



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ
الَّذِي عَلَّمَ بِالْقَلَمِ ۖ عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ ۝



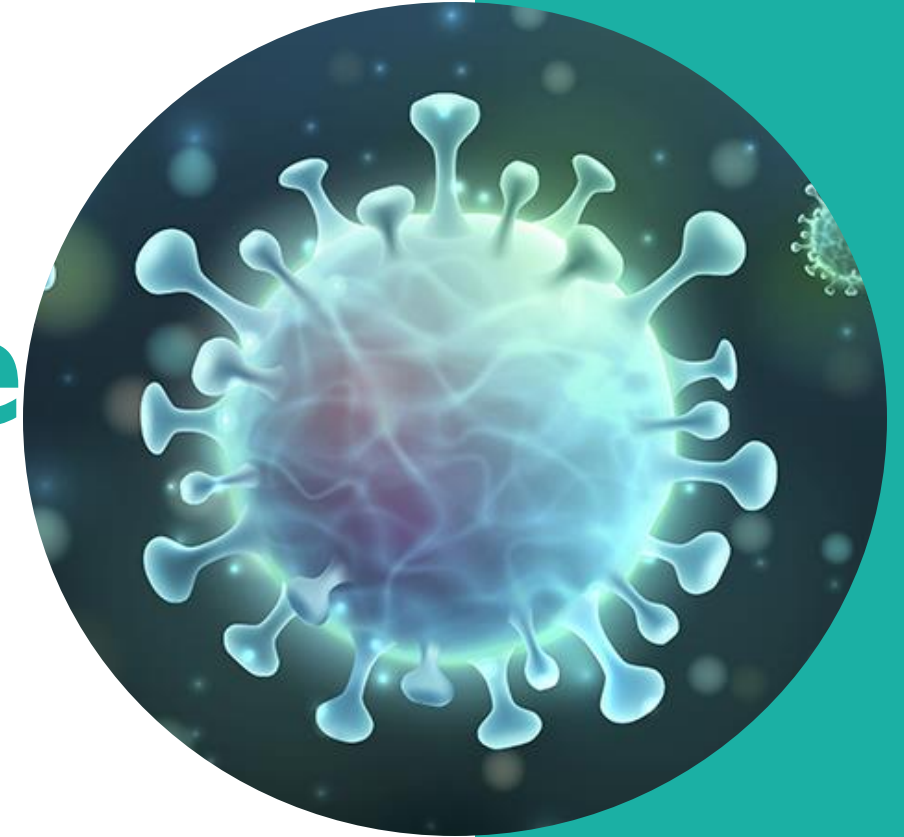
MICROBIOLOGY

MID | Lecture 3

Bacterial Structure

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Color coding used in the modified:



Black: the original slides



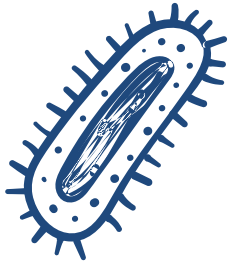
Teal: the doctor's explanation/words



*Gray: additional information and
explanation*



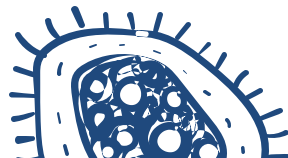
Red: important information



LECTURE 2

Bacterial structure

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

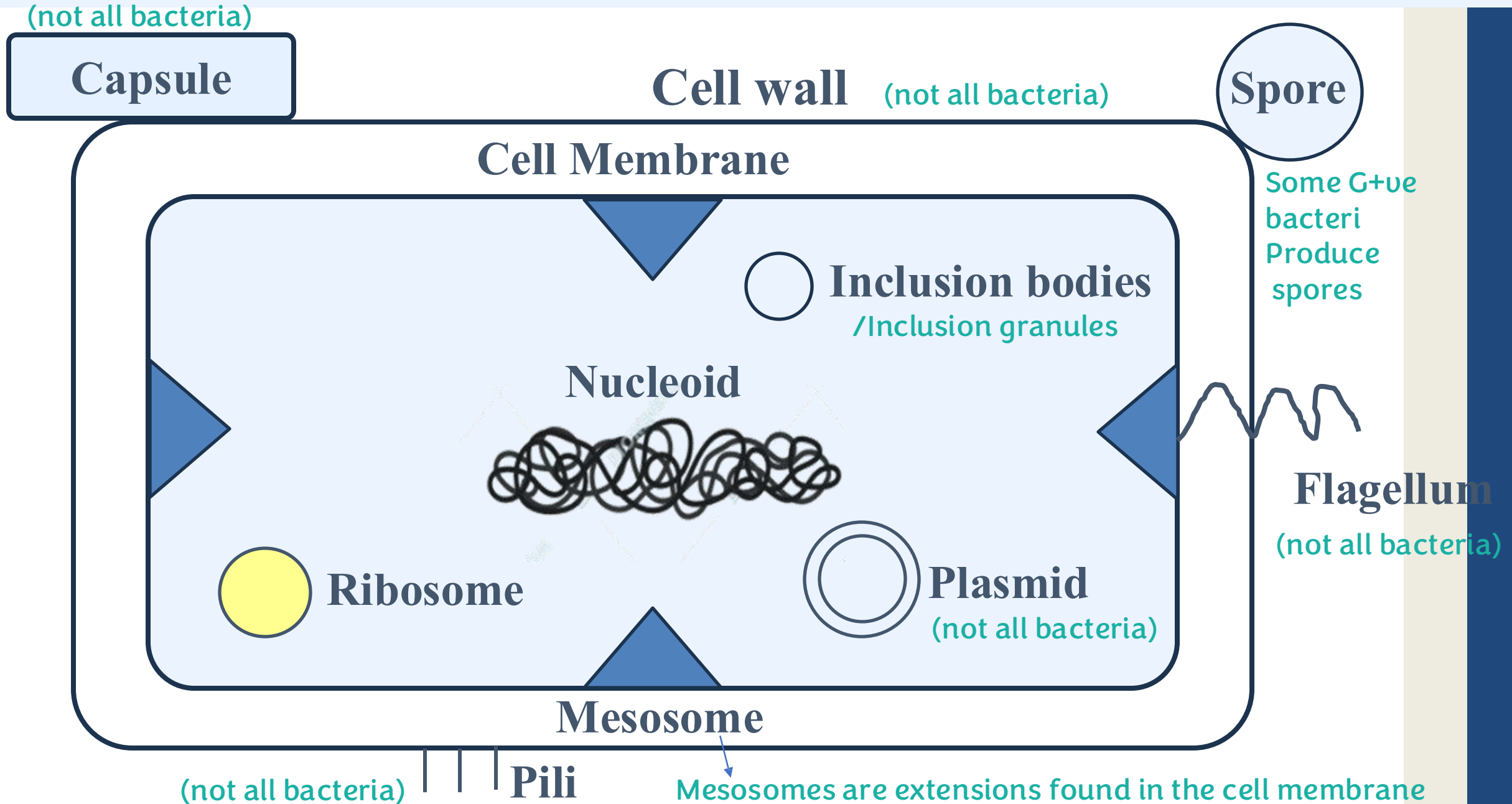


Objectives

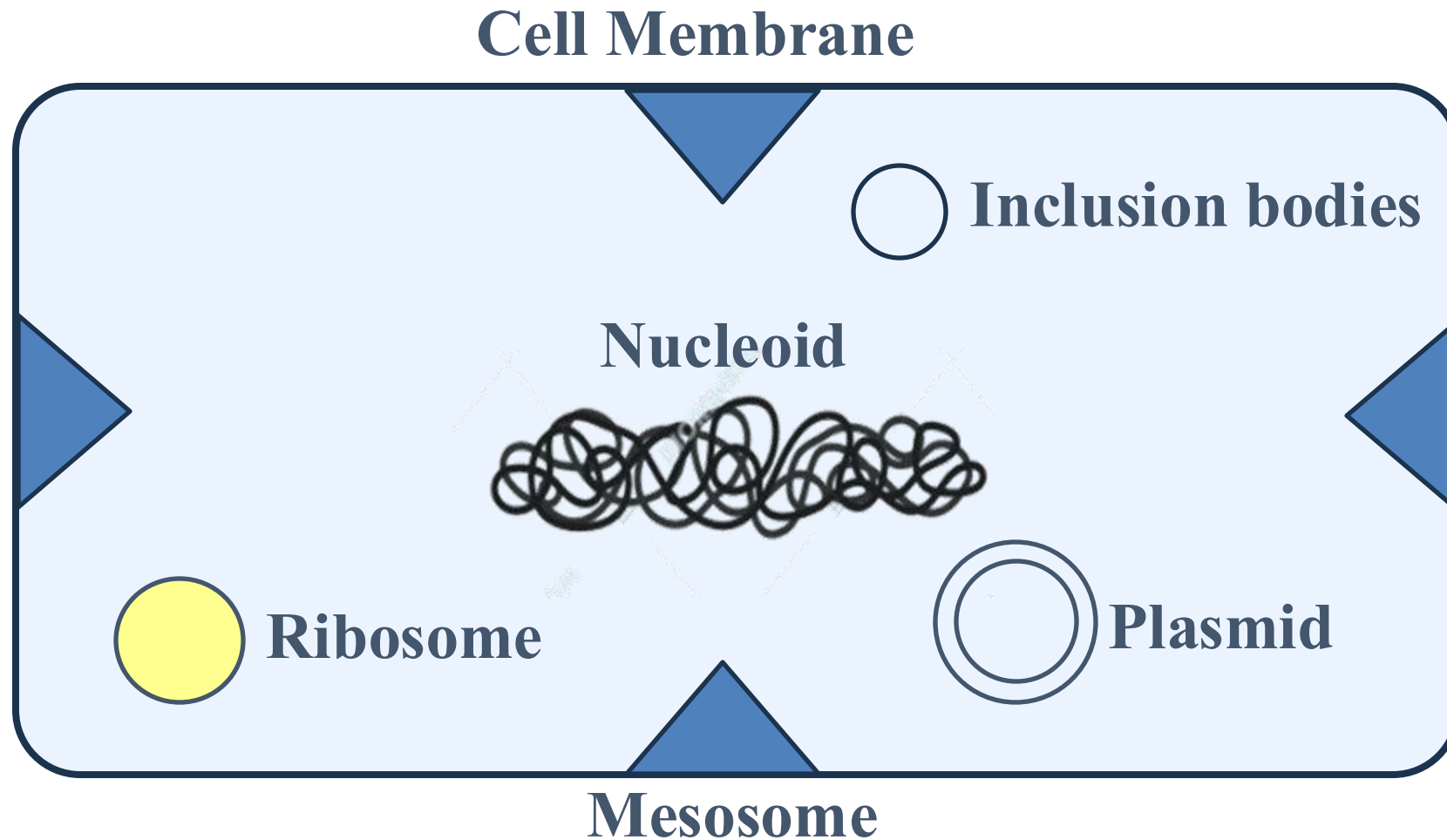
Intracytoplasmic structure

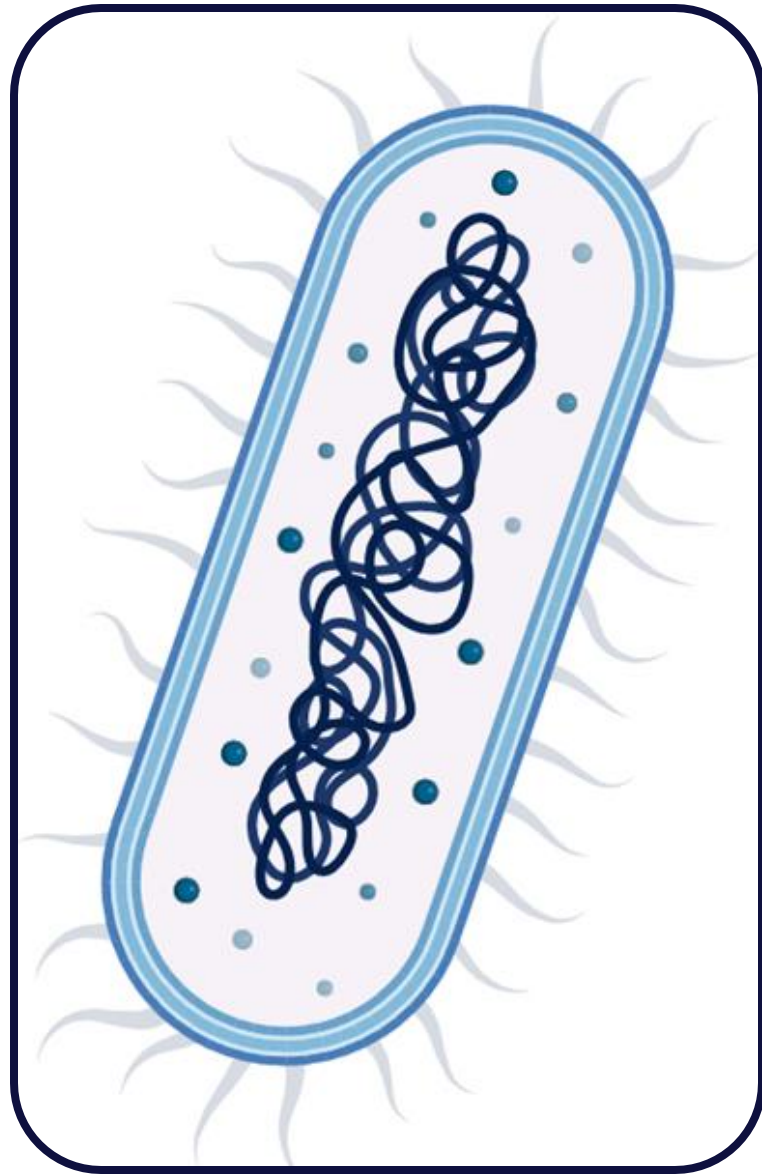
- 1) Nucleoid
- 2) Ribosome
- 3) Inclusion granules
- 4) Cell membrane
- 5) Plasmid

Bacterial structure



Intracytoplasmic structure





1) Nucleoid

1

Single chromosome (not all bacteria)

2

Circular

3

dsDNA (double stranded DNA)

4

1mm in length

(considered long compared to its size, so it is supercoiled in order to fit in bacteria)

5

supercoiled (so that it fits the size of the bacteria which is $(0.5-1)\mu\text{m}$)

6

Carry genetic information for growth & survival

Essential

→ all bacteria have Nucleoids

2) Ribosome

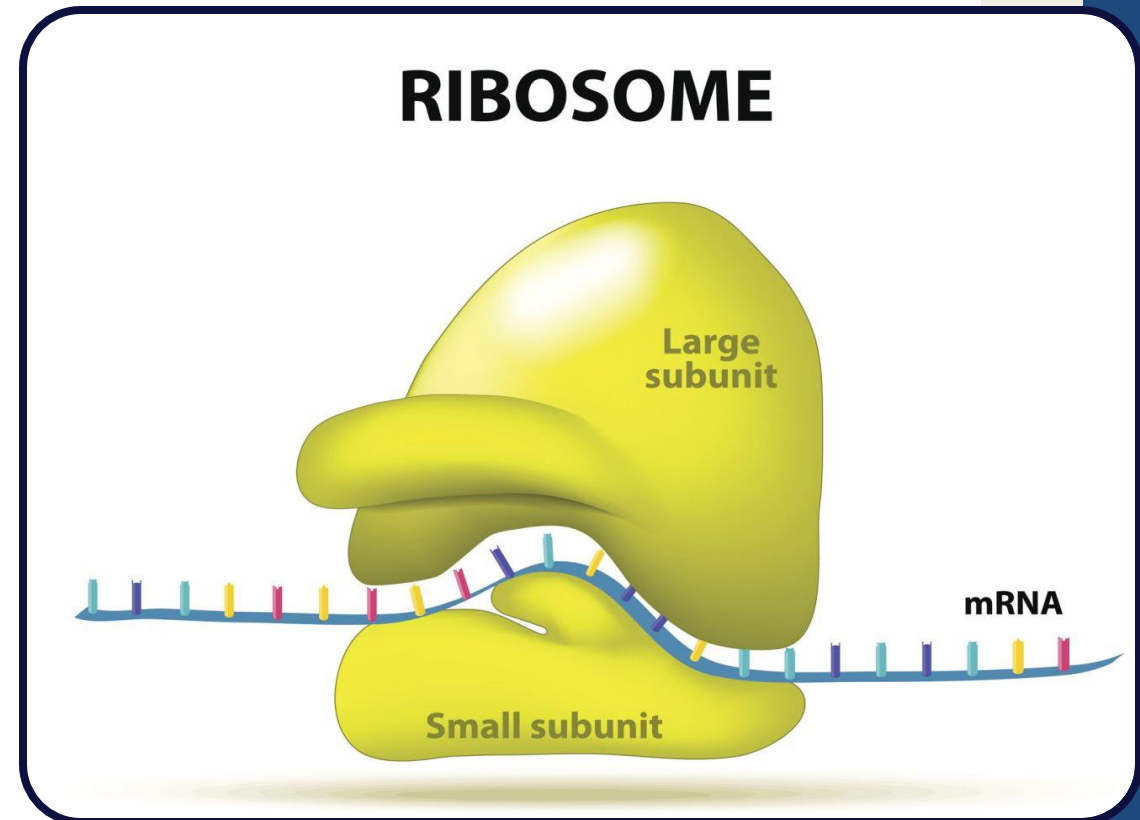
1 Ribo=RNA

2 Some=body

3 Site of Protein synthesis

(by translating the instructions carried by mRNA)

