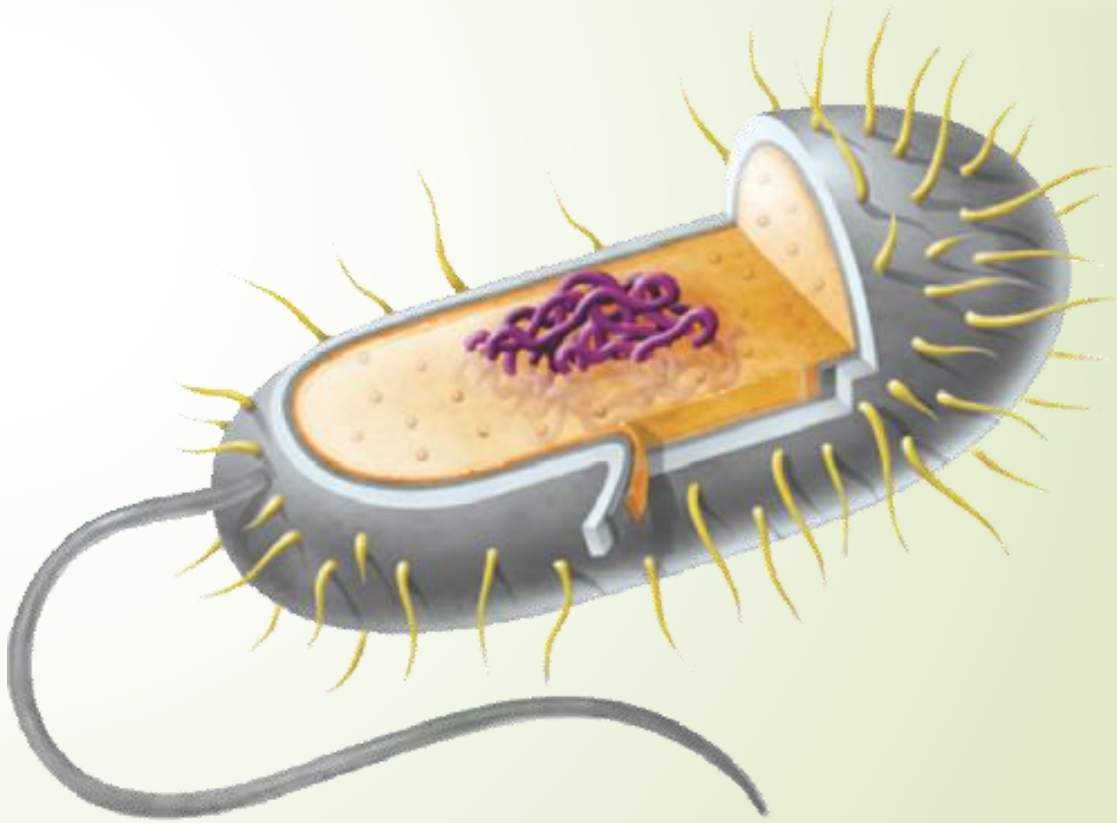
Lecture (3)

