



## LECTURE 2

# Bacterial structure

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

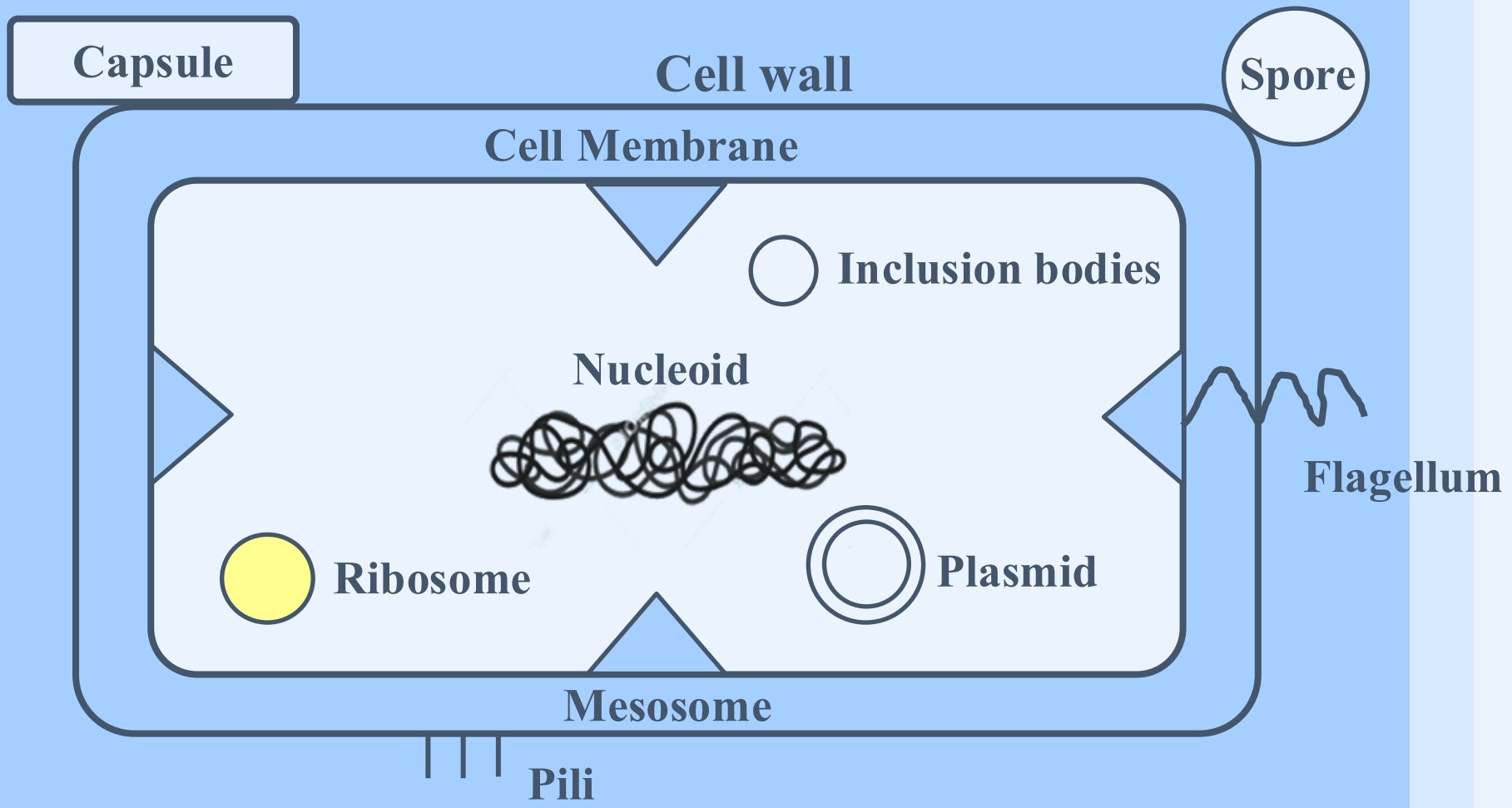


# Objectives

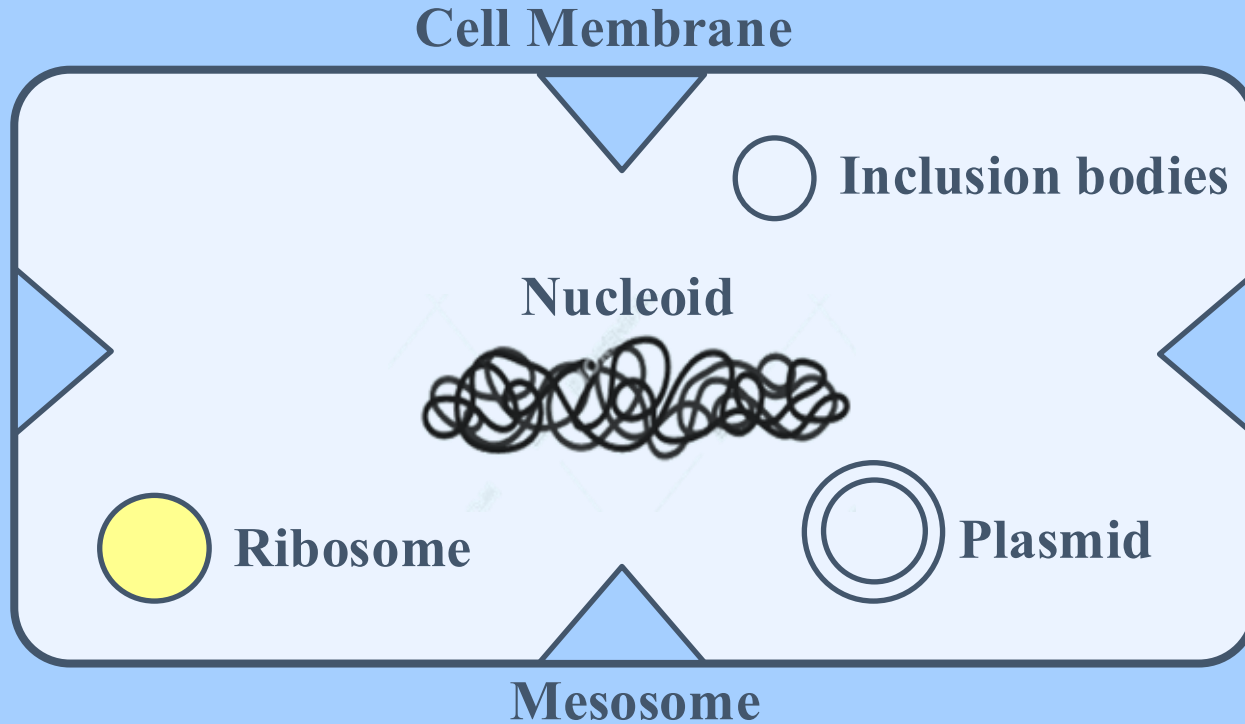
## Intracytoplasmic structure

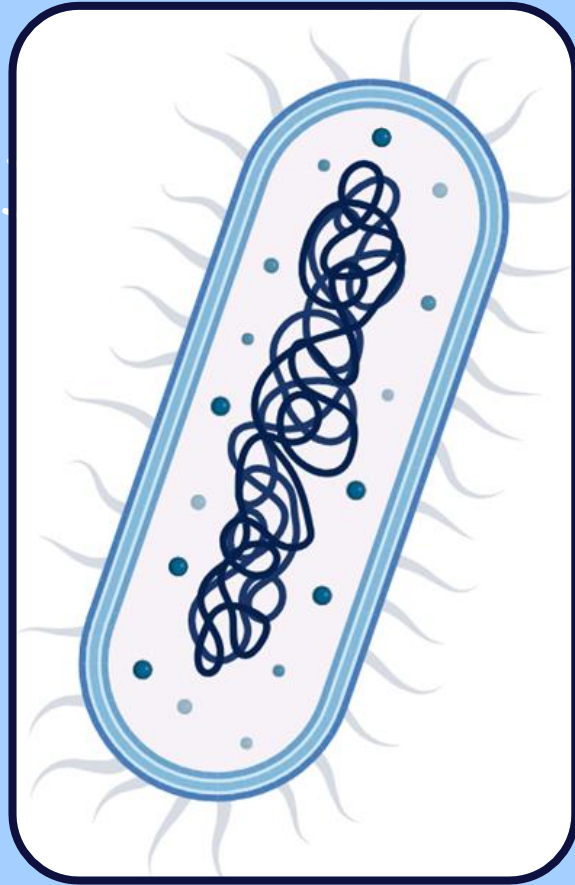
- 1) Nucleoid
- 2) Ribosome
- 3) Inclusion granules
- 4) Cell membrane
- 5) Plasmid

# Bacterial structure



# Intracytoplasmic structure





## 1) Nucleoid

1

**Single chromosome**

2

**Circular**

3

**dsDNA**

4

**1mm in length**

5

**supercoiled**

6

**Carry genetic information for growth  
& survival**

**Essential**

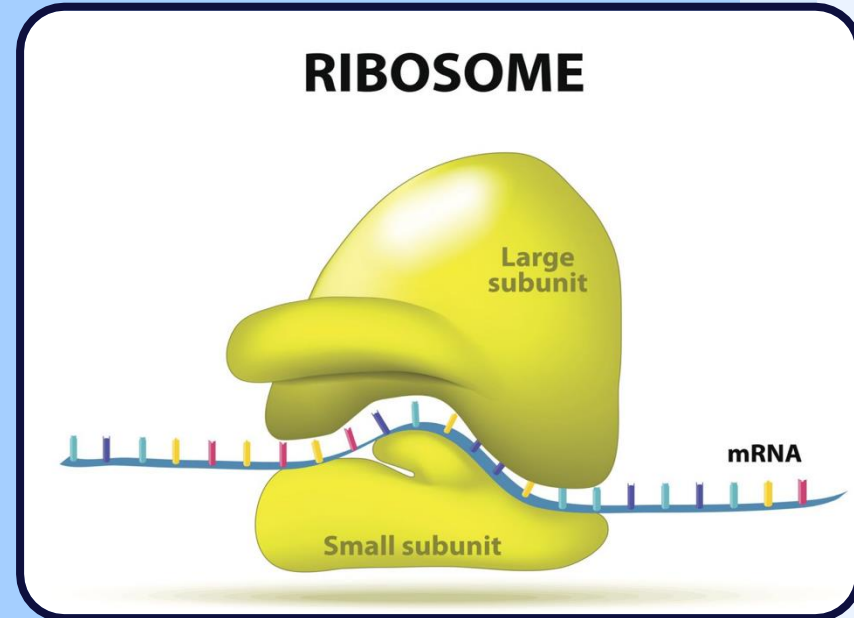
## 2) Ribosome

1 Ribo=RNA

2 Some=body

3 Site of Protein synthesis

**Essential**



## 2) Ribosome

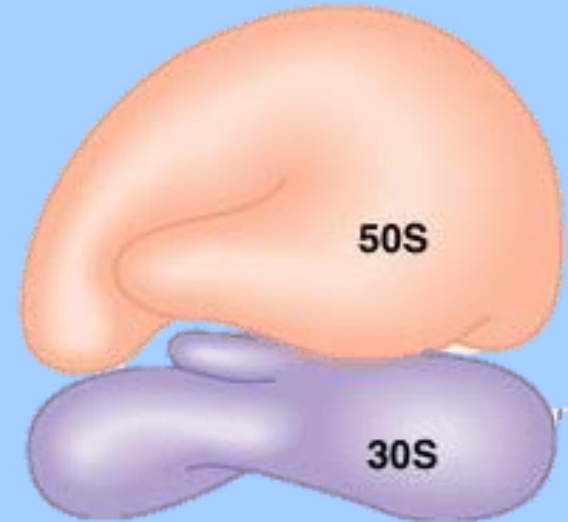
**Bacterial ribosomes**



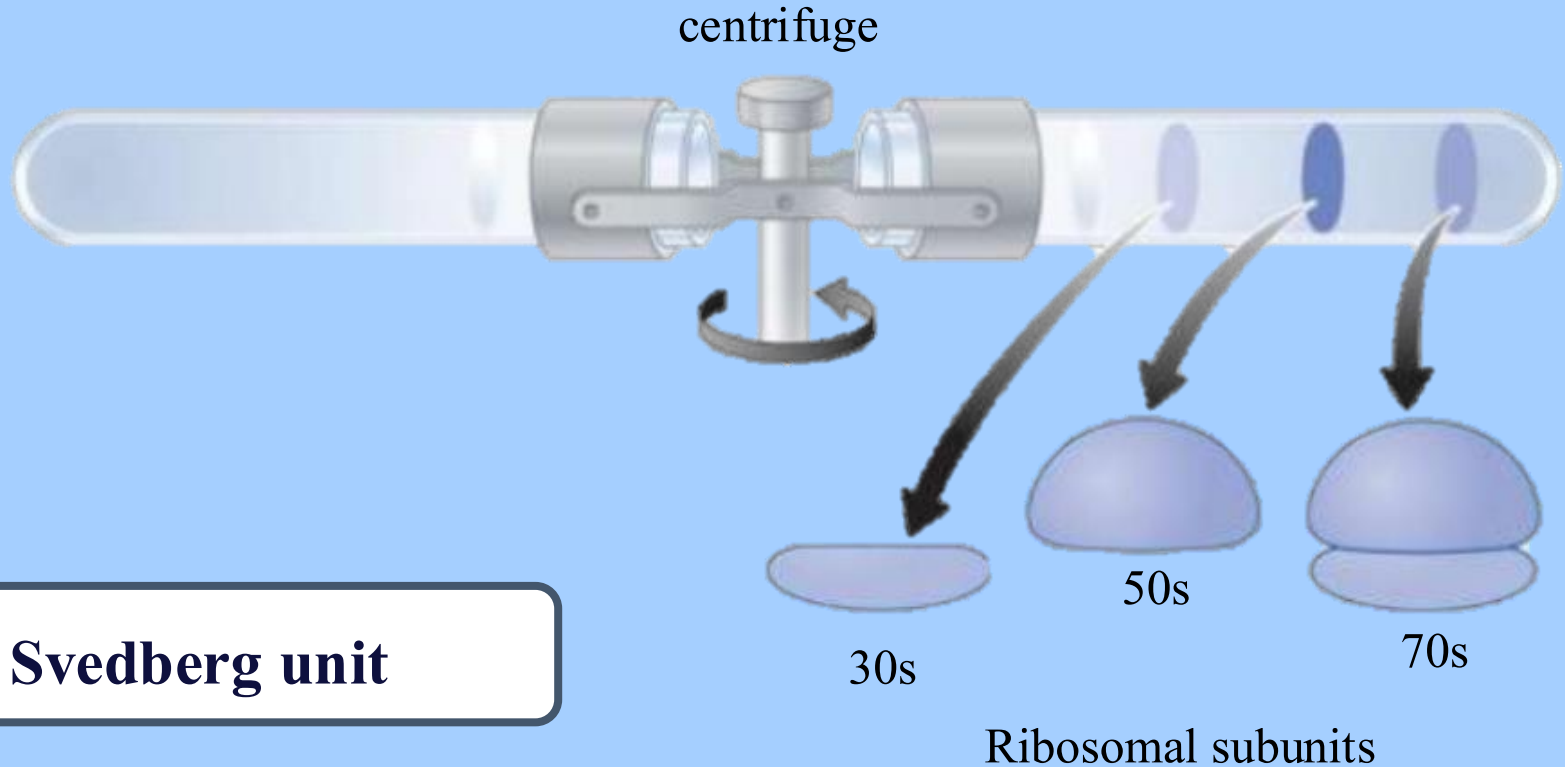
**(70S)**



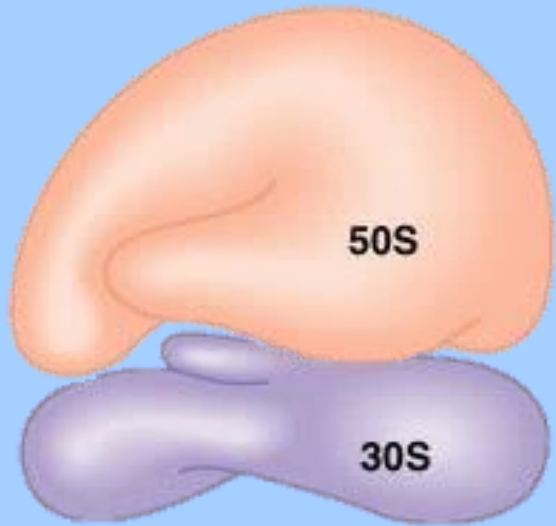
**Svedberg unit**



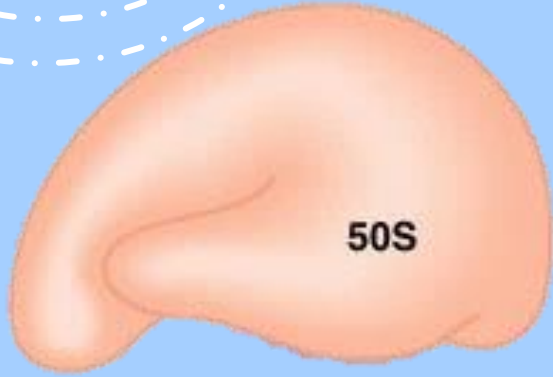
## 2) Ribosome



## 2) Ribosome



## 2) Ribosome



50S

60S

Target of antibiotics

Human



30S

40S

### 3) Inclusion granules

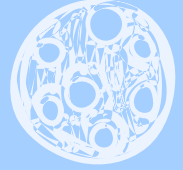
**Store of nutrient**

**Glycogen**

**Starch**

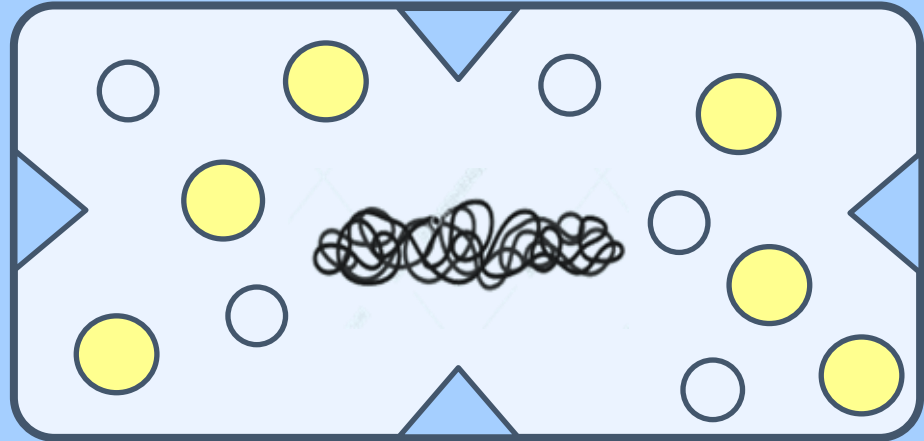
**Phosphate**

**Volutin granule  
(Metachromatic  
granules)**



# Definition of the cell membrane

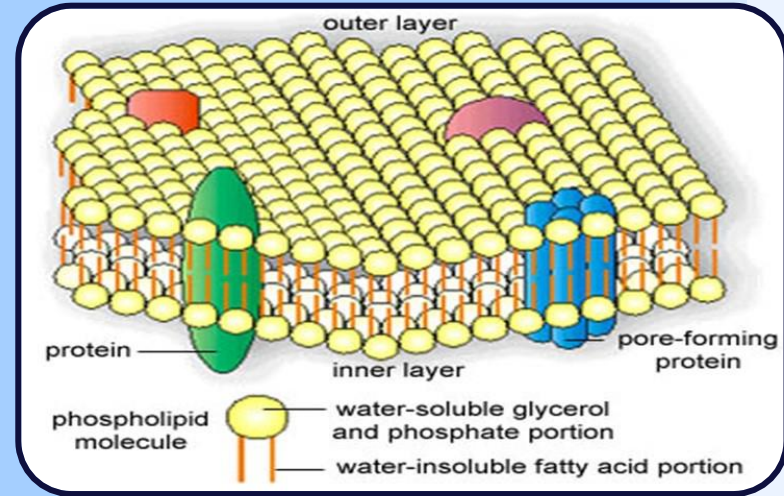
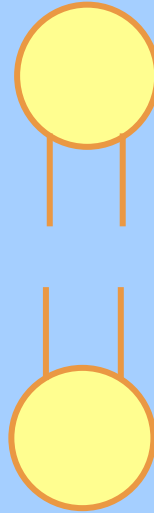
**Thin, fragile membrane  
located just  
inside the cell wall**



