

MID – Lecture 2

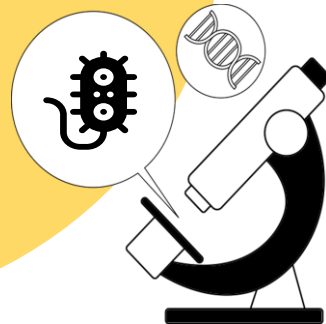
Bacterial Structure (Pt.1)

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﴿ وَإِن تَتَوَلَّوْا يَسْتَبَدِلْ قَوْمًا غَيْرَكُمْ ثُمَّ لَا يَكُونُوا أَمْثَلَكُمْ ﴾

اللهم استعملنا ولا تستبدلنا



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:

GRAM stain is to be discussed see slide 30

Capsule

Cell wall

Some GRAM (+) bacteria have:

Spore

Cell Membrane

Inclusion bodies

Nucleoid

Some bacteria have:

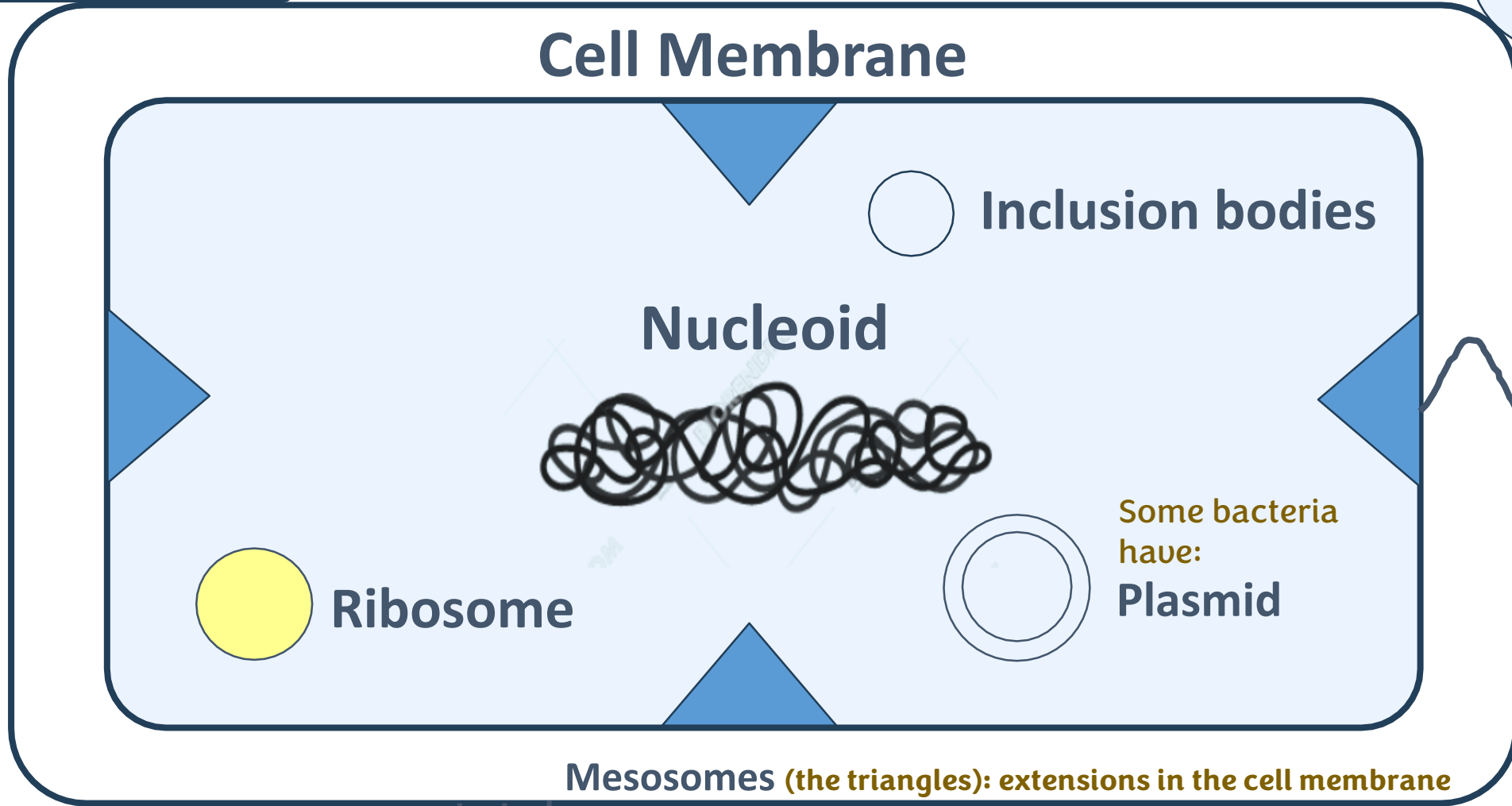
Flagellum

Ribosome

Some bacteria have:
Plasmid

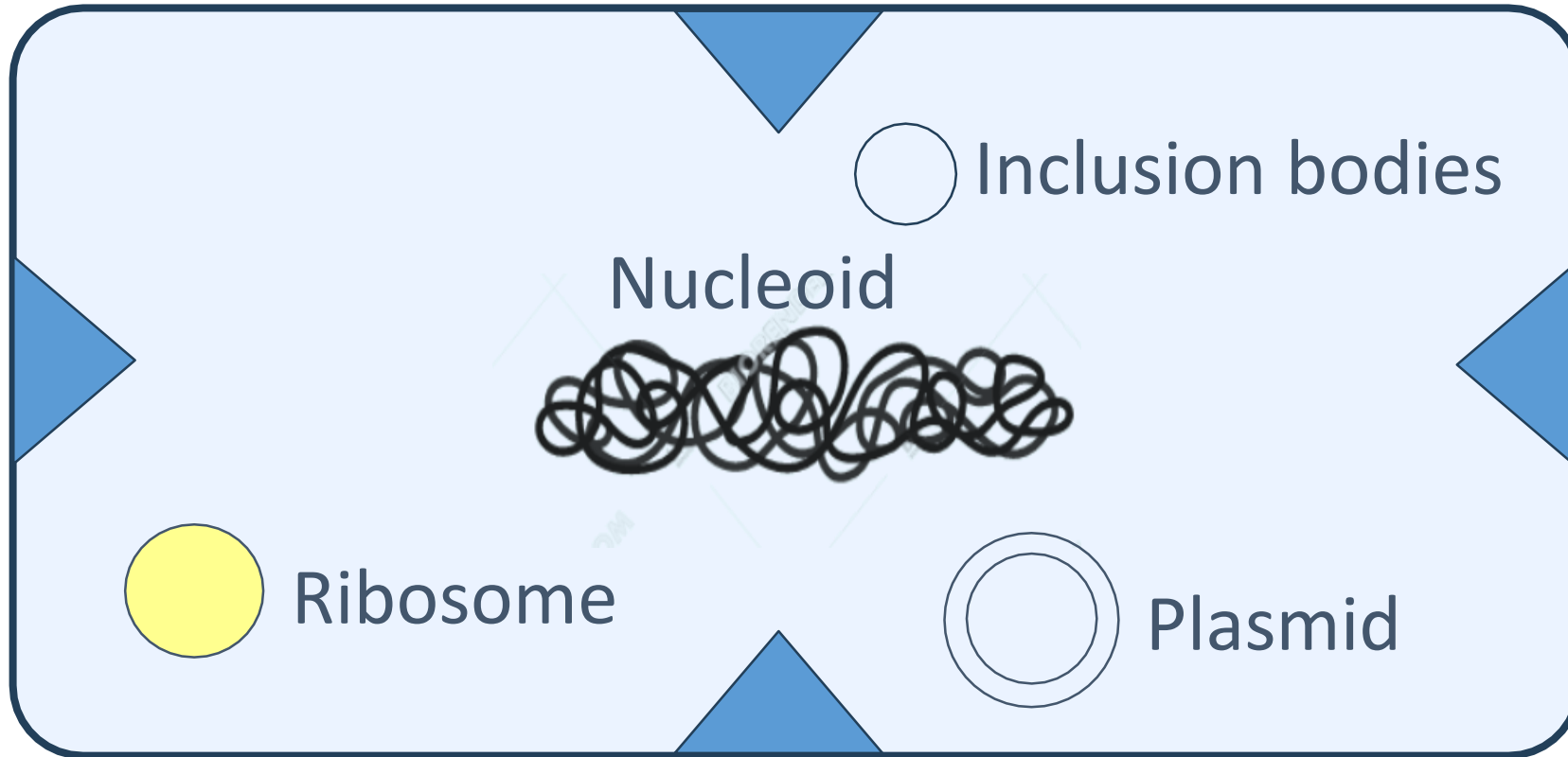
Mesosomes (the triangles): extensions in the cell membrane

Some bacteria have:
Pili



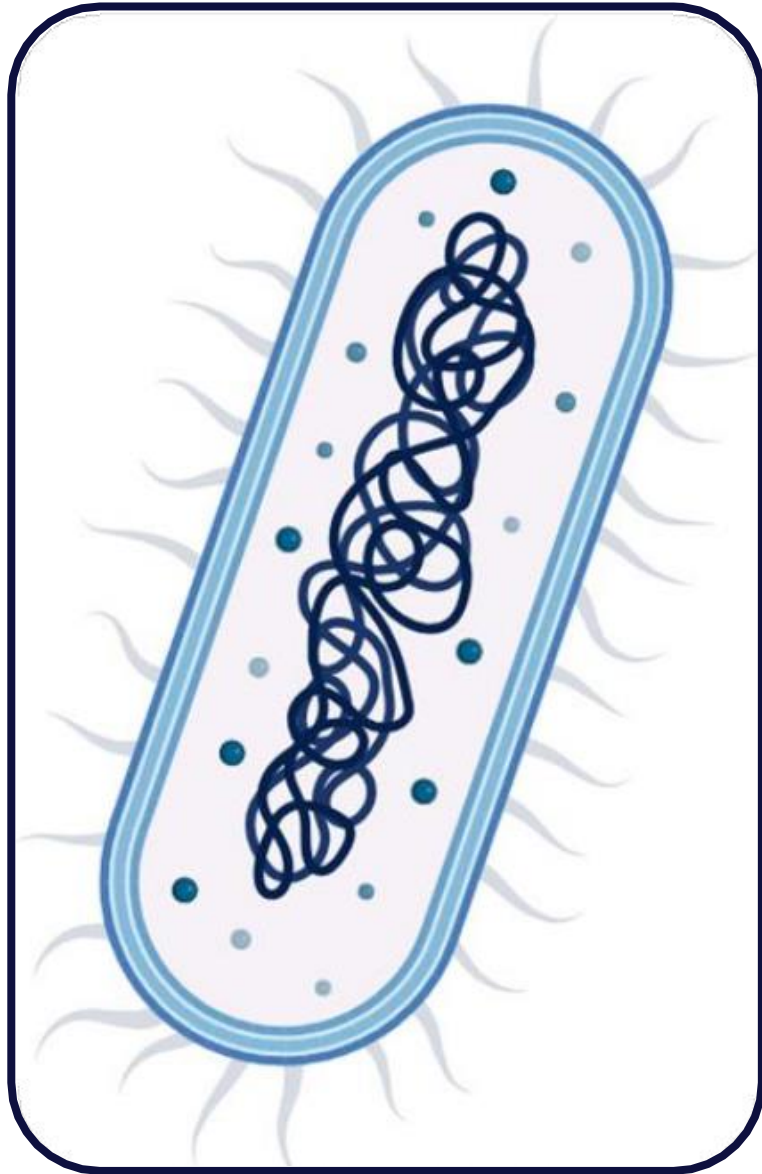
Intracytoplasmic structure

Cell Membrane



Mesosome

1) Nucleoid



1

Single chromosome

2

Circular

3

dsDNA

ds=Double-stranded

4

1mm in length

5

Supercoiled

6

Carry genetic information
for growth & survival

-> It is what distinguishes bacteria from eukaryotes.
-> Bacteria doesn't have a nuclear membrane, so the nucleoid exists in the cytoplasm.

Bacteria's length is measured by microns, and 1mm is 1000 microns! So, DNA must be supercoiled to fit inside the bacteria.

Essential means that all bacteria have it.

Essential

2) Ribosome

1 Ribo=RNA

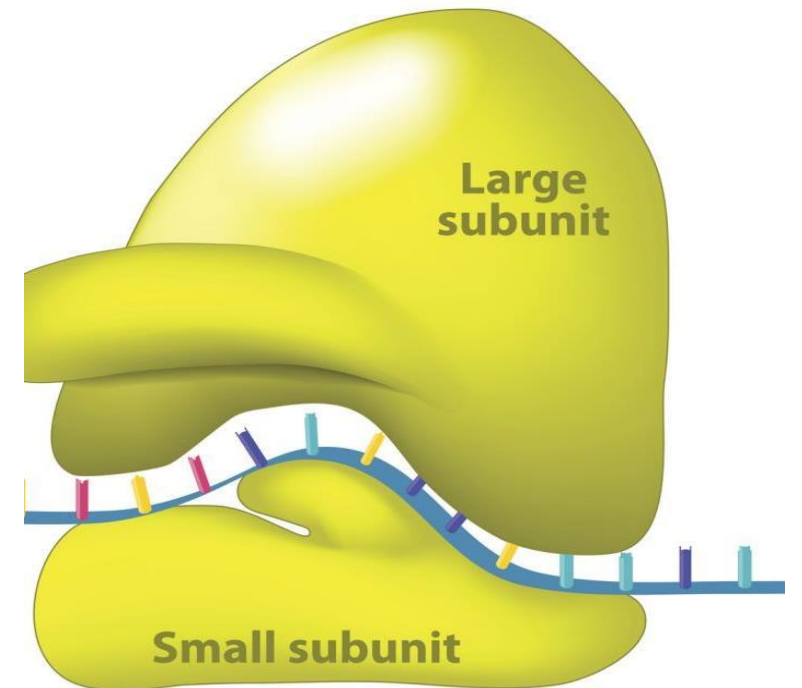
2 Some=body

3 Site of Protein synthesis

Protein synthesis = mRNA + Ribosome

Essential

RIBOSOME



2) Ribosome

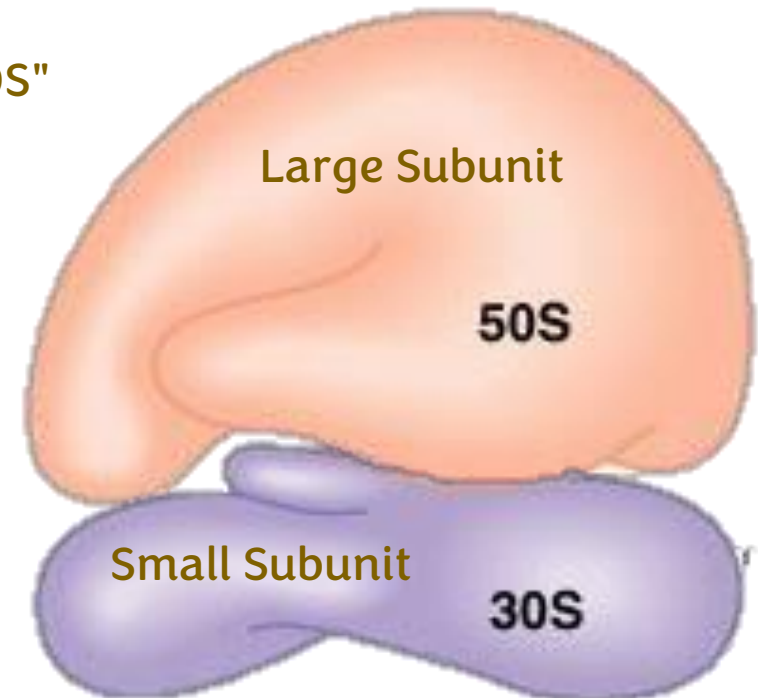
Bacterial ribosomes

(70S)

