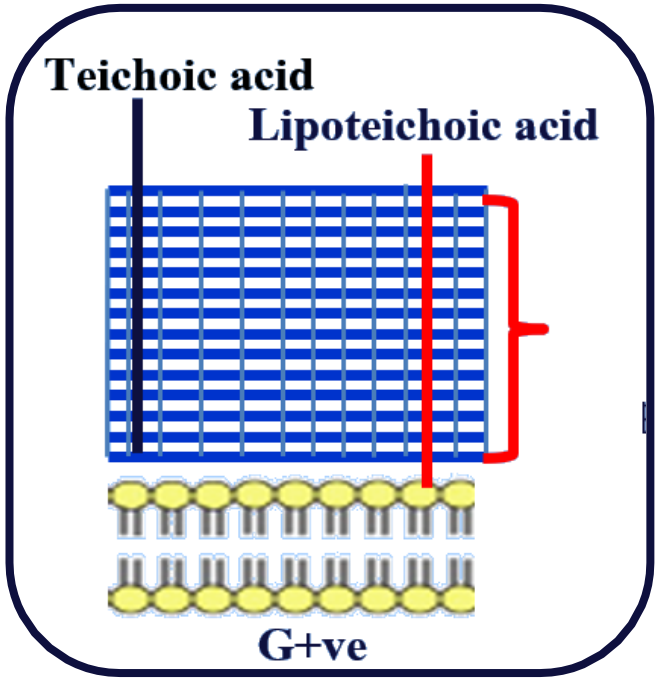
The space between the 2 membranes

Space between cytoplasmic & outer membrane

Consists of Peptidoglycan layer & gel-like protein



Gram positive/Negative bacteria



1) **Peptidoglycan**

- Thick

2) **Teichoic acid/ Lipoteichoic acid**

- Yes

3) **Outer membrane**

- No

1) **Peptidoglycan**

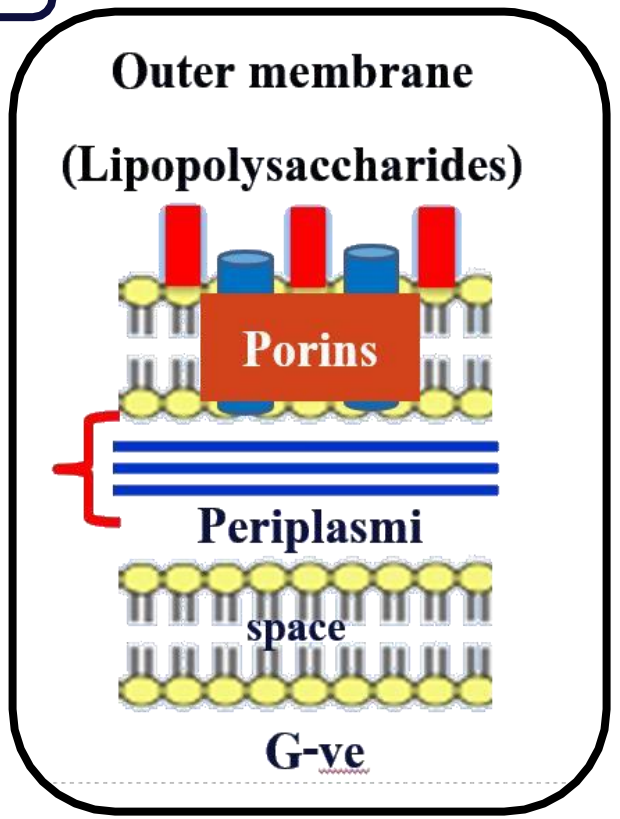
- Thin

2) **Teichoic acid/ Lipoteichoic acid**