**Essential**

# Composition of cell membrane

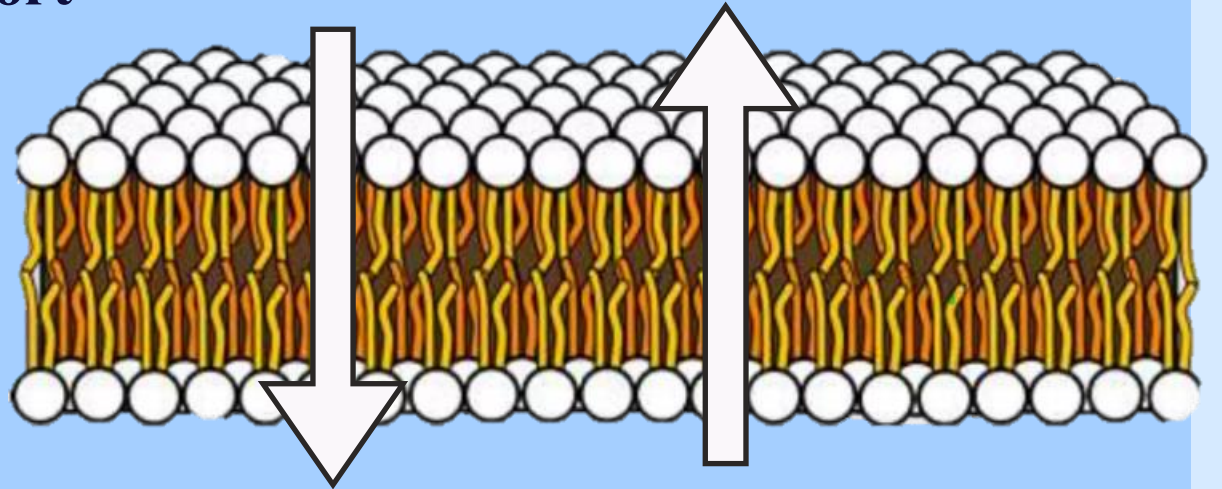
**Phospholipid bilayer + Protein**  
**(No sterols)**



# Function of the cell membrane

1

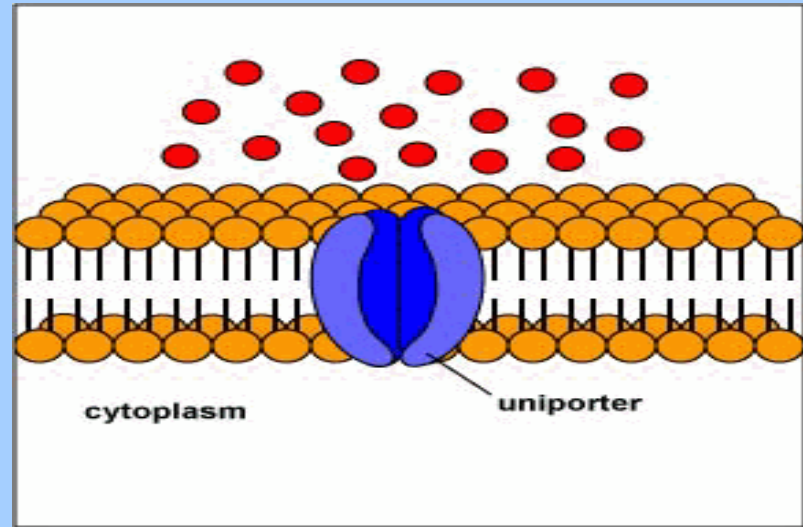
**Selective transport**  
**(Passive)**



# Function of the cell membrane

1

**Selective transport (Active)**



# Function of the cell membrane

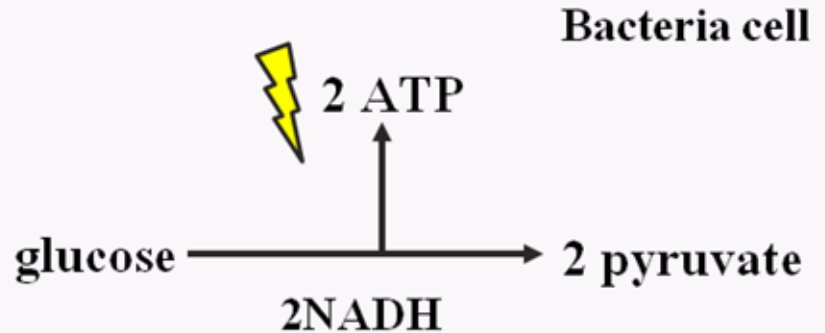
2

**Mesosomes**

**Respiration enzyme**

**(Making energy)**

**(Like Mitochondria)**



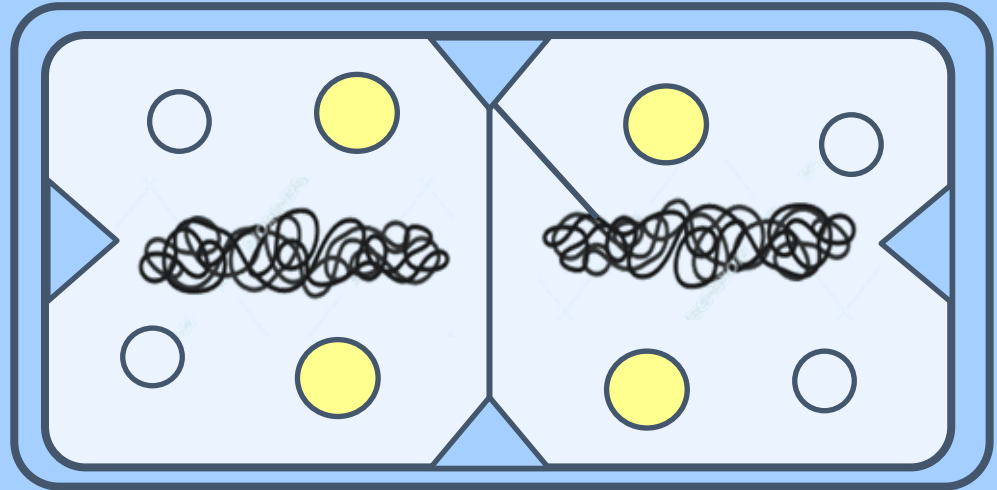
# Function of the cell membrane

2

**Cell division**

**Separate DNA**

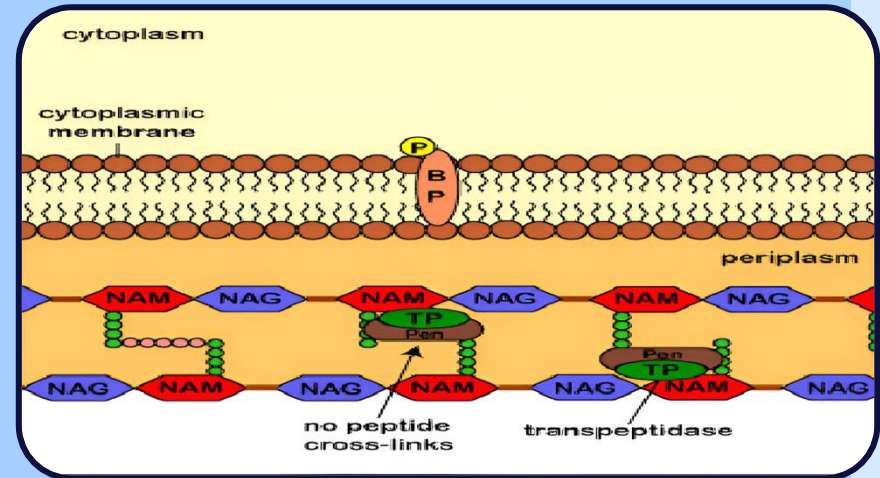
**Septal mesosome**



# Function of the cell membrane

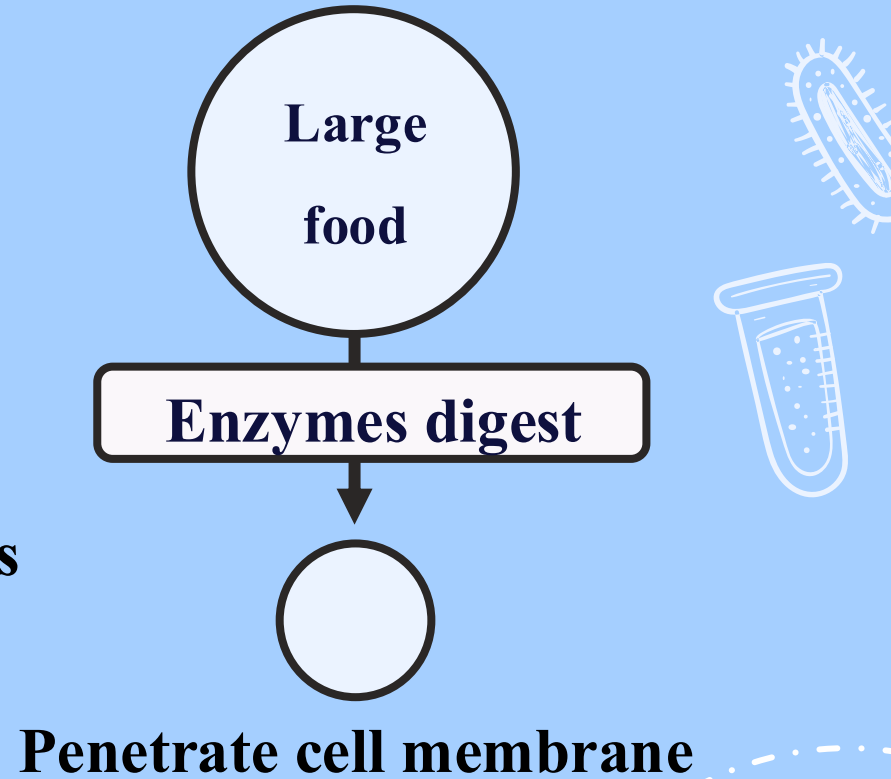
3

## Biosynthesis of cell wall



**4**

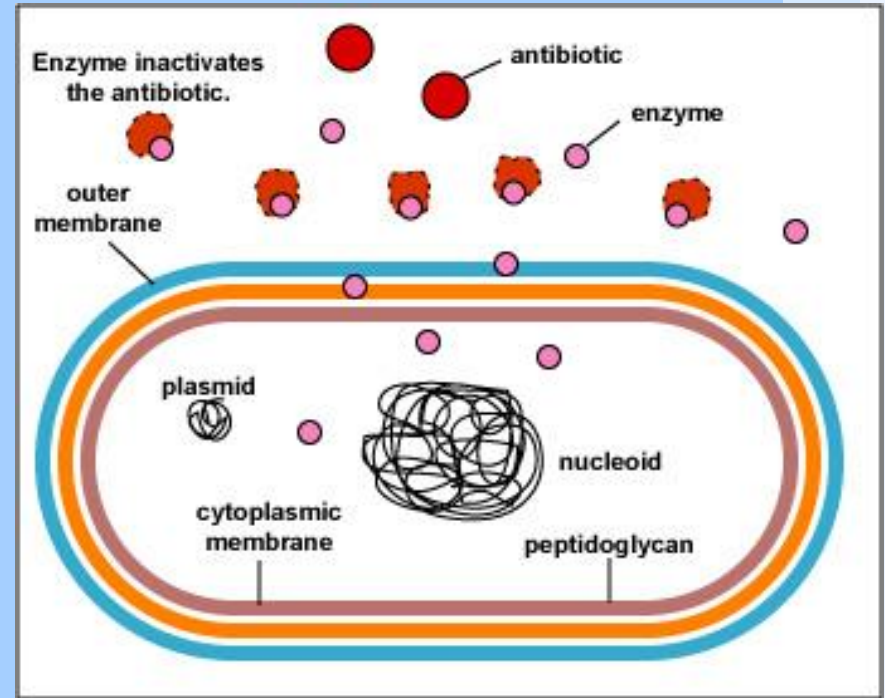
**Excretion of extracellular enzymes  
(Hydrolytic enzymes)**



# Function of the cell membrane

5

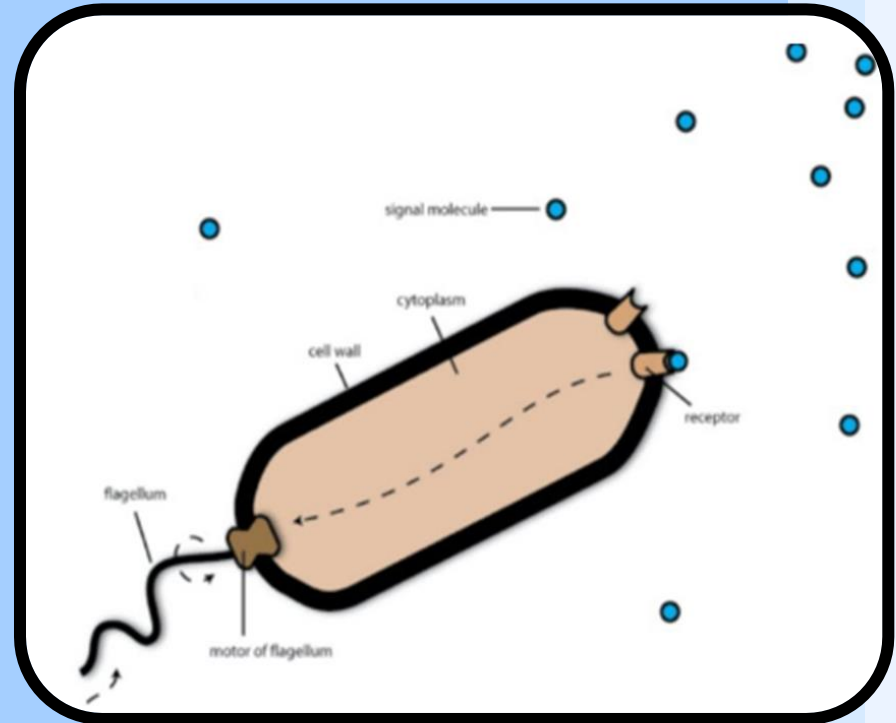
## Excretion of extracellular enzymes (Penicillinase)