Svedberg unit

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

The type of the ribosome is "70S"

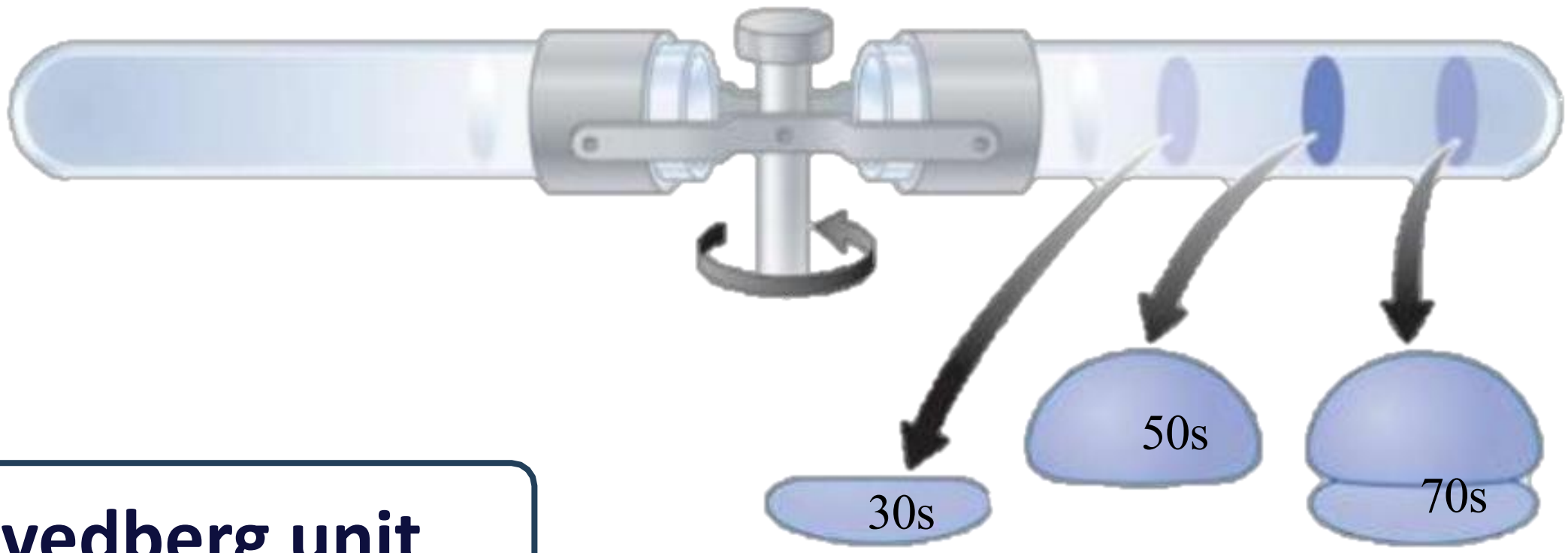


2) Ribosome

Small & large subunits binds together when they bind with mRNA

Small subunit's density is 30s
Large subunit's density is 50s
Their density when together is 70s

Centrifuge

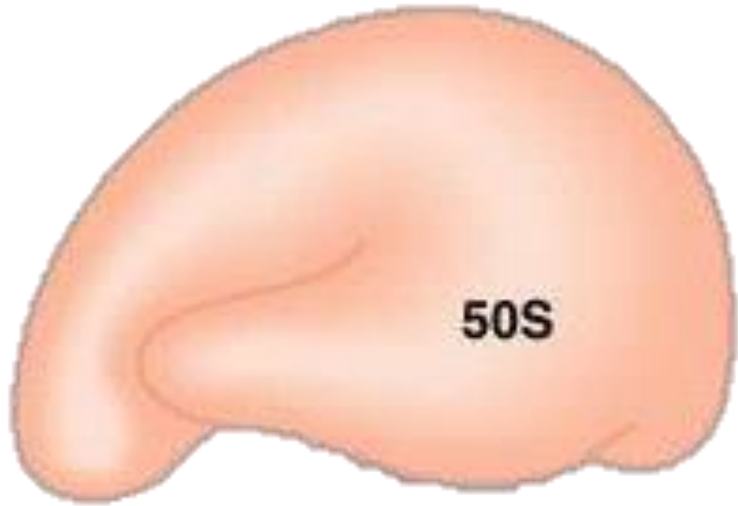


Ribosomal subunits

Svedberg unit

2) Ribosome

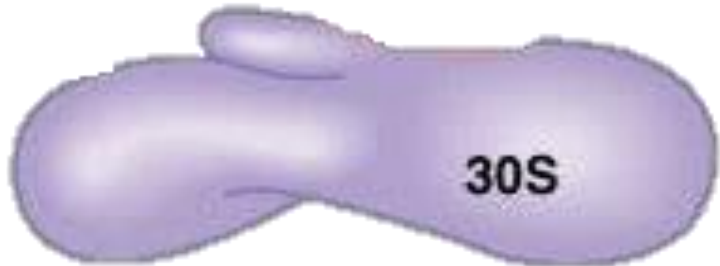
Scientists used this difference in density to develop antibiotics that specifically attack bacterial ribosomes, without damaging our ribosomes.



50S

50S

Target of antibiotics



30S

30S

60S

Human

40S

3) Inclusion granules

Its main function is

Store of nutrient

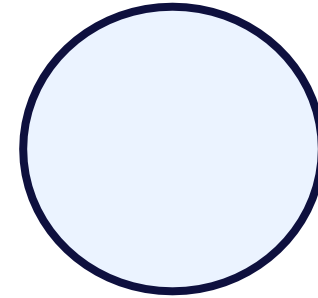
Glycogen

Starch

Phosphate

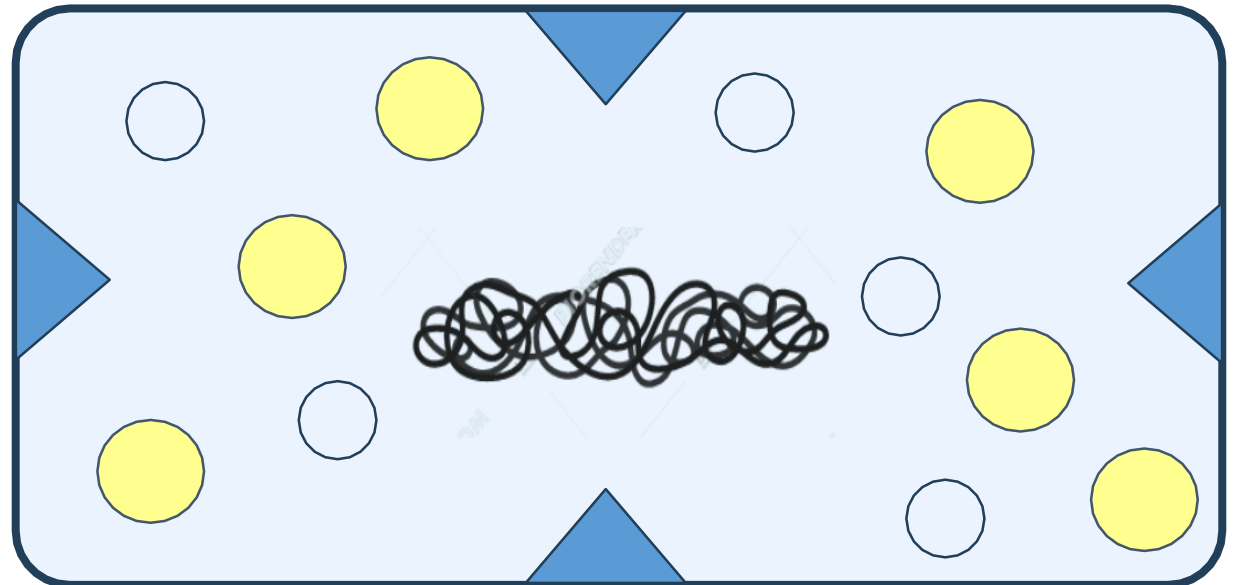
Some type of bacteria
mainly stores phosphate in
its inclusion bodies, that's
why we call its granules as:

**Volutin granule
(Metachromatic
granules)**



Definition of the cell membrane

**Thin, fragile membrane
located just
inside the cell wall**

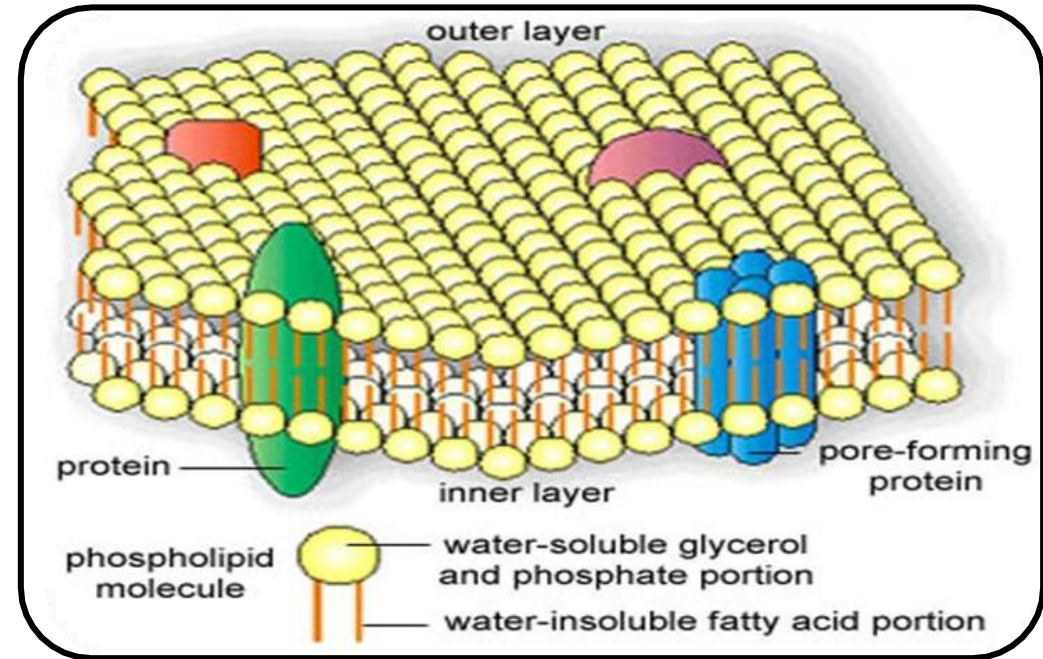
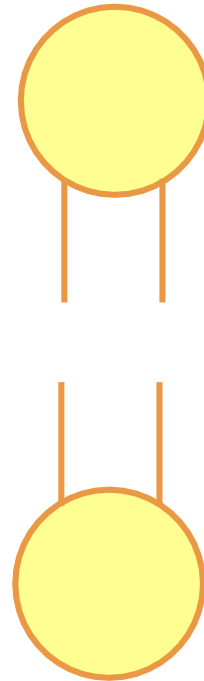


Essential

Composition of cell membrane

Phospholipid bilayer + Protein (No sterols)

An exception is
Mycoplasma which have
sterols

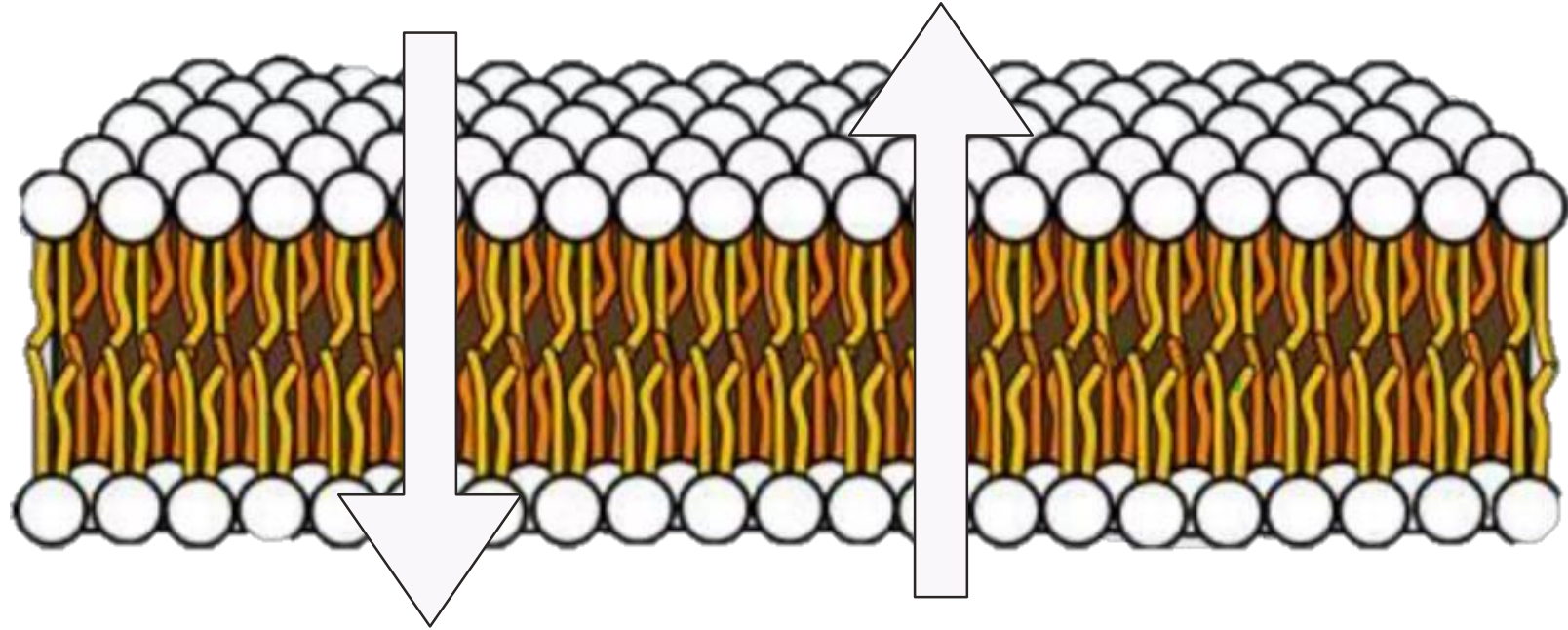


Function of the cell membrane

1

Selective transport (Passive)