Essential



2) Ribosome

Bacterial ribosomes

(70S)

Svedberg unit (S)

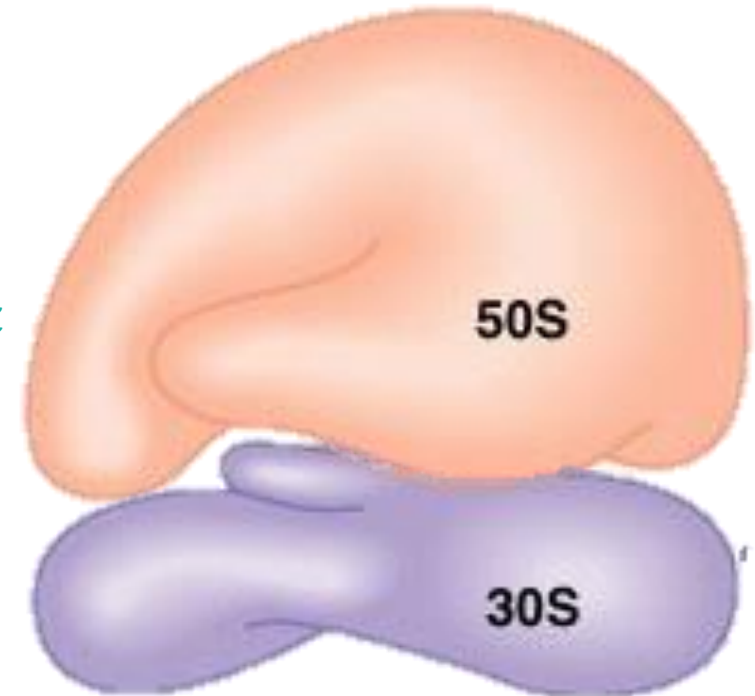
Svedberg unit is the unit given to measure the density of a subunit after centrifugation. It was discovered by the scientist Svedberg.
Note: it is not additive since we are talking about density ($50+30 \neq 70$)

Large Subunit

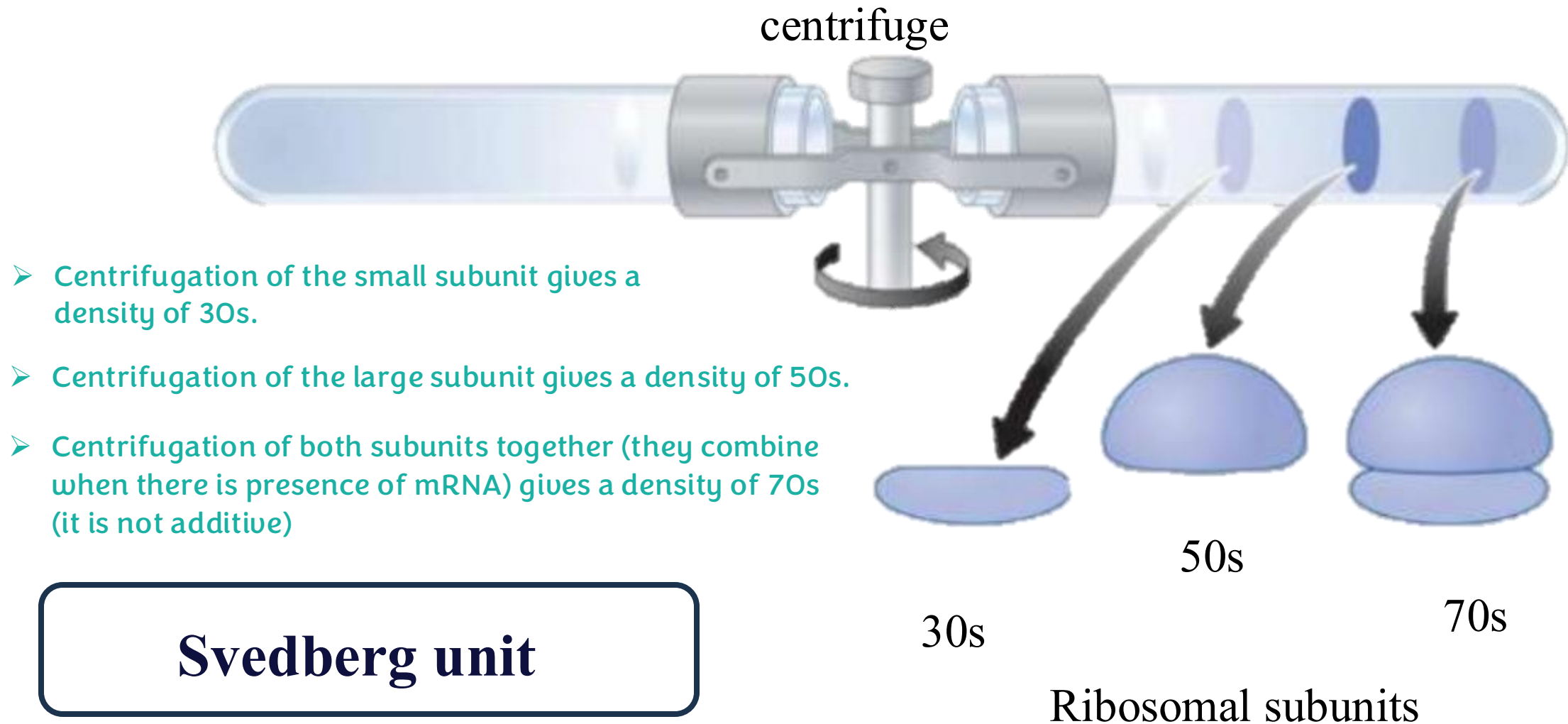
50S

Small Subunit

30S

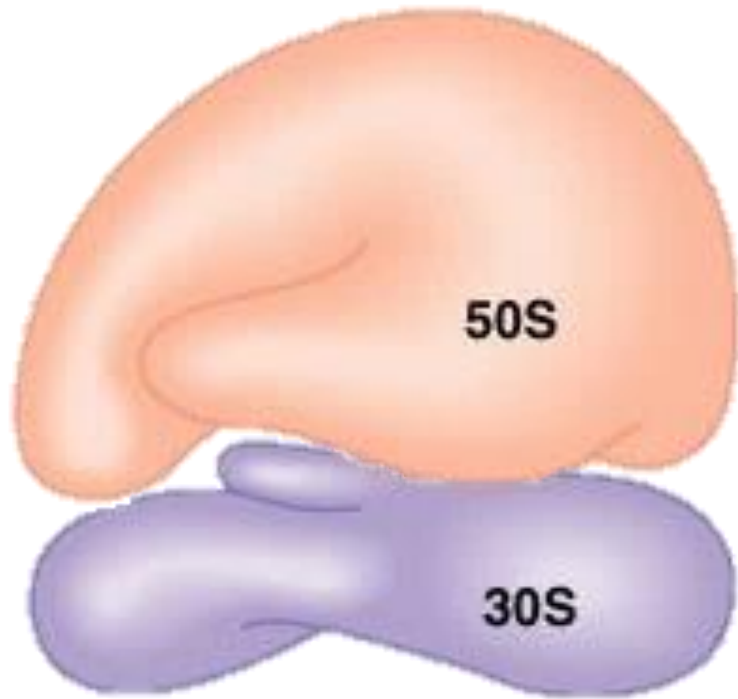


2) Ribosome



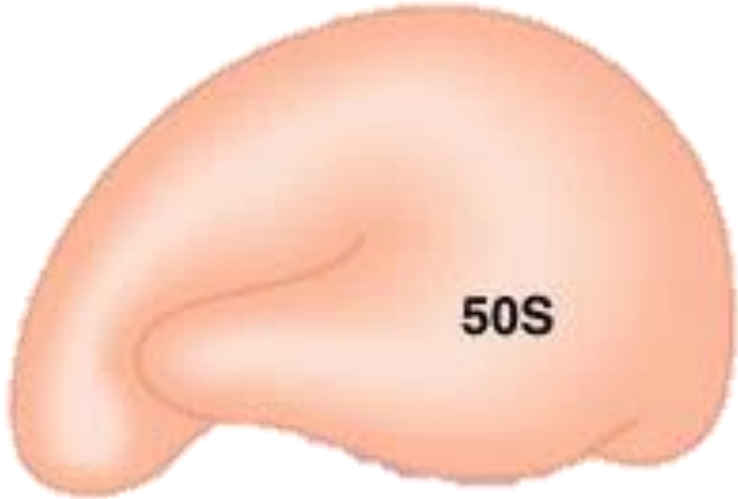
Svedberg unit

2) Ribosome



- Human ribosomes (80s) being different from bacterial ribosomes (70s) is good since we can design antibiotics that are able to target bacterial ribosomes without targeting human ribosomes.
- Antibiotics can target multiple organelles of bacteria including cell wall, large and small subunits of ribosomes, mRNA.
- Targeting of large/small subunits of bacteria prevents them from attaching to mRNA, making them unable to synthesise proteins.

2) Ribosome

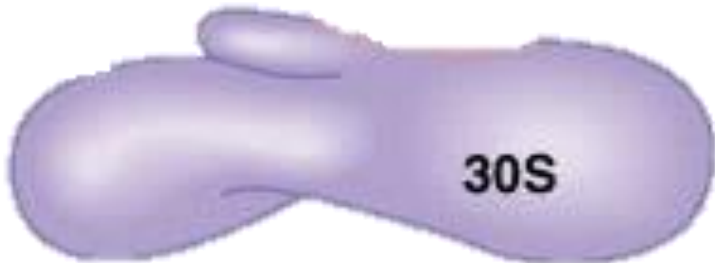


50S

50S

Large Subunit

Target of antibiotics



30S

30S

Small Subunit

60S

Large Subunit

Human

40S

Small Subunit

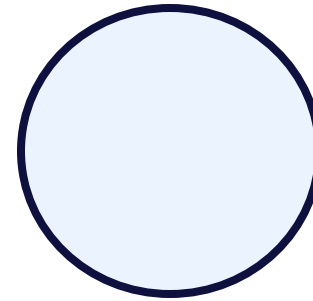
3) Inclusion granules /bodies

Store of nutrient

Glycogen

Starch

Phosphate

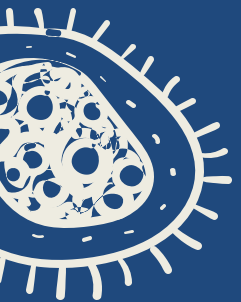
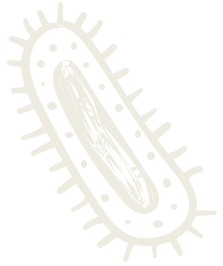
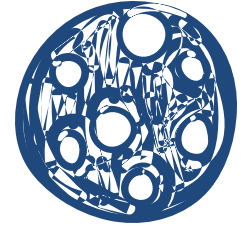


Volutin granule

A granule that stores phosphates.

Other name : **(Metachromatic granules)**

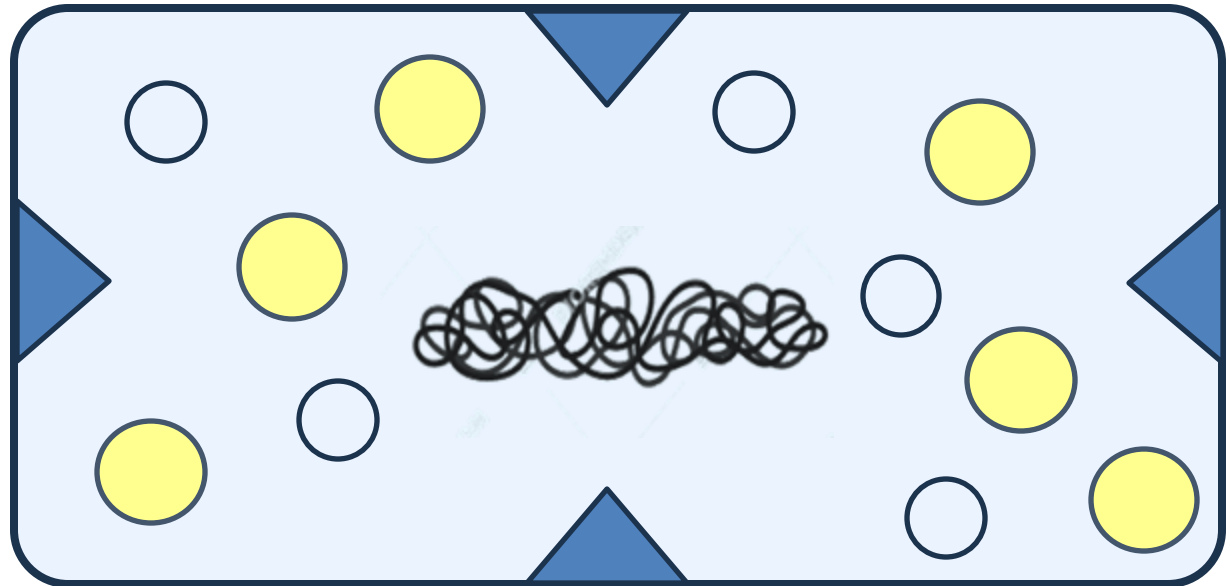
It is found in some bacteria such as :
Corynebacterium diphtheriae bacteria
which stores phosphates).