# Function of the cell membrane

6

## Chemotactic system



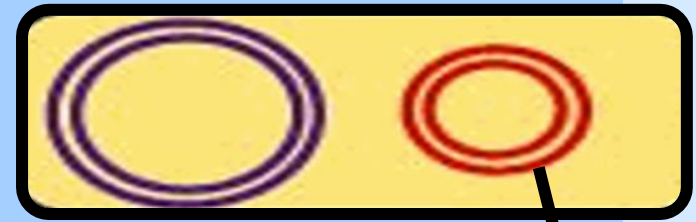
# Plasmid

## EXTRA chromosomal dsDNA

1 Replicate autonomously (Independent of bacterial chromosome)

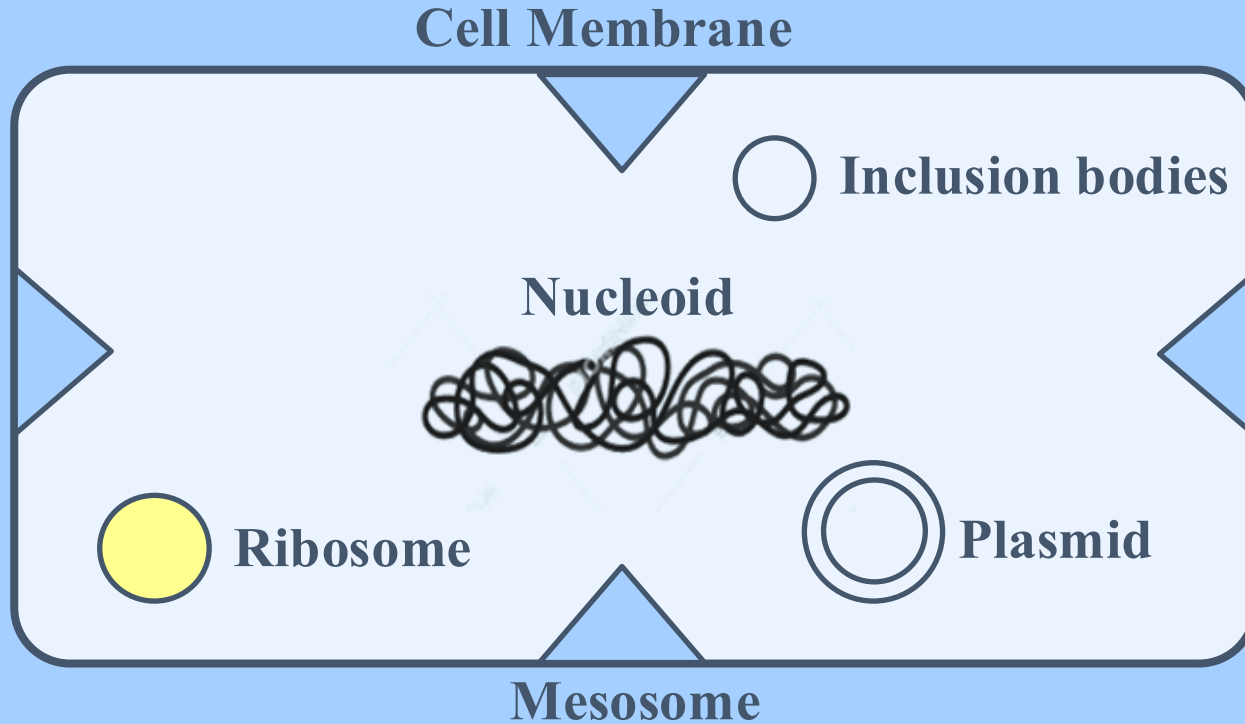
2 Toxin production      Drug resistance

Not essential



Plasmid

# Intracytoplasmic structure



# Objectives

## Cell wall

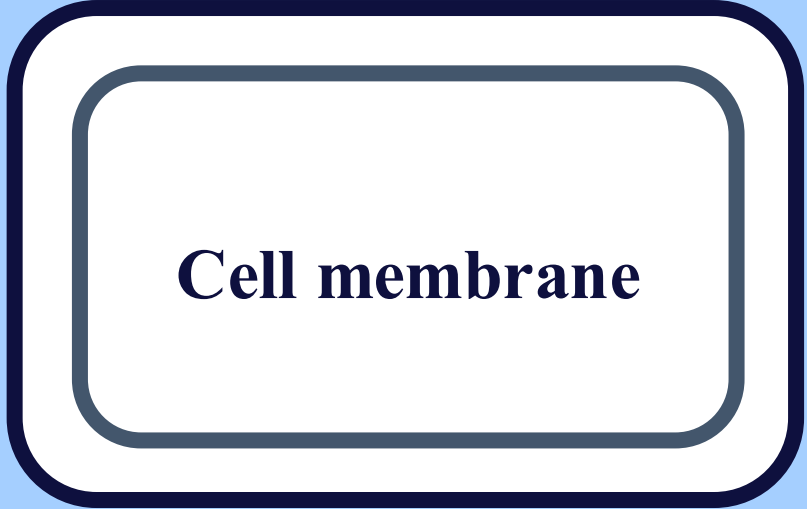
- 1) Definition
- 2) Composition
- 3) Synthesis
- 4) Function
- 5) Cell wall Deficient

## **Definition of cell wall**

**Outermost layer!!!**

**Surrounds the cell membrane**

**Rigid**



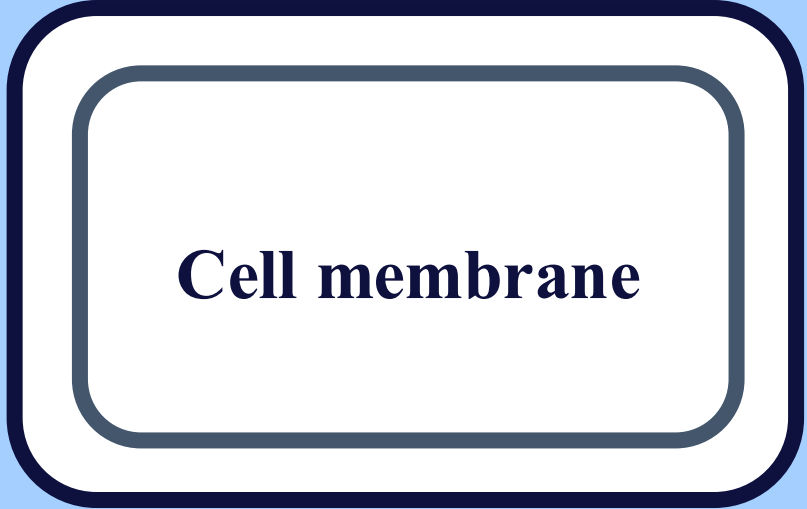
The diagram illustrates the structure of a cell. It features a large, light blue rounded rectangle representing the cell wall. Inside this rectangle is a smaller, white rounded rectangle representing the cell membrane. The text 'Cell membrane' is written in bold, dark blue font inside the white rectangle. The background of the slide is light blue, and there are decorative dashed white lines in the top left corner.

**Cell membrane**



## **Composition of cell wall**

**Rigidity  
(Peptidoglycan)**



**Cell membrane**

# Composition

**N-acetylmuramic acid**

**Glycans**

**NAM**

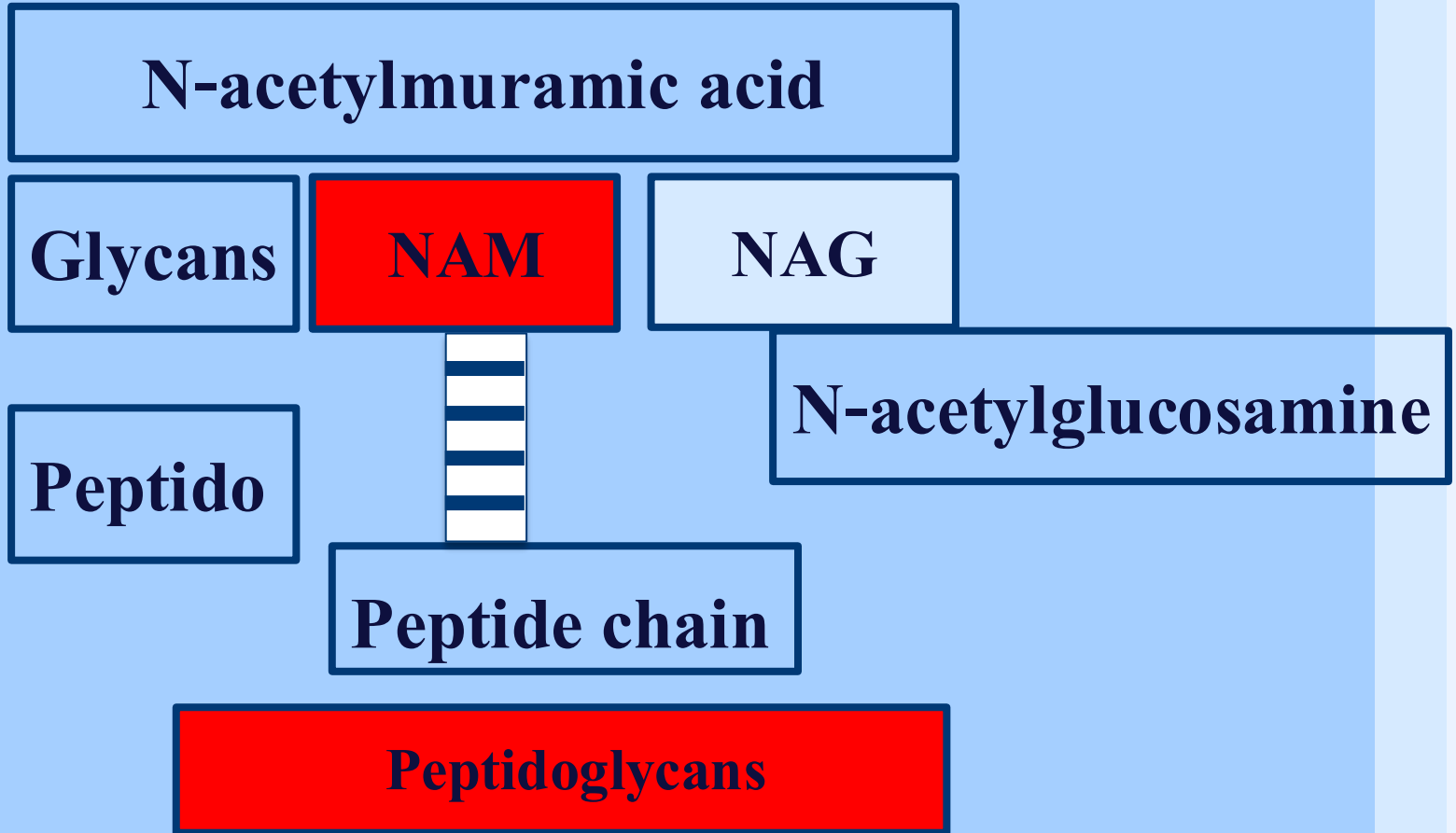
**NAG**

**N-acetylglucosamine**

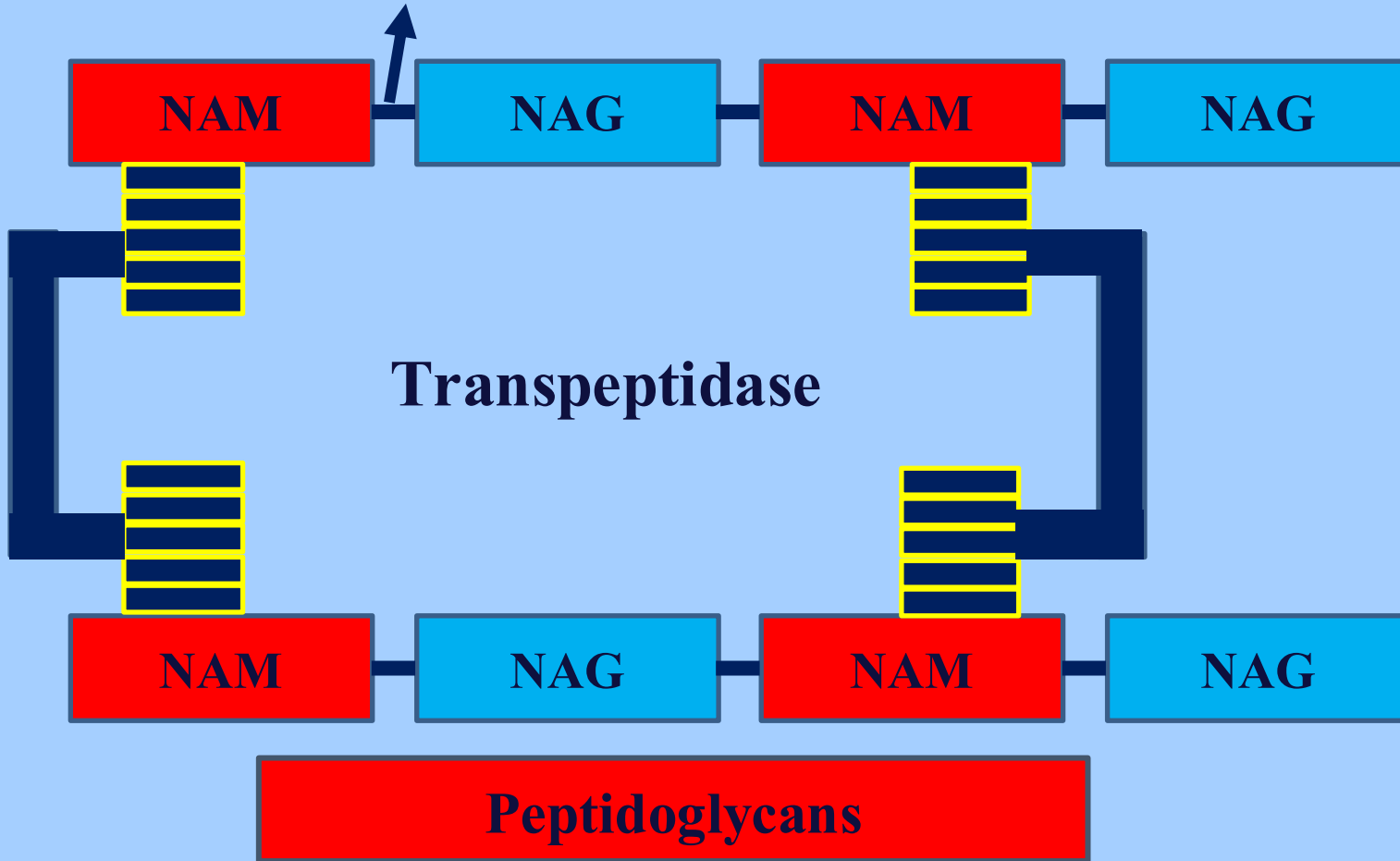
**Peptido**

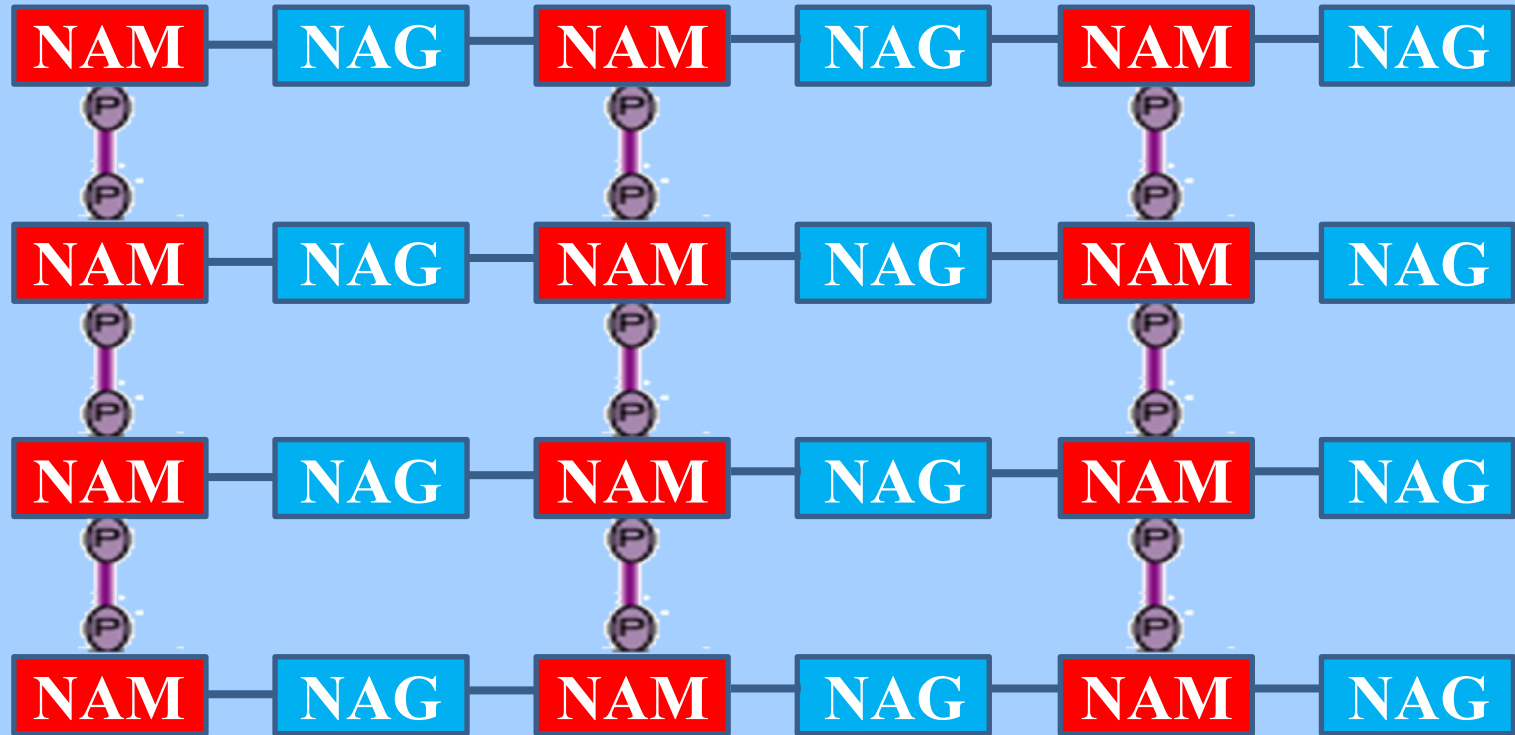
**Peptide chain**

**Peptidoglycans**

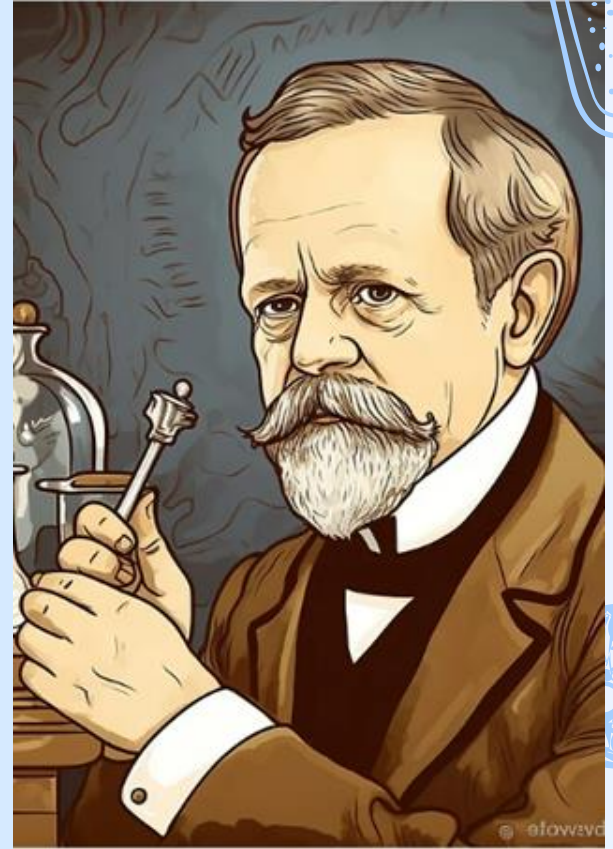
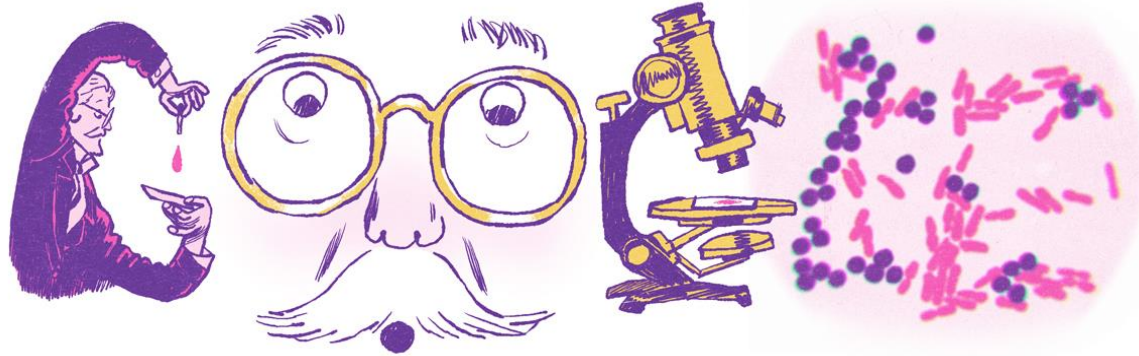