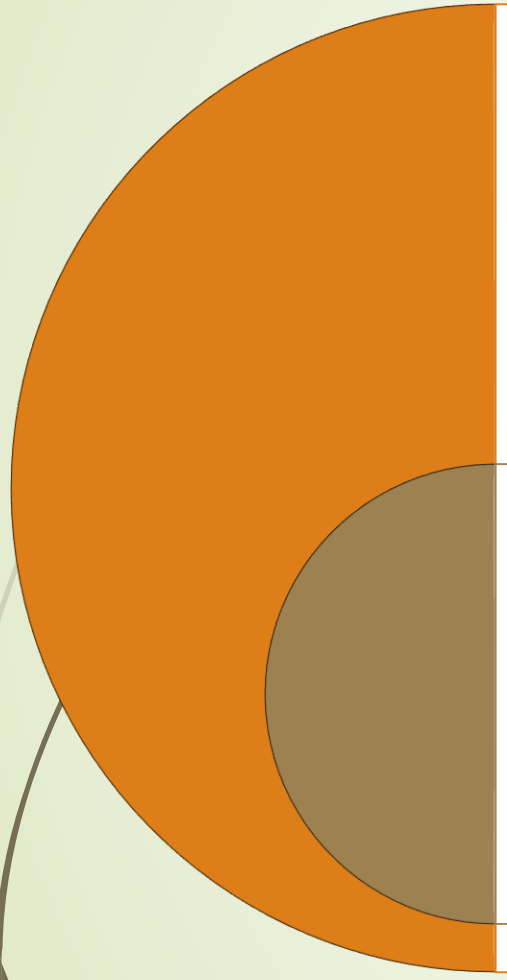
Bacterial cell structure



Objectives

1. Enumerate Essential and non-essential bacterial cell components
2. Describe Cell wall structure and function
3. Compare Gram-positive and Gram-negative cell wall structure.
4. Describe structure and functions of bacterial **cell membrane** and cytoplasm.
5. Compare bacterial **chromosome** and bacterial **plasmids**
6. Describe structure and function of some **bacterial structures**: [flagella, pili, capsule, and inclusion granules].
7. Describe characters of bacterial **spores** and explain their medical implications