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

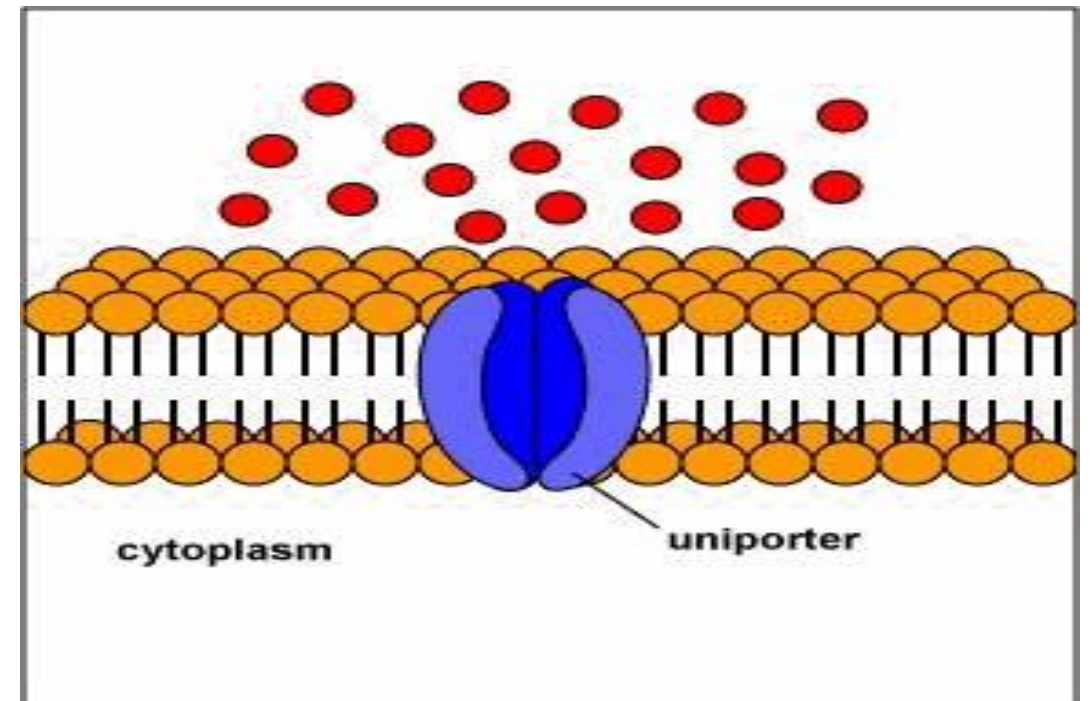


Function of the cell membrane

1

Selective transport (Active)

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

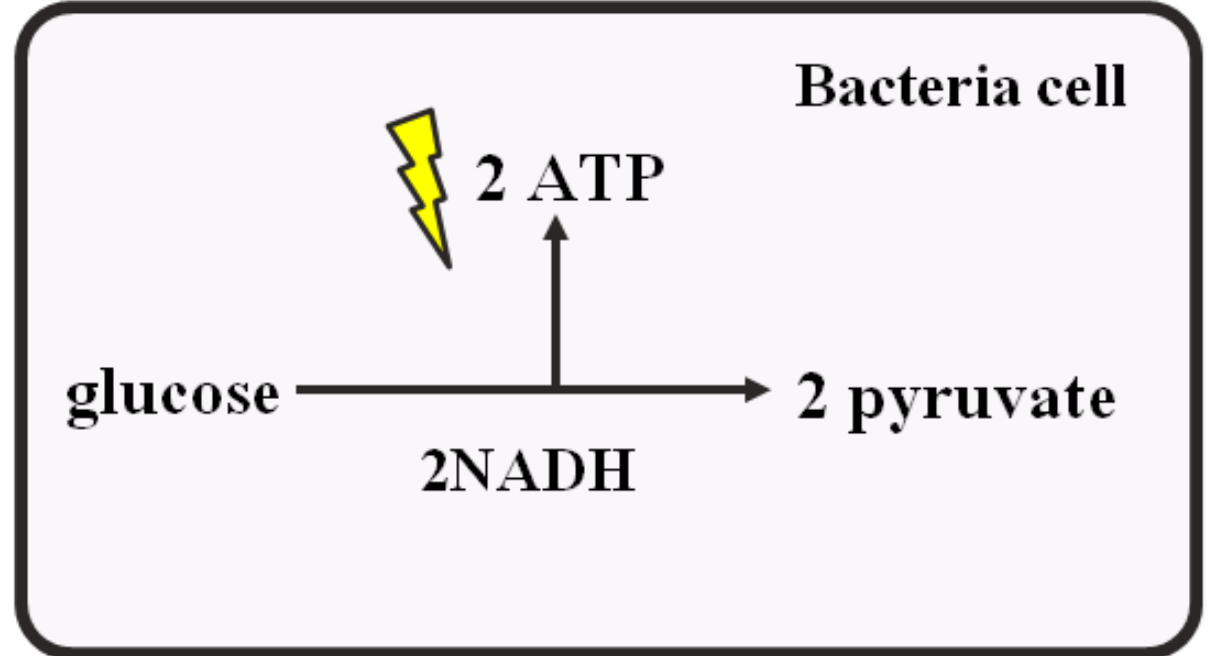


Function of the cell membrane

2

Mesosomes
Respiration enzyme
(Making energy)
(Like Mitochondria)