Definition of the cell membrane

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

Essential



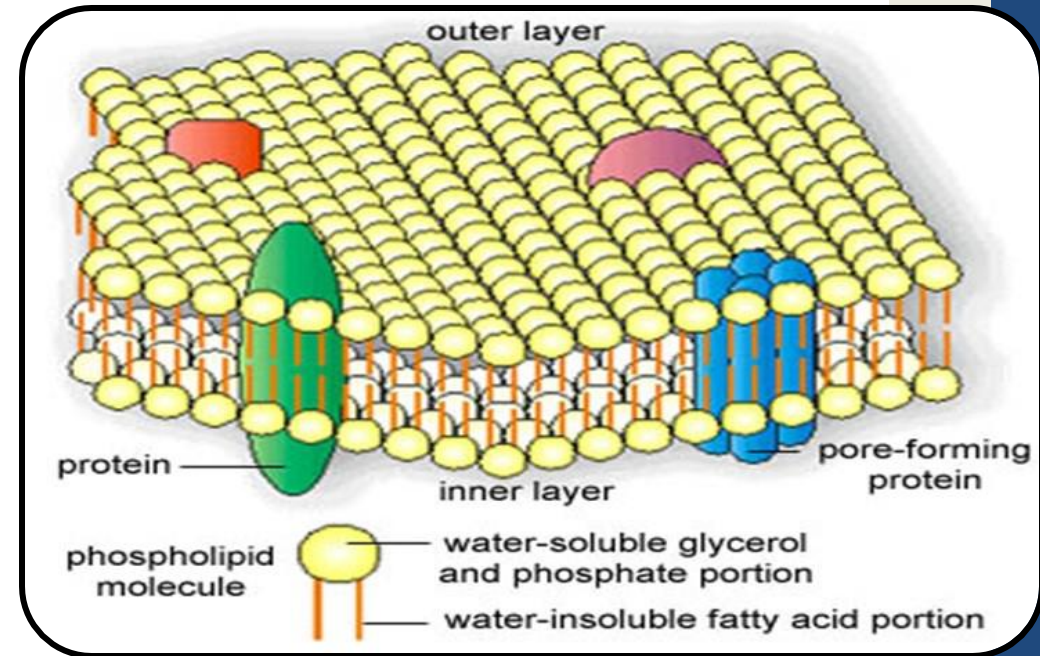
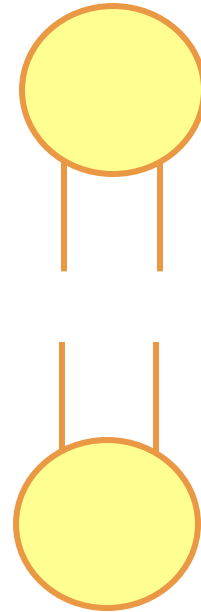
Composition of cell membrane

Phospholipid bilayer + Protein

(No sterols)

apart from mycoplasma

which lacks a cell wall so it has sterol for
in its cell for protection



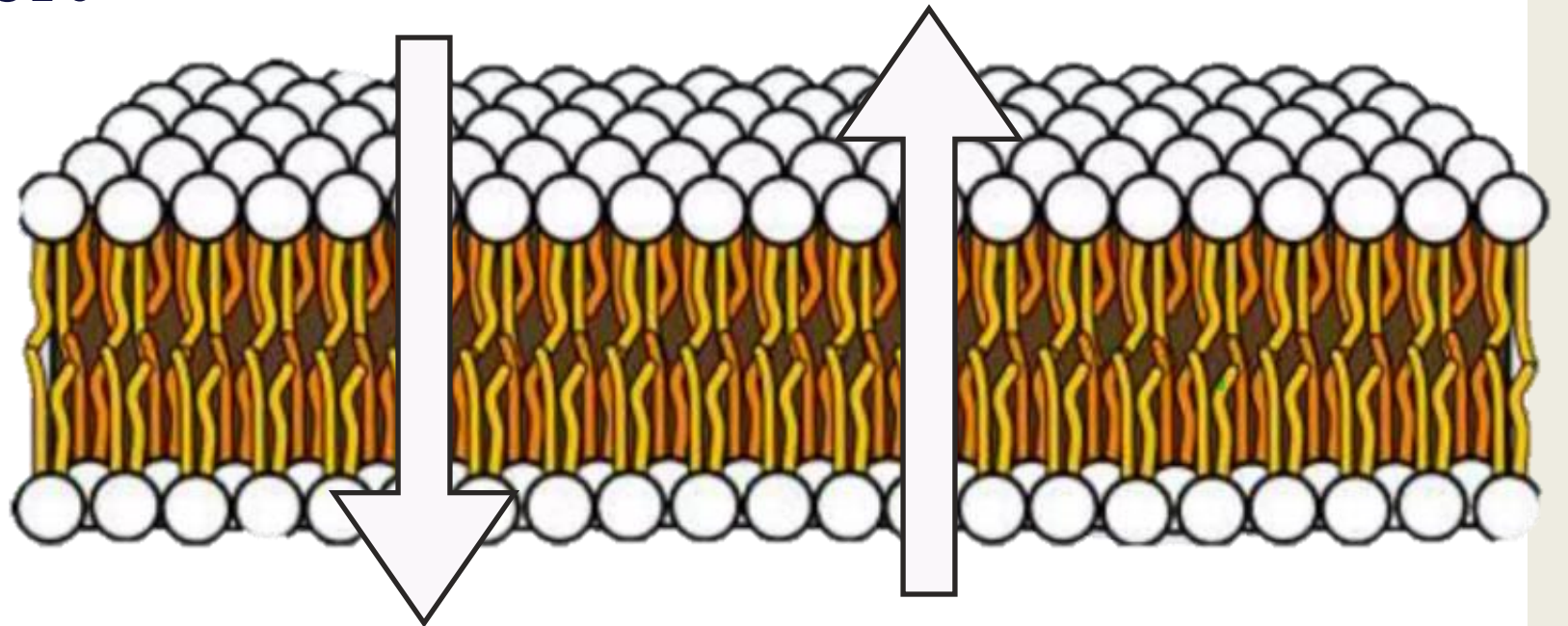
Function of the cell membrane

1

Selective transport

(Passive)

molecules enter the cell from high to low concentration.

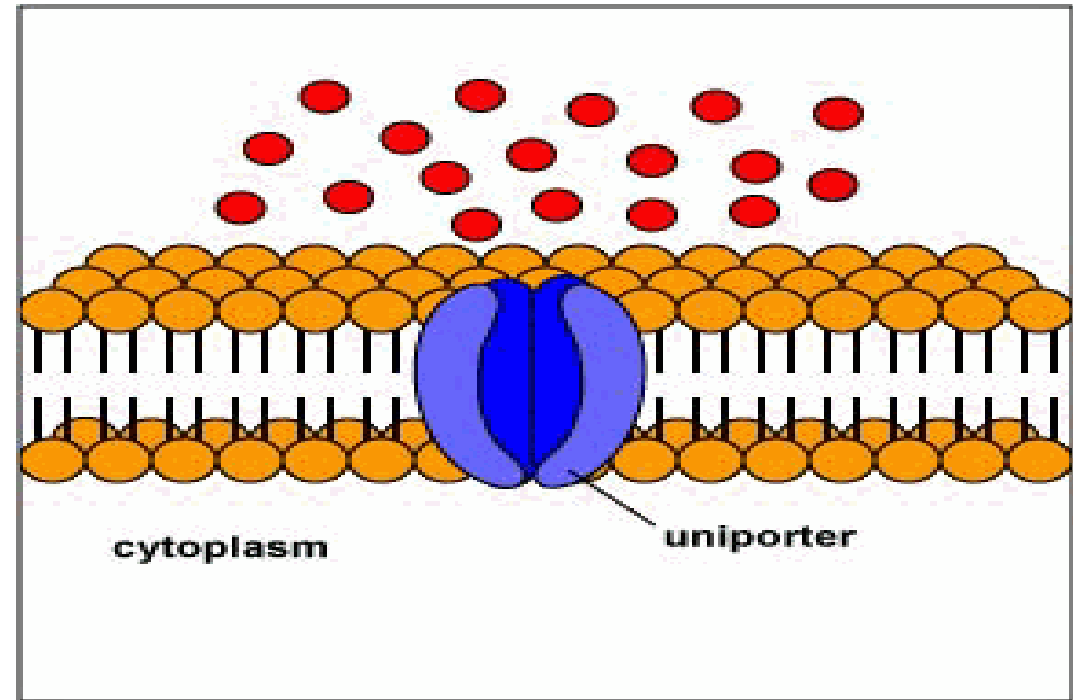


Function of the cell membrane

1

Selective transport (Active)

requires energy to enter the cell



Function of the cell membrane

2

Mesosomes

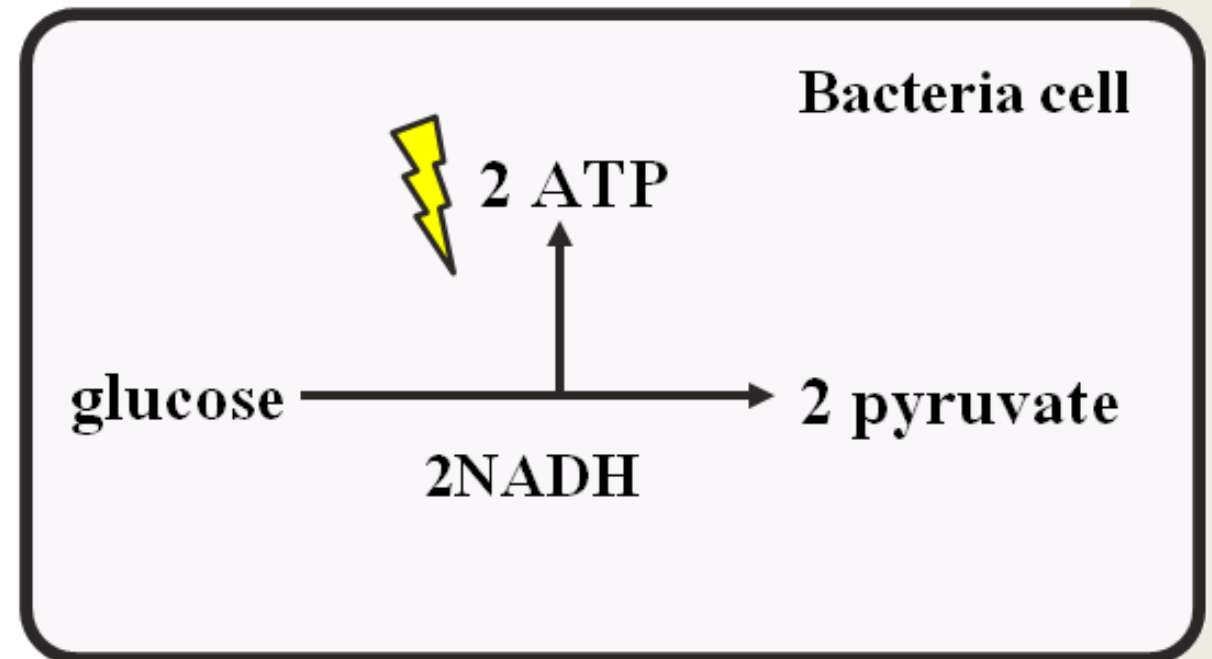
(extensions from the cell membrane)

Respiration enzyme

(Making energy)

(Like Mitochondria)

Bacteria have no mitochondria so mesosomes produce energy instead.



Function of the cell membrane

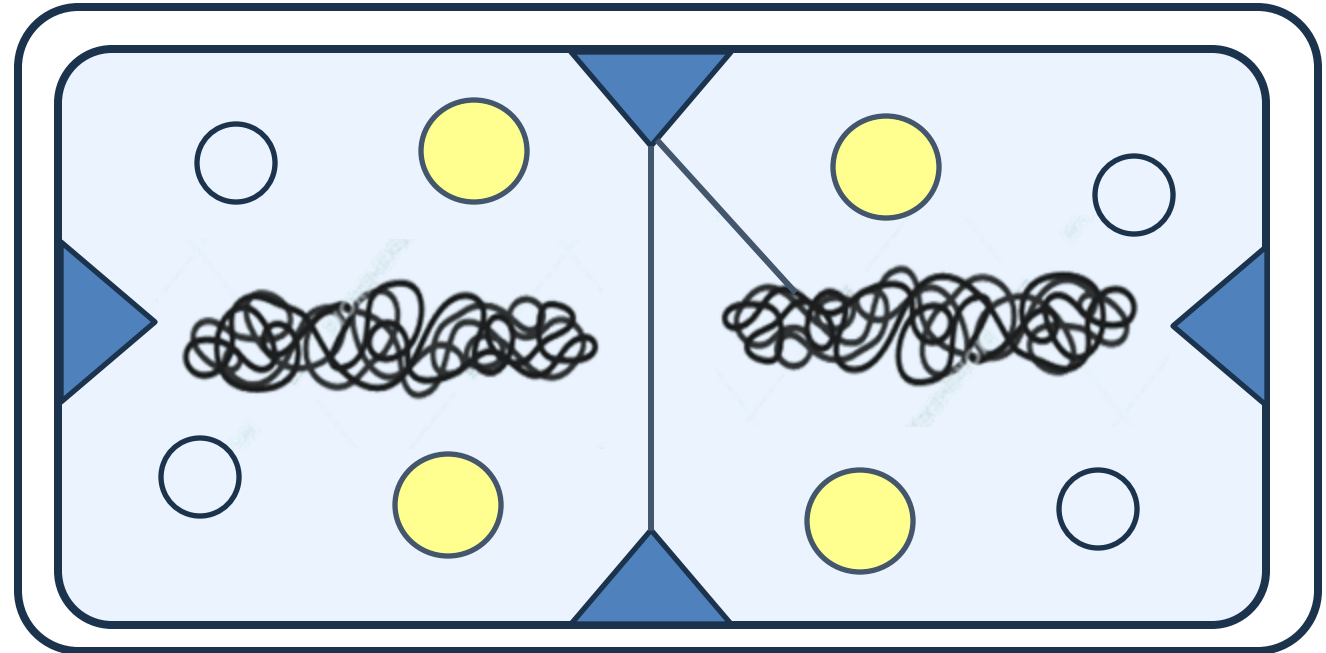
2

Cell division

Separate DNA

Septal mesosome

- 1) DNA replication starts.
- 2) Then DNA strands attach to the mesosome.
- 3) Then a septum forms between 2 mesosomes, making the bacteria divide.
(will be discussed in more details later).