Bacterial cell structure



Essential Structures

- Cell wall
- Cytoplasmic Membrane
- Cytoplasm
- Nuclear body

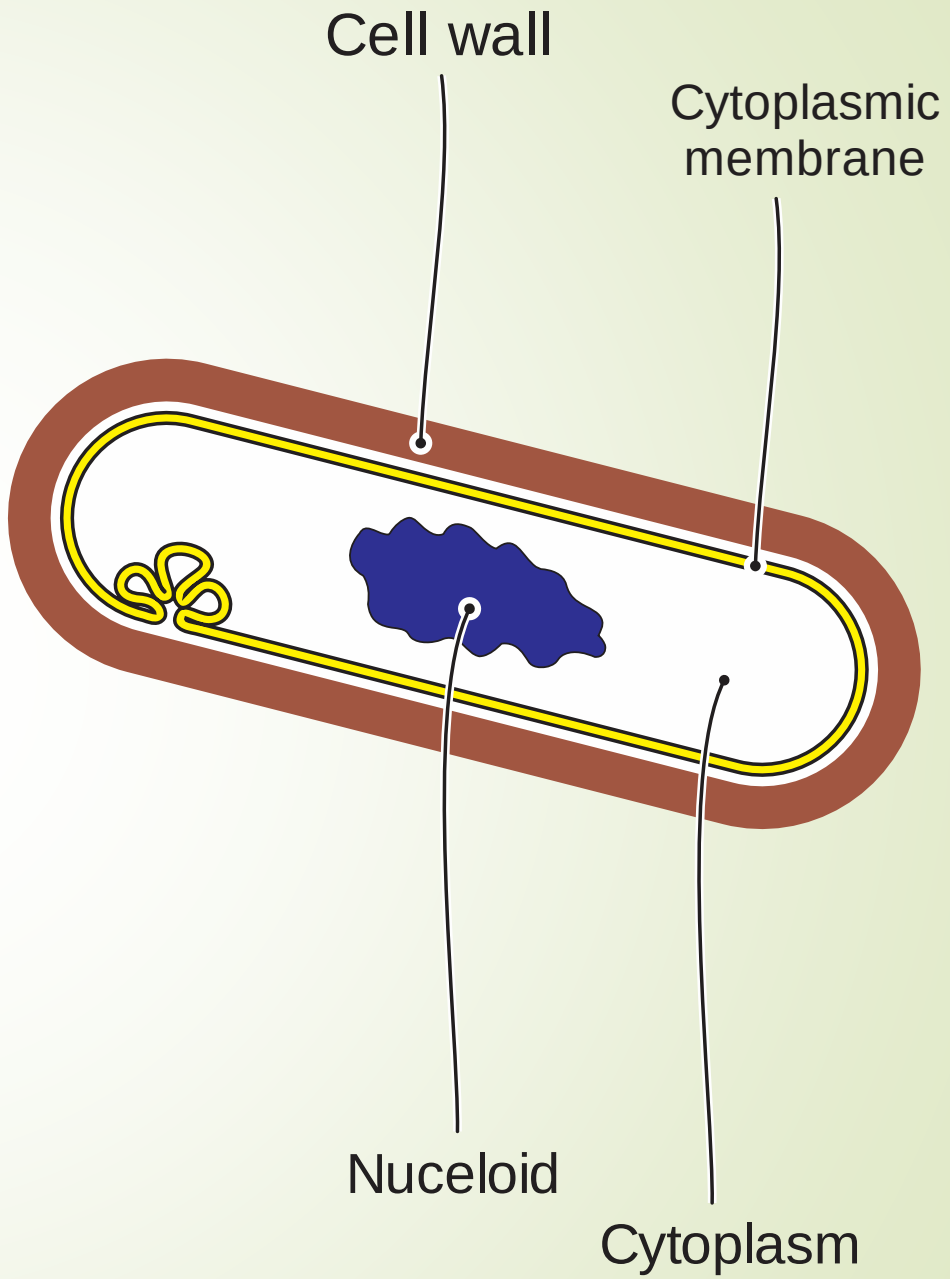
Non Essential structures

- Capsule.
- Flagella
- Pili
- Inclusion granules

Essential structures

Any bacterial cell is composed of the following structures (Essential structures):

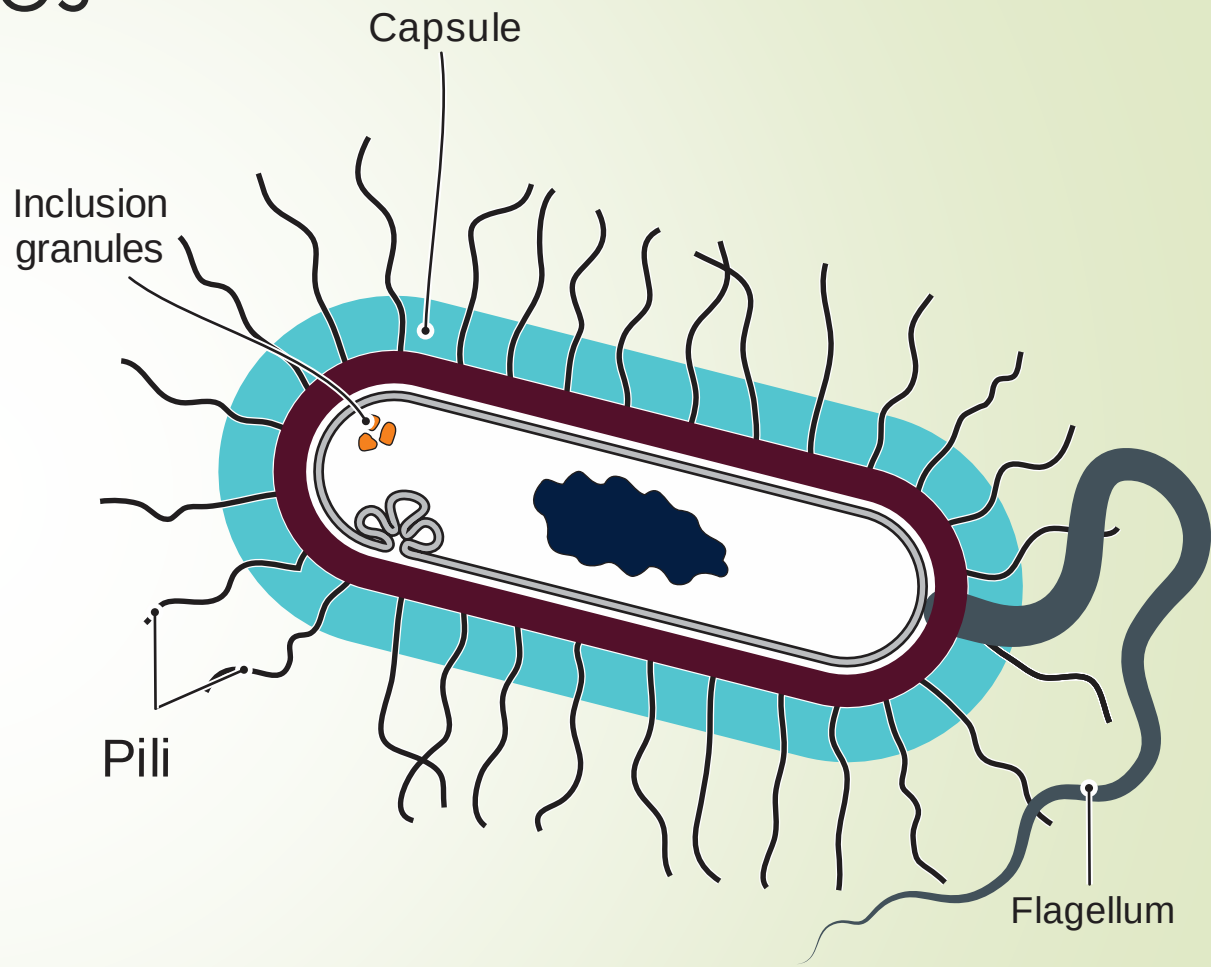
1. Cell wall.
2. Cytoplasmic membrane.
3. Cytoplasm.
4. Nuclear body.