- No

3) **Outer membrane**

- Yes

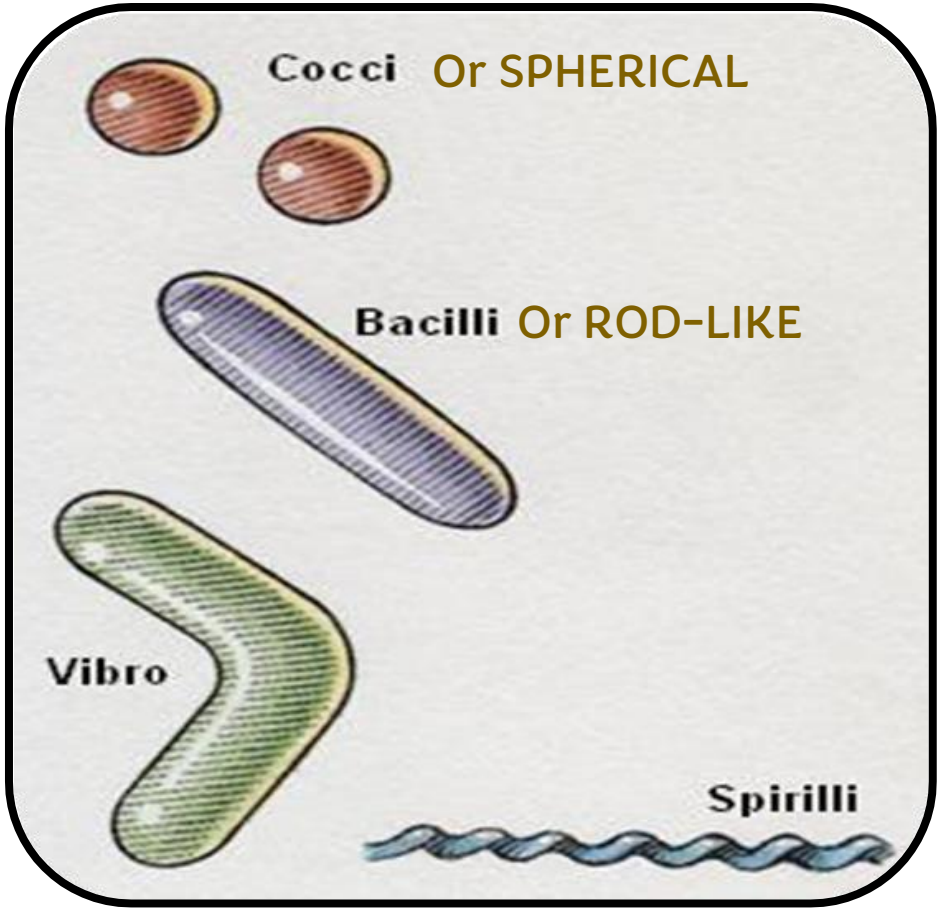


Function of cell wall

1

Maintenance of the shape (Rigid)

Different shapes depending on the CELL WALL



Function of cell wall

1

Deficient of cell wall

Main example is the MYCOPLASMA

Takes many shapes (no certain shape)

Polymorphic

Function of cell wall

2

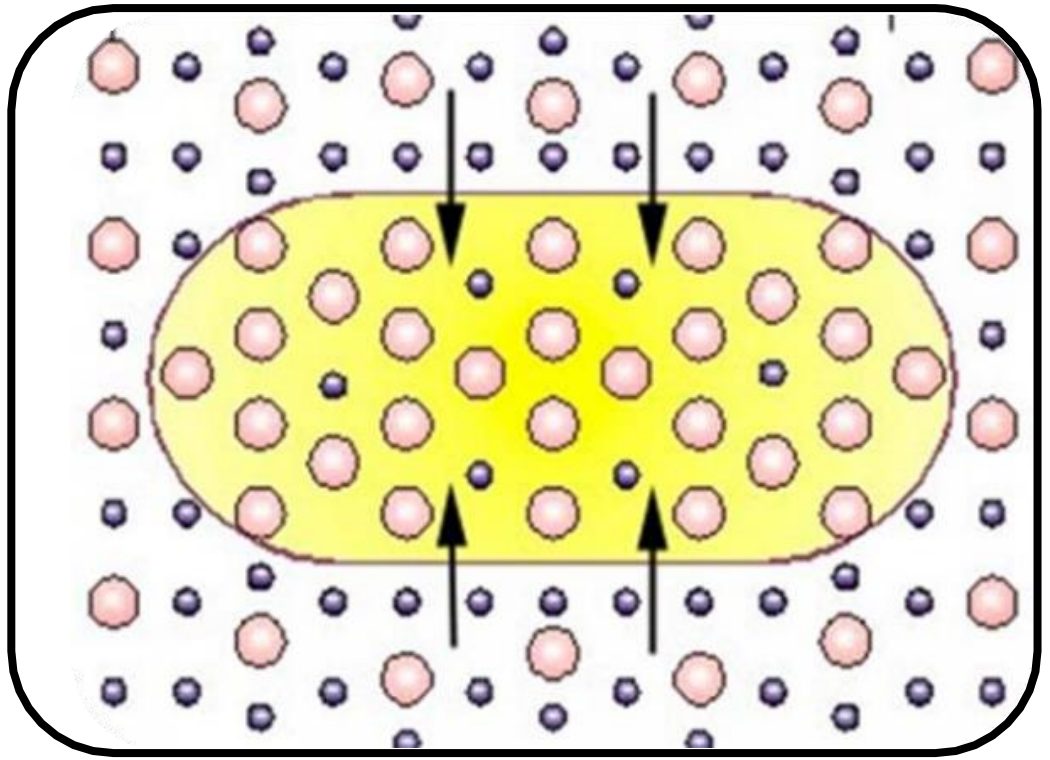
Protection

(Osmosis insensitive)