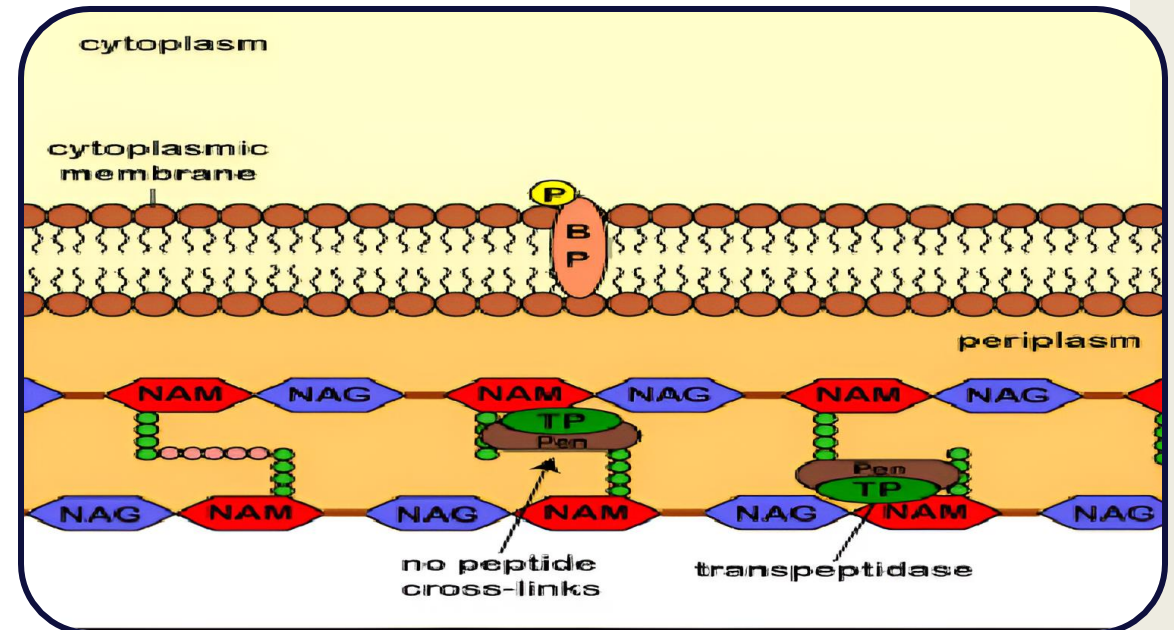


Function of the cell membrane

3

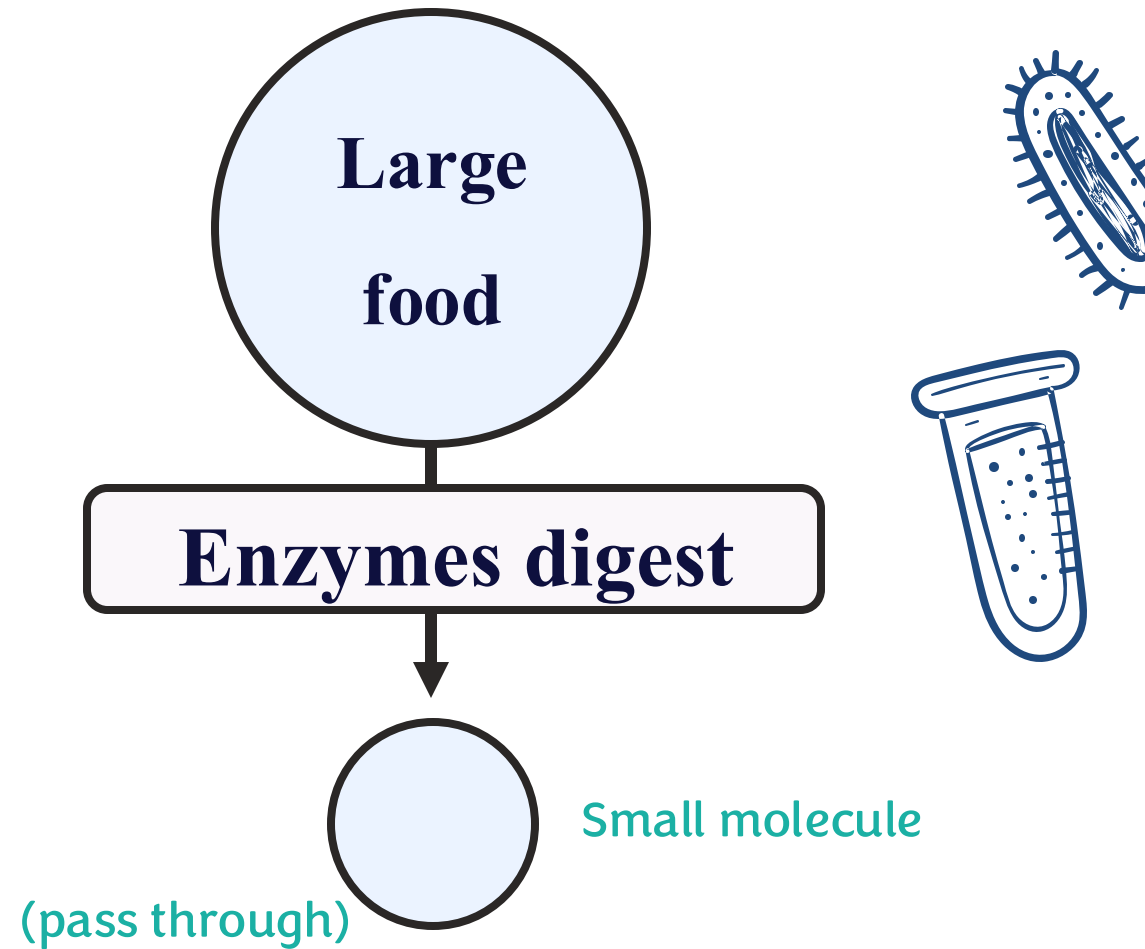
Biosynthesis of cell wall

membrane has the precursors/building units and some enzymes that help build the cell wall.



4

Excretion of extracellular enzymes (Hydrolytic enzymes)



Penetrate cell membrane

When there is large food extracellularly. The cell membrane **excretes (releases) enzymes** out of the cell where it **digests this large food**, then the digested small molecules **enter the cell for use**.

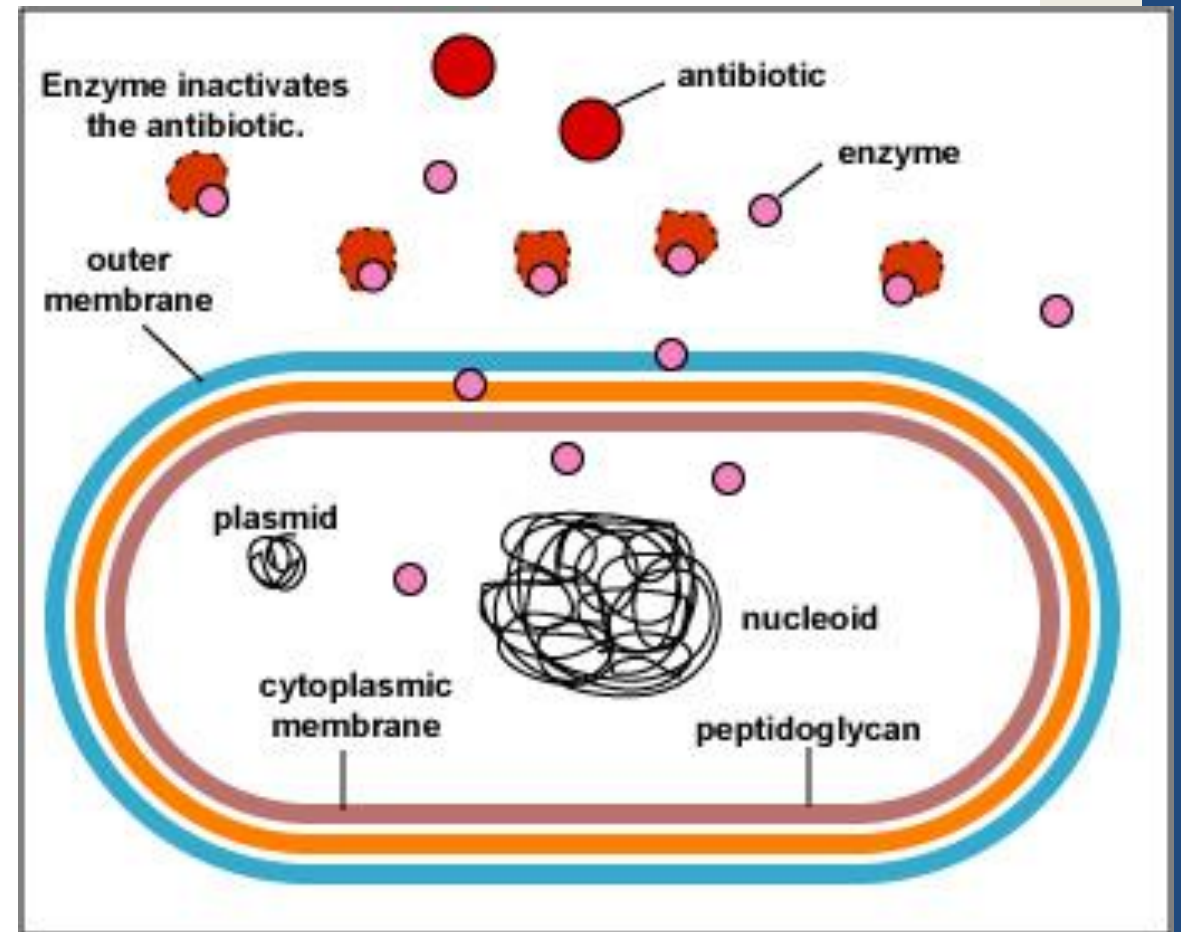
Function of the cell membrane

5

Excretion of extracellular enzymes

(**Penicillinase**) (against antibiotics)

The bacterial cell excretes enzymes outside the cell to treat with antibiotics such as **cephalosporin and penicillin**. The cell releases **penicillinase** against penicillin (which - the penicillin- acts on cell wall of bacteria) as a form of protection against antibiotic effects.



Function of the cell membrane

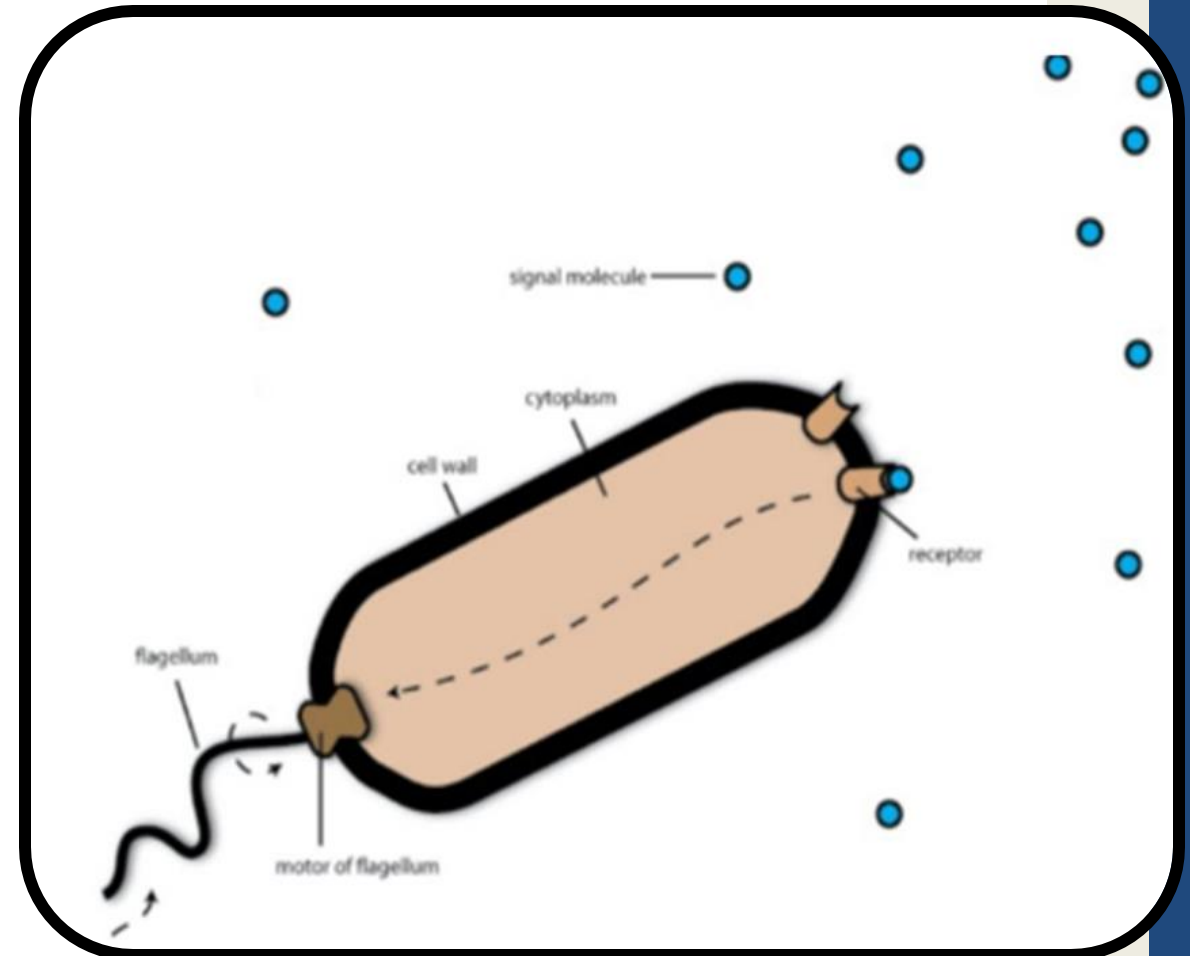
6

This function is not found in all bacteria. It is only found in bacteria that have flagella.

Chemotactic system

This mechanism occurs when the **receptor** of the cell **binds to useful substances** for the bacteria. this stimulates the flagella to move faster towards these useful substances.

And vice versa (when the **receptor** of the cell binds to **harmful substances** for the bacteria, this stimulates the flagella to move away from these harmful substances),



Plasmid

It's not present in all
types of bacteria

Double stranded

EXTRA chromosomal dsDNA

Plasmids are not considered a part of the bacterial DNA due to the following reasons:

1 Replicate autonomously (Independent of bacterial chromosome)

It replicates independently from the bacteria.

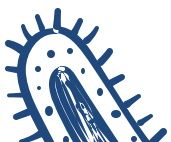
2 Toxin production Drug resistance

It doesn't function in growth and survival of the bacteria,
Instead, its functions occur due its natural property of
acquiring extra properties such as toxin production and
drug resistance.

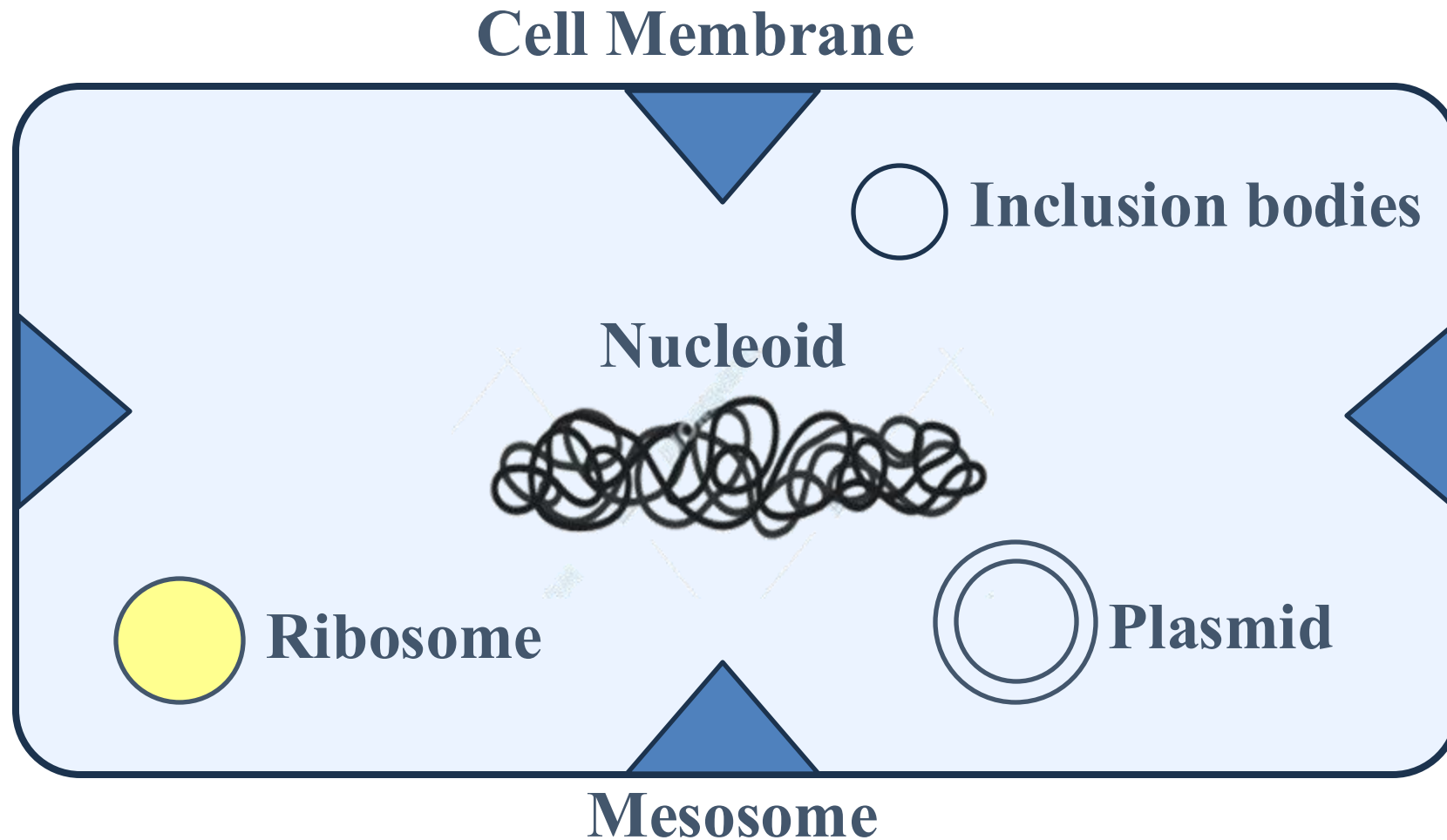


Not essential

Plasmid



Intracytoplasmic structure



Objectives

Cell wall

- 1) Definition**
- 2) Composition**
- 3) Synthesis**
- 4) Function**
- 5) Cell wall Deficient**

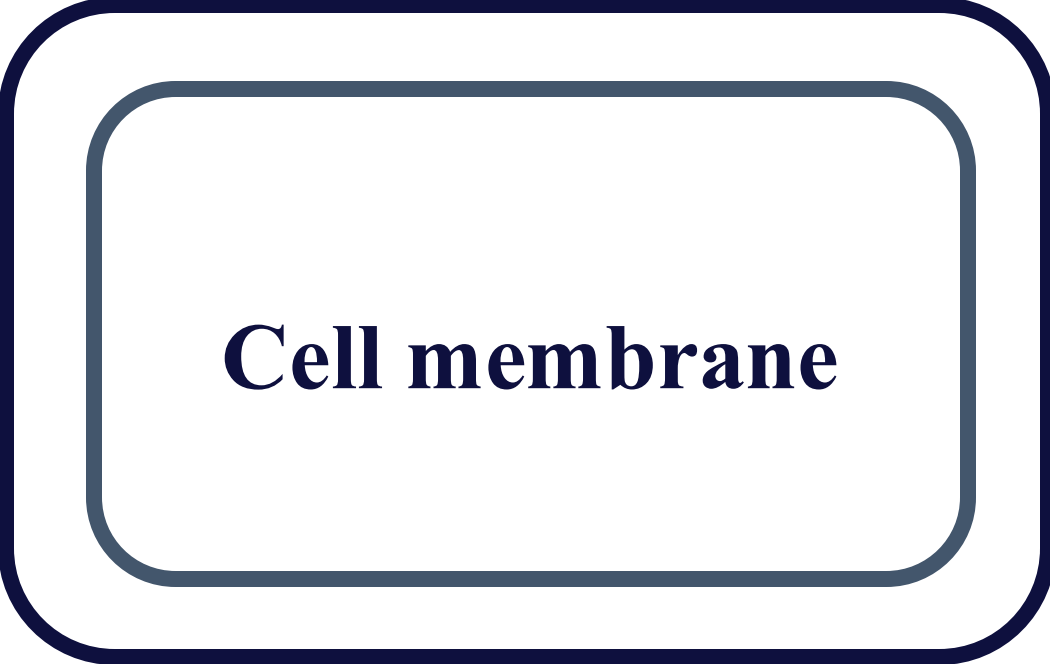
Definition of cell wall

Outermost layer!!!