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

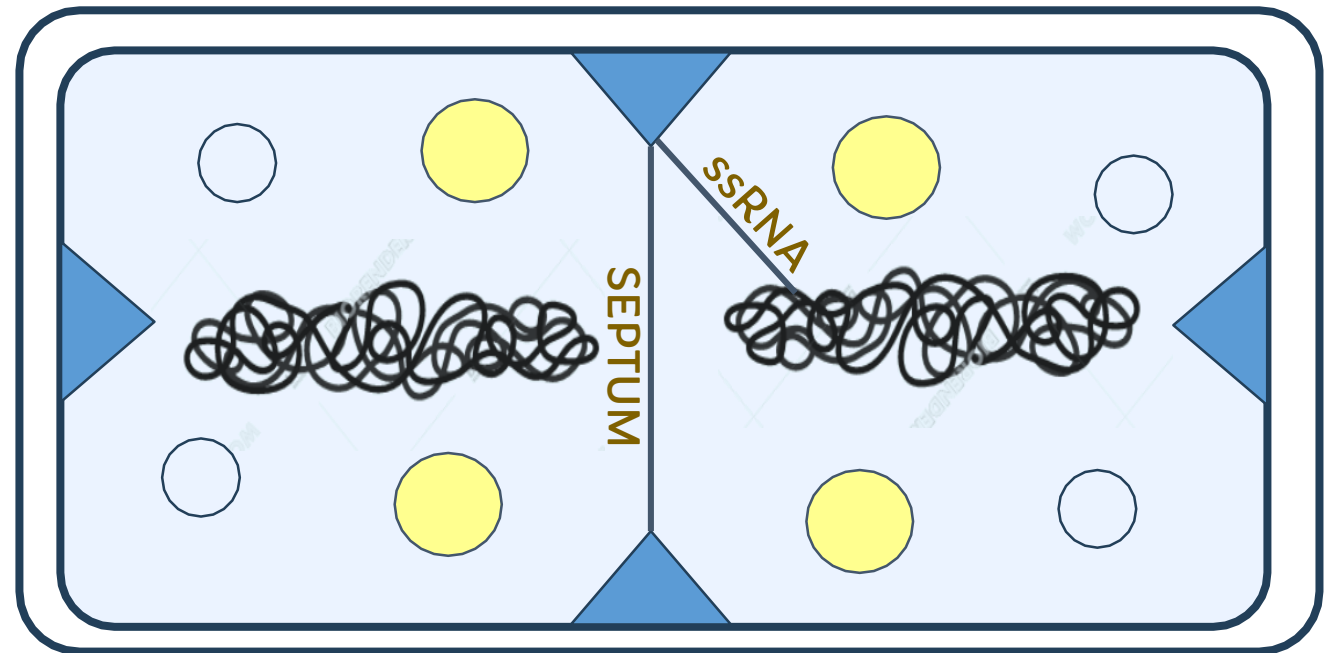


Function of the cell membrane

2

Mesosomes
Cell division
Separate DNA
Septal mesosomes

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

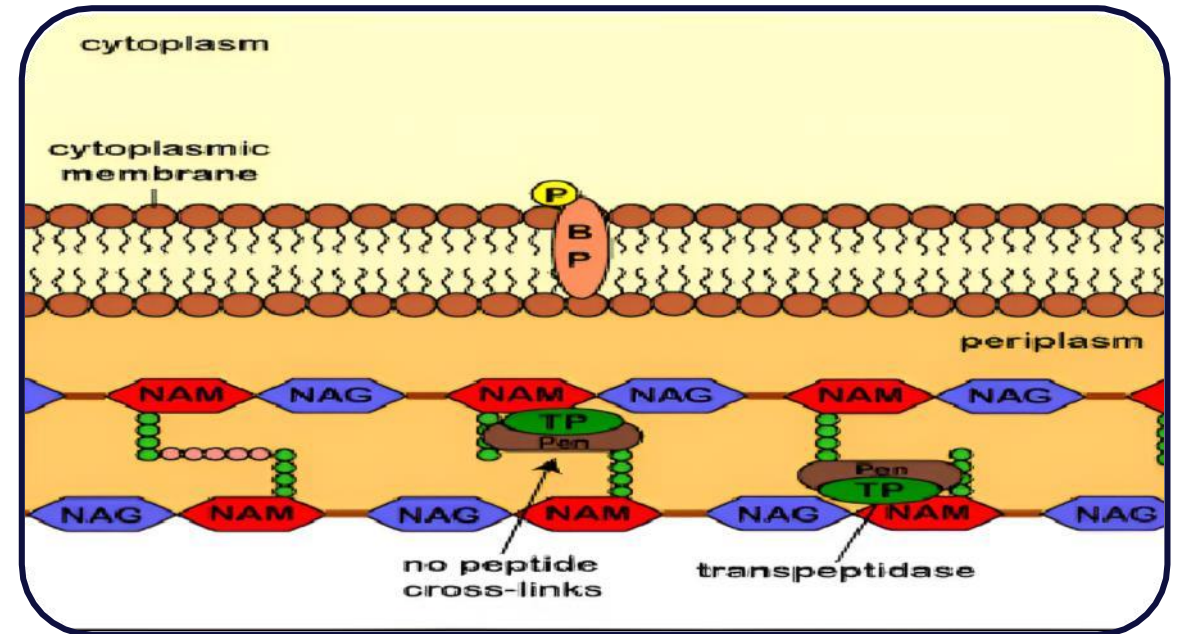


Function of the cell membrane

3

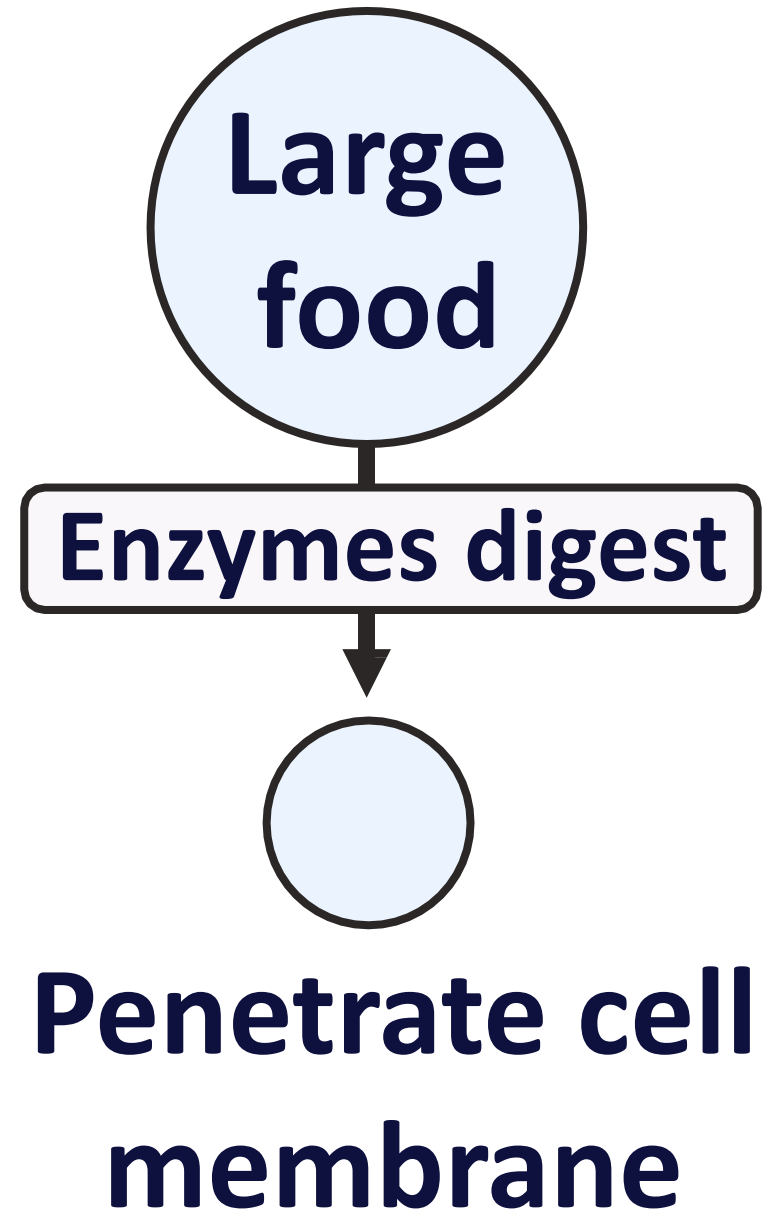
Biosynthesis of cell wall

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



4

**Excretion of extracellular enzymes
(Hydrolytic enzymes)**

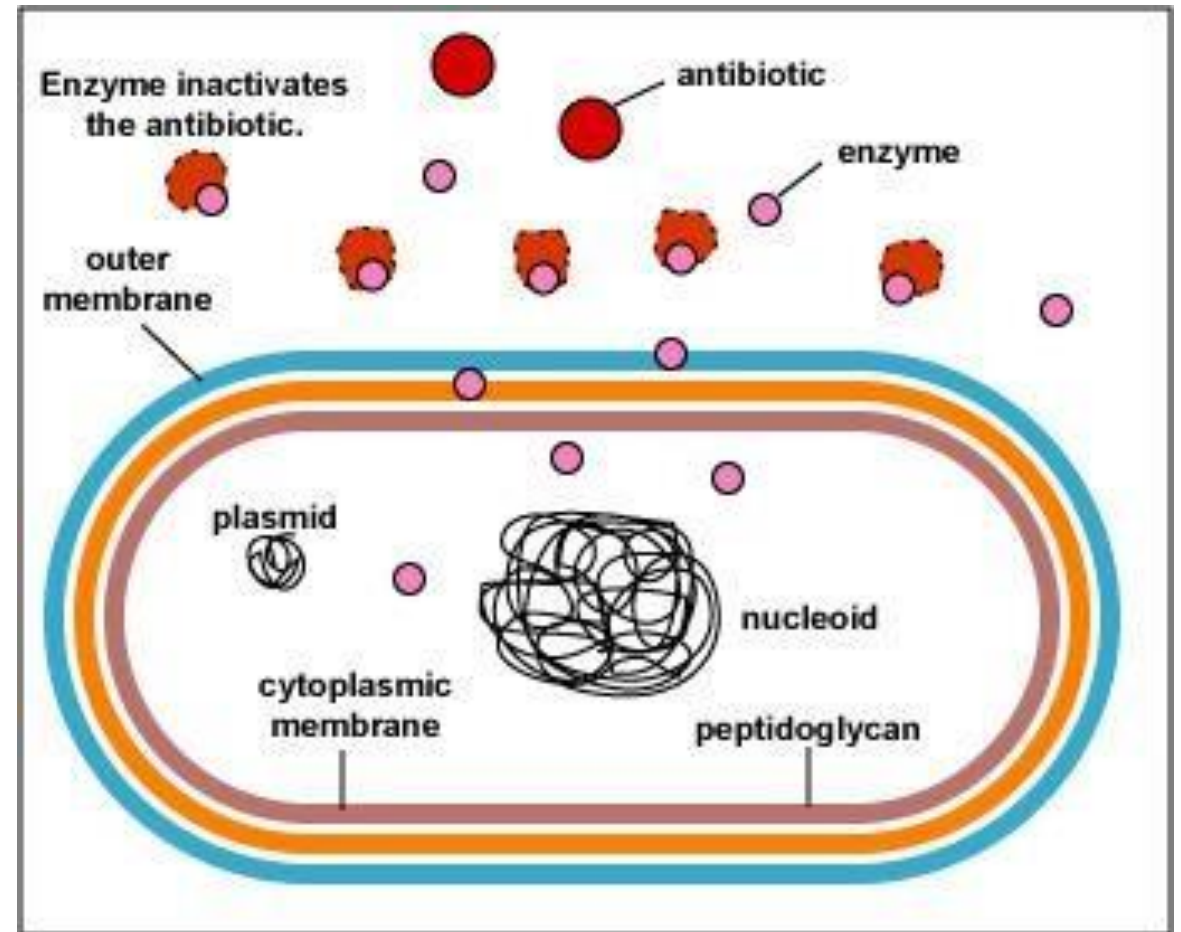


Function of the cell membrane

5

Excretion of extracellular enzymes (Penicillinase)

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



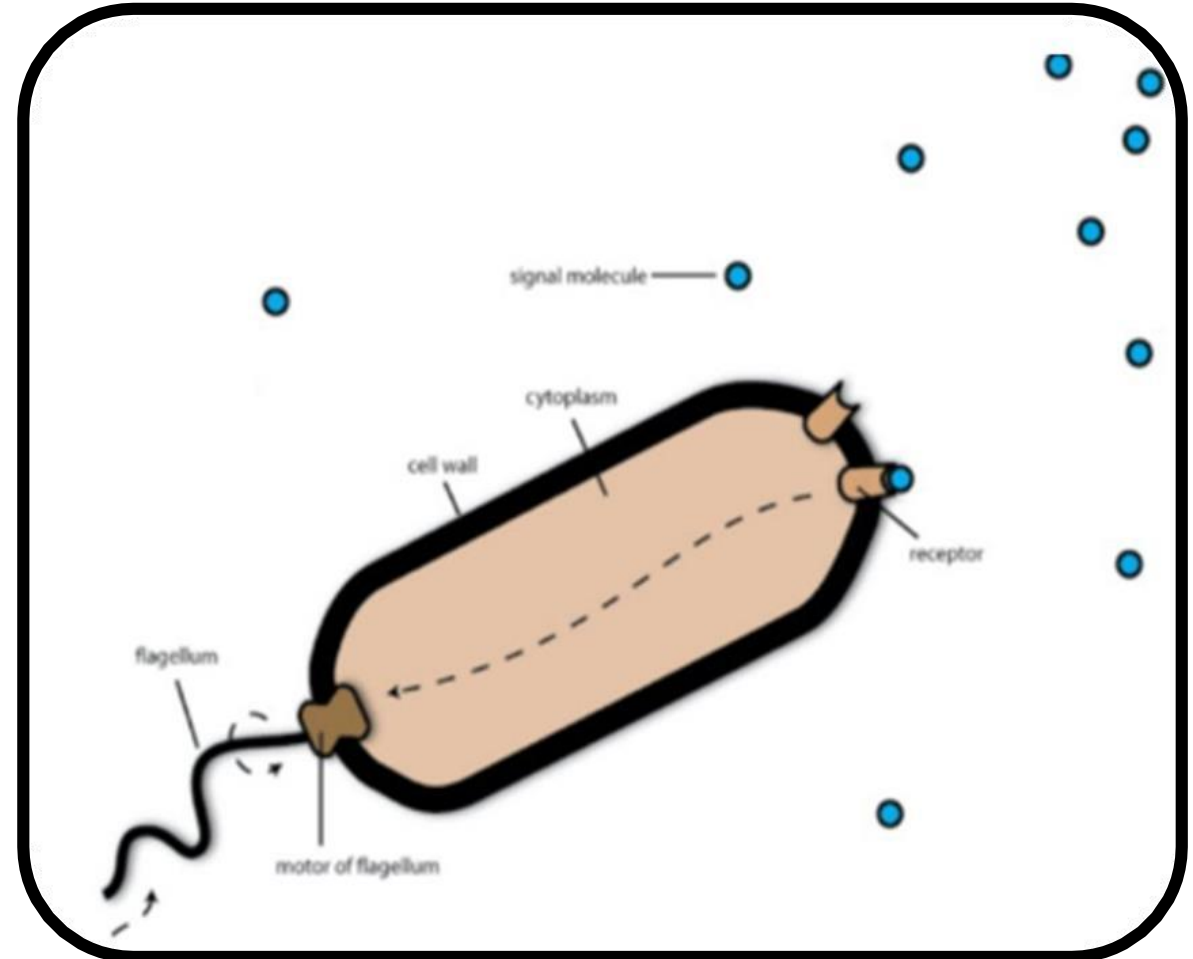
Function of the cell membrane

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 **circ**ular chromosomal dsDNA

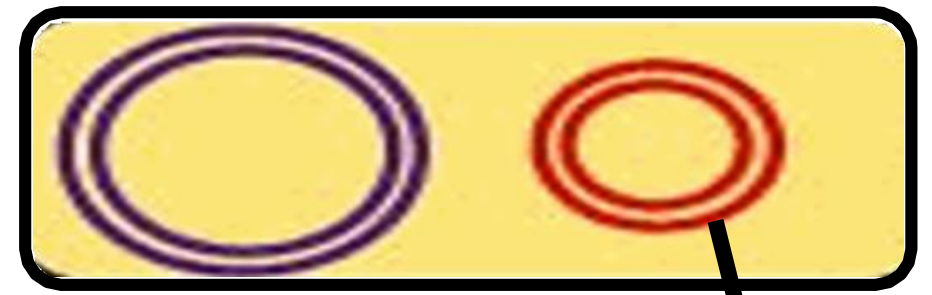
Why isn't plasmid considered a part of the bacterial chromosome?

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

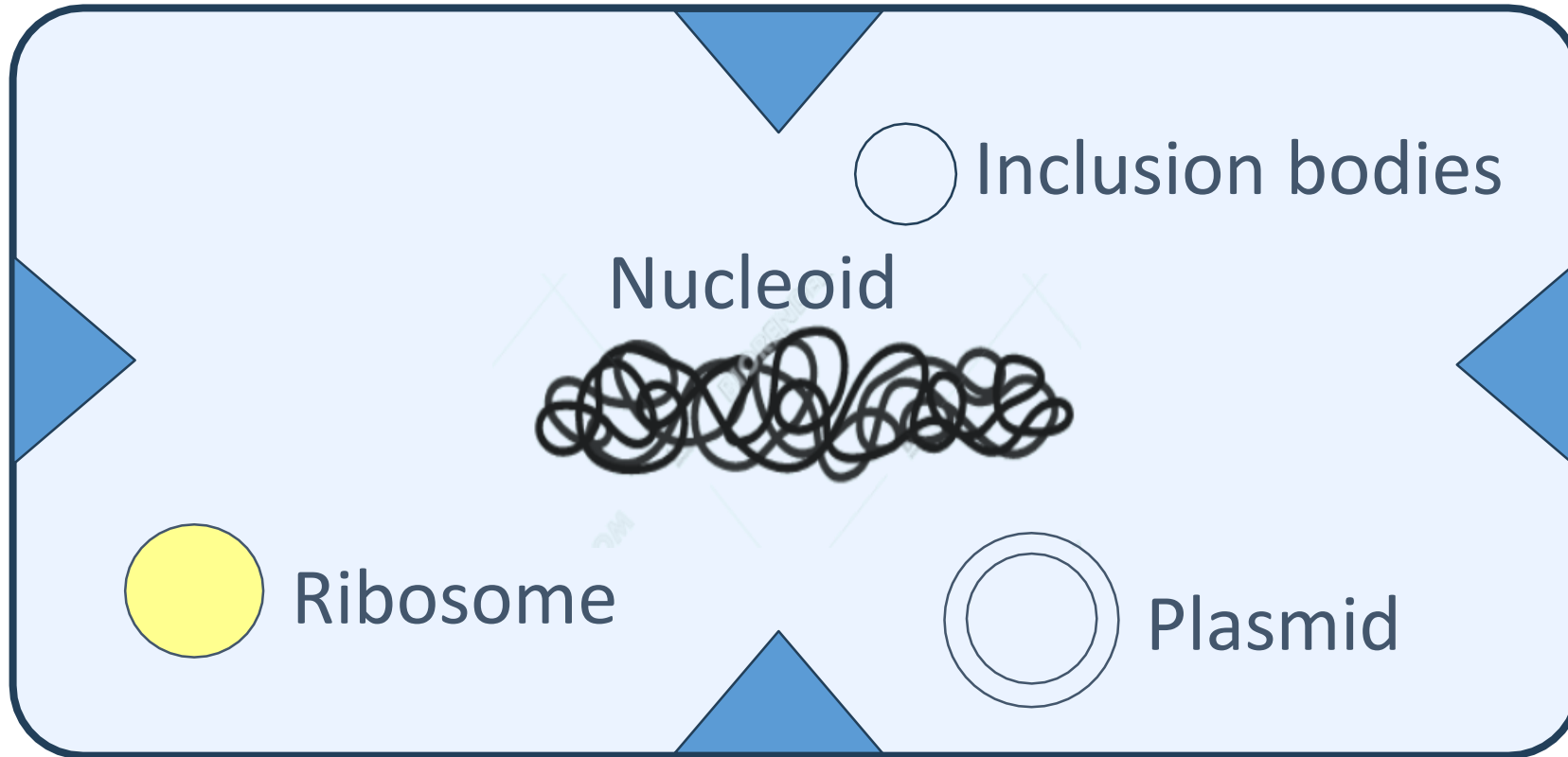
Not essential



Plasmid

Intracytoplasmic structure

Cell Membrane



Mesosome

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



The diagram consists of two concentric rounded rectangles. The inner rectangle is dark blue and contains the text 'Cell Membrane'. The outer rectangle is a lighter blue and represents the cell wall, surrounding the cell membrane.

Cell Membrane

Composition of cell wall

Rigidity

(Peptidoglycan)



Cell membrane

The diagram illustrates the structure of a cell wall. It consists of two concentric rounded rectangular layers. The outer layer is a thick, dark blue border. Inside this is a thinner, lighter blue border. The space between these two layers represents the cell wall, which is associated with rigidity and peptidoglycan. The innermost space is labeled 'Cell membrane'.