# Glycosidic bond (Transglycosidase) Alternating repeating unit





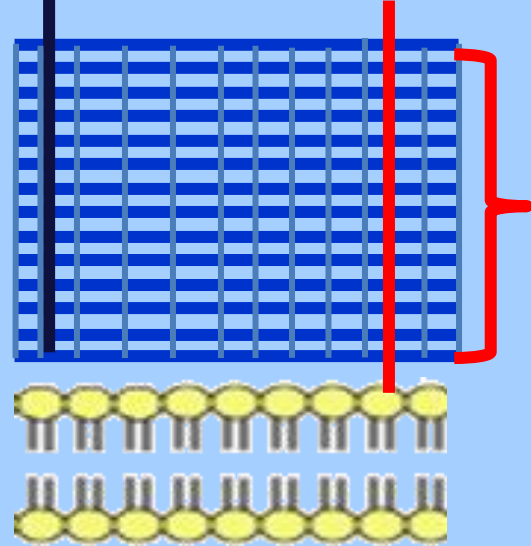
# Gram scientist



# Gram positive/negative bacteria

Teichoic acid

Lipoteichoic acid

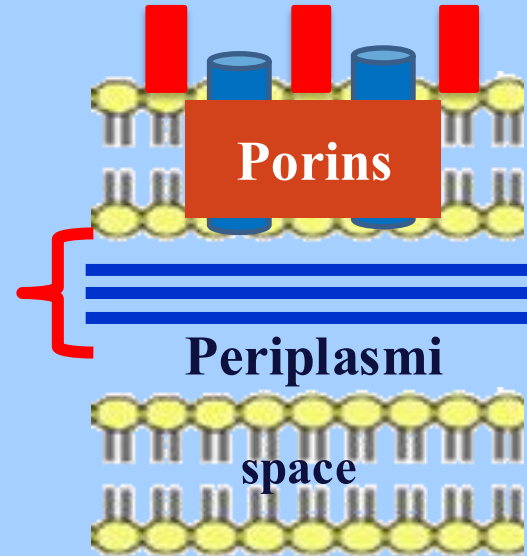


G+ve

Peptidoglycan

Outer membrane

(Lipopolysaccharides)



Porins

Periplasmic

space

G-ve

# Gram positive bacteria

## 1) Peptidoglycan

(50%)

NAM-NAG

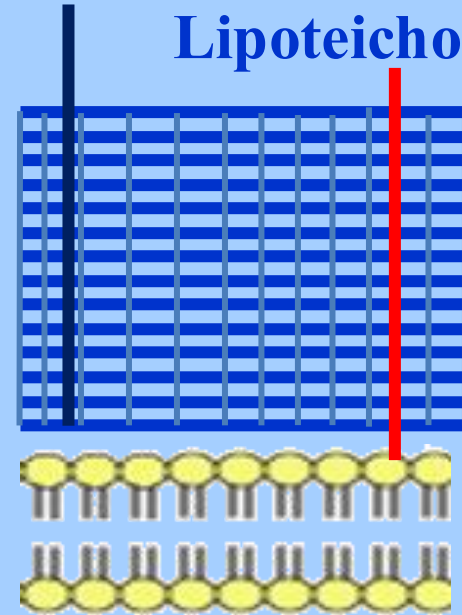


Peptide

Porous

Teichoic acid

Lipoteichoic acid



G+ve

# Composition of Gram positive

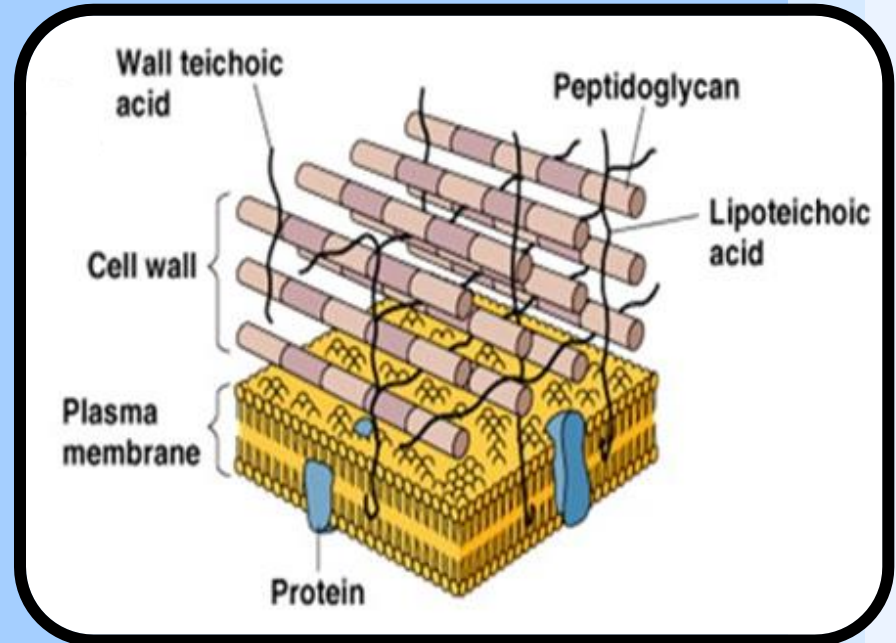
Polymers of glycerol or

Rbitol

Lipoteichoic acid  
(Cell membrane)

Teichoic acid  
(Cell wall)

## 2) Teichoic acid



# Composition of Gram positive

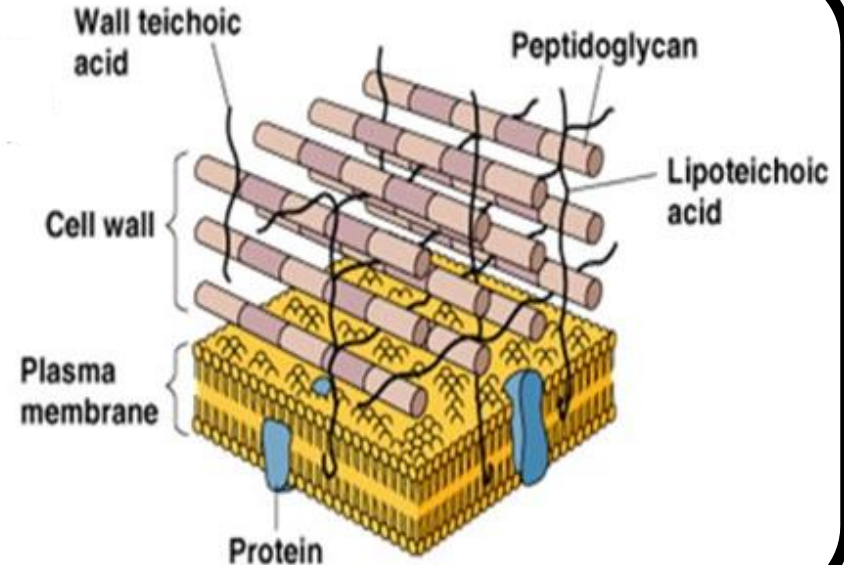
Major surface Ag of G+ve

Highly  
immunogenic

TNF- $\alpha$

IL-1

## 2) Teichoic acid



# Composition of Gram positive

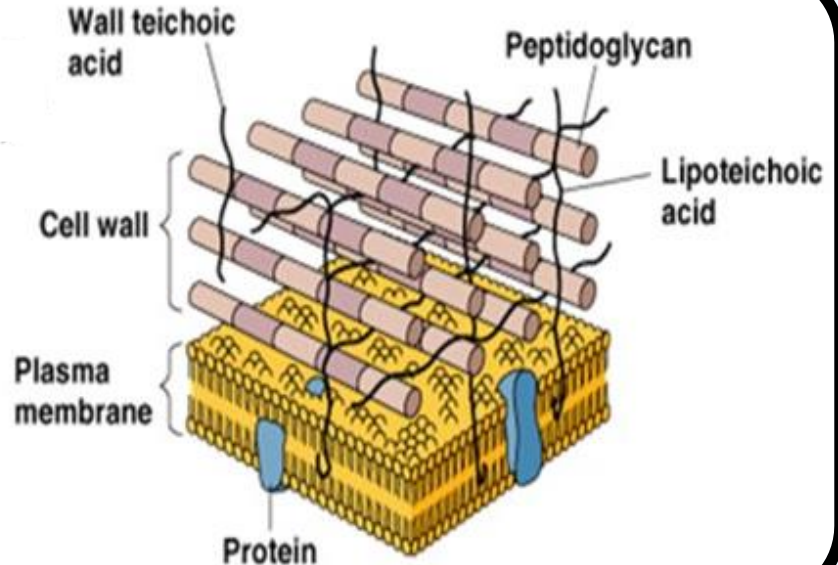
Major surface Ag of G+ve

Highly  
immunogenic

TNF- $\alpha$

IL-1

## 2) Teichoic acid



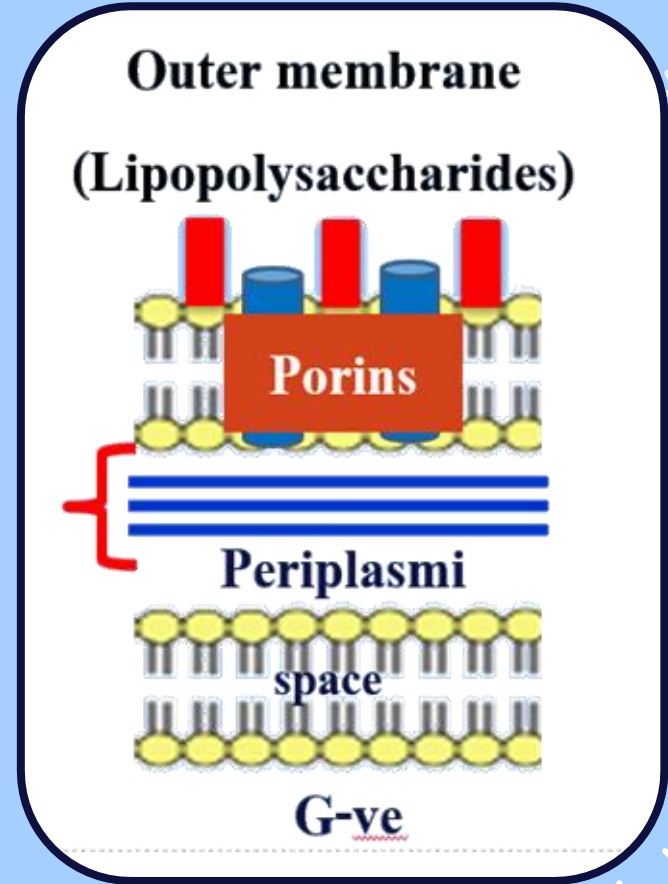
# Composition of Gram Negative

## 1) Peptidoglycan

A thin layer (5%)

2 sheets of  
(NAM & NAG)

Peptides



# Outer membrane

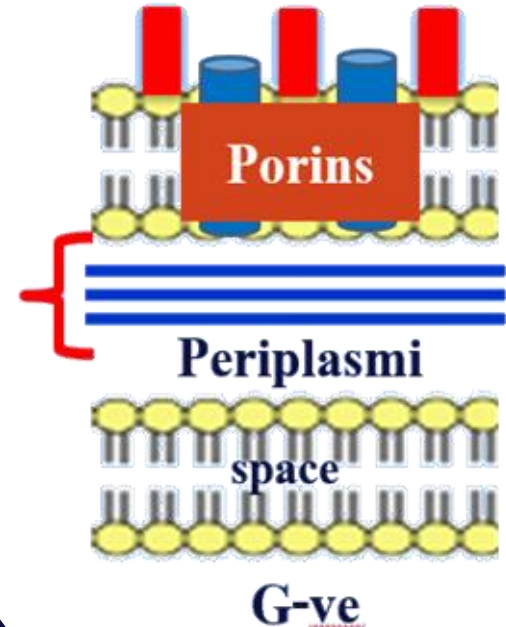
A) Bilayer phospholipids

B) Lipopolysaccharides

Lipid A  
(Endotoxin)

Polysaccharides  
(somatic O Ag)

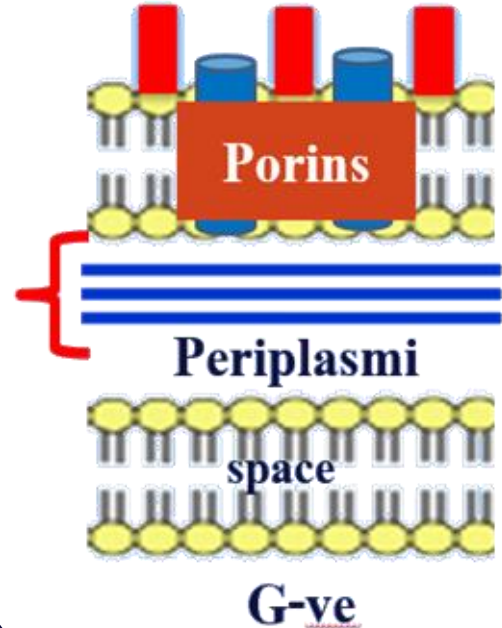
Outer membrane  
(Lipopolysaccharides)



## Outer membrane

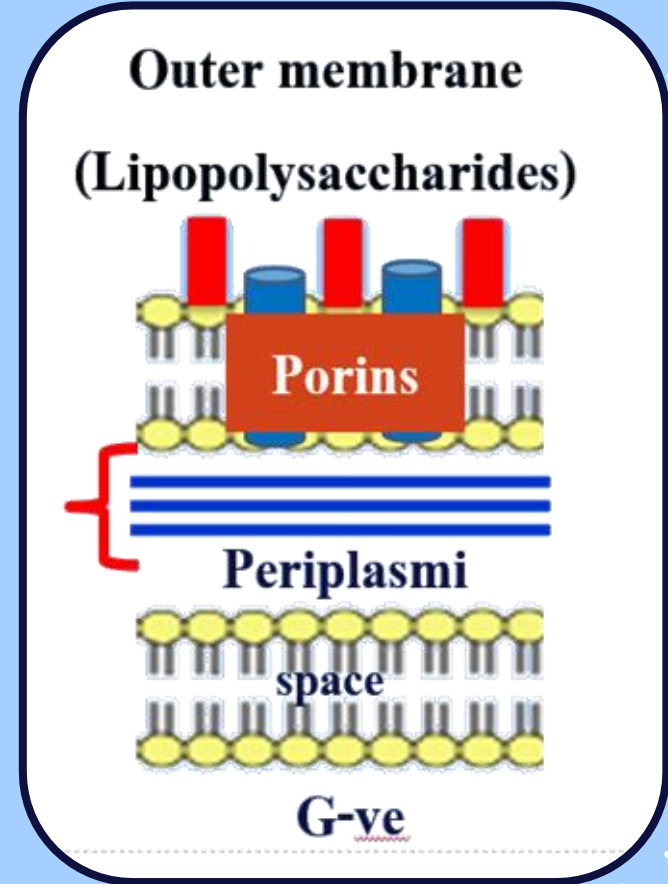
**C) Porins**  
**(hydrophilic Protein)**  
**in the outer membrane**  
**( Transportation)**

**Outer membrane**  
**(Lipopolysaccharides)**

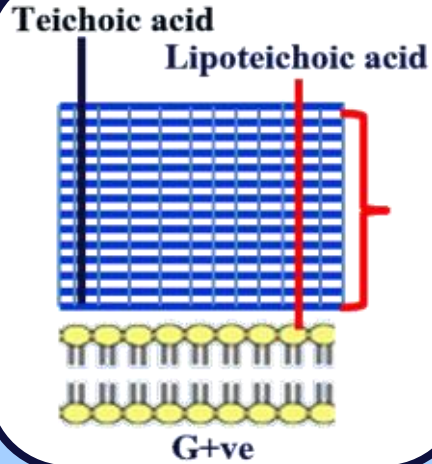


# Periplasmic space

Space between cytoplasmic &  
outer membrane  
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

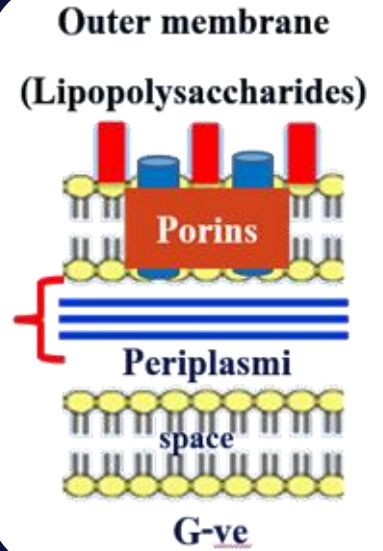
## 2) Teichoic acid/

## Lipoteichoic acid

No

## 3) Outer membrane

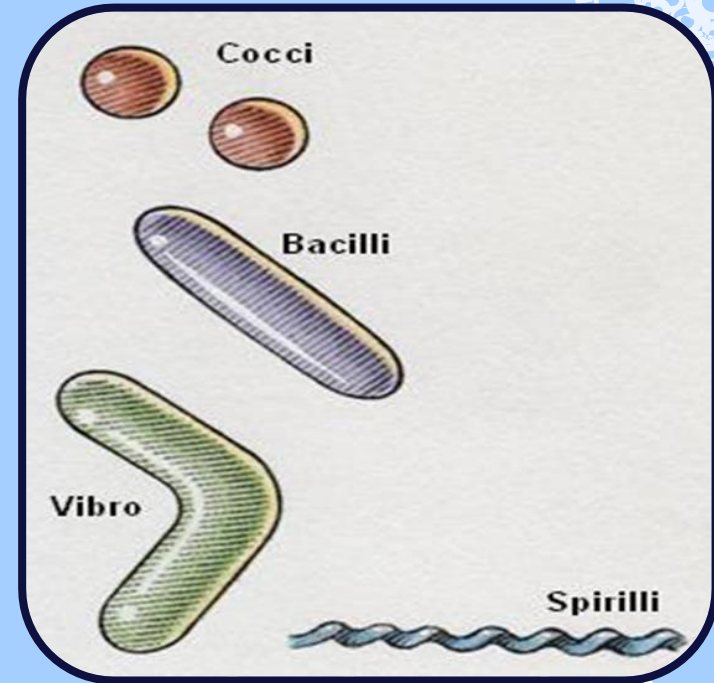
Yes



## Function of cell wall

1

**Maintenance of the  
shape (Rigid)**

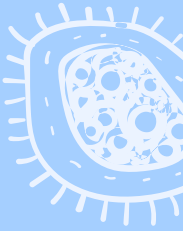


## Function of cell wall

1

**Deficient of cell wall**

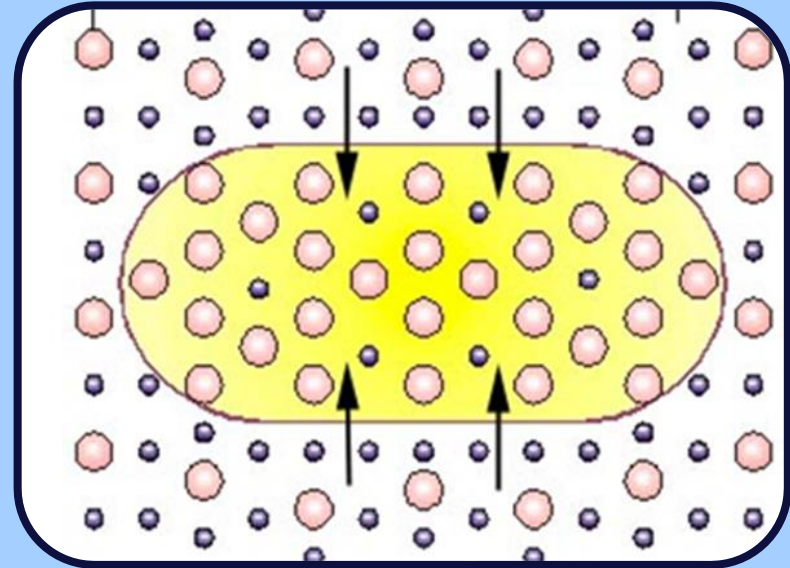
**Polymorphic**



# Function of cell wall

2

**Protection**  
(Osmosis insensitive)



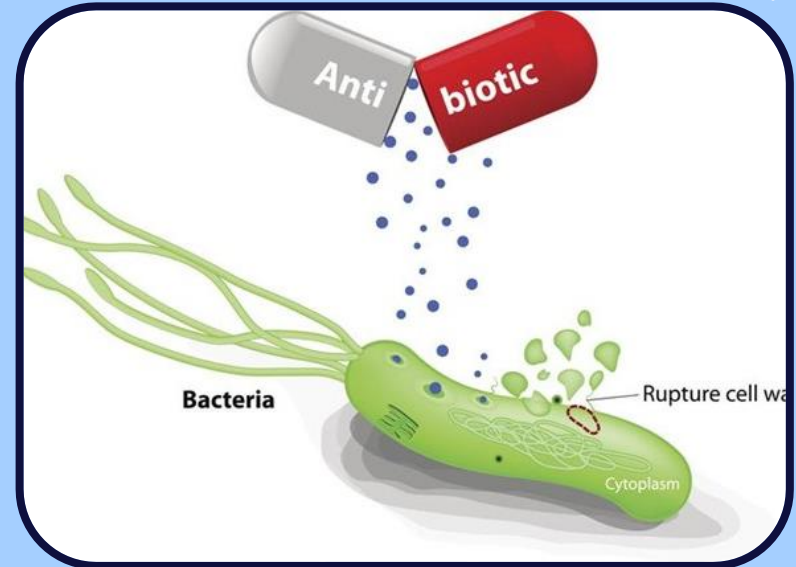
# Function of cell wall

3

Target site for antibiotics

Penicillin

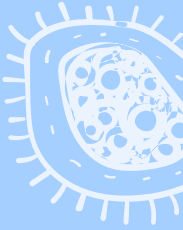
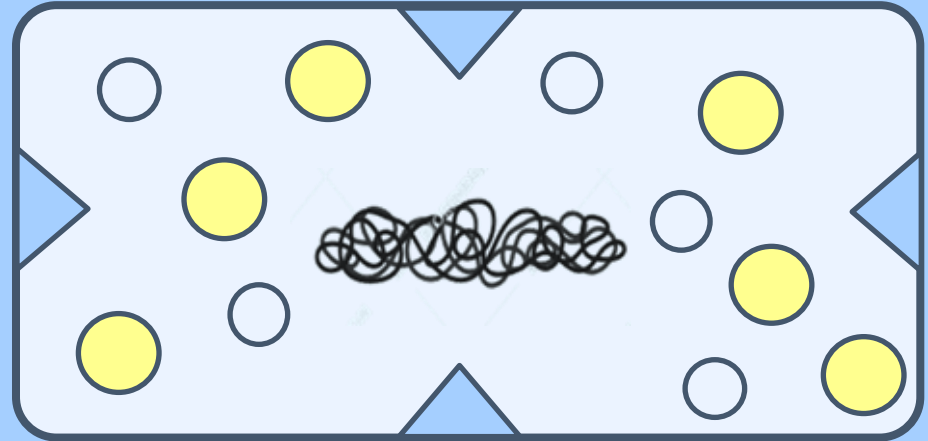
Cephalosporines



# Function of cell wall

4

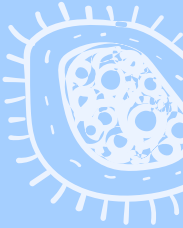
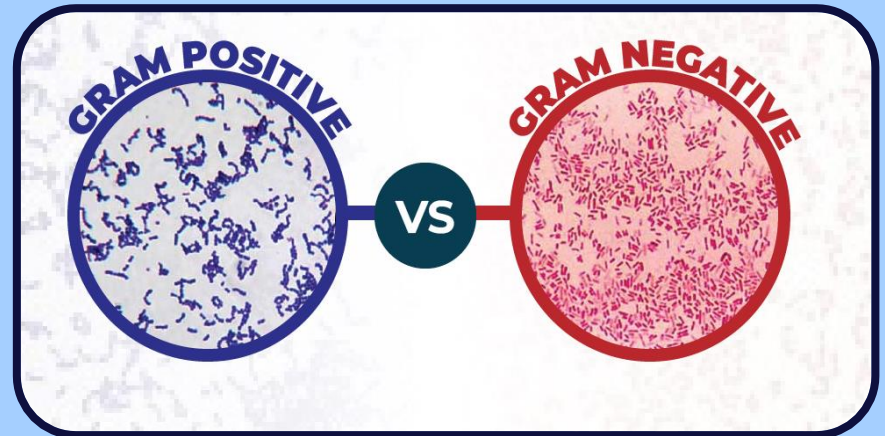
Role in cell division



## Function of cell wall

5

Responsible  
for staining



# Function of cell wall

## Responsible for staining

G+ve



Fixation



G-ve



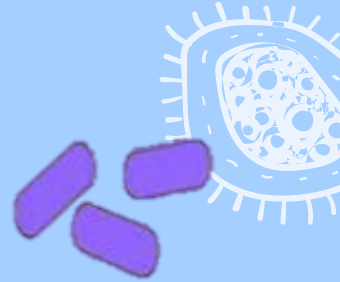
Crystal  
violet



Iodine



Acetone

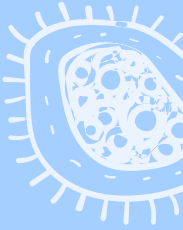
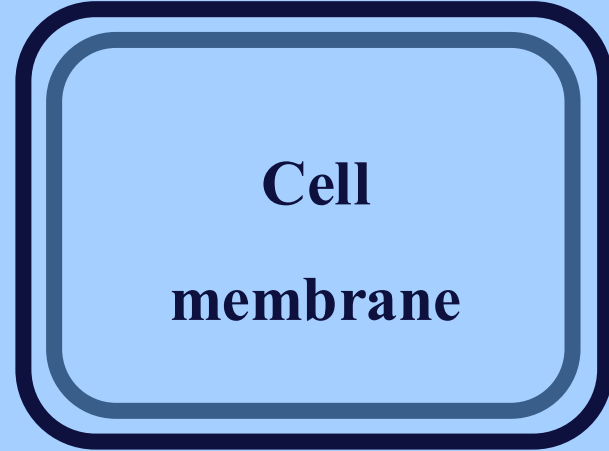


Counter  
stain



## Cell wall Deficient

**Bacteria without cell  
wall**



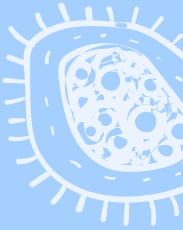
# Cell wall Deficient

**1) Naturally**

**Mycoplasma  
(Sterol)**

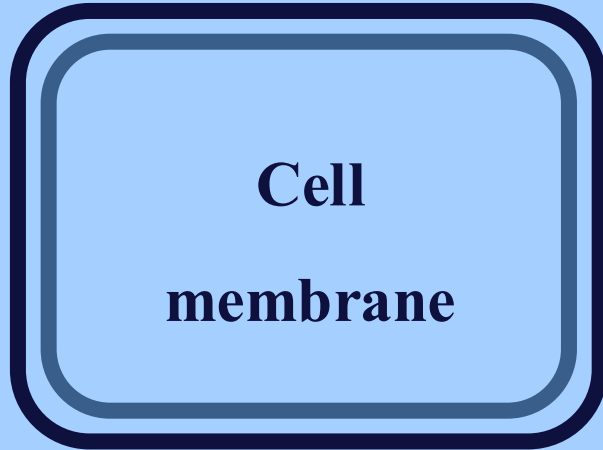
**2) Induced**

**Cell wall inhibitors  
Lysozyme**



## 2) Induced

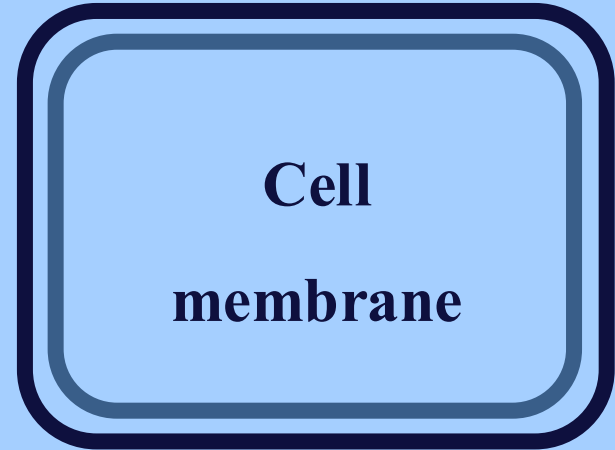
**Completely**



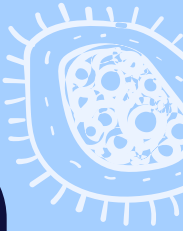
**Protoplast (+ve)**

**Spheroplast (-ve)**

**Partially**

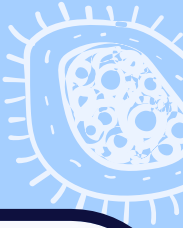


**L-form bacteria**



# **L-form & Mycoplasma**

**Resist to Penicillin &  
Cephalosporines**



# Objectives

## Structures outside the cell wall

1) Capsule

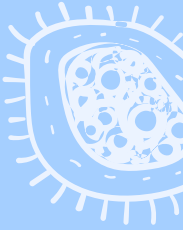
2) Flagella

3) Pili

4) Spore formation

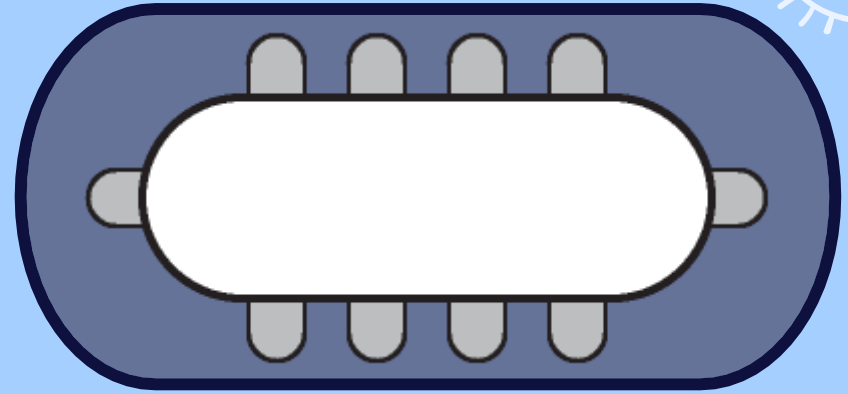
## Capsule - Definition

**Glyco**      **calyx**  
↓                    ↓  
**carbohydrate**    **enveloped**



## Capsule - Definition

**Gelatinous (Viscous) layer  
covering cell wall of some  
bacteria**

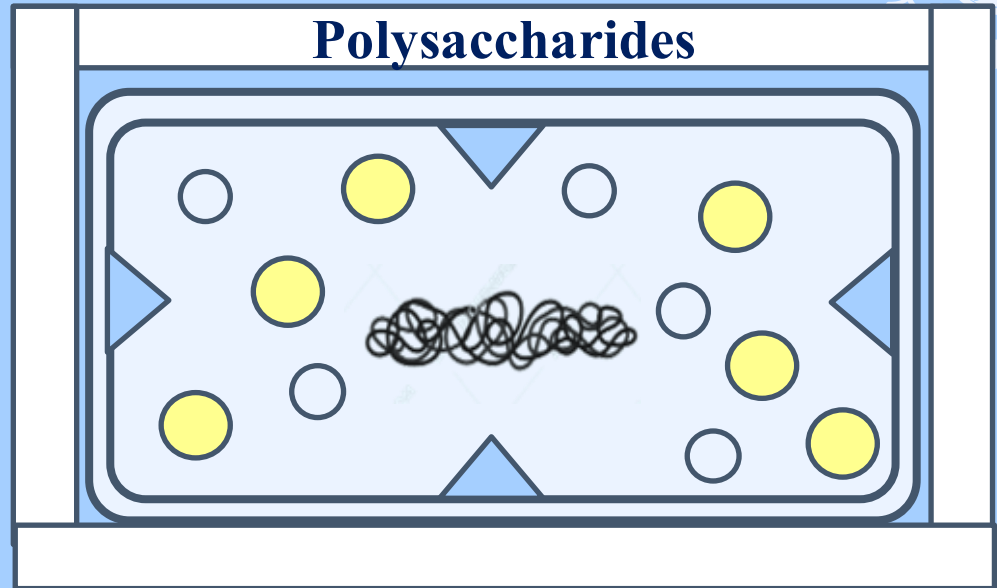


**Extra layer**

# Capsule - Composition

Usually Polysaccharides

Polypeptides  
(*B. anthracis*)



## Capsule - Composition

**Variation of Capsule**

**(Arrangement of  
Polysaccharides)**

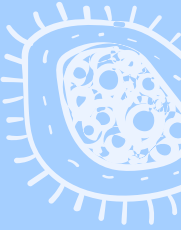
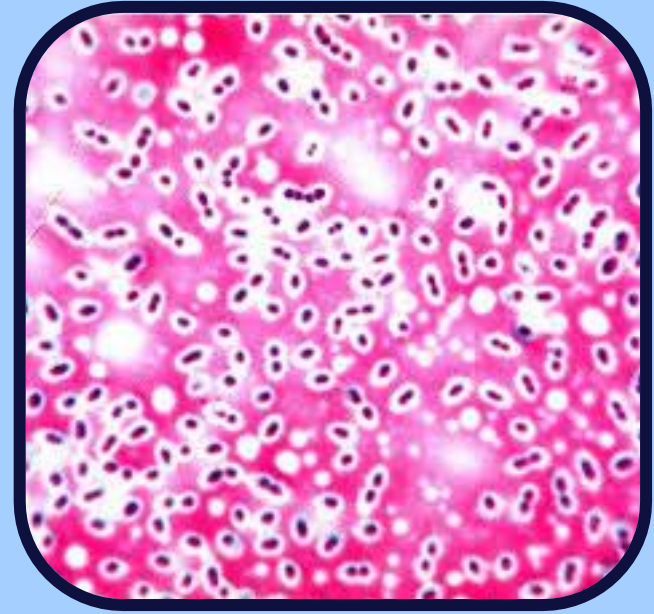
|                |                |                |
|----------------|----------------|----------------|
| <b>Sucrose</b> | <b>Mannose</b> | <b>Lactose</b> |
| <b>Mannose</b> | <b>Sucrose</b> | <b>Mannose</b> |
| <b>Lactose</b> | <b>Sucrose</b> | <b>Mannose</b> |

e.g. 91 types of

*Str. pneumoniae*

## Capsule - Composition

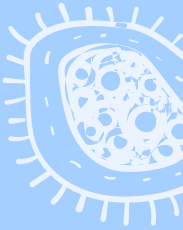
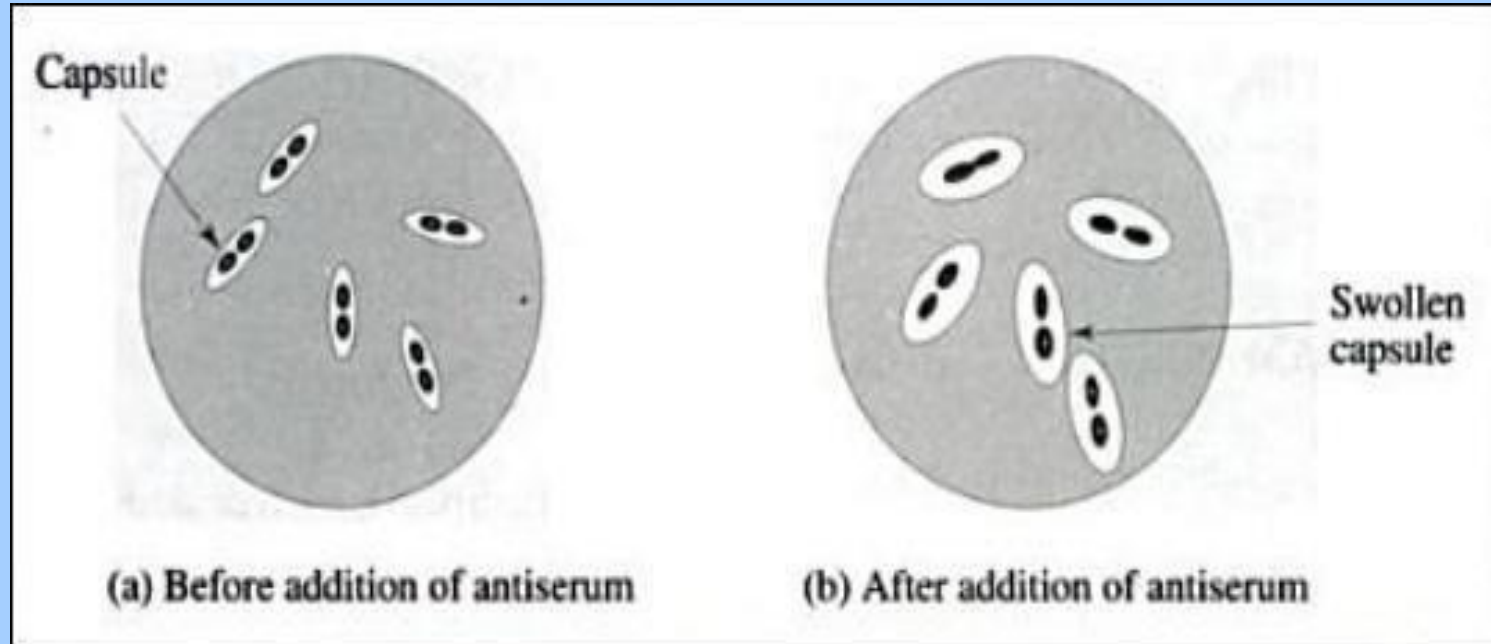
**Do Not stained by  
Gram stain**