Not accurate since some cells have capsules and then cell wall is not the outer most layer.

Surrounds the cell membrane

Accurate



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 surrounds the inner one, representing the cell wall.

Cell membrane

Rigid

Composition of cell wall

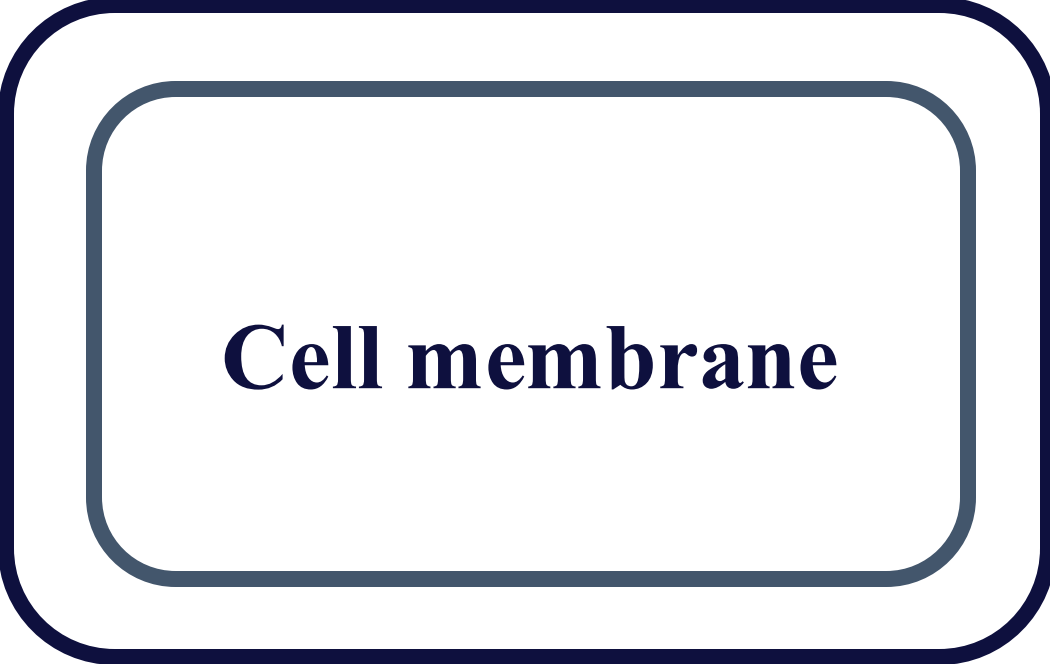
Rigidity

This rigidity is provided by an essential component of the cell wall called peptidoglycan.

(Peptidoglycan)

Composed of glycans (sugars) and peptides (proteins). There are 2 sugars :

- N-acetylmuramic acid (NAM)
- N-acetylglucosamine (NAG).



Cell membrane

Composition

N-acetylmuramic acid

Glycans

NAM

NAG

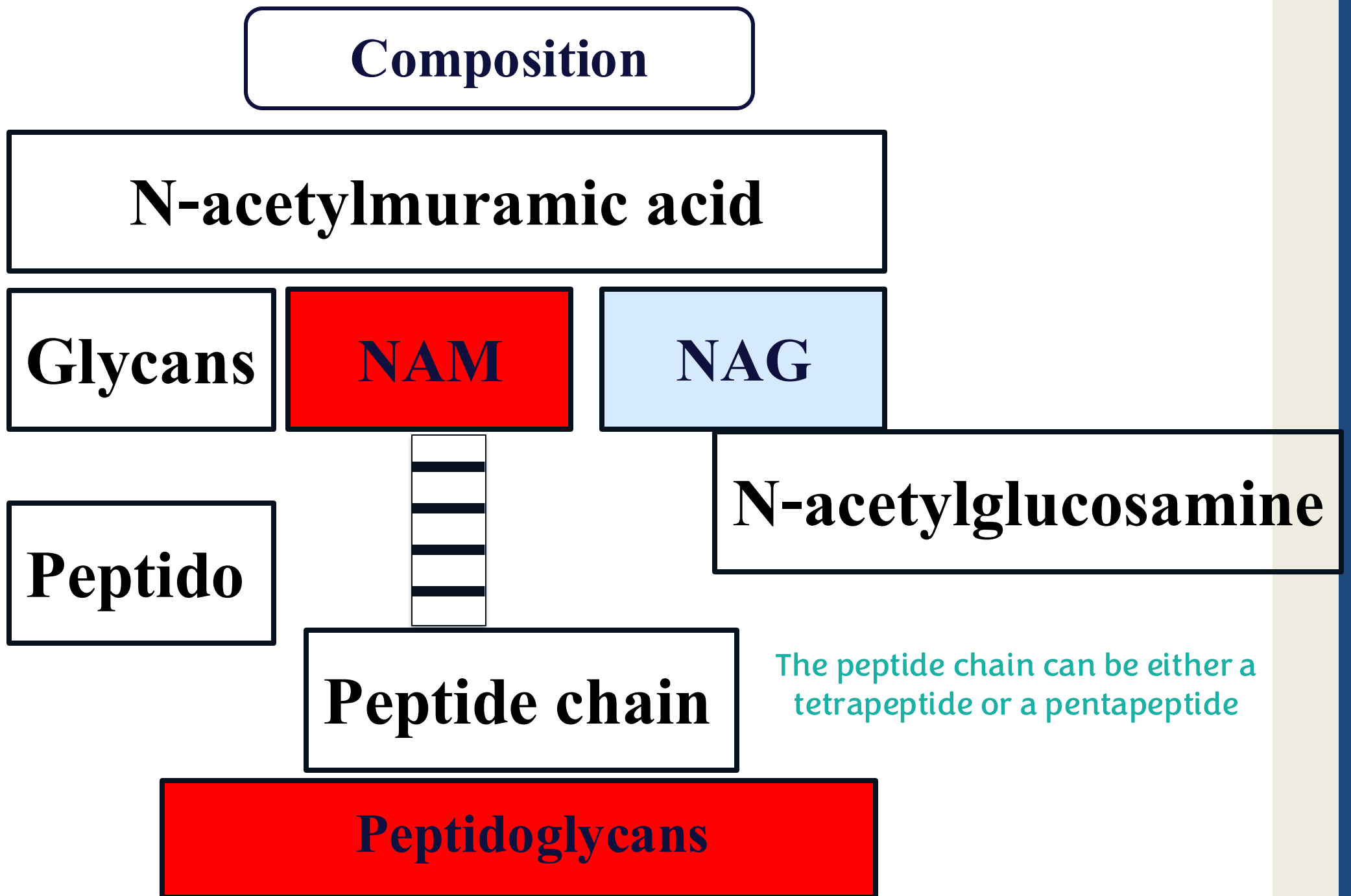
Peptido

N-acetylglucosamine

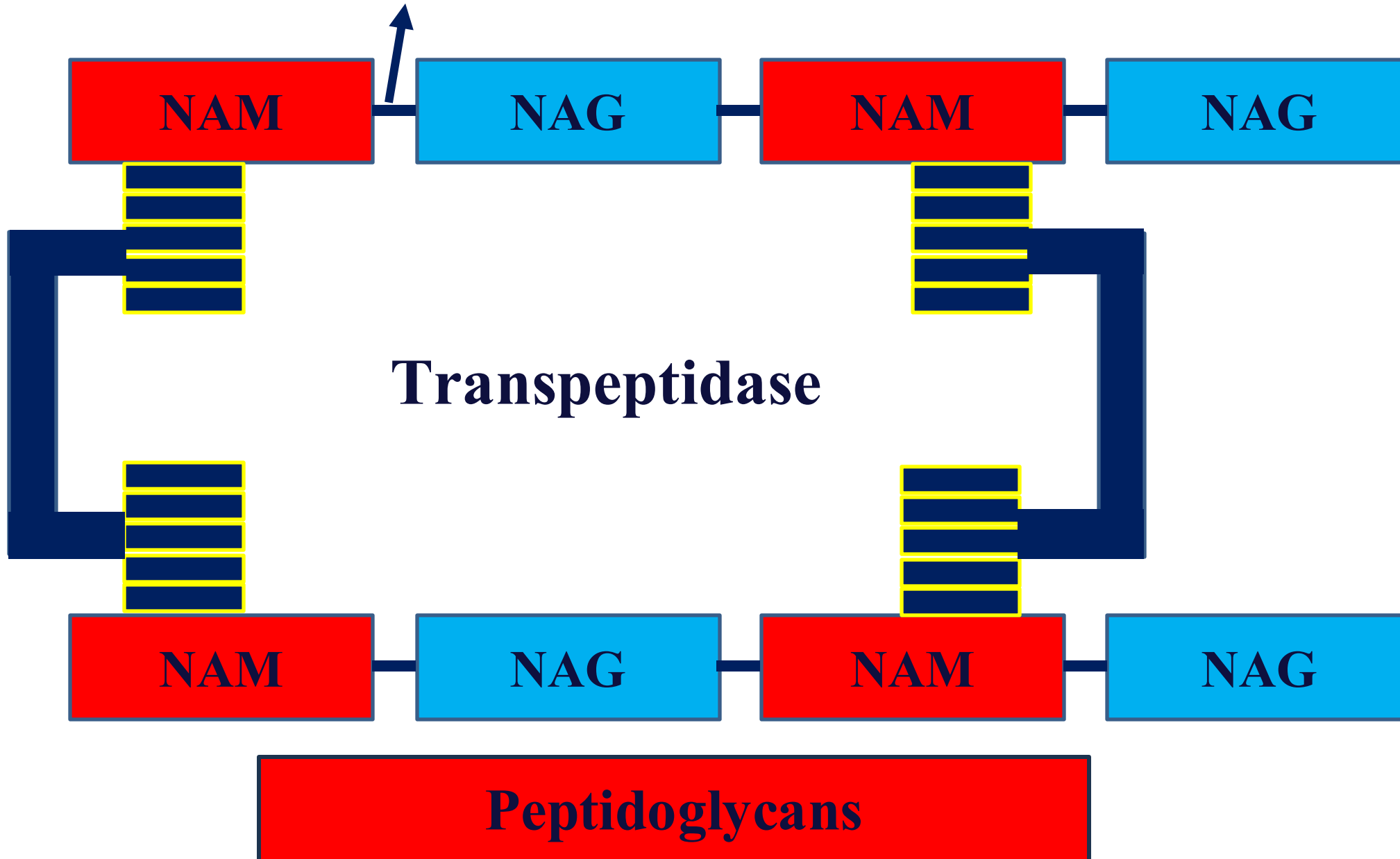
Peptide chain

The peptide chain can be either a tetrapeptide or a pentapeptide

Peptidoglycans

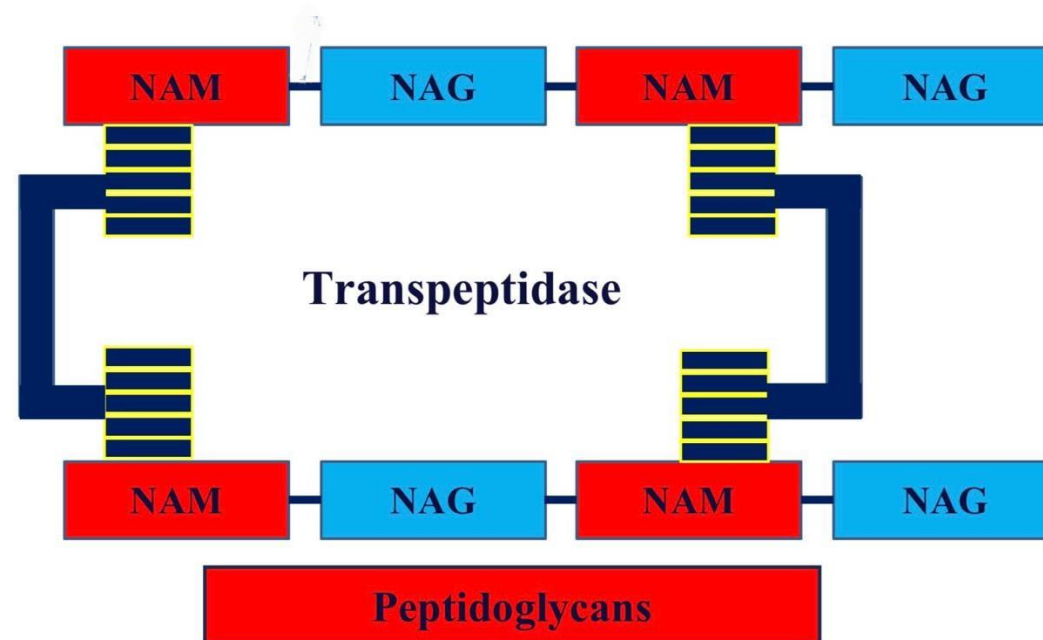


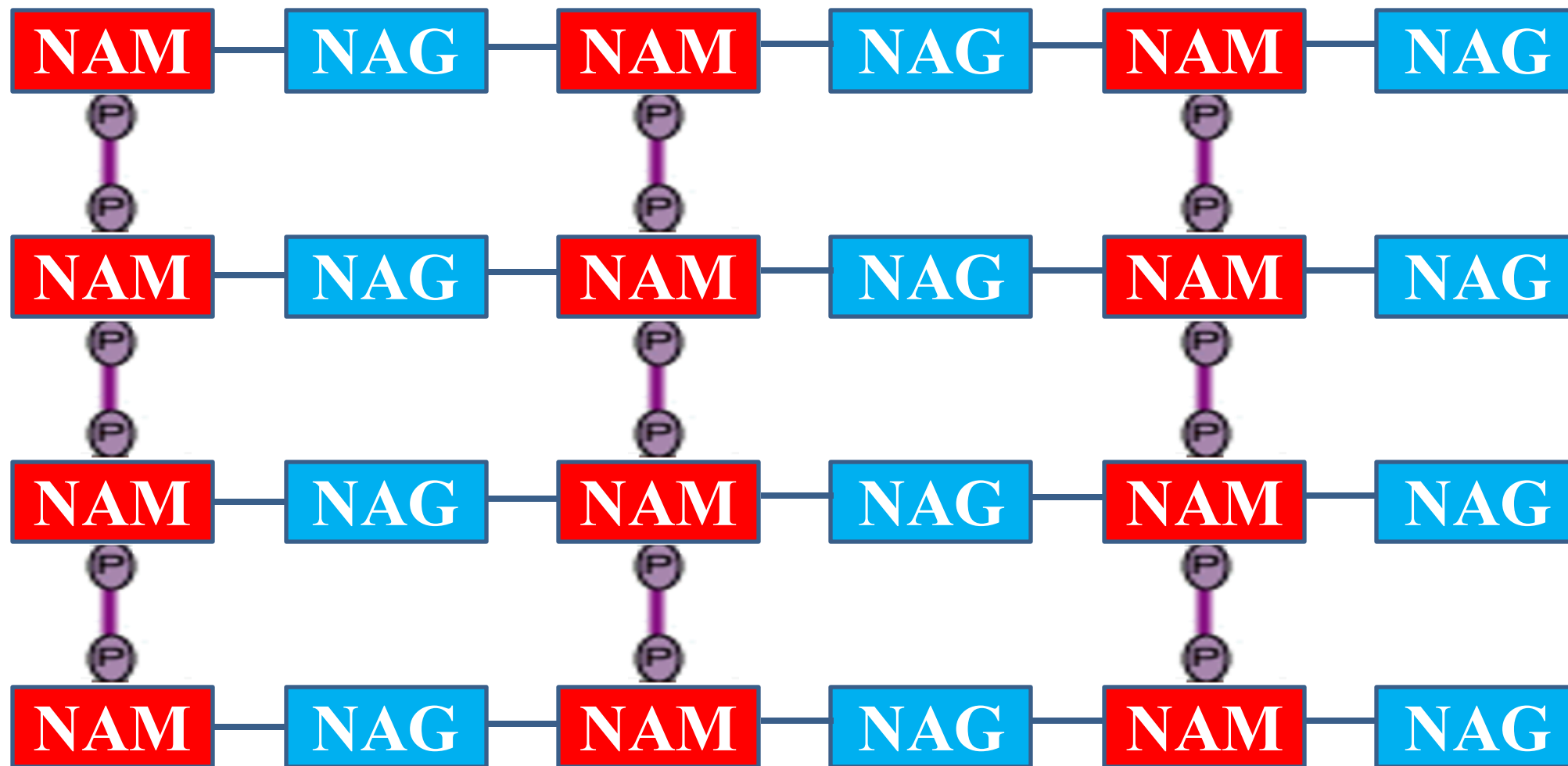
Glycosidic bond (Transglycosidase) Alternating repeating unit