Composition

The one that links with peptides is NAM and not NAG

N-acetylmuramic acid

Glycans

Sugars

NAM

NAG

Peptido

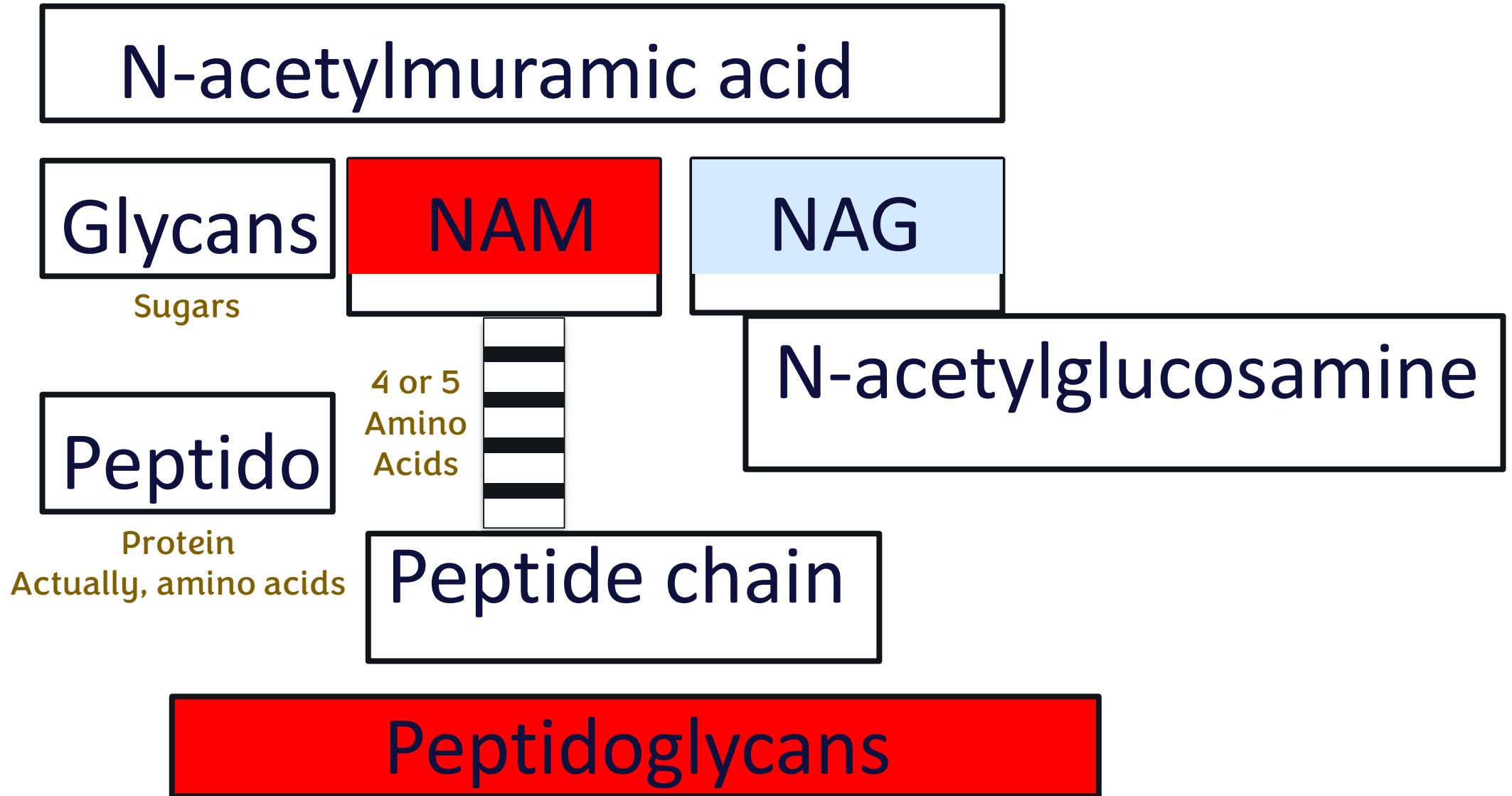
Protein
Actually, amino acids

4 or 5
Amino
Acids

Peptide chain

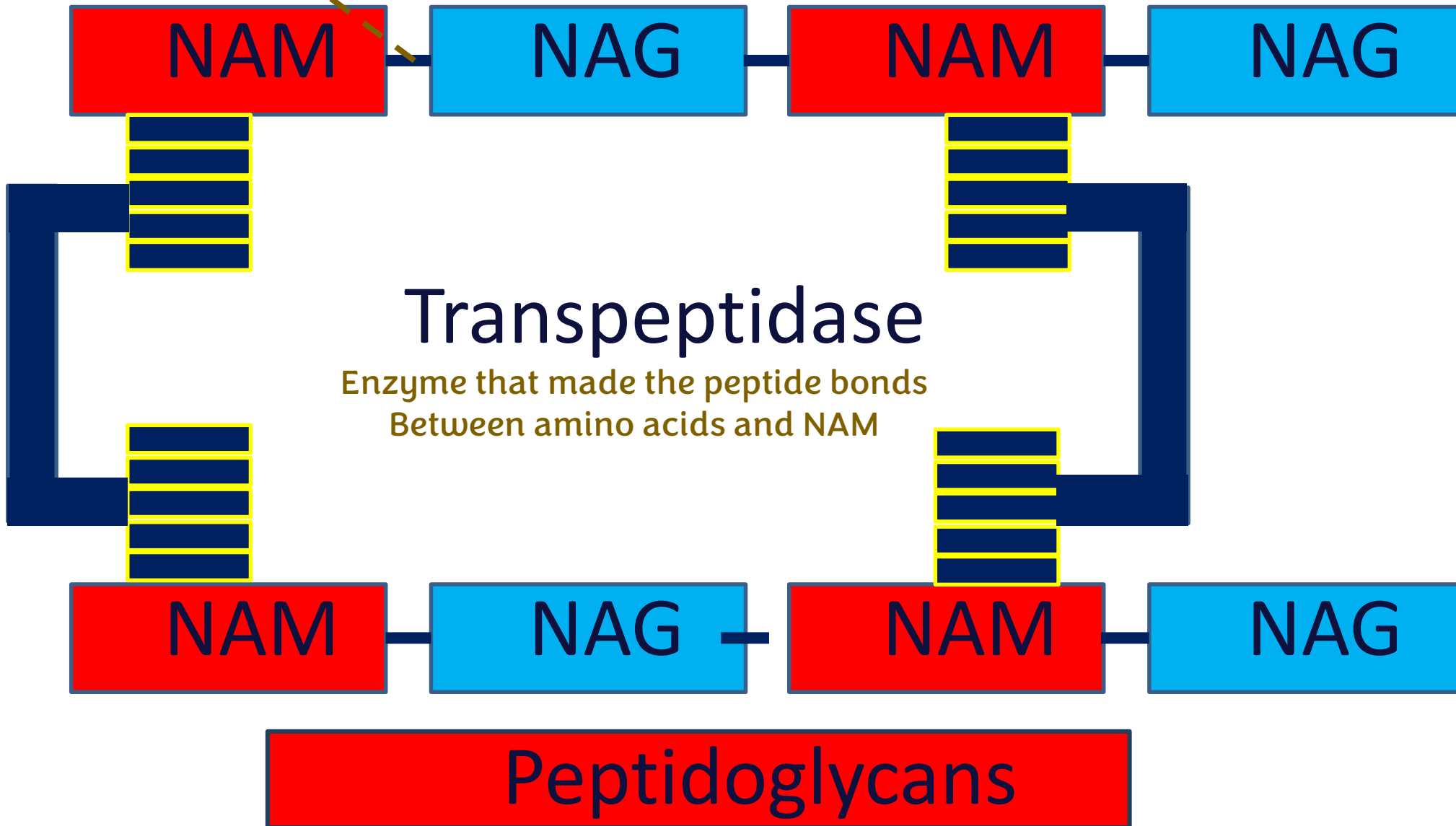
N-acetylglucosamine

Peptidoglycans



Glycosidic bond (Transglycosidase) Alternating repeating unit (sugars)

Enzyme that made these bonds

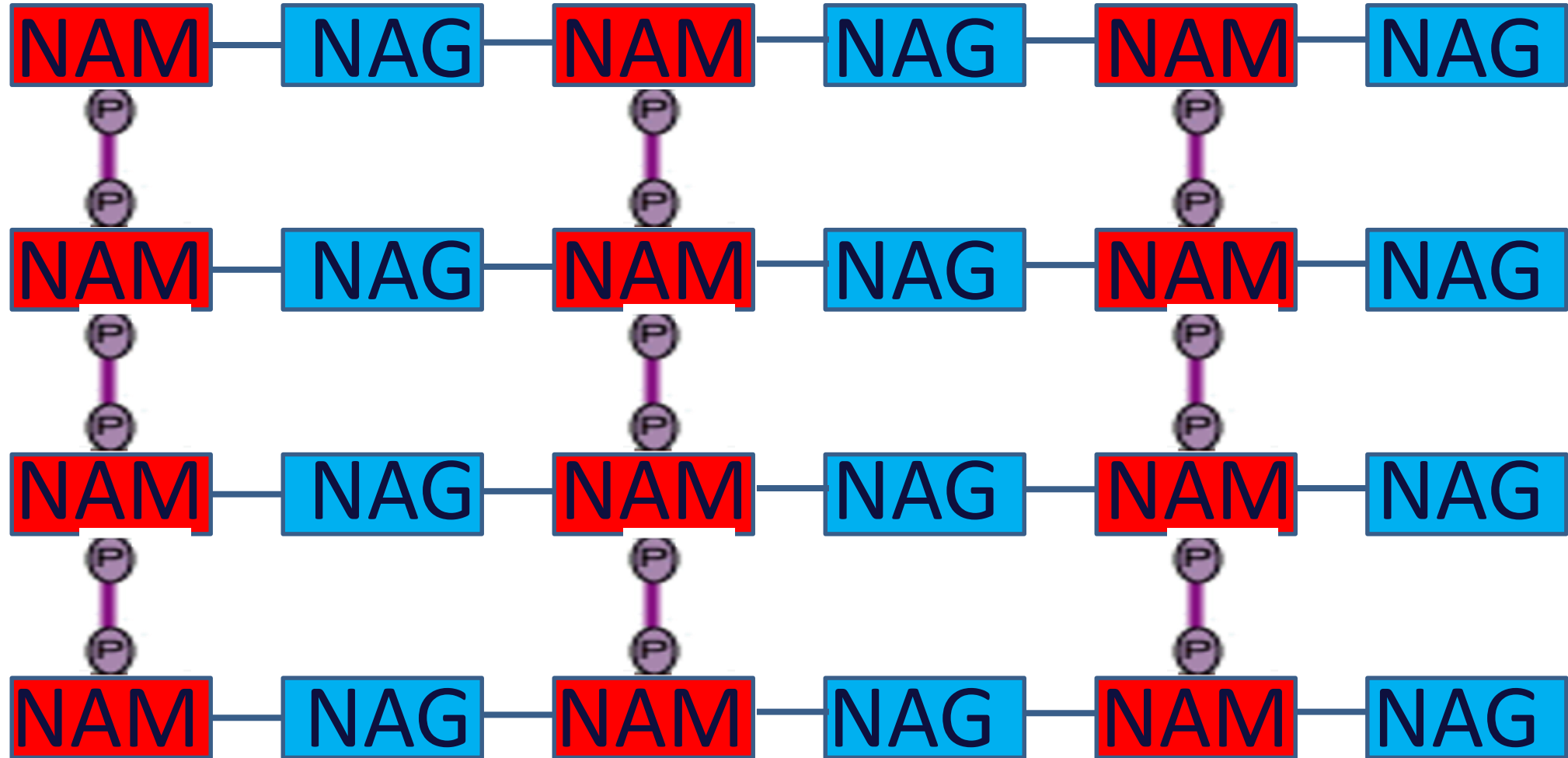


Transpeptidase

Enzyme that made the peptide bonds
Between amino acids and NAM

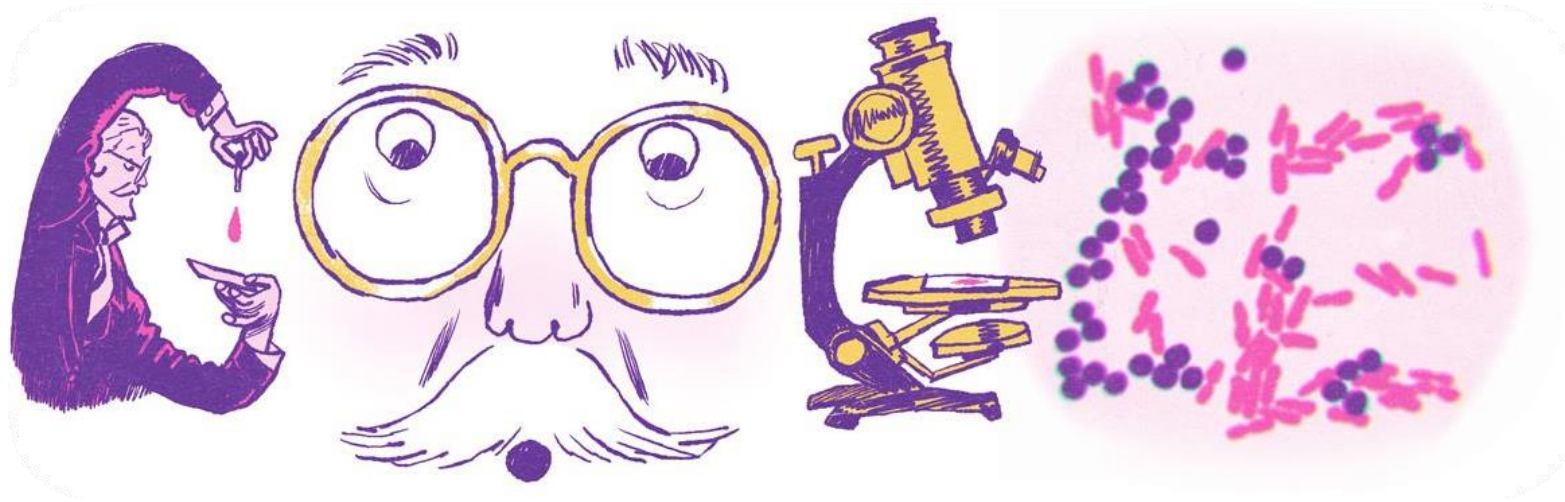
Peptidoglycans

Peptidoglycan Structure (Overall)