Non Essential Structures

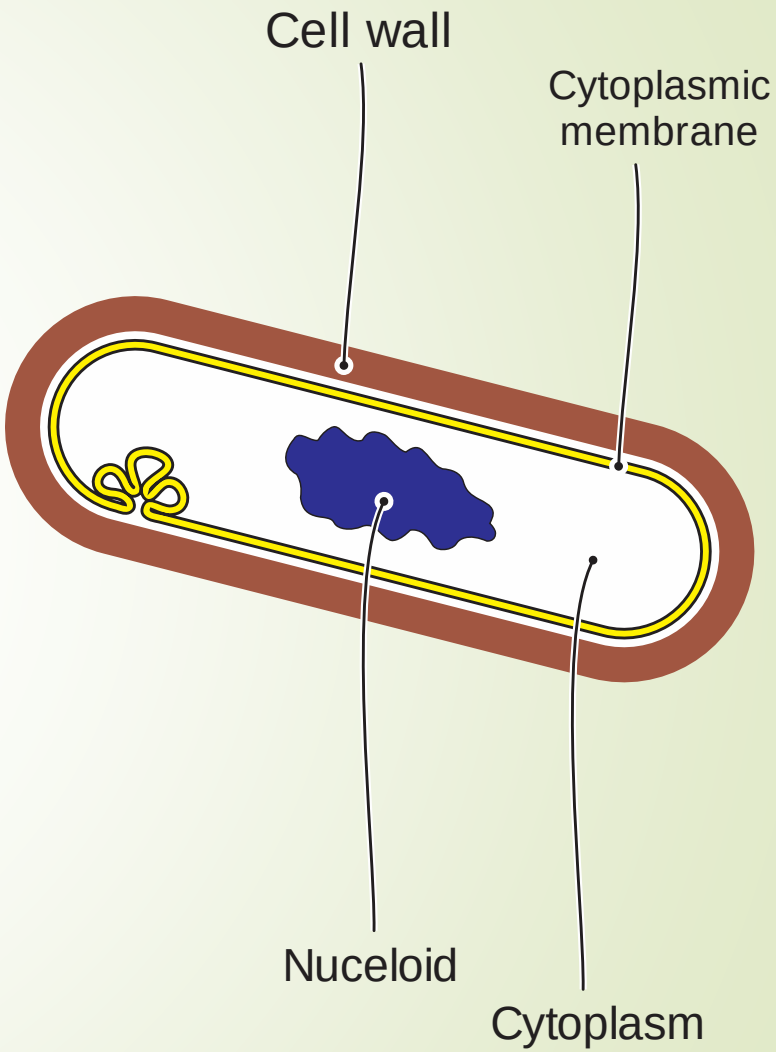
Some (Not all) bacteria may contain one or more of the following structures:

1. Capsule.
2. Flagella (single Flagellum)
3. Fimbria (pili).
4. Inclusion granules



THE CELL WALL

The cell wall is a ***rigid structure*** that ***surrounds*** the bacterial cell just outside of the plasma membrane.