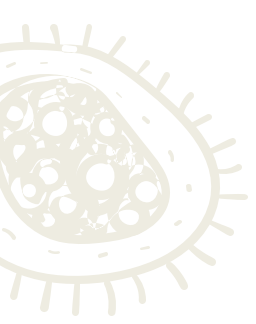


Composition of cell wall

- The sugars are **alternating** between **NAM** and **NAG**. The bond between NAM and NAG is a **glycosidic bond** created by the enzyme **transglycosidase**.
- There is a **peptide chain** composed of **4 or 5 amino acids** which are attached to **NAM**.
- **Peptidoglycans** are made of **several layers**, some bacteria have only 3-4 layers of peptidoglycan, while others may have 40-70 layers. These layers are connected **by the peptide chains** with the help of the enzyme **transpeptidase**.





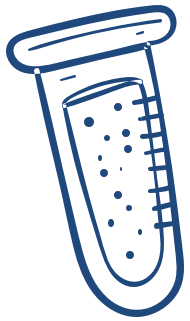


He used specific dyes and developed a procedure called **Gram staining**. The word “Gram” comes from the scientist Hans Christian Gram, while “staining” refers to the use of different dyes during the procedure.

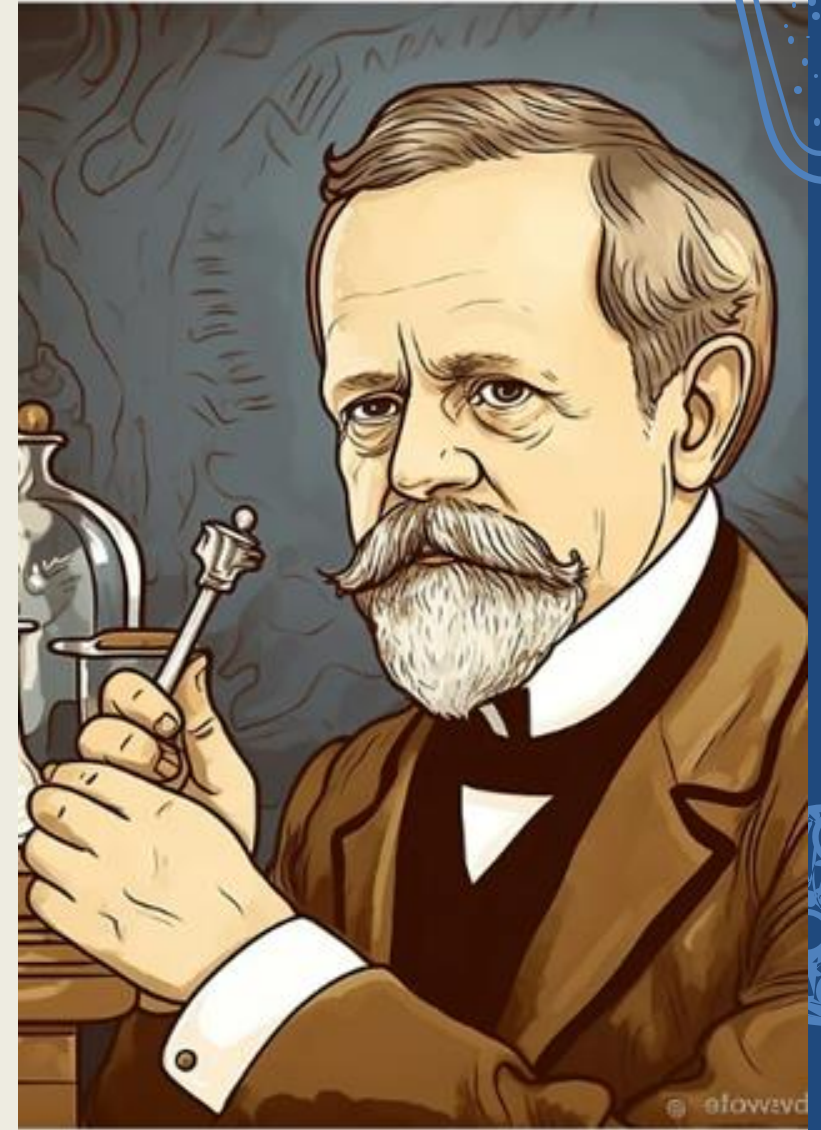
He observed that bacteria can retain different colors after the staining procedure, which helps us identify their type. Based on the final color, bacteria are classified into two groups: **Gram-positive bacteria**, which appear purple, and **Gram-negative bacteria**, which appear pink to reddish.

The term “Gram-negative” does not mean that these bacteria do not exist; it simply refers to a different group of bacteria based on their staining reaction.

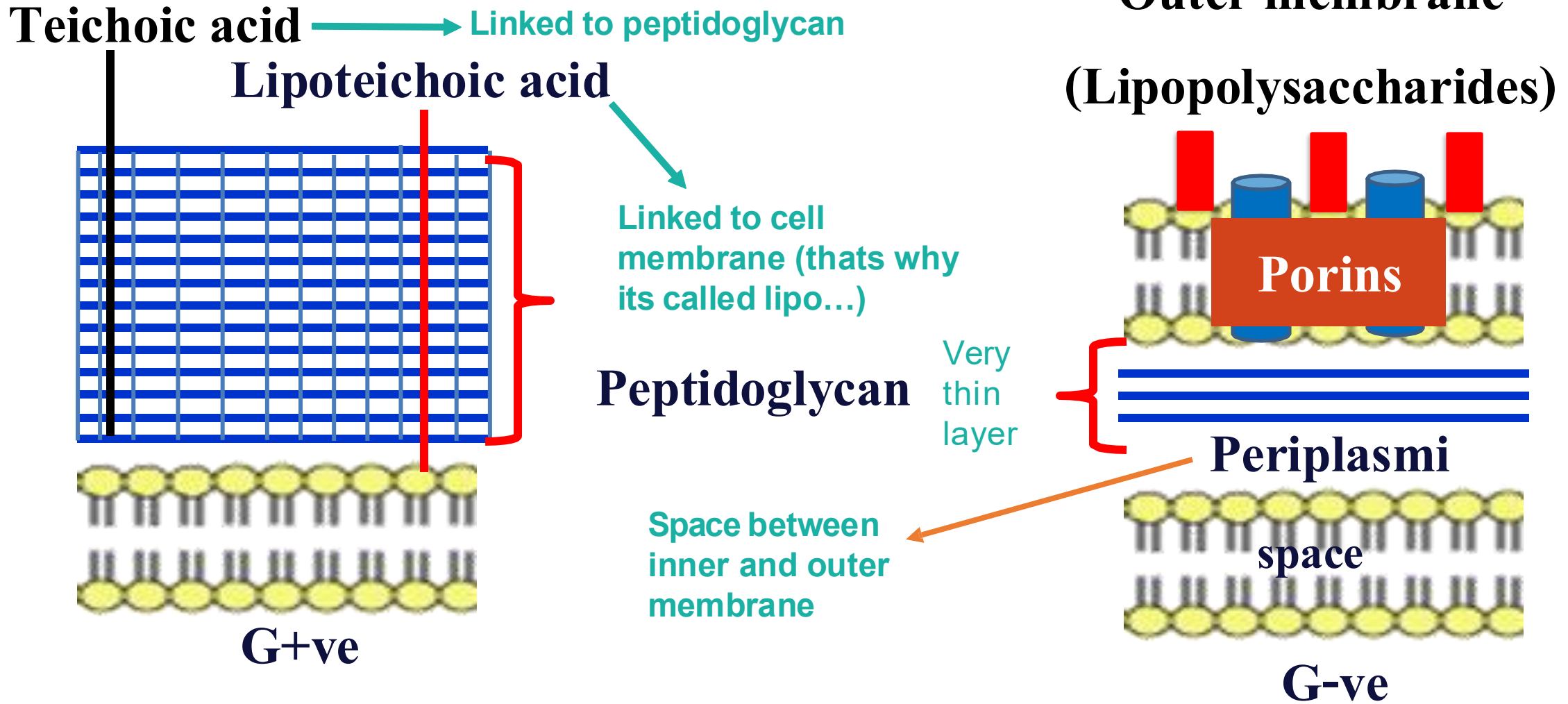
The classification is based on the **bacterial cell wall structure** that is different in the 2 types.



Gram scientist



Gram positive/negative bacteria



Gram positive bacteria

1) Peptidoglycan

(50%) → Of cell wall

NAM-NAG

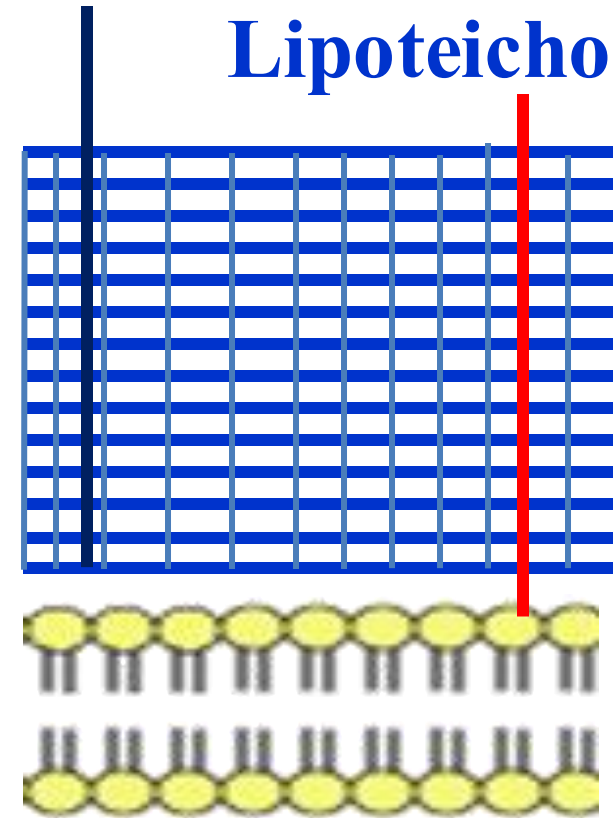


Peptide

Porous

Teichoic acid

Lipoteichoic acid



G+ve

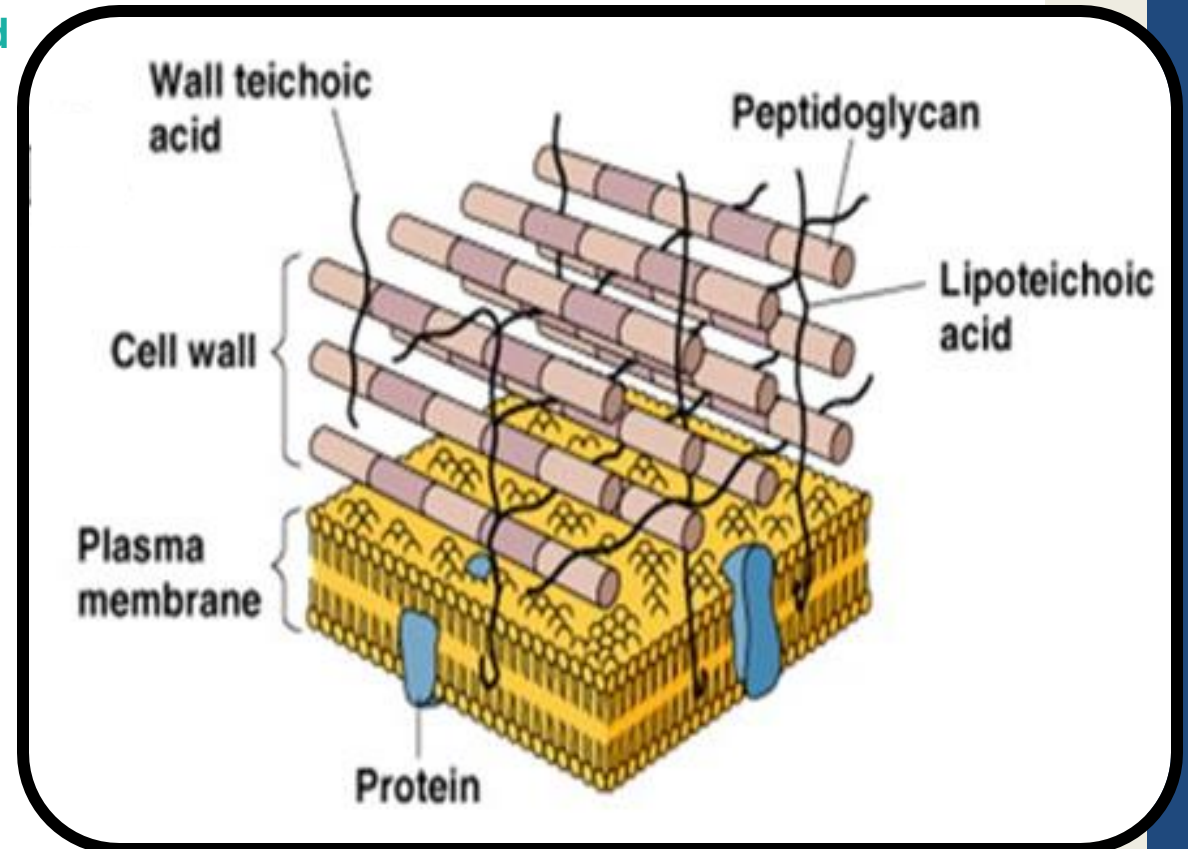
Composition of Gram positive

Polymers of glycerol or Rbitol

2) Teichoic acid

Lipoteichoic acid → Teichoic acid + lipid
of cell membrane
(Cell membrane)

Teichoic acid
(Peptidoglycane)