Protects the cell membrane which is Osmosis **Sensitive**

Recall the tonicity concept:
If the cell is
in a hypertonic solution → it shrinks
in a hypotonic solution → it lyses (bursts)

This effect is countered by the present of the cell wall ☺



Function of cell wall

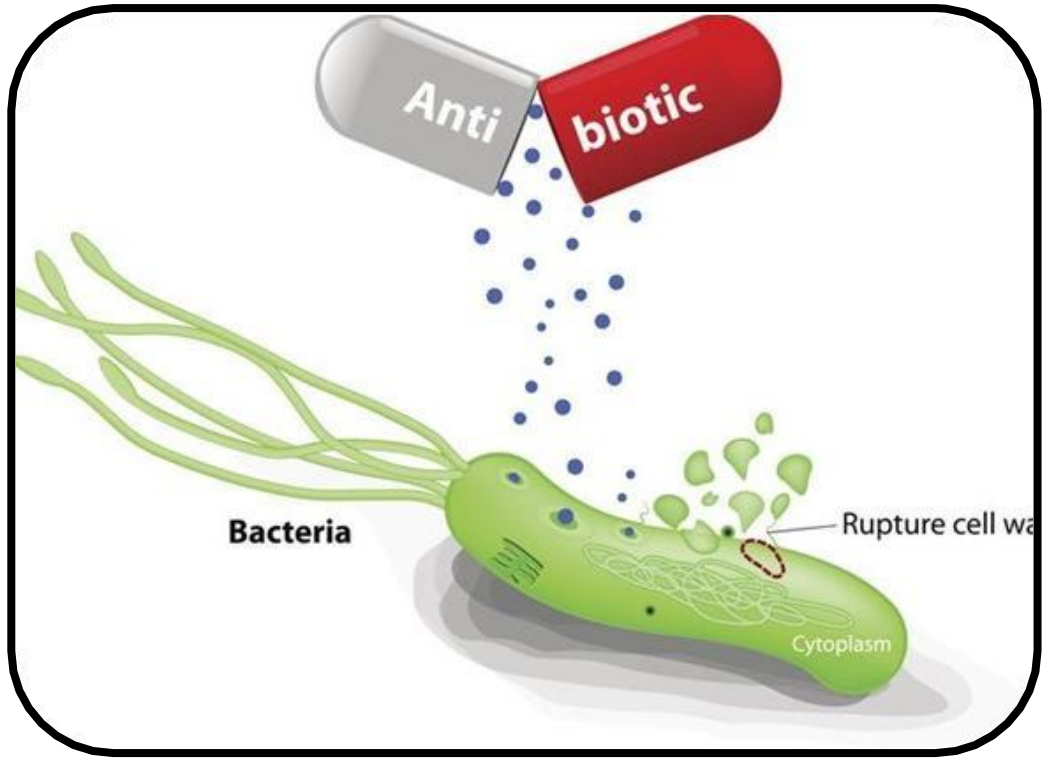
3

Target site for antibiotics

Penicillin

Cephalosporines

they attack the cell wall of bacteria

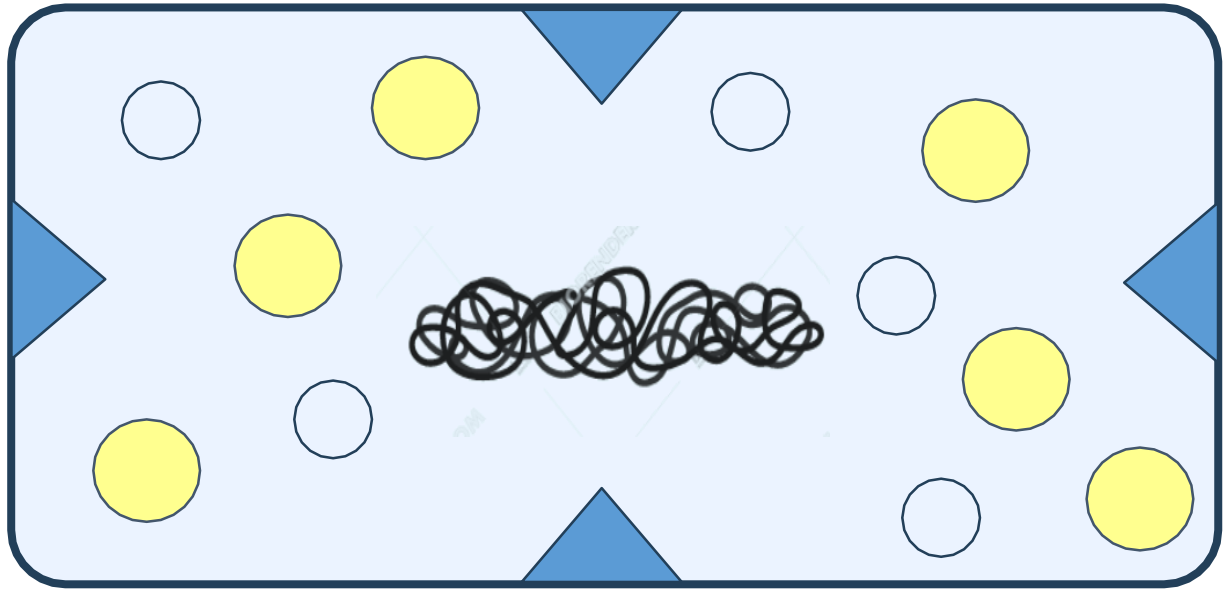


Function of cell wall

4

Role in cell division

to be discussed later

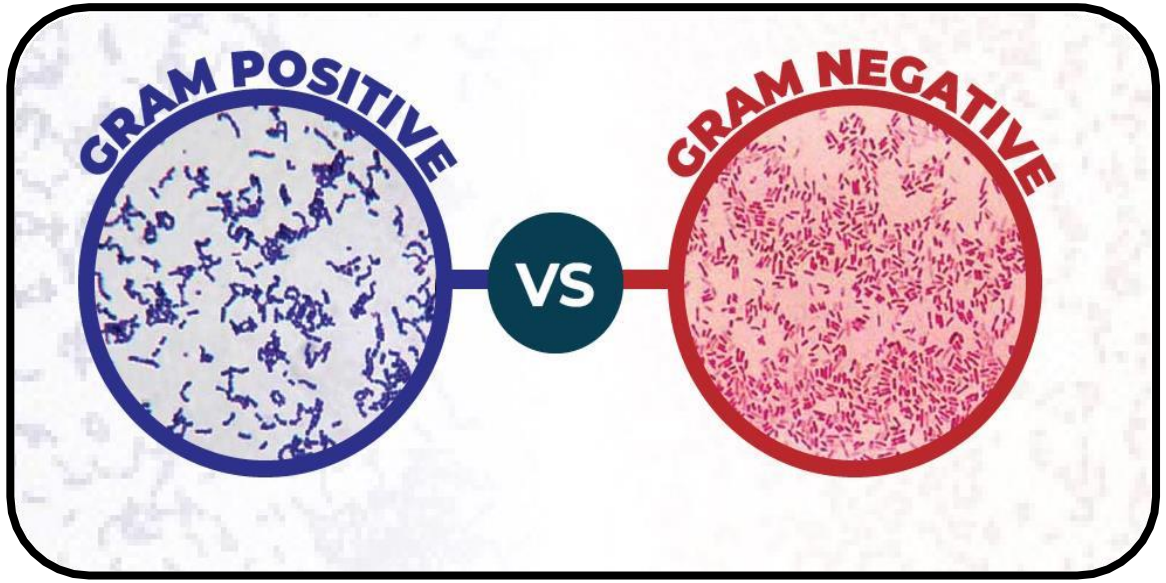


Function of cell wall

5

Responsible for staining

remember the colors very well and distinguish between them



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

G+ve

Fixation

1. Crystal Violet

The primary stain

2. Iodine

For fixation

3. Acetone

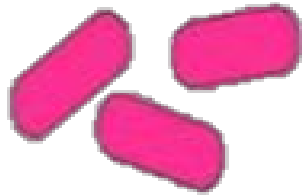
Or alcohol (95%)

For decolorization

Little to no effect on GRAM (+) at this step

4. Counter Stain

Saffranine



G-ve

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 without cell wall

2 types; see next slides.

Cell membrane

Cell wall Deficient

1) Naturally

Mycoplasma (Sterol)

Sterols (in the cell membrane) give some protection because this type lacks a cell wall.

2) Induced

Some antibiotics

Cell wall inhibitors

Lysozyme

From our bodies

2) Induced

Completely

Partially

Cell membrane

Cell membrane

Named after *Leister city* in England

Protoplast (G+ve)
Spheroplast (G-ve)

L-form bacteria

L-form & Mycoplasma

They resist these because their mechanism is attacking the cell wall (slide 44).

Resist to

Penicillin & Cephalosporines

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	28	**Transpeptidase** Enzyme that made the peptide bonds Between amino acids and NAM	**Transpeptidase** Enzyme that made the peptide bonds between the peptide chains
V1 → V2			

Additional Resources:

رسالة من الفريق العلمي:

أسبوع انتهى
ما زال المشوار طويلًا
استعينوا بالله فهو نعم المعين