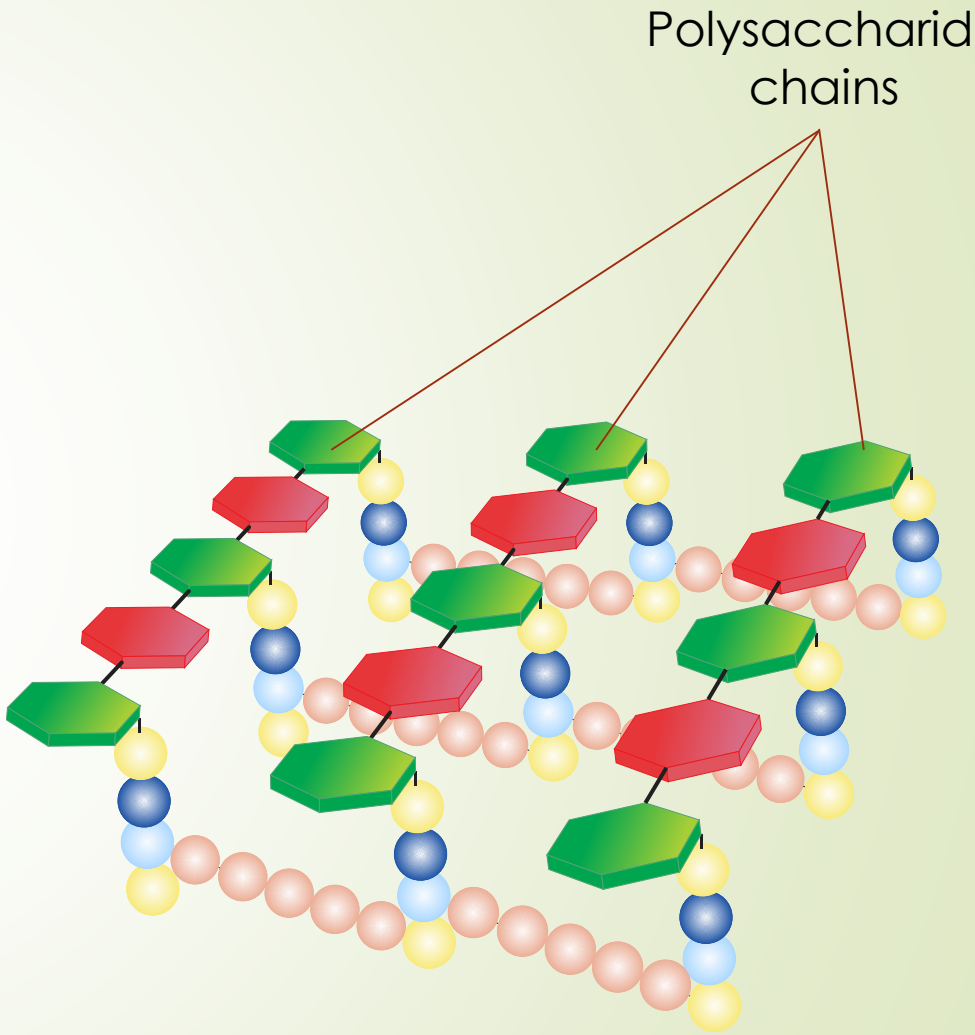
Cell wall Structure

Bacteria are classified according to their cell wall as:

- **Gram positive** or
- **Gram negative**.