Created the GRAM stain

Hans Gram

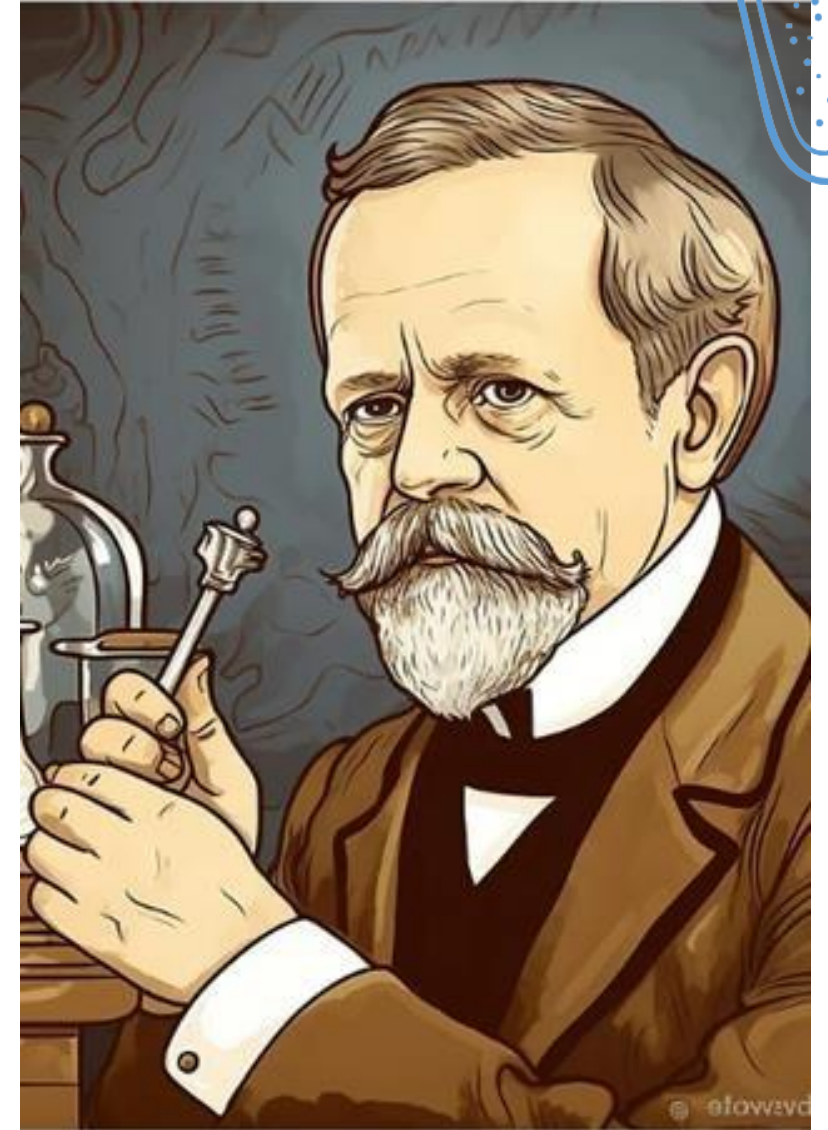


Bacteria are (mainly)
either **GRAM +** or **GRAM -**

2 Colors in this stain:

Purple
GRAM +

Pink
GRAM -



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

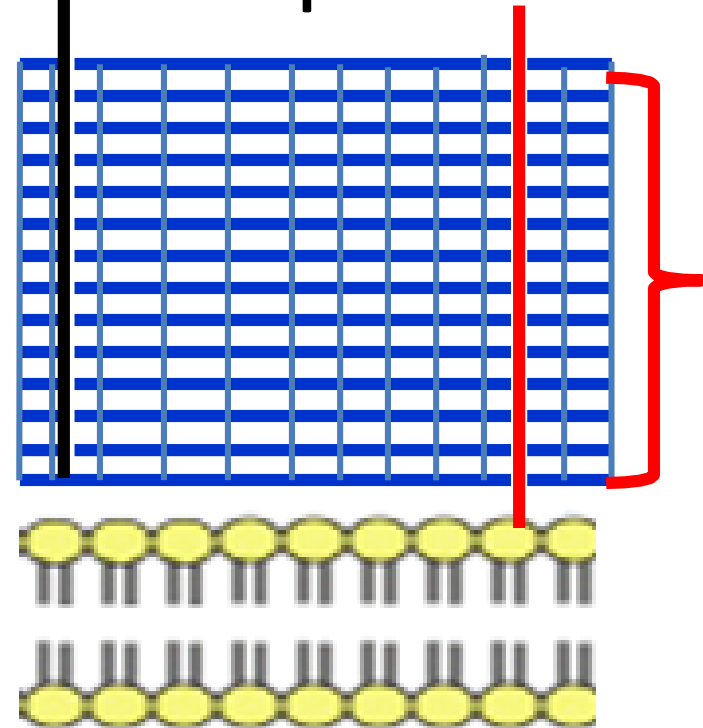
Gram (+)

vs

Gram (-)

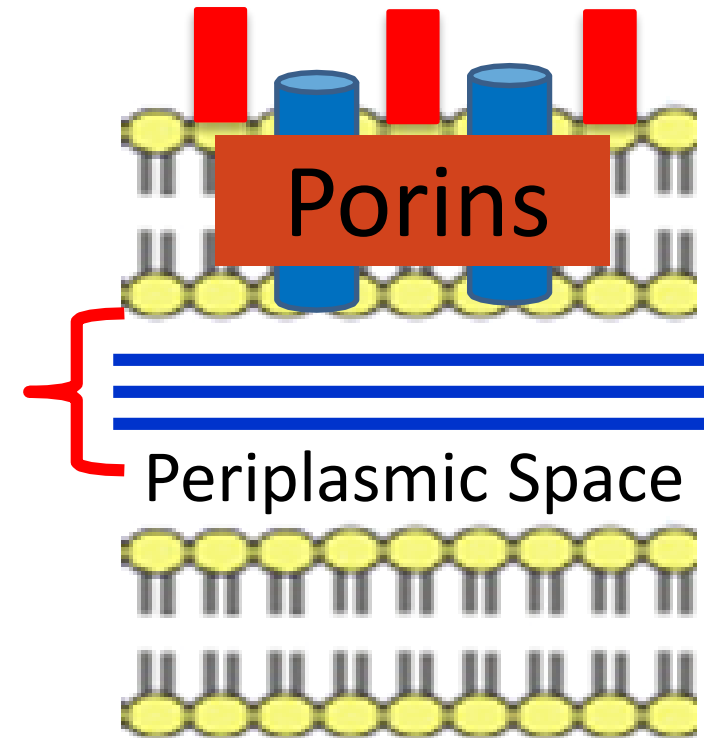
Teichoic acid

Lipoteichoic acid



Peptidoglycan

Outer membrane
(Lipopolysaccharides)



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

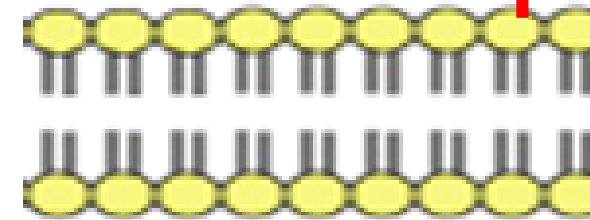
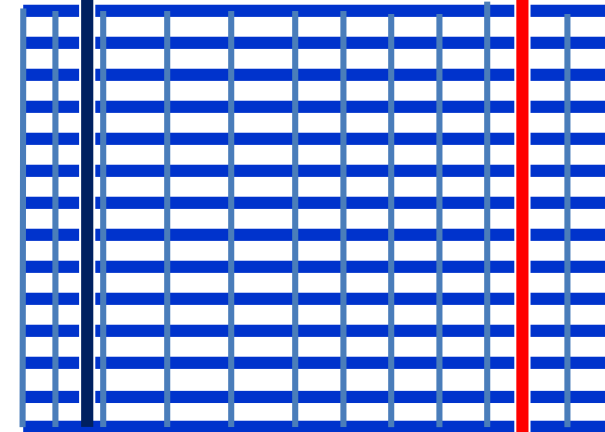


Peptide

(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

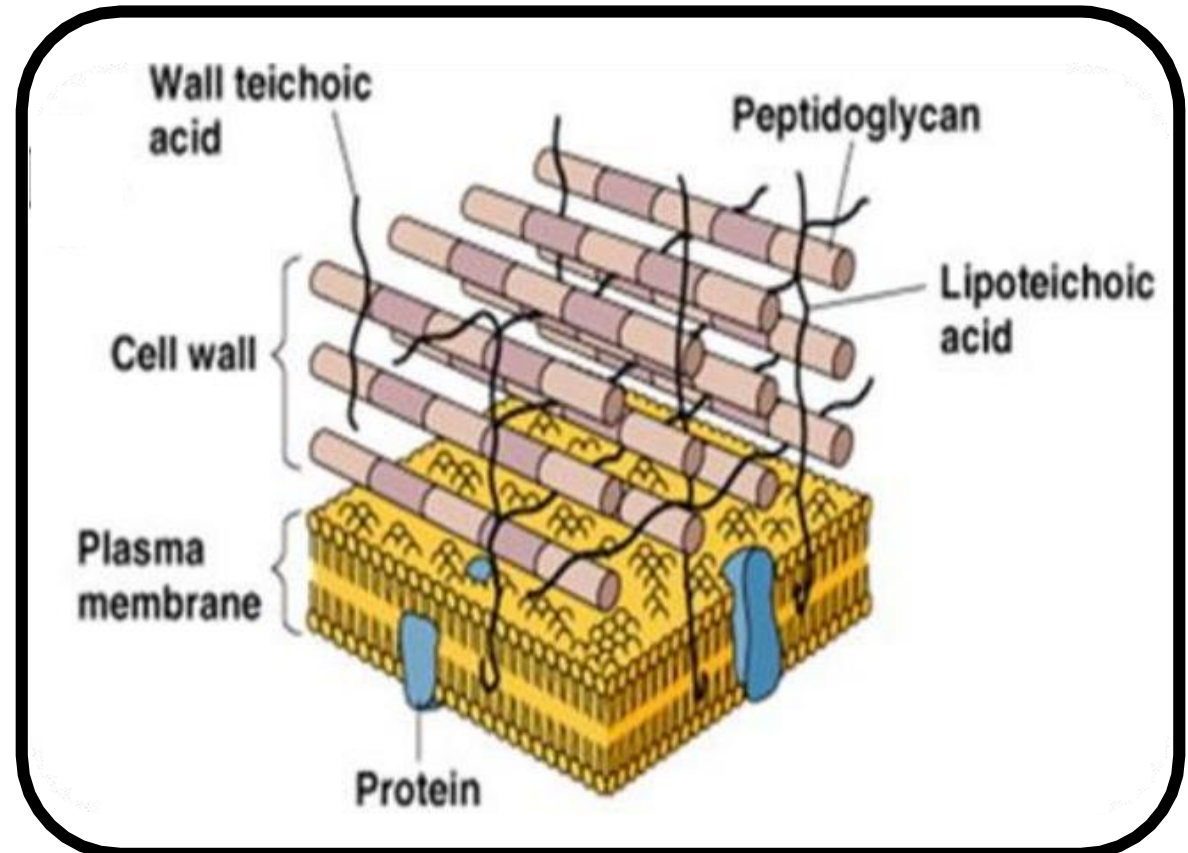
(Cell membrane-bound)

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

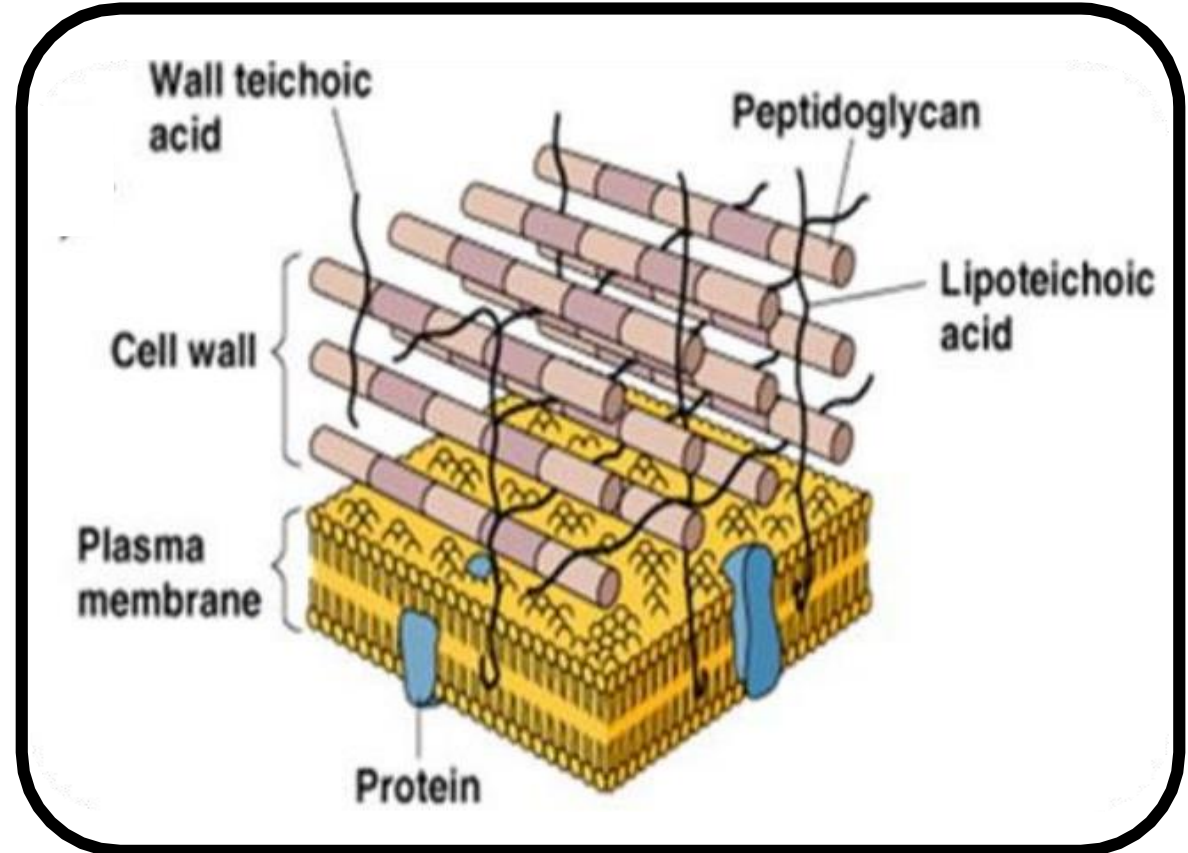
Cytokines
Released after detecting the antigen

IL-1

Interleukin - 1

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

2) Teichoic acid



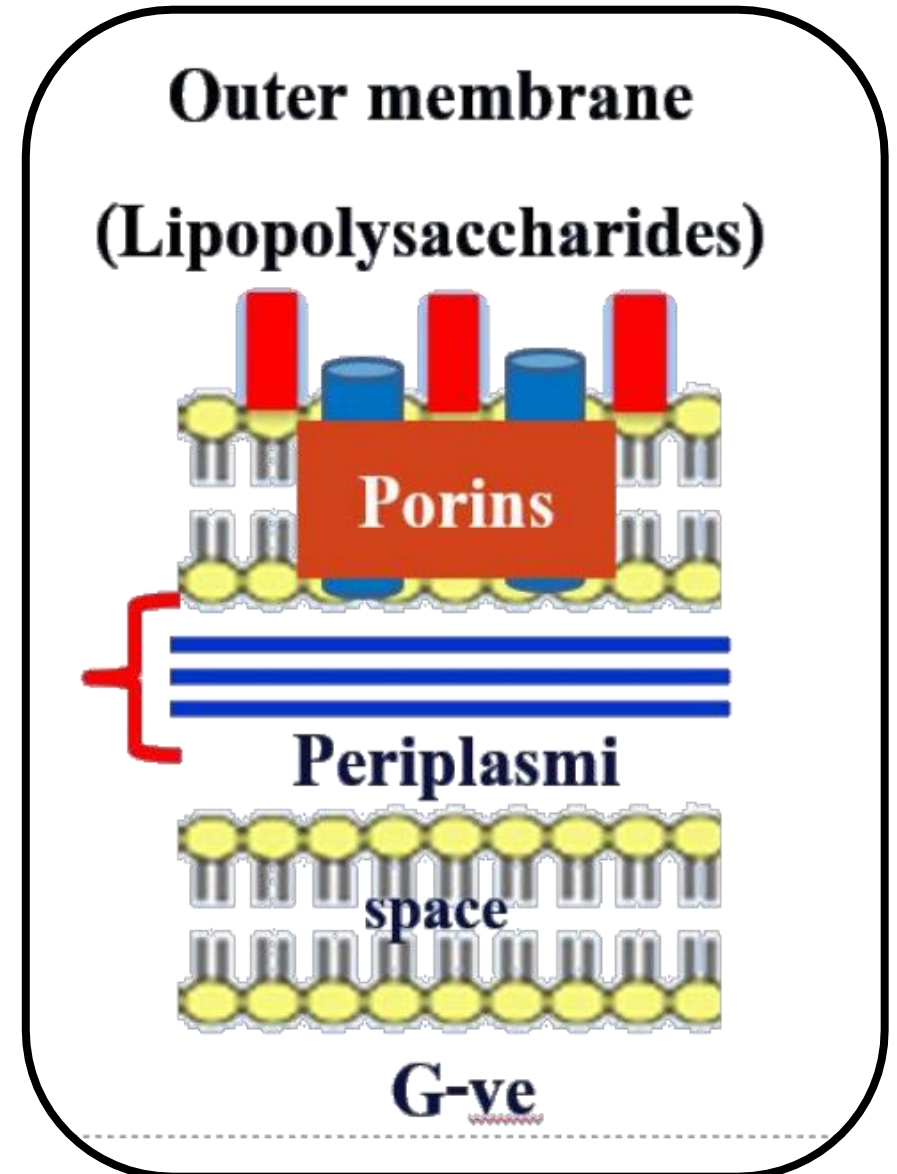
Composition of Gram Negative

1) Peptidoglycan
A thin layer (5%)