Composition of Gram positive

Antigen

Major surface Ag of G+ve

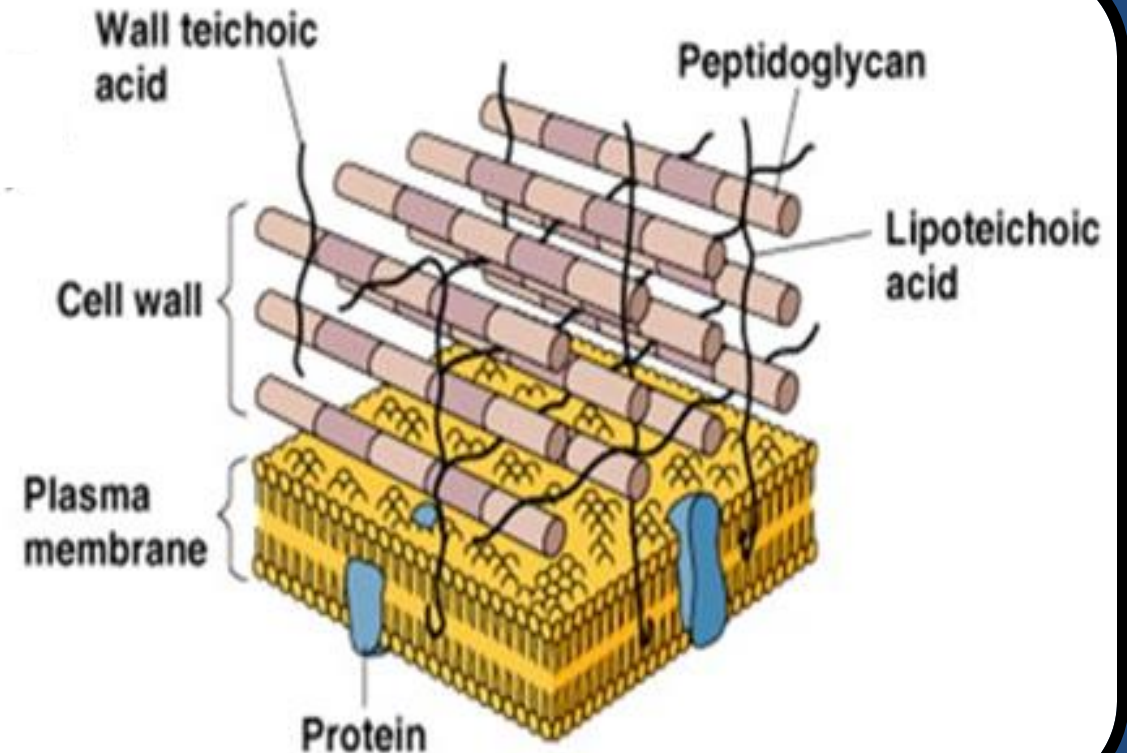
Highly
immunogenic

Trigger or induce the immune response to produce cytokines like Interleukin 1& Tumor Necrosis Factor alpha

TNF- α

IL-1

2) Teichoic acid



Composition of Gram Negative

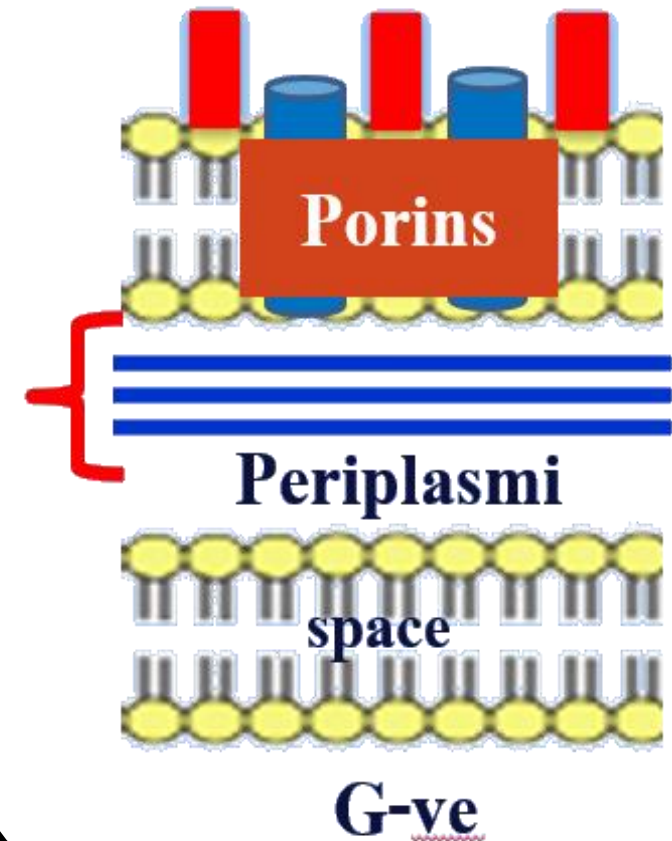
1) Peptidoglycan

A thin layer (5%)

2 sheets of
(NAM & NAG)

Peptides

Outer membrane
(Lipopolysaccharides)



Both lipid A and somatic O antigen are responsible for toxic shock. That will be discussed later on.

Outer membrane

A) Bilayer phospholipids

B) Lipopolysaccharides

Lipid A
(Endotoxin)

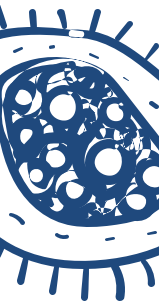
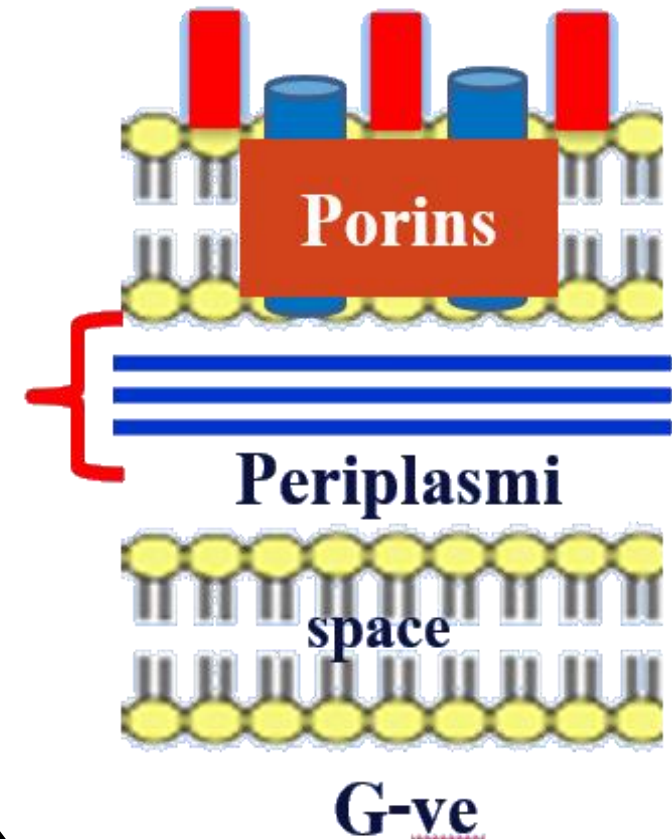
Endotoxins: Toxins that are part of the bacteria's structure and that are not actively secreted.

Bacteria can have two types of toxins, endotoxins and exotoxins.

Polysaccharides
(somatic O Ag)

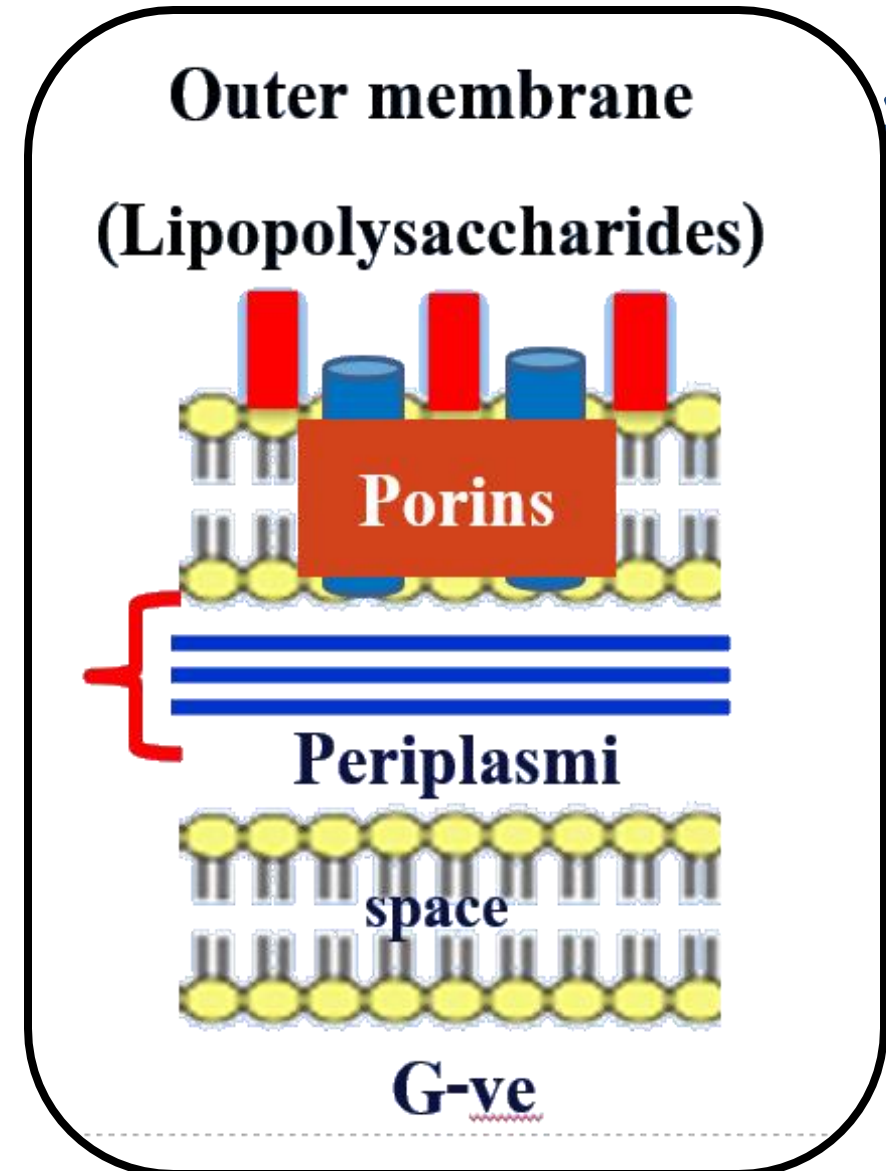
Triggers
antibodies

Outer membrane (Lipopolysaccharides)



Outer membrane

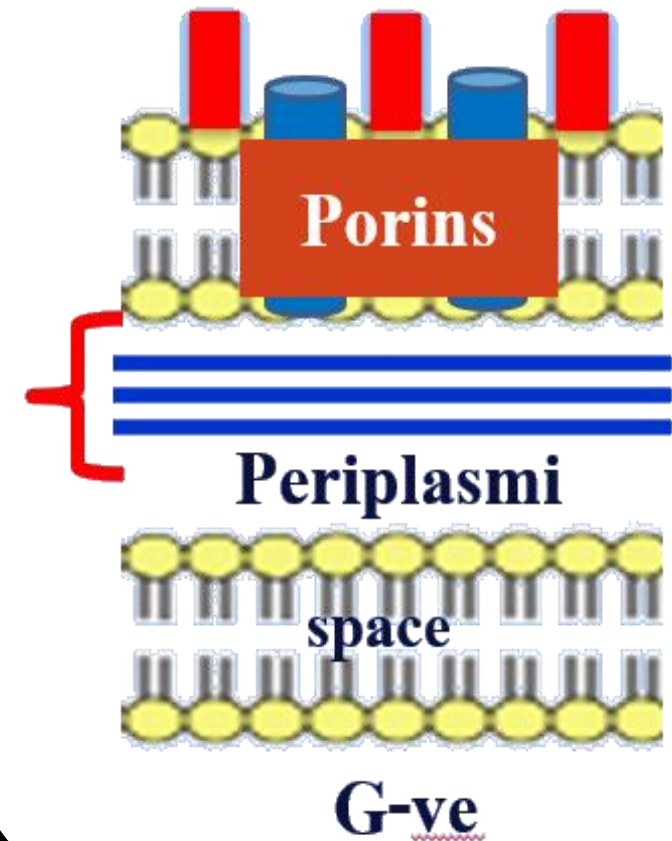
C) Porins
(hydrophilic Protein)
in the outer membrane
(Transportation)



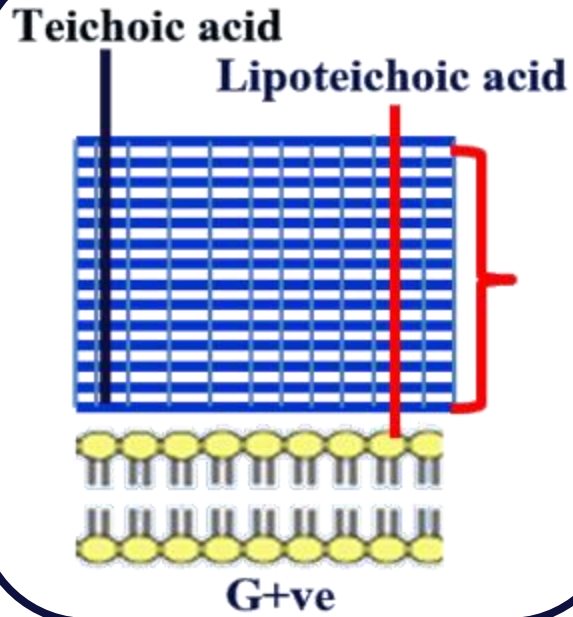
Periplasmic space

Space between cytoplasmic &
outer membrane
Peptidoglycan layer &
gel-like protein

Outer membrane
(Lipopolysaccharides)