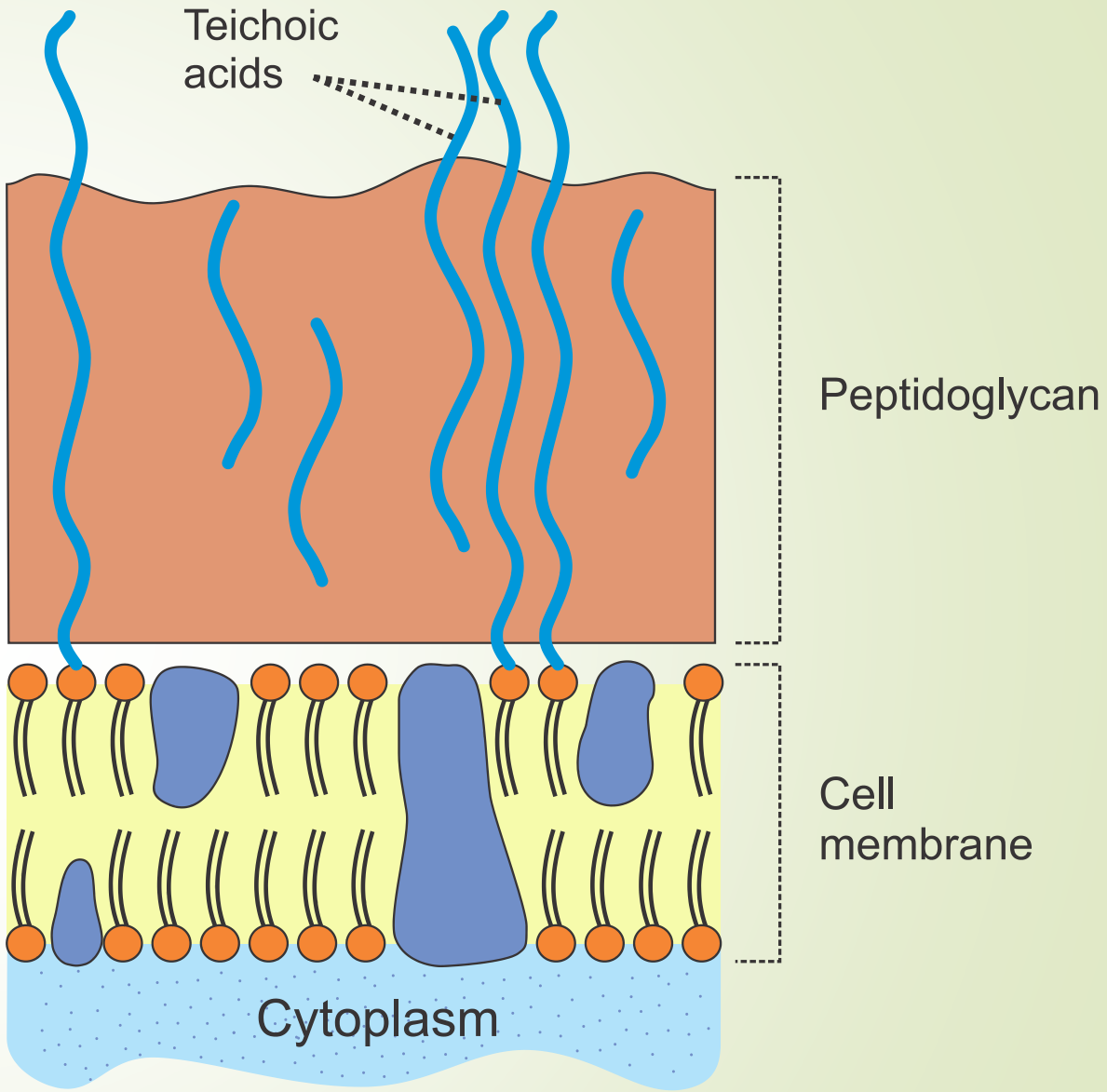
Peptidoglycan

- The main structural component of the cell wall.
- Peptidoglycan is formed of carbohydrate + protein.
- It consists of long polysaccharide **chains** that are **cross-linked** by amino acid **bridges.**