2 sheets of

NAM & NAG

Peptides



2) Outer membrane

A) Bilayer phospholipids

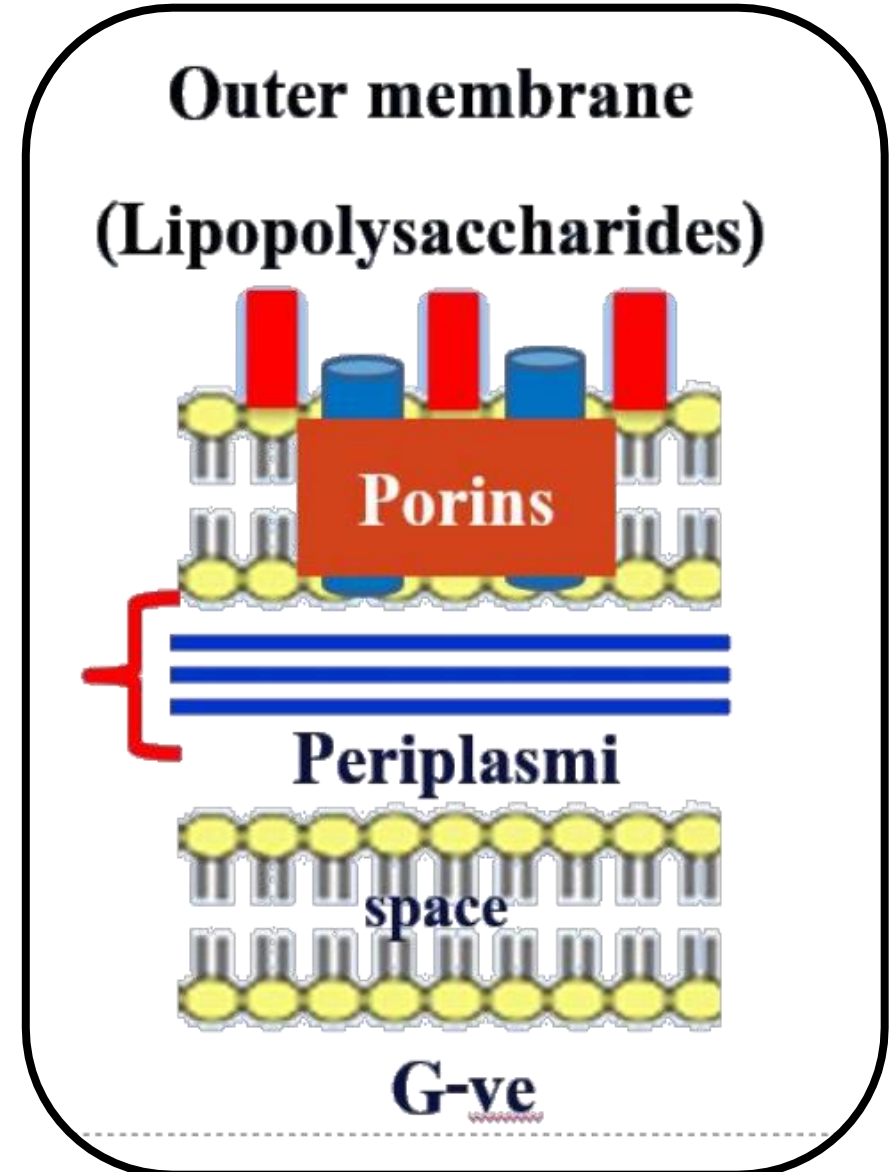
B) Lipopolysaccharides

Lipid A
(Endotoxin)

Toxin inside the GRAM (-)

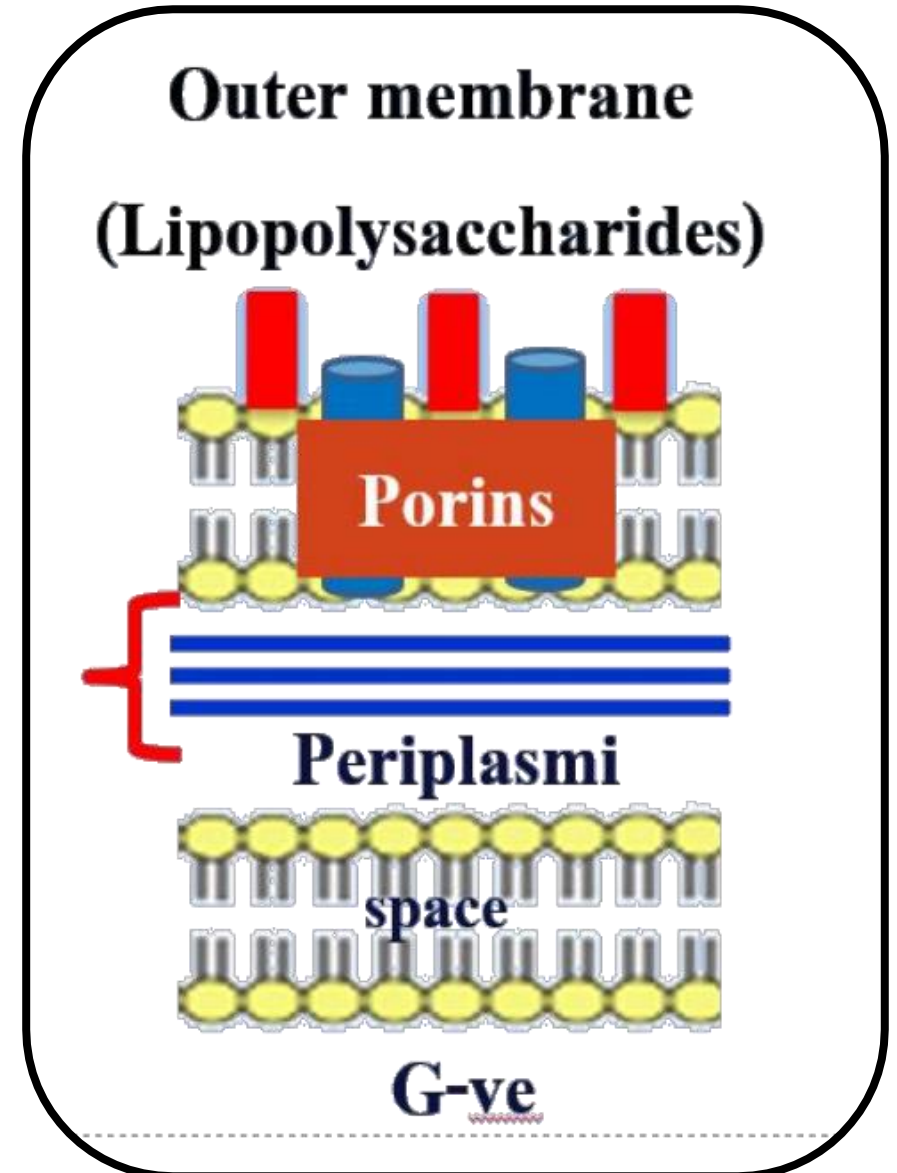
Polysaccharides
(somatic O Ag)

Antigen



2) Outer membrane

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

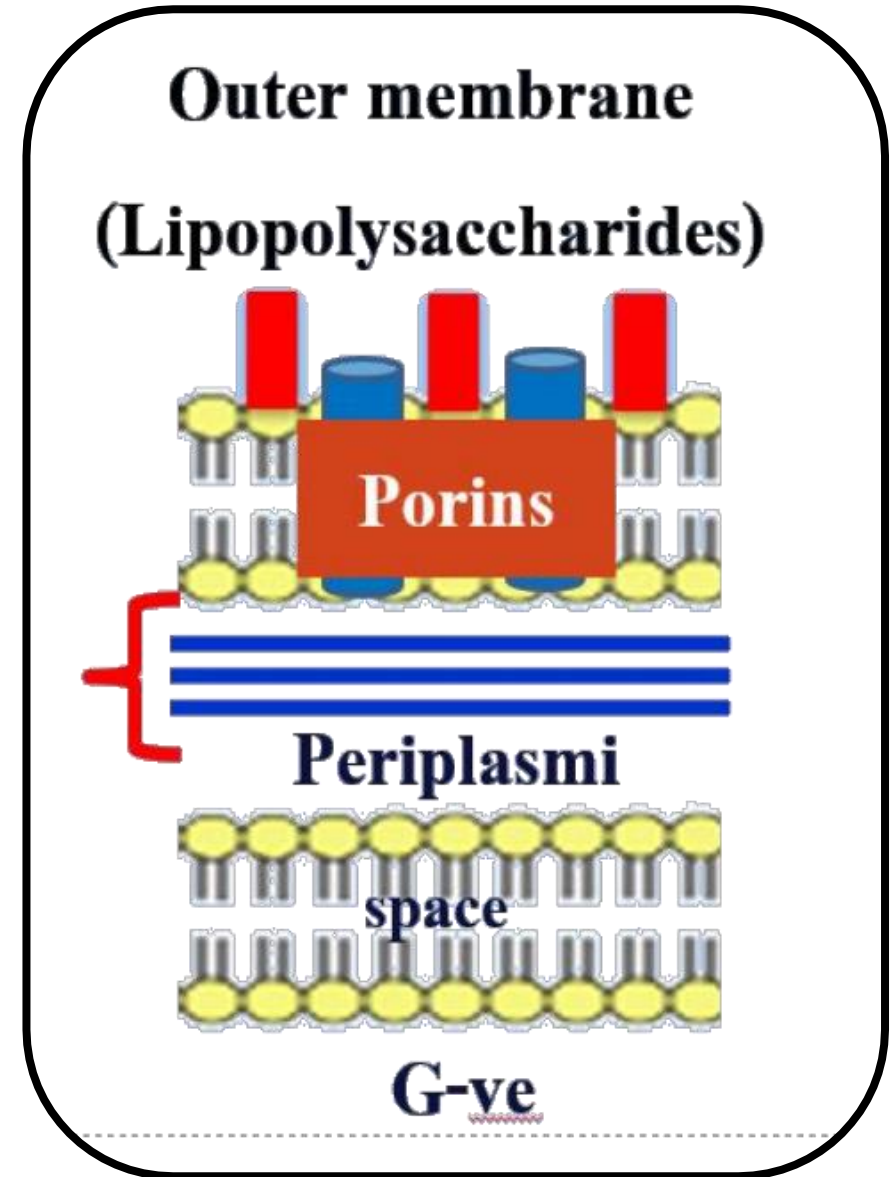


3) Periplasmic space

The space between the 2 membranes

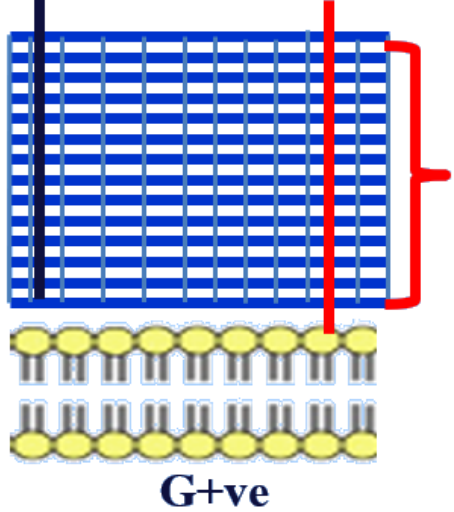
Space between
cytoplasmic & outer
membrane

Consists of Peptidoglycan layer &
gel-like protein



Gram positive/Negative bacteria

Teichoic acid
Lipoteichoic acid



1) **Peptidoglycan**

- Thick

2) **Teichoic acid/
Lipoteichoic acid**

- Yes

3) **Outer membrane**

- No

1) **Peptidoglycan**

- Thin

2) **Teichoic acid/
Lipoteichoic acid**

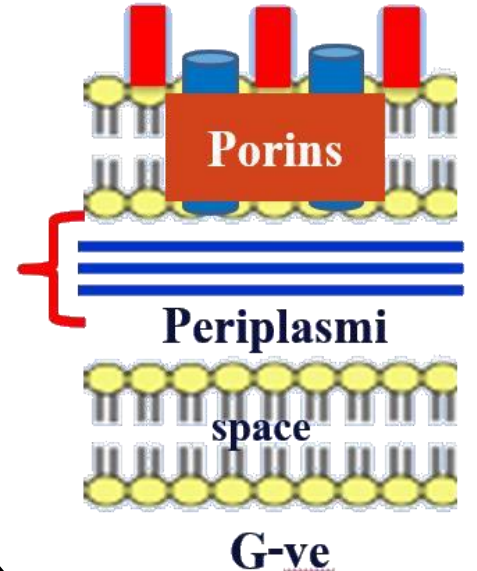
- No

3) **Outer membrane**

- Yes

Outer membrane

(Lipopolysaccharides)