Gram positive/Negative bacteria



1) Peptidoglycan

Thick

2) Teichoic acid/ Lipoteichoic acid

Yes

3) Outer membrane

No

1) Peptidoglycan

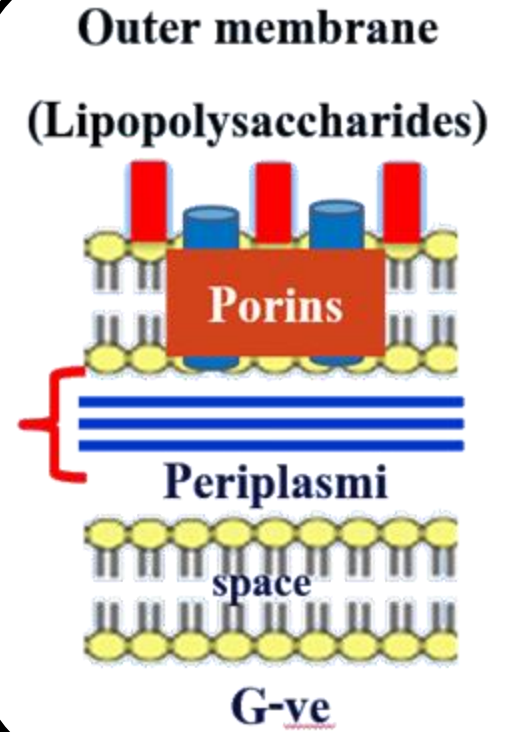
Thin

2) Teichoic acid/ Lipoteichoic acid

No

3) Outer membrane

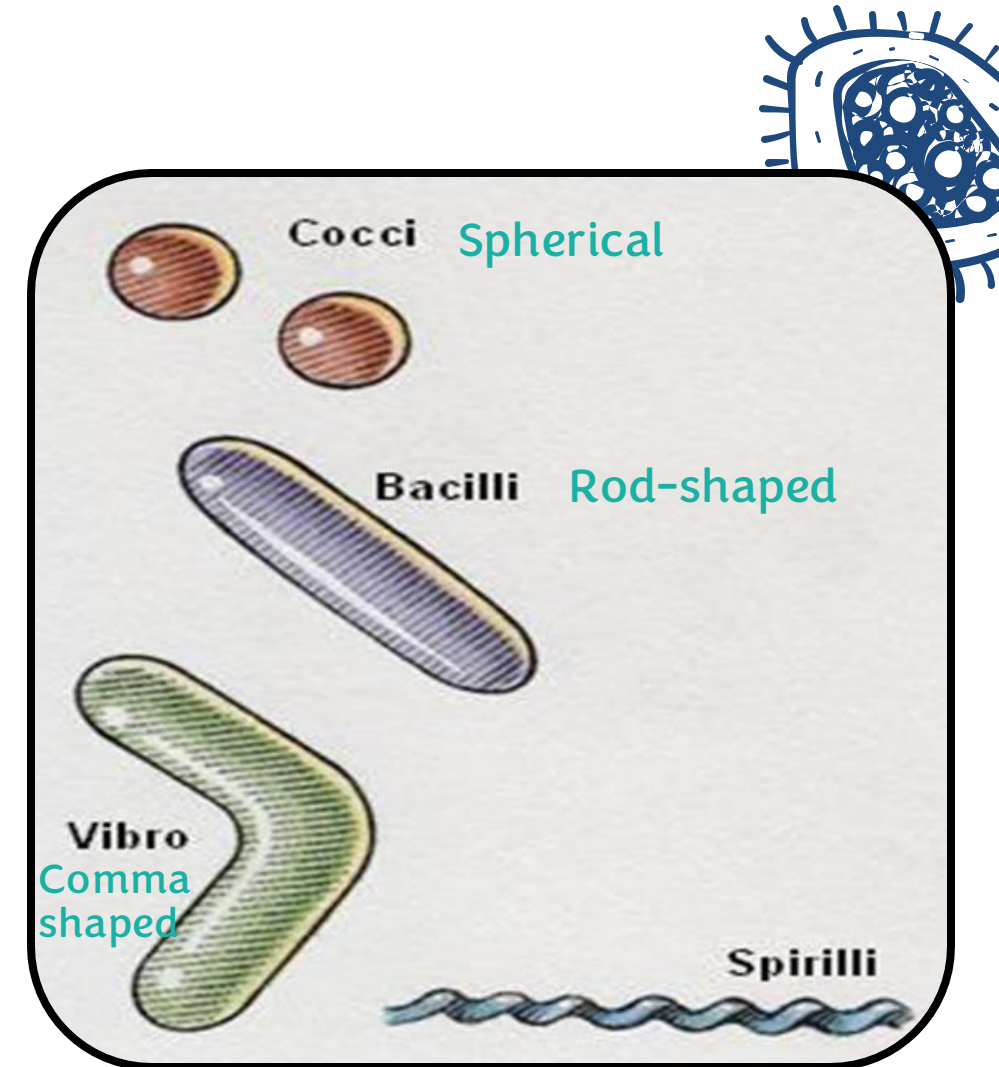
Yes



Function of cell wall

1

**Maintenance of the
shape (Rigid)**



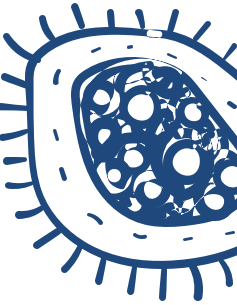
Function of cell wall

1

Deficient of cell wall

Myoplasma is polymorphic because there's no cell wall to hold it in a specific shape.

Polymorphic



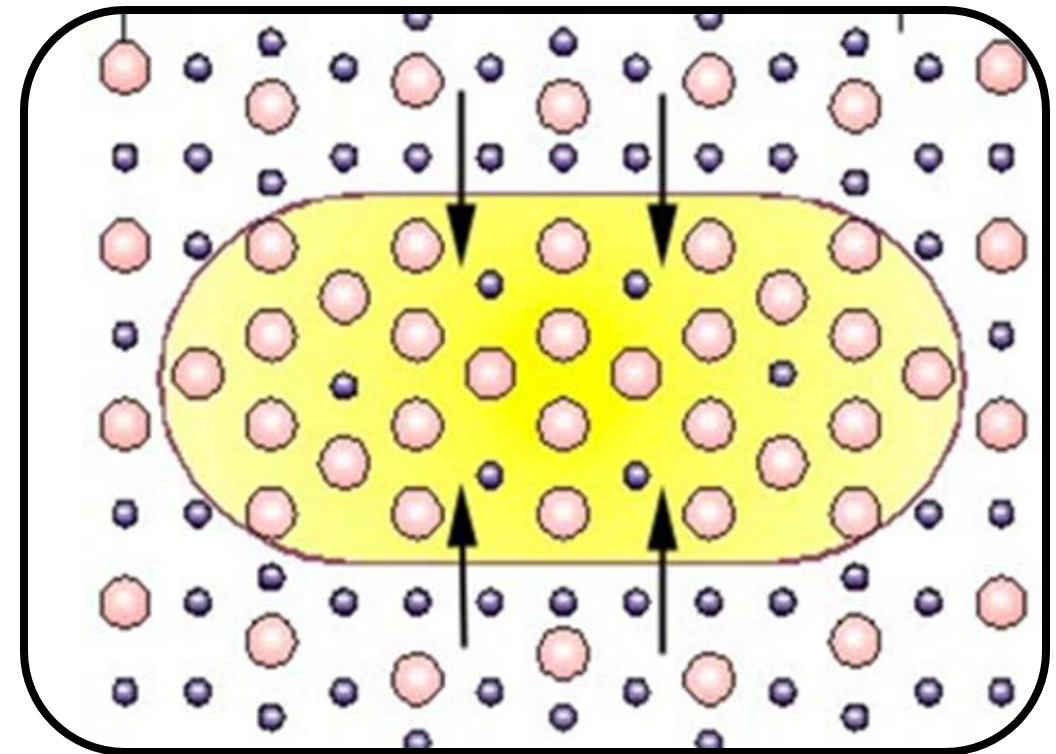
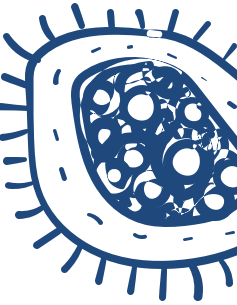
Function of cell wall

2

Protection (Osmosis insensitive)

Protection of the thin and fragile cell membrane

Since cell wall is present it does resist water movement across the membrane due to osmolarity



Function of cell wall

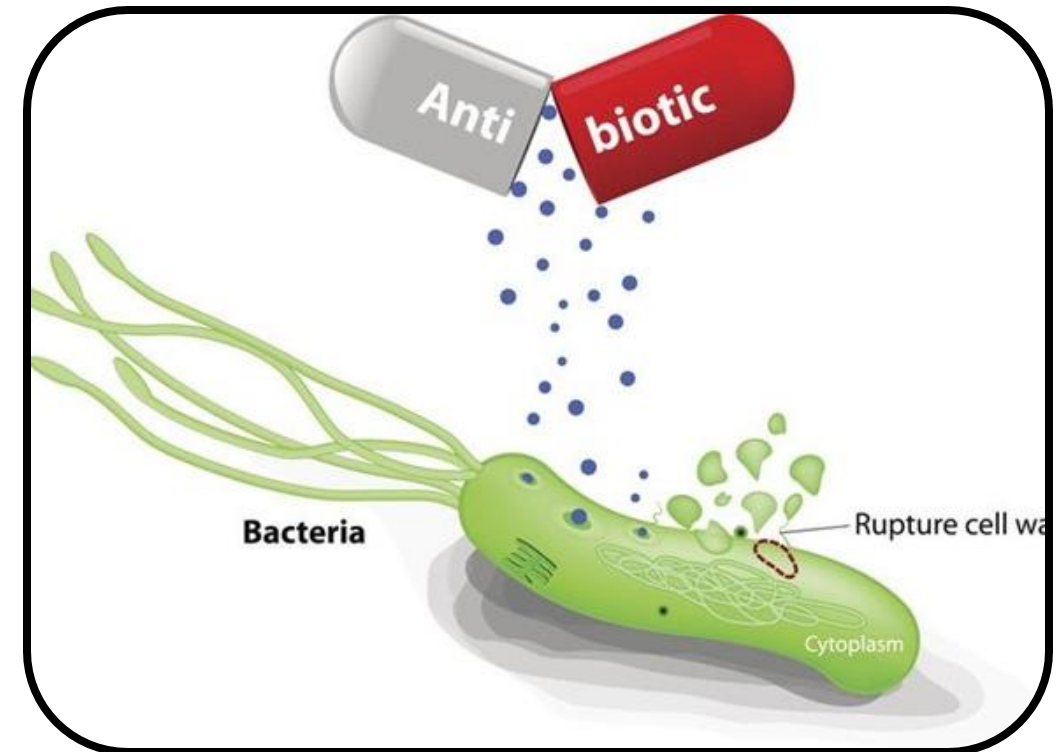
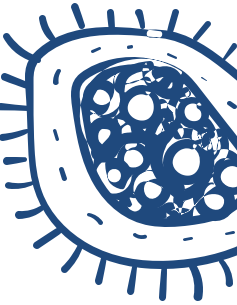
3

Target site for antibiotics

Penicillin

Cephalosporines

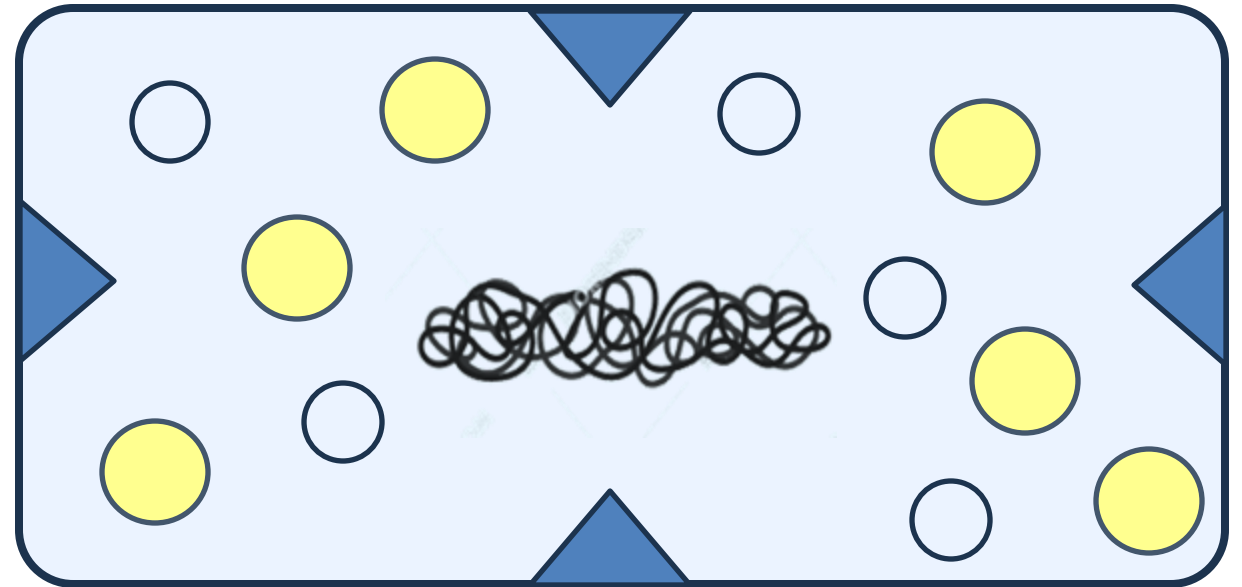
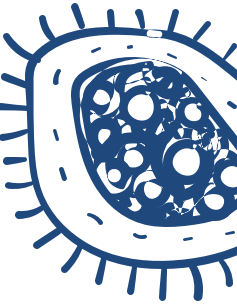
They are used for the prevention of forming the bacterial cell wall after reproduction, thus killing the bacteria.



Function of cell wall

4

Role in cell division

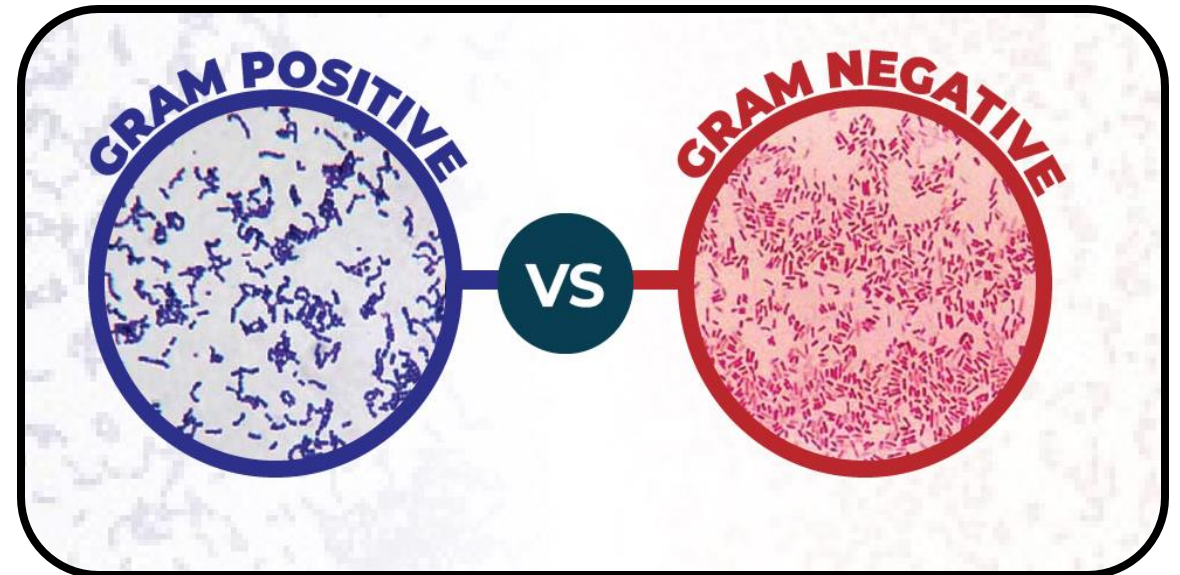
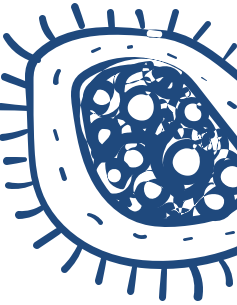


Function of cell wall

5

Responsible
for staining

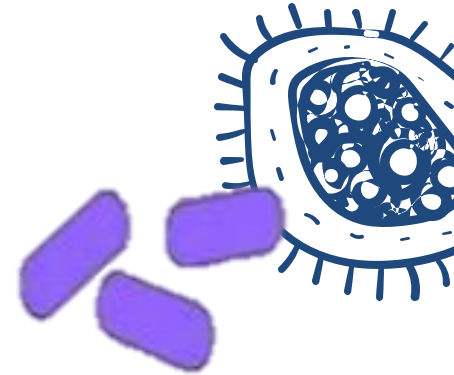
(Gram Stain)



Function of cell wall

Responsible for staining

G+ve



Fixation

Crystal
violet

Iodine

Acetone

Counter
stain



G-ve

Read and follow the last figure (previous slide) for understanding.

Function of cell wall

Responsible for staining

1. Gram staining starts by preparing two slides with bacterial cultures mixed in distilled water. They get heat-fixed briefly over a flame to attach bacteria to the slide, which is essential because multiple stains and washes follow.
2. The primary stain, crystal violet, colors both Gram-positive and Gram-negative bacteria purple.
3. Iodine is then applied for fixation of color, forming a crystal violet-iodine complex that stabilizes the dye; both types of bacteria remain purple.
4. The critical step is decolorization using acetone or 90% -70alcohol: Gram-positive bacteria retain the purple color due to their thick peptidoglycan wall, while Gram-negative bacteria become colorless because the alcohol dissolves their outer membrane and decolorize the thin cell wall. This step must be brief to avoid over-decolorizing.
5. Finally, a counterstain (safranin) colors Gram-negative bacteria pink while Gram-positive remain purple. Although microscopes are normally used only at the end, checking after each step can help understand the staining principle.

Quiz

<https://forms.gle/gqDYwz58TF29y6z1A>

Additional resources:

Reference Used:

Dr. Alaa Matakah lecture

"وقد أجمع عقلاء كل أمةٍ على أنَّ النعيم لا يدرك بالنعيم، وأنَّ مَنْ أثر الراحة فاتته الراحة، وأنه بحسب ركوب الأهوال واحتمال المشاق تكون الفرحة واللذة.. فلا فرحة لِمَنْ لا همَّ له، ولا لذة لِمَنْ لا صبر له، ولا نعيم لِمَنْ لا شقاء له، ولا راحة لِمَنْ لا تعب له.. بل إذا تعب العبد قليلاً استراح طويلاً، وإذا تحمَّل مشقة الصبر ساعةً قادَه لحياة الأبد، وكلُّ ما فيه أهل النعيم المقيم فهو صبر ساعة، والله المستعان، ولا قوة إلا بالله." 

- الإمام ابن القيم | مفتاح دار السعادة

رسالة من الفريق العلمي:

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



Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			