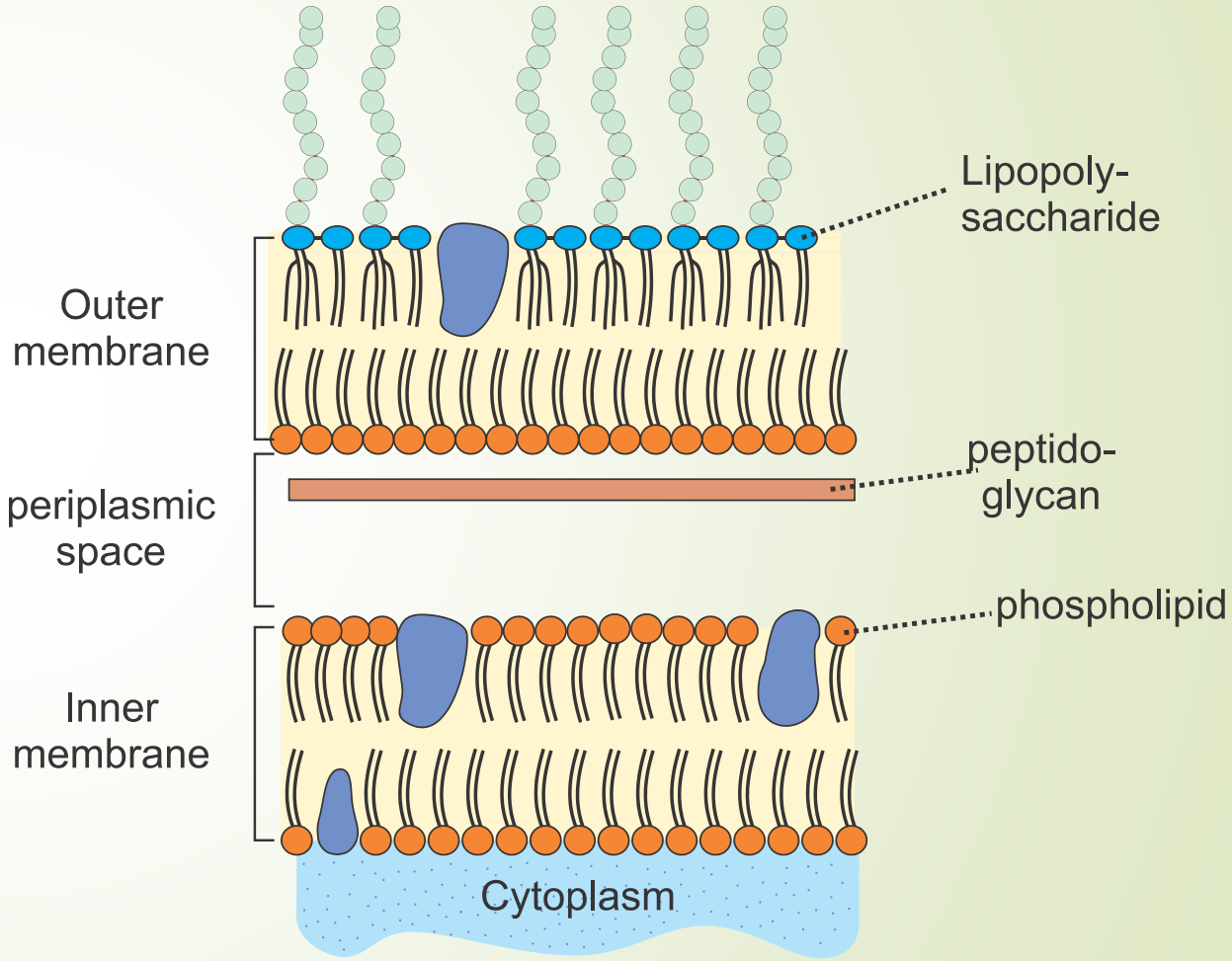
Gram positive Cell Wall

- In Gram-positive bacteria the **peptidoglycan** forms a **thick** layer external to the cell membrane.
- Cell wall of gram positive bacteria also contain **teichoic acid molecules.**



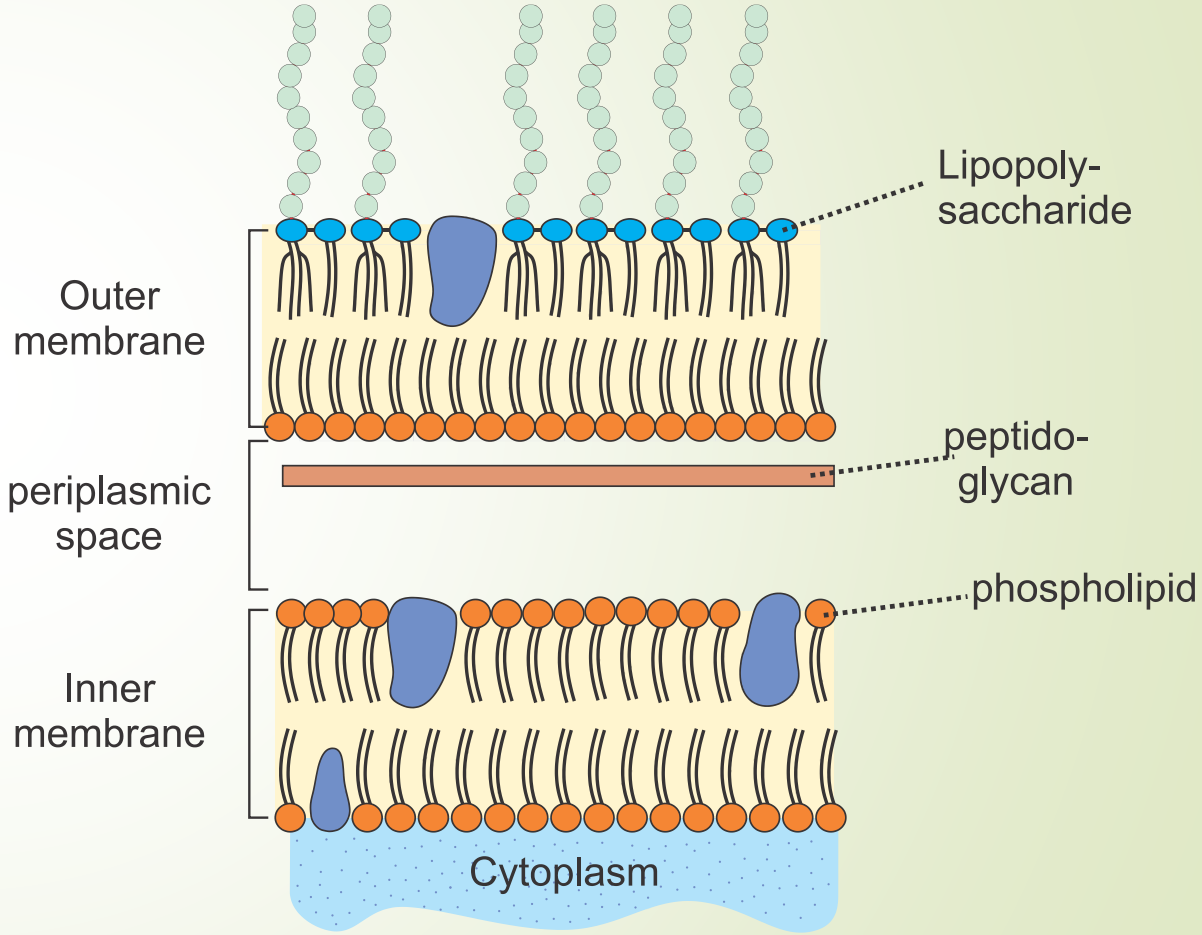
Gram negative Cell Wall

- In Gram-negative bacteria, the peptidoglycan layer is **thin** and is overlaid by an **outer membrane**.
- The space between the plasma membrane and the outer membranes, is called the **periplasmic space.**

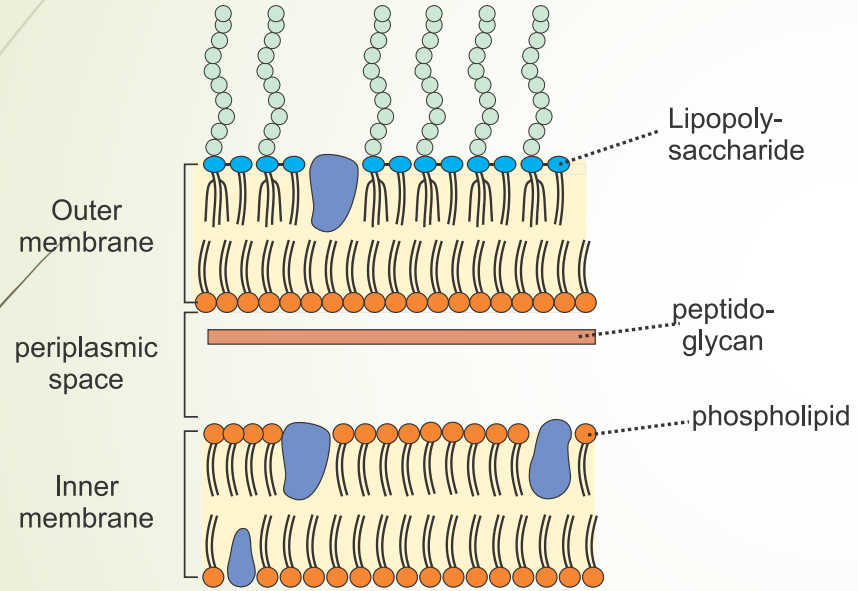
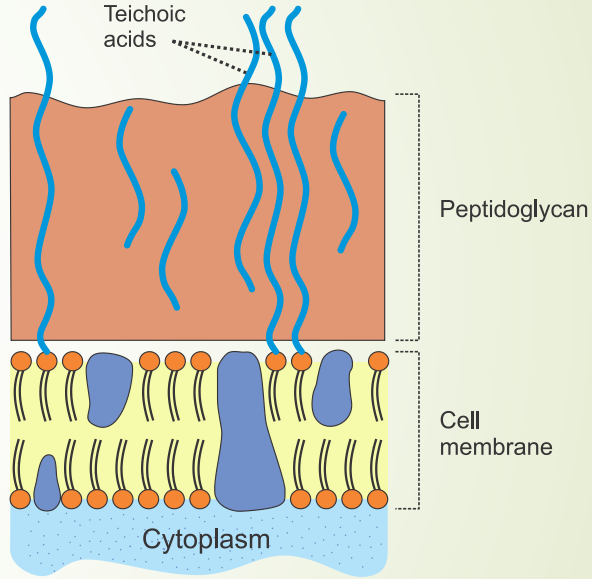


Gram negative Cell Wall

- The Outer membrane of Gram negative bacteria contains **lipopolysaccharide** (LPS).
- LPS is toxic (endotoxin).