**Unstained halo around the  
organism**

# Capsule - Composition

## Quellung reaction (swelling)



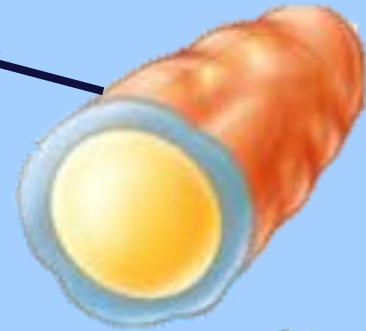
# Capsule - Composition

**Capsule**

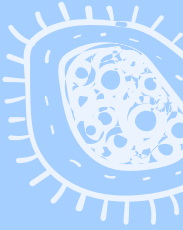
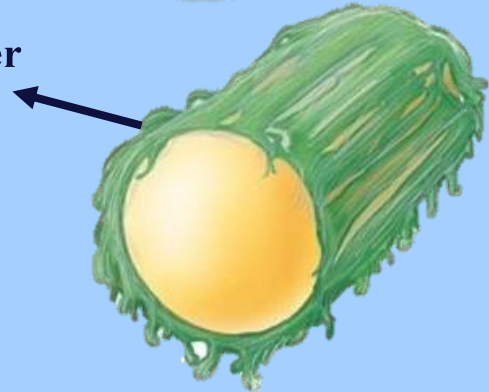
**Glycocalyx**

**Slime layer**

Capsule



Slime layer

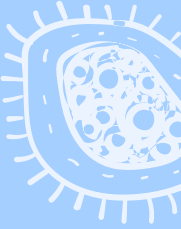


# Capsule - Composition

## Capsule

**Tightly, organized bound  
around all cell wall**

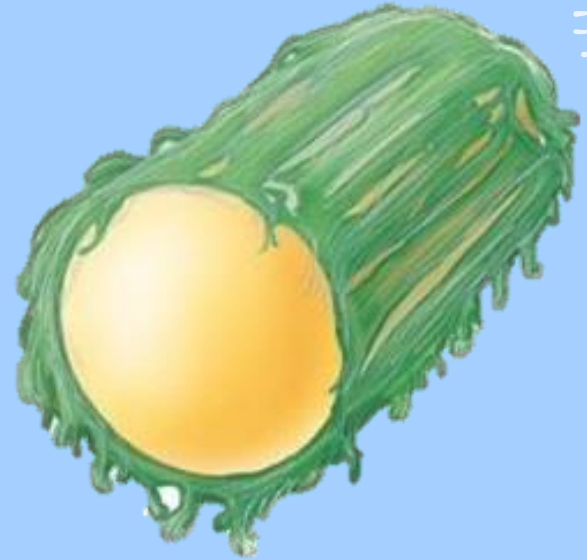
**Firmly adherence to  
surface organism**



## Capsule - Composition

**Glycocalyx**  
**(Slime layer)**

**Loosely & unorganized attached**



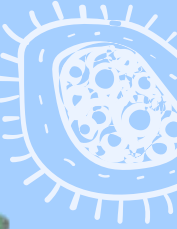
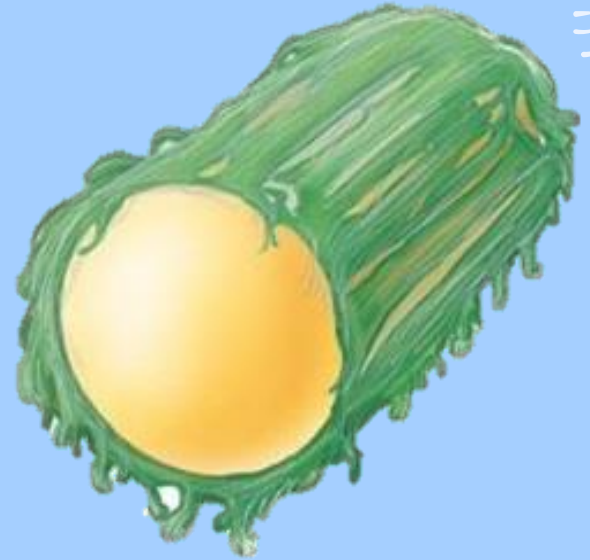
# Capsule - Composition

## Glycocalyx

Fibrils extending

It adhere firmly to skin, heart, etc

e.g. *Strept. mutans*



Loosely & unorganized attached

# Capsule - Function

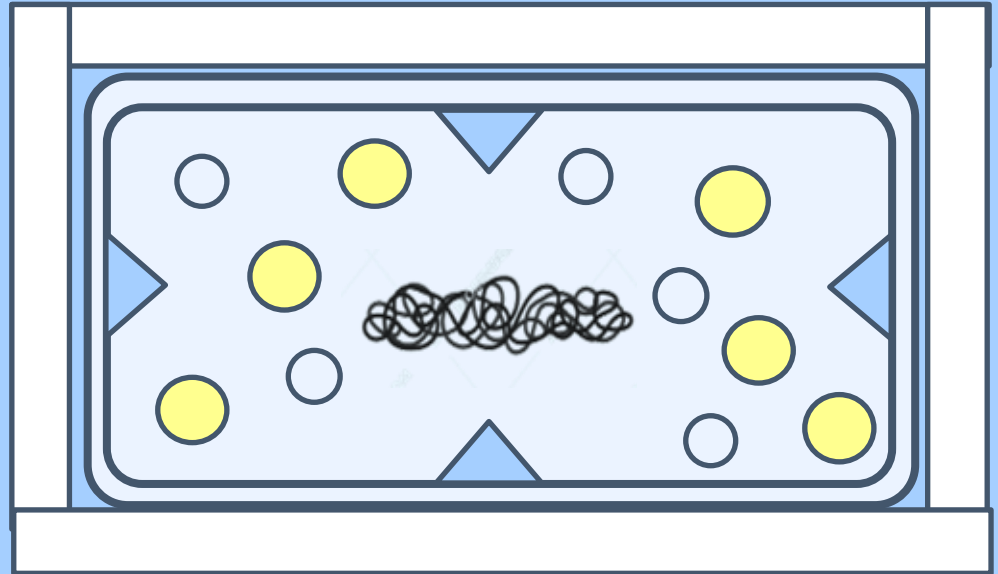
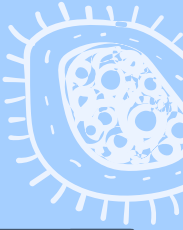
A

Protect Cell wall

Bacteriophage

Complement

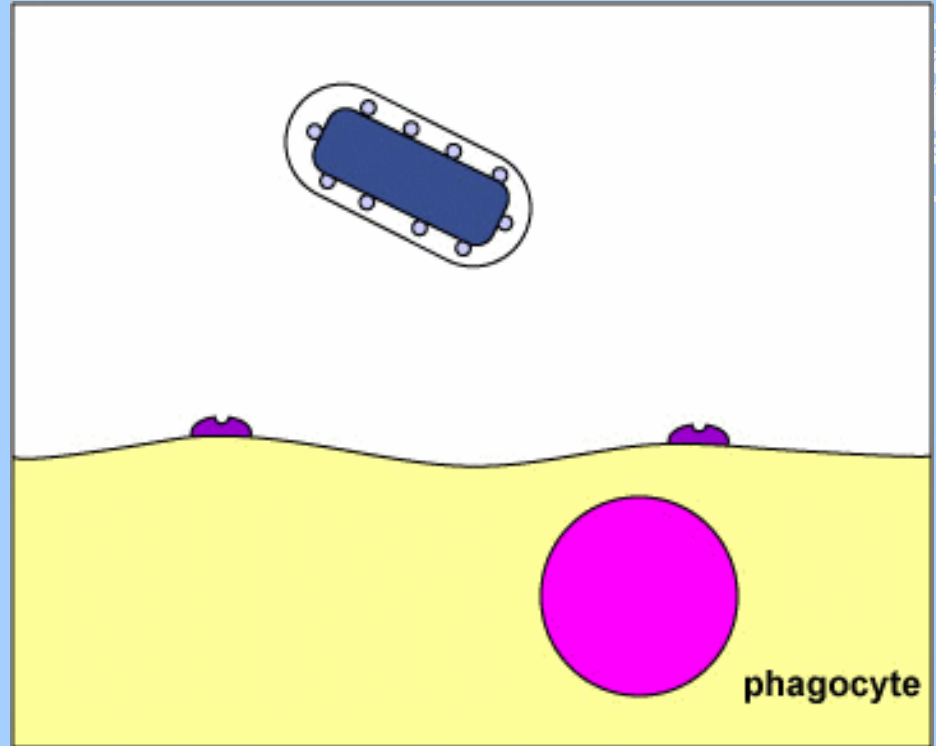
lysozyme



## Capsule - Function

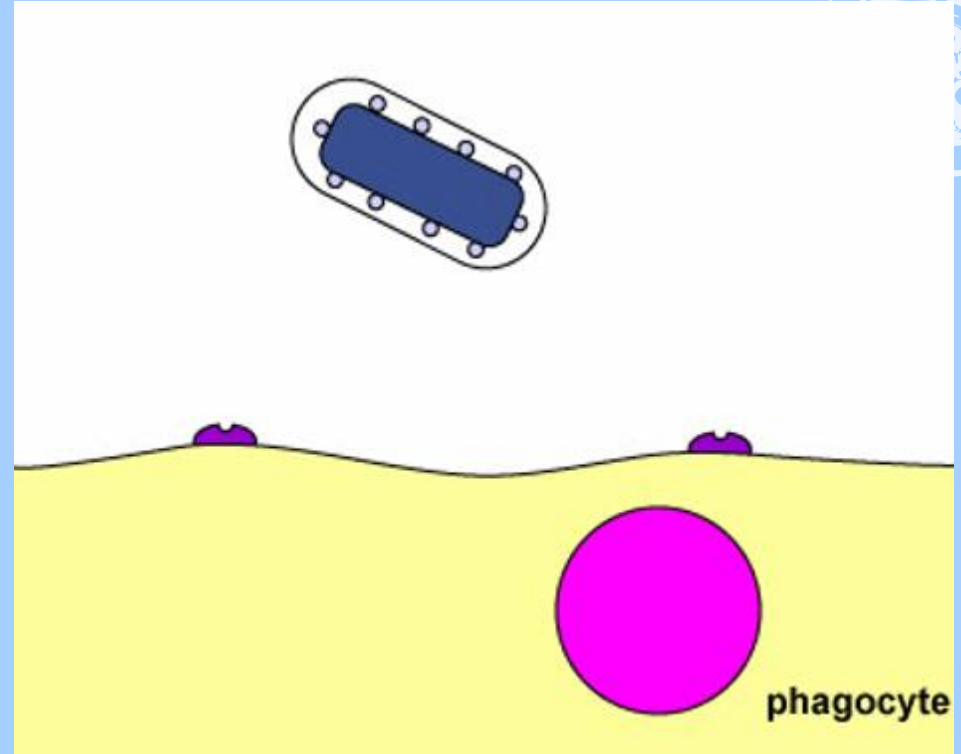
**B**

**Prevent phagocytosis  
(Virulence)**



## Capsule - Function

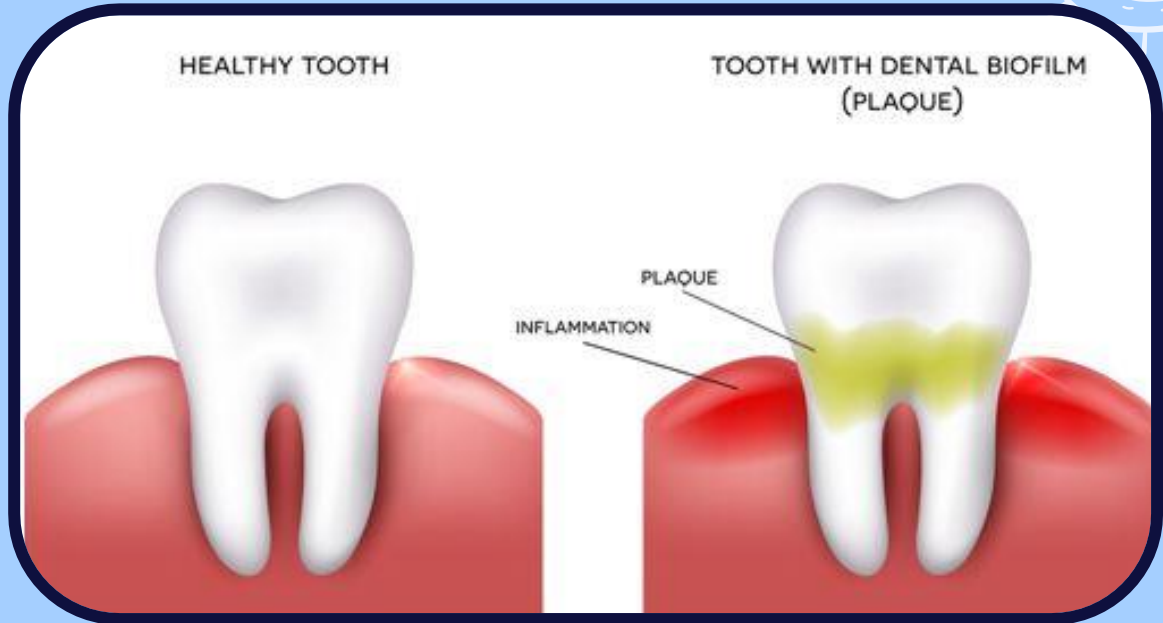
**Capsules are formed  
in VIVO ONLY**



# Capsule - Function



**Attachment**  
**(Glycocalyx)**  
**Dental caries**



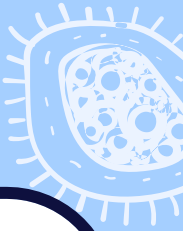
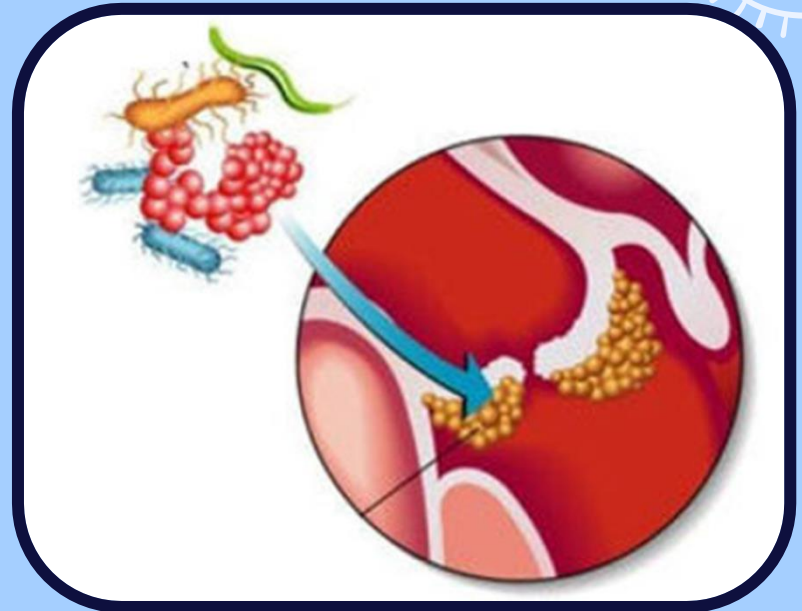
# Capsule - Function



**Attachment  
(Glycocalyx)**



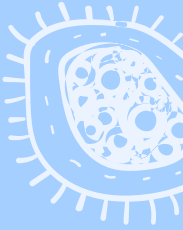
**Prosthetic heart  
valves**



# Capsule - Function

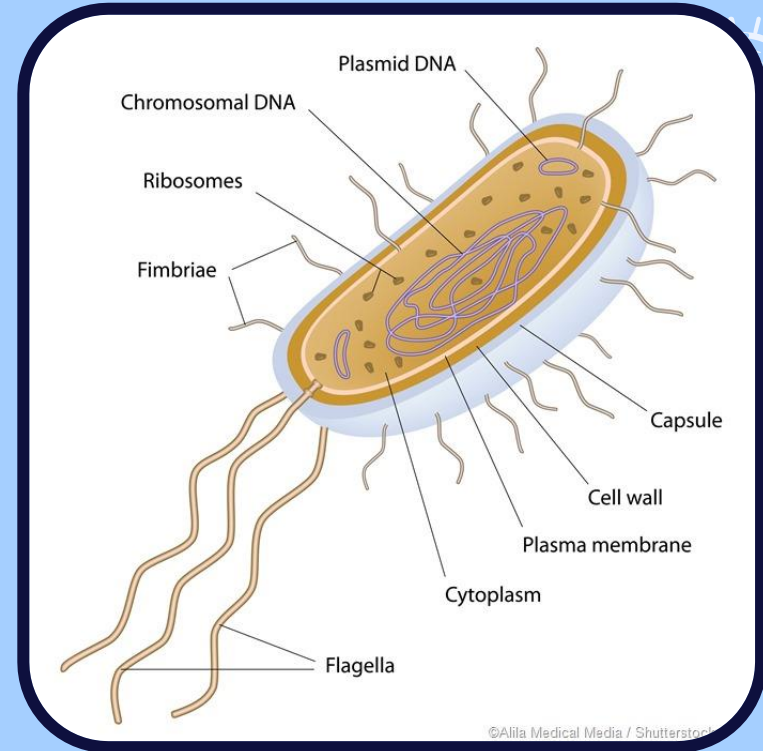
D

## Development of vaccine



# Flagella - Definition

**Long thick threads like (filamentous),  
formed from protein (flagellin)  
(H Ag)**



# Flagella - Definition

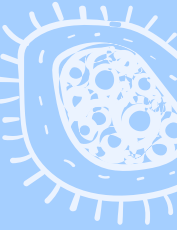
**Seen by EM**  
**(20nm)**



# Flagella - Definition

## Polar

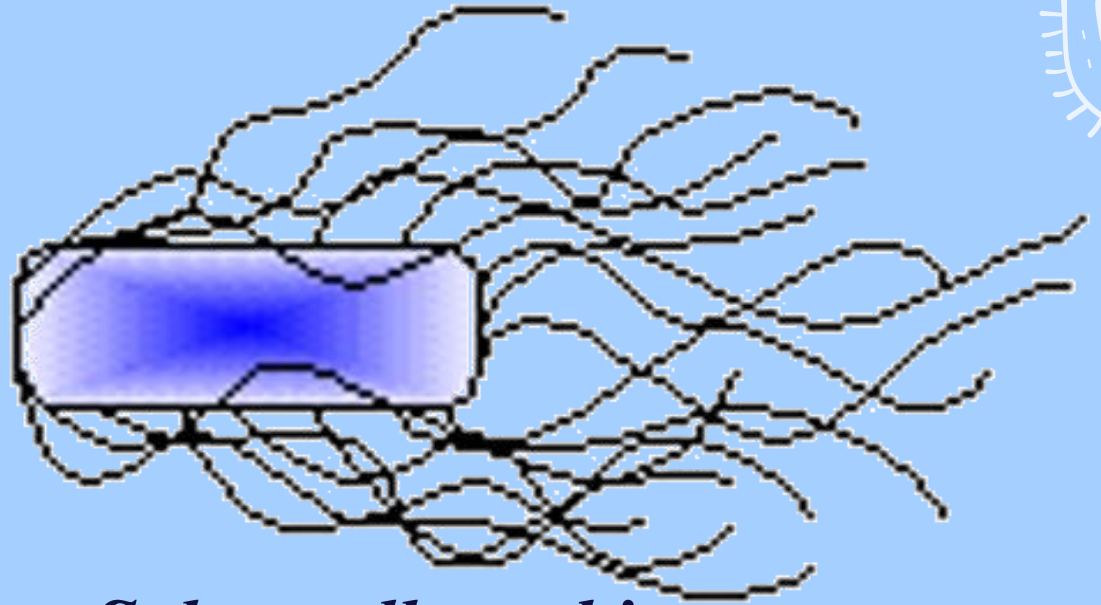
## Spiral



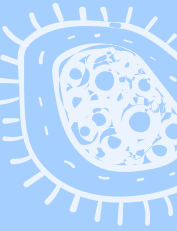
## Flagella - Definition

**Peri/trichous**

**around**  
peritrichous

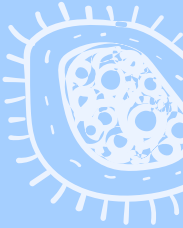
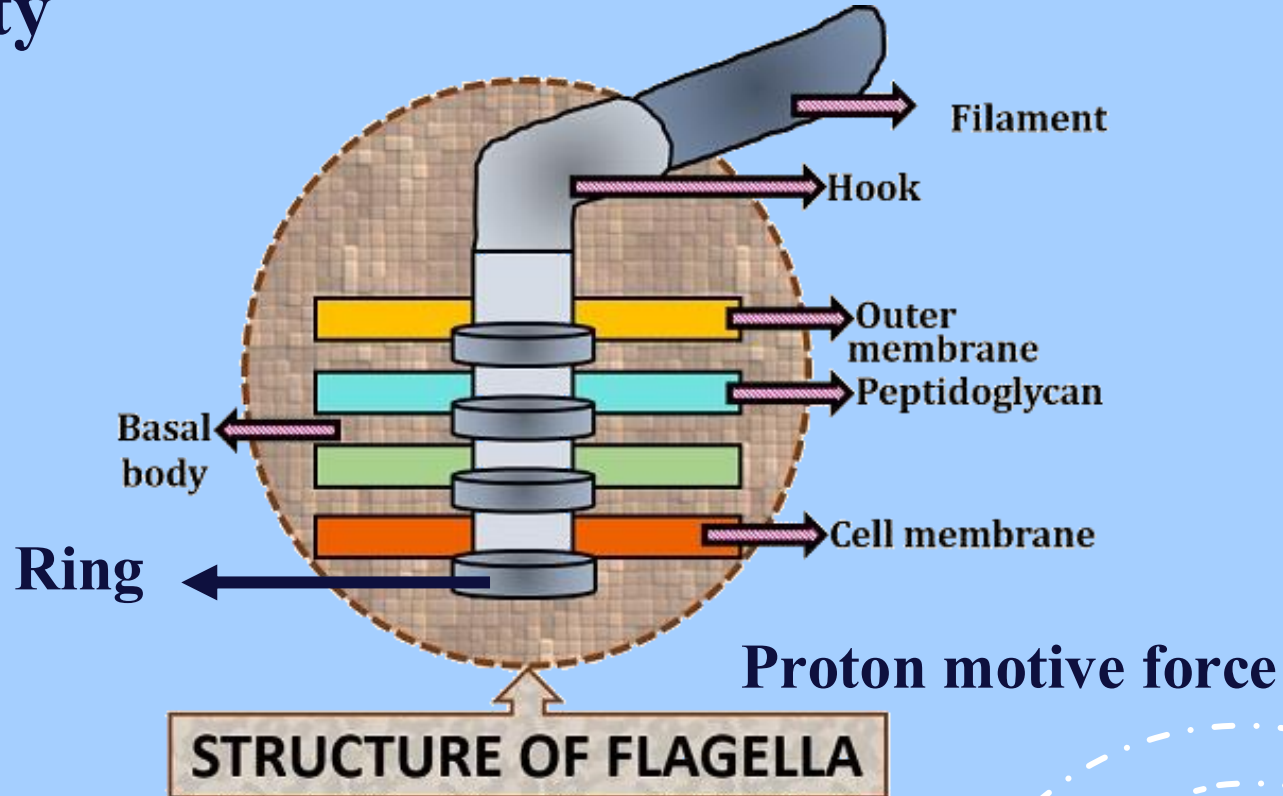


*Salmonella typhi*



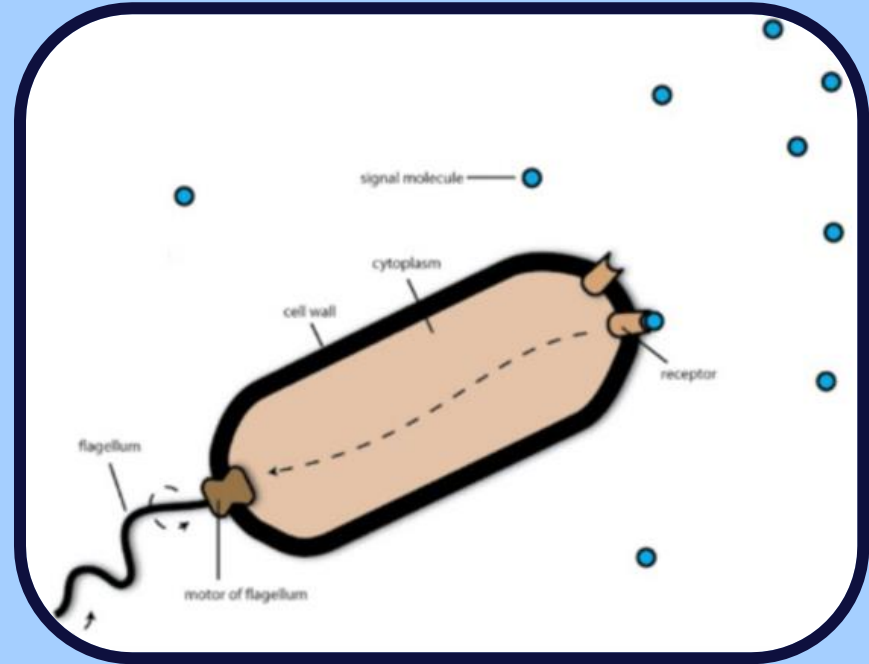
# Flagella - Function

## Motility



# Flagella - Function

The organs of  
motility

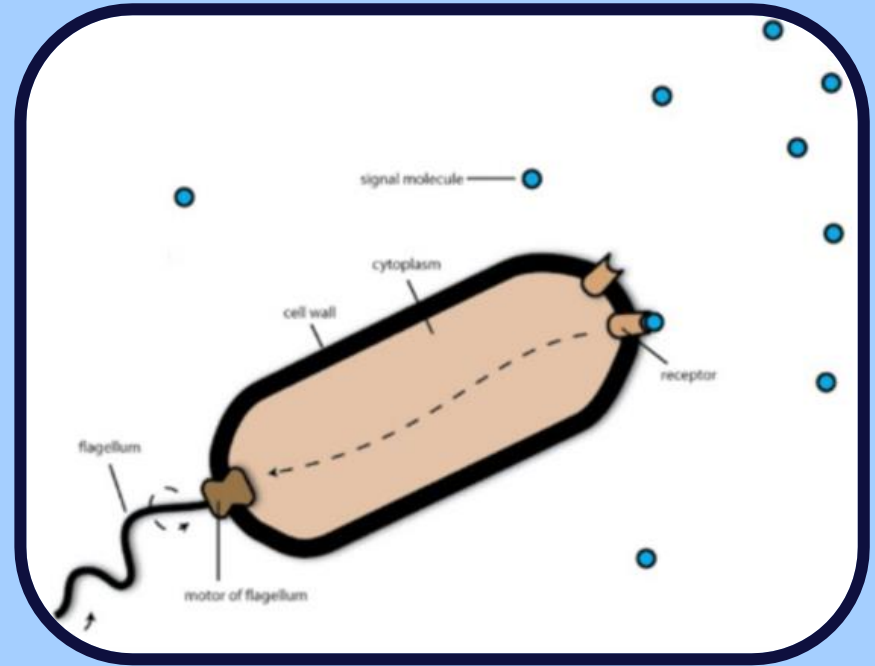


# Flagella - Function

**Tactic response (Taxis)**

**(Stimulus)**

**( movement of bacteria to  
toward (+ve) or away (-ve)  
from stimulating agent)**



# Flagella - Function

Tactic response (Taxis)

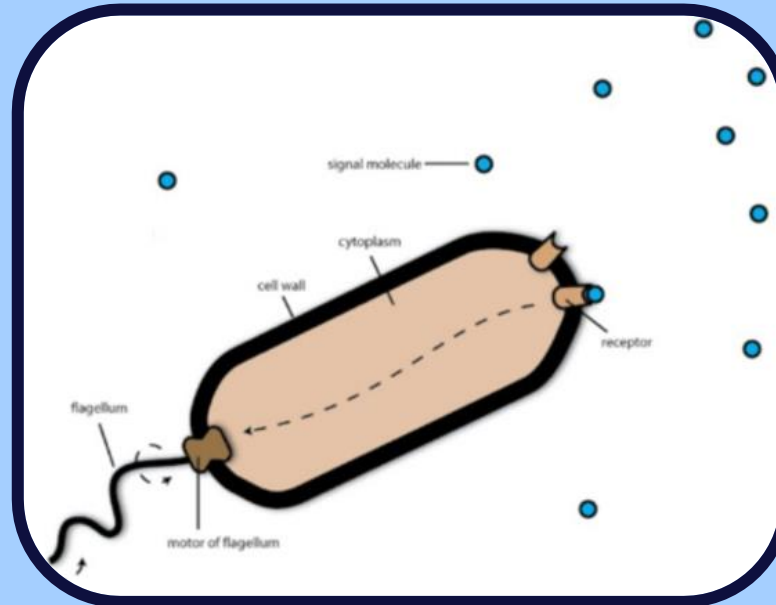
*Stimulating agent*

ChemoTaxis

Light

PhotoTaxis

Chemical



## Axial Filaments

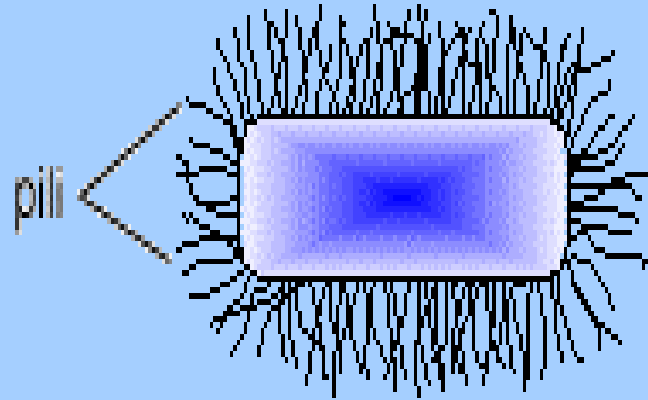
**Endoflagella**  
**In spirochetes**



## Pili (Fimbriae)

**Short and thin**

**Hair like formed from  
protein  
(Pilin)**



# Pili

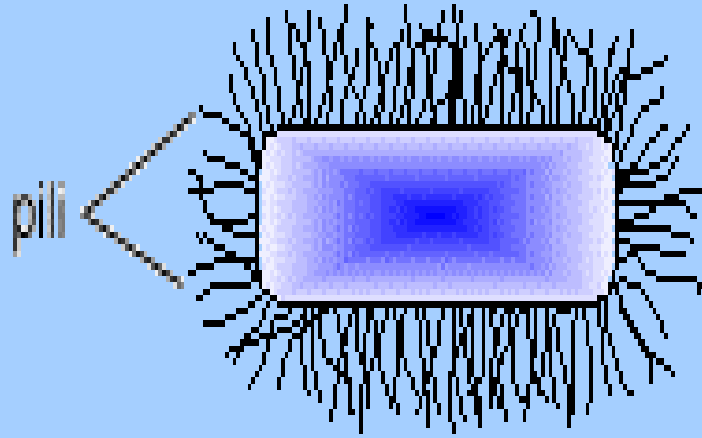
Seen by EM



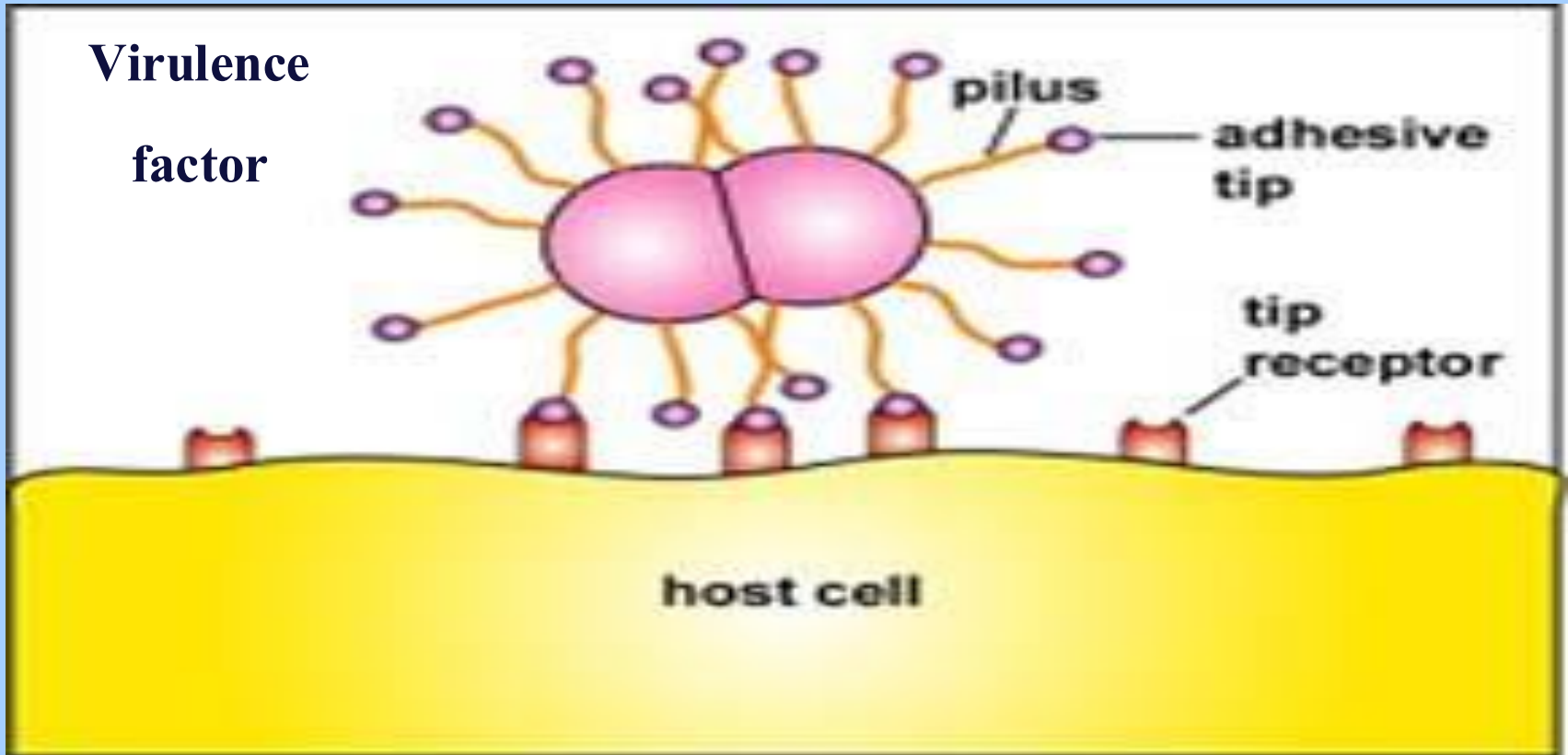
# Pili

**A) Ordinary pili**  
**(Attachment)**

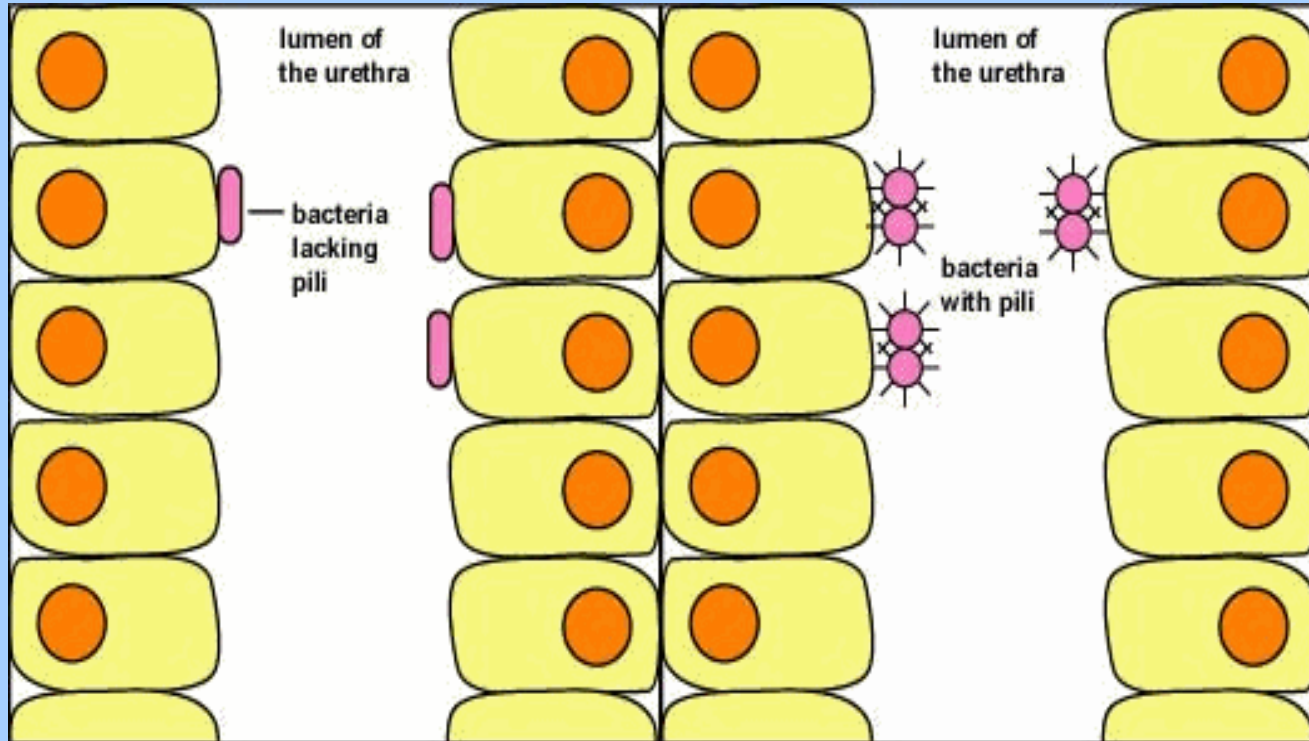
**B) Sex pili**  
**(Genetic transfer)**



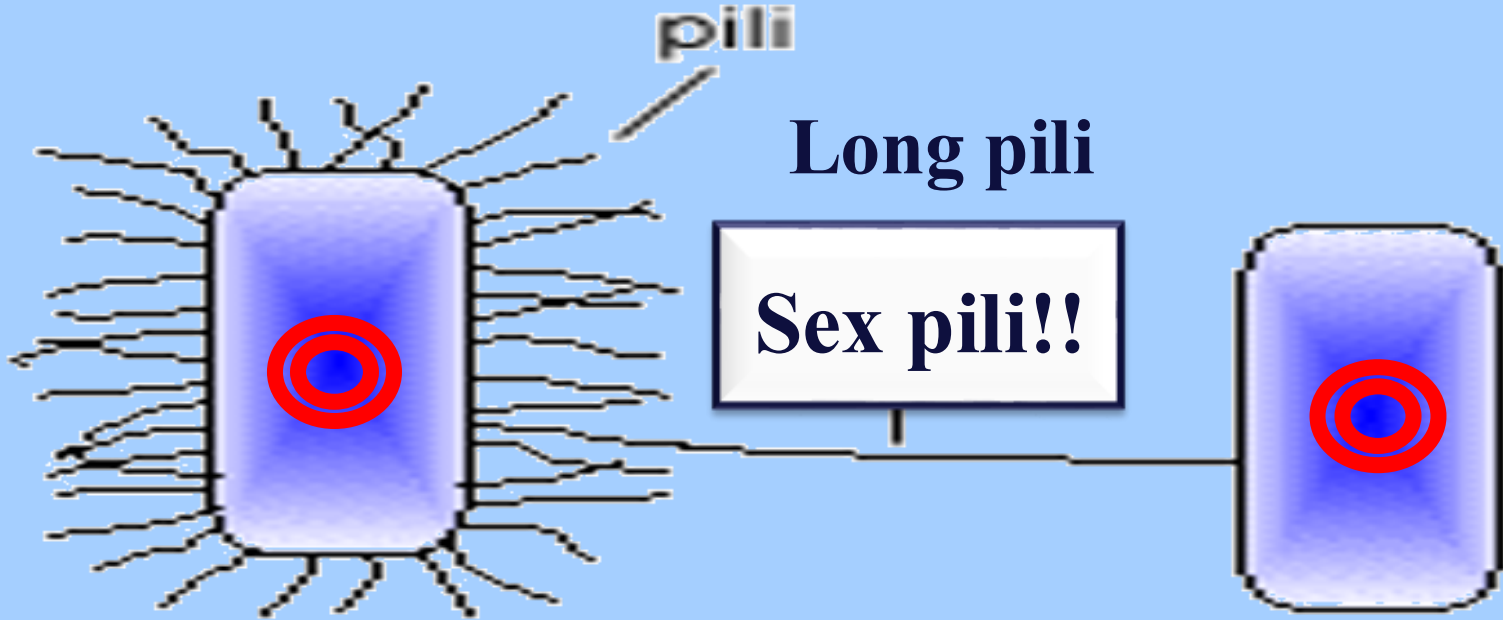
# Ordinary Pili



# Ordinary Pili



# Sex Pili



**F+**

**Donor**

**Conjugation**

**F-**

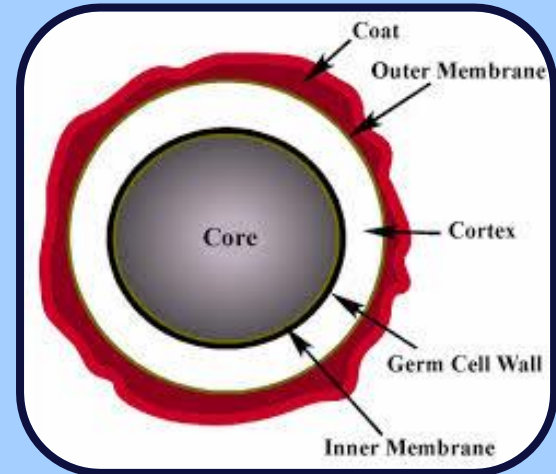
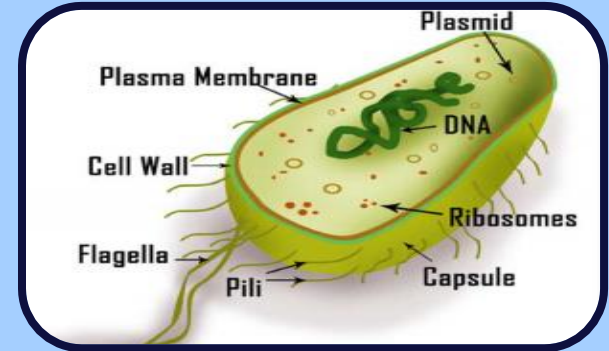
**Recipient**

# Spore formation

**Vegetative bacteria**

**Unsuitable condition**

**Spore formation  
(Outside)**

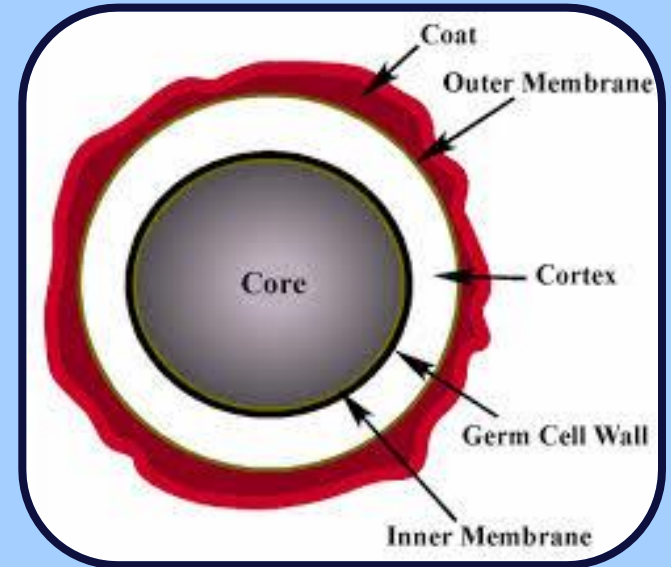


# Spore formation

Forming highly resistant resting  
phase (Endospores) in VITRO

*Bacillus*

*Clostridium*



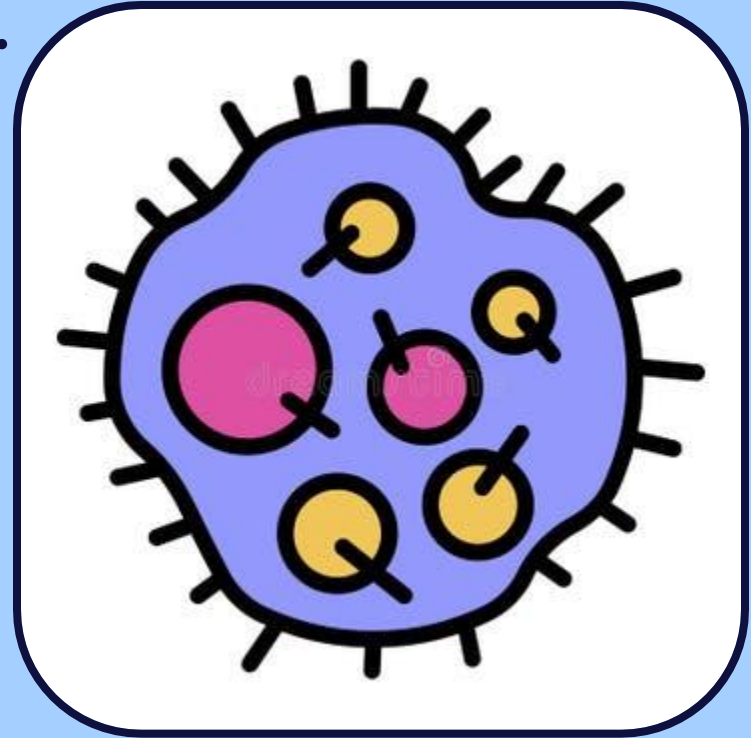
# Spore formation

Occur to unfavorable conditions e.g.

High temp.

Drying

Depletion of  
nutrition



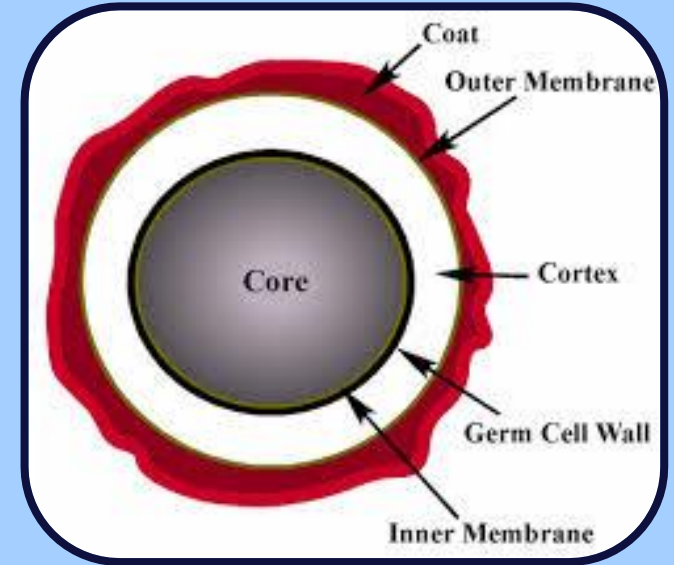
## **Spore formation**

**Formed outside the body (in VITRO)**

**Can not stained by ordinary stain**

# Spore formation

**Highly resistant to dryness,  
heat & Disinfectant**



**Spore formation**

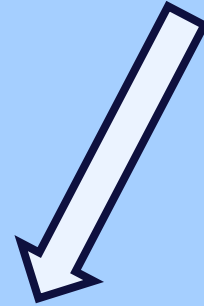
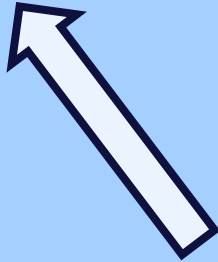
**Vegetative**



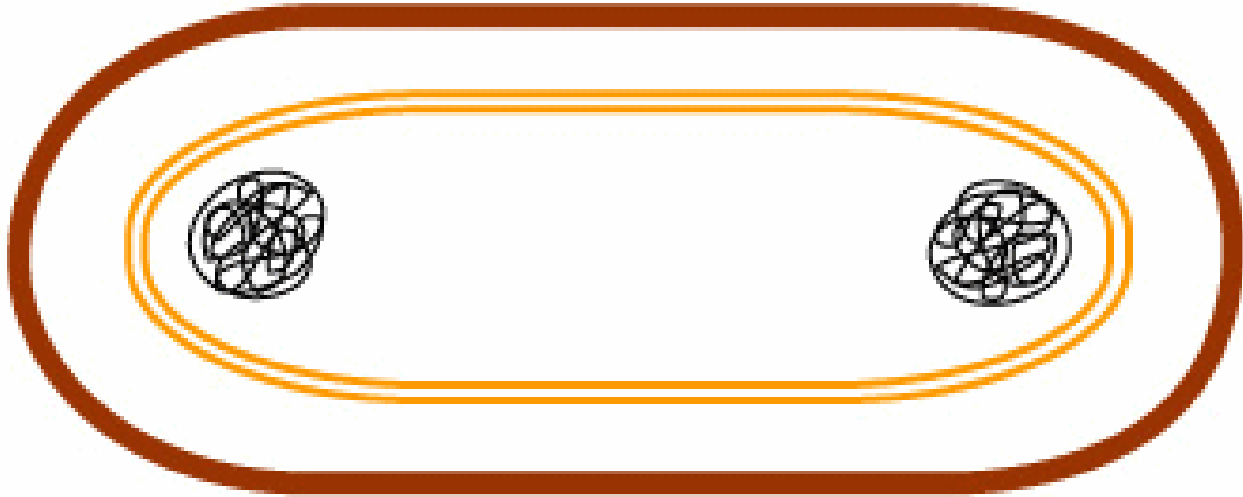
**Sporulation**

*Bacillus & Clostridium*

**Germination**



# Spore formation



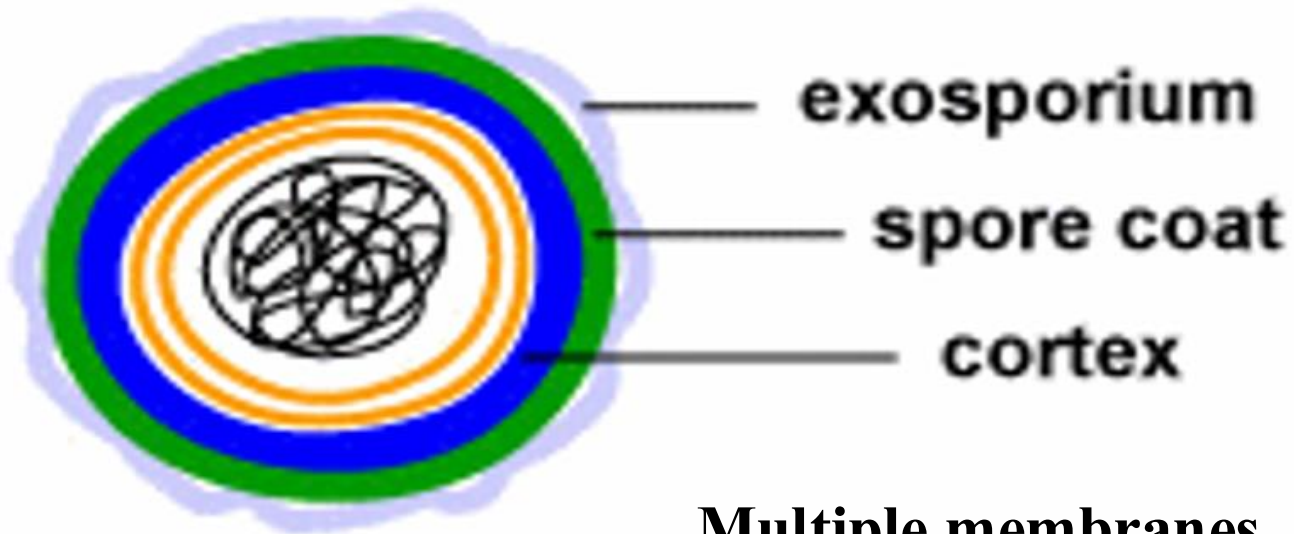
**Ca<sup>2+</sup> &**

**Dipicolonic acid**

**Multiple membranes**

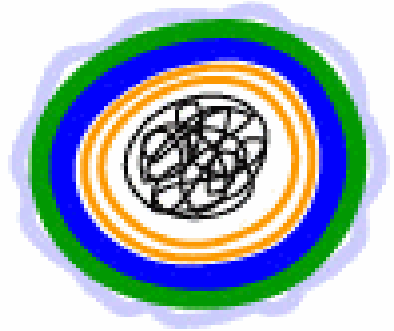
## Spore formation

**endospore**

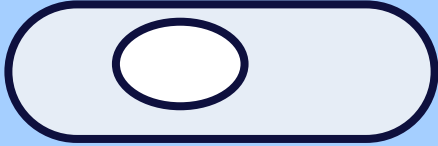


**Multiple membranes**

# Germination



## Position of spores



*B. anthracis*

**Central & Oval**



*Cl. perfringens*

**Sub-terminal & Oval**



*Cl. Tetani*

**Terminal & Spherical**