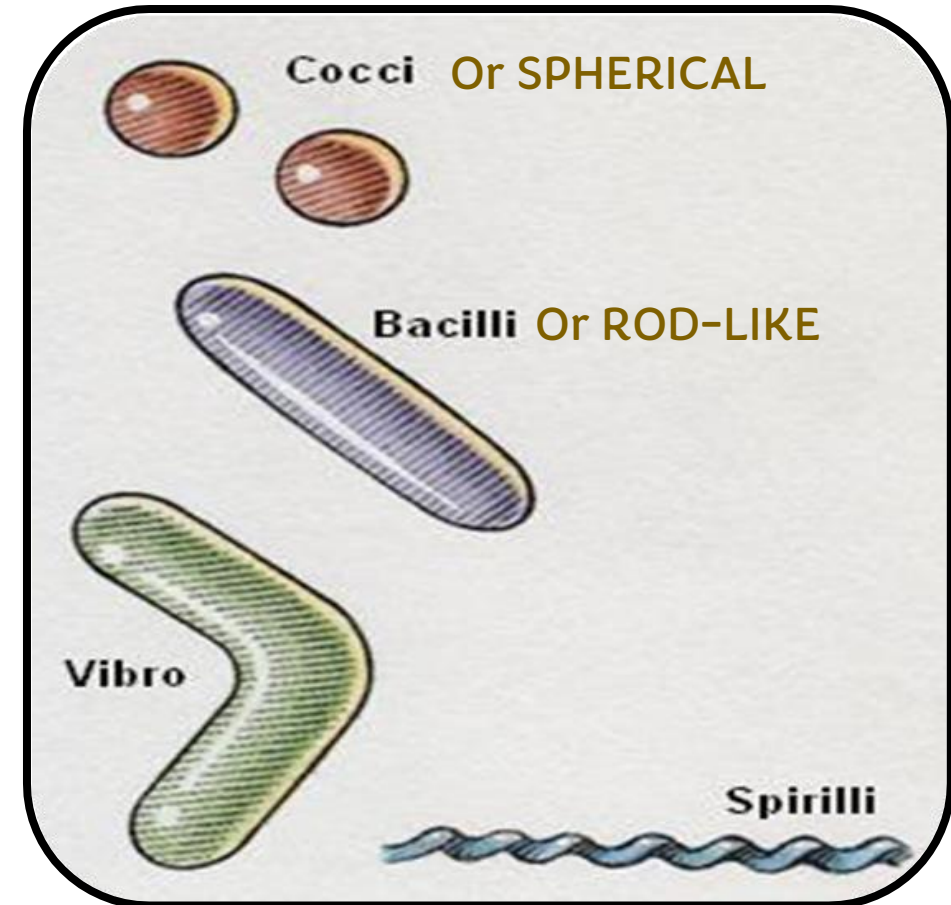


Function of cell wall

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

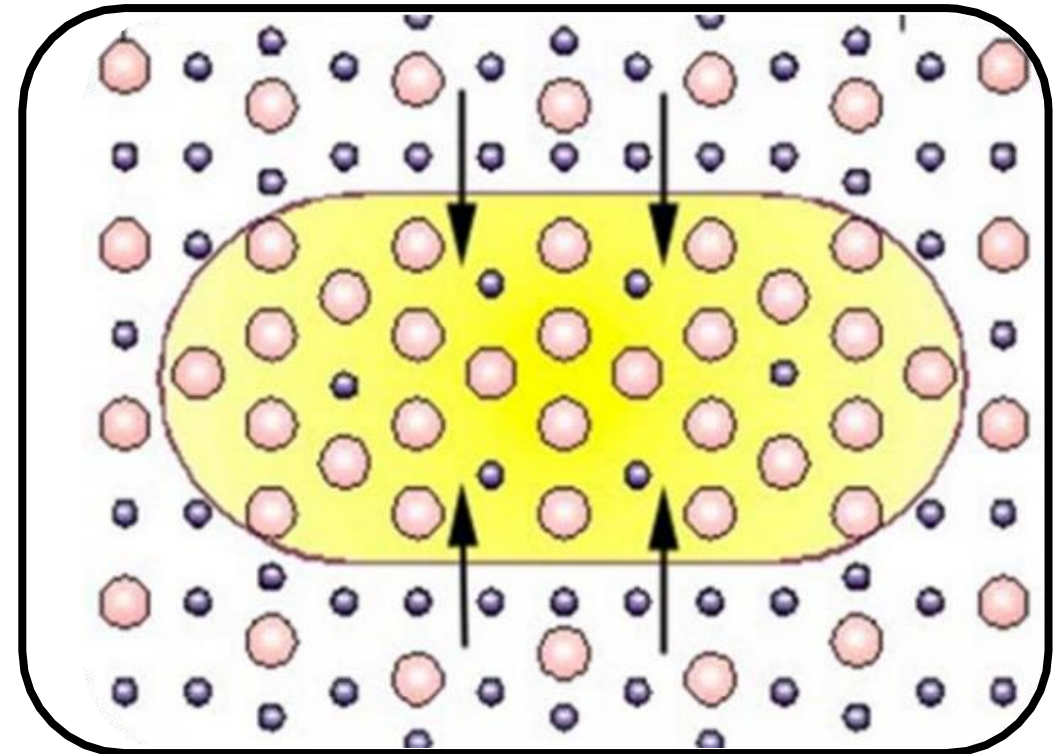
Recall the tonicity concept:

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

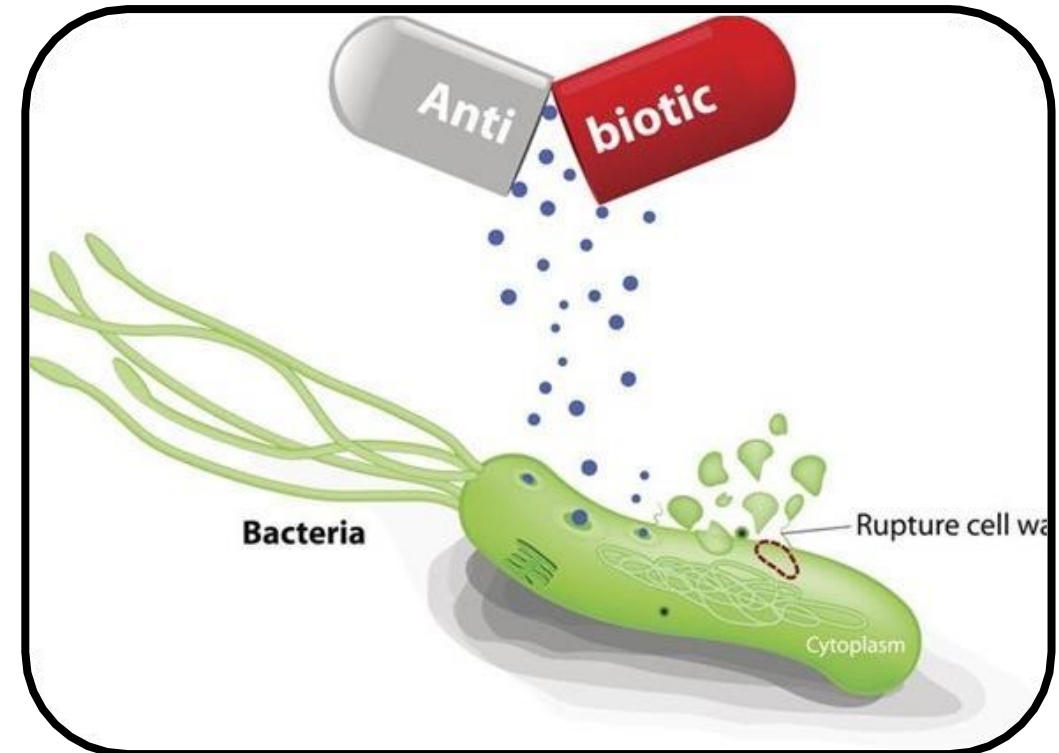
3

Target site for antibiotics

Penicillin

Cephalosporines

they attack the cell wall of bacteria

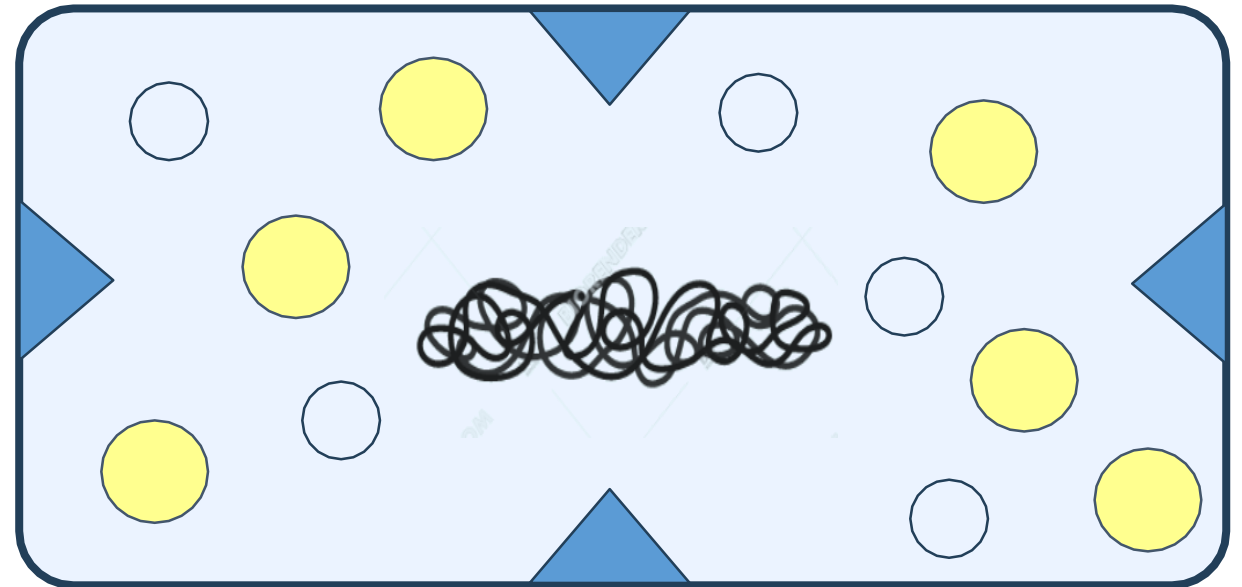


Function of cell wall

4

Role in cell division

to be discussed later

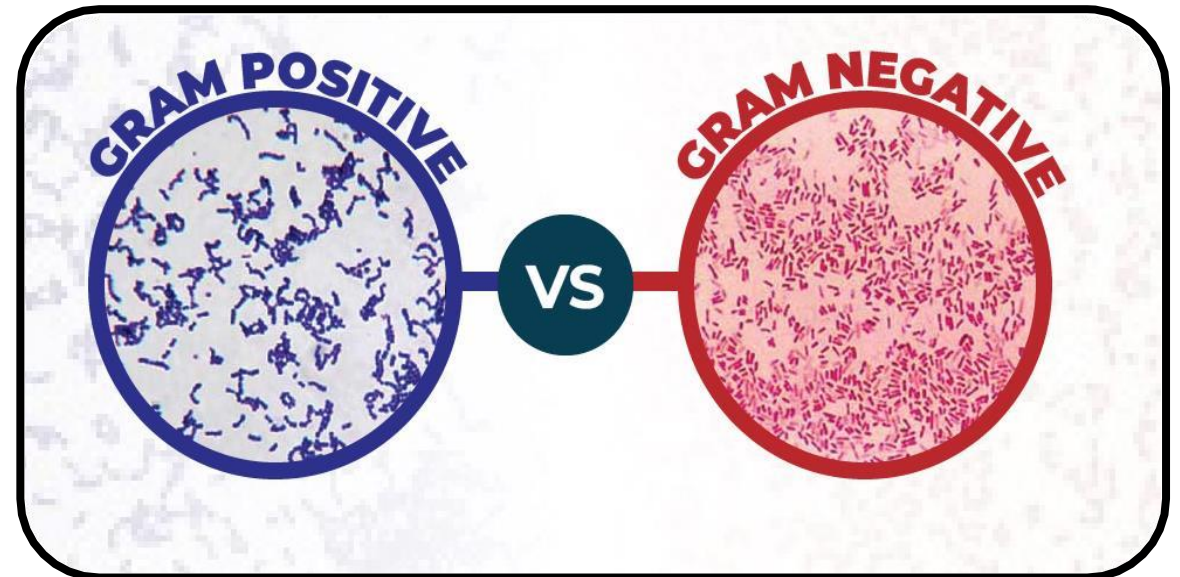


Function of cell wall

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

Critical step: It must be performed quickly and accurately

GRAM stain procedure (4 stains):

G+ve



Fixation



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.

1. Crystal Violet
The primary stain



2. Iodine
For fixation

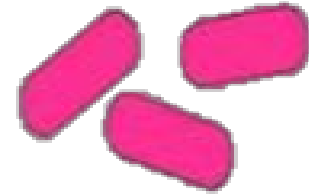


3. Acetone
Or alcohol (95%)
For decolorization



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

4. Counter Stain
Saffranine



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

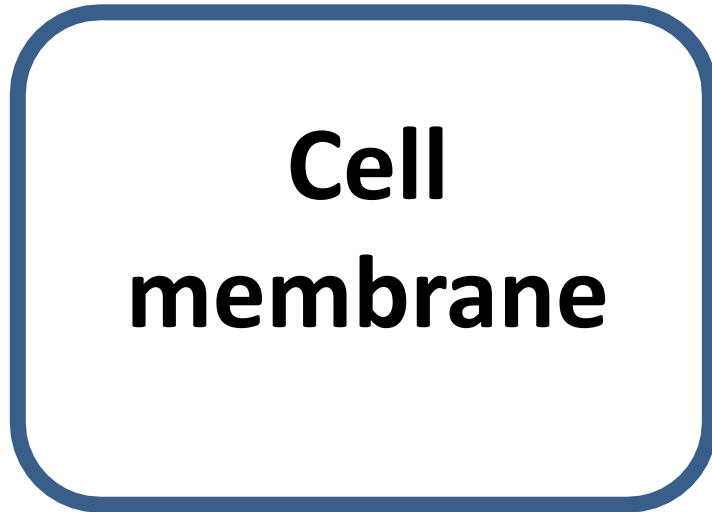
Cell wall inhibitors

Lysozyme

From our bodies

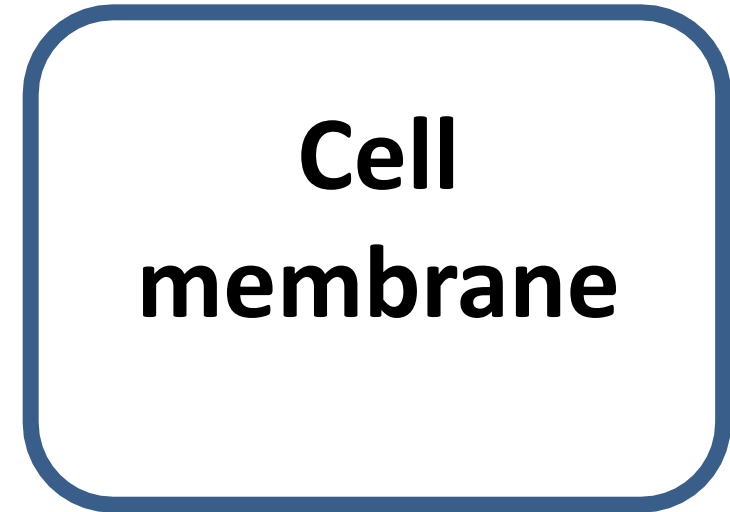
2) Induced

Completely



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

Partially



Named after *Leister city* in England

**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			
V1 → V2			

Additional Resources:

رسالة من الفريق العلمي:

أسبوع انتهى
ما زال المشوار طويلاً
استعينوا بالله فهو نعم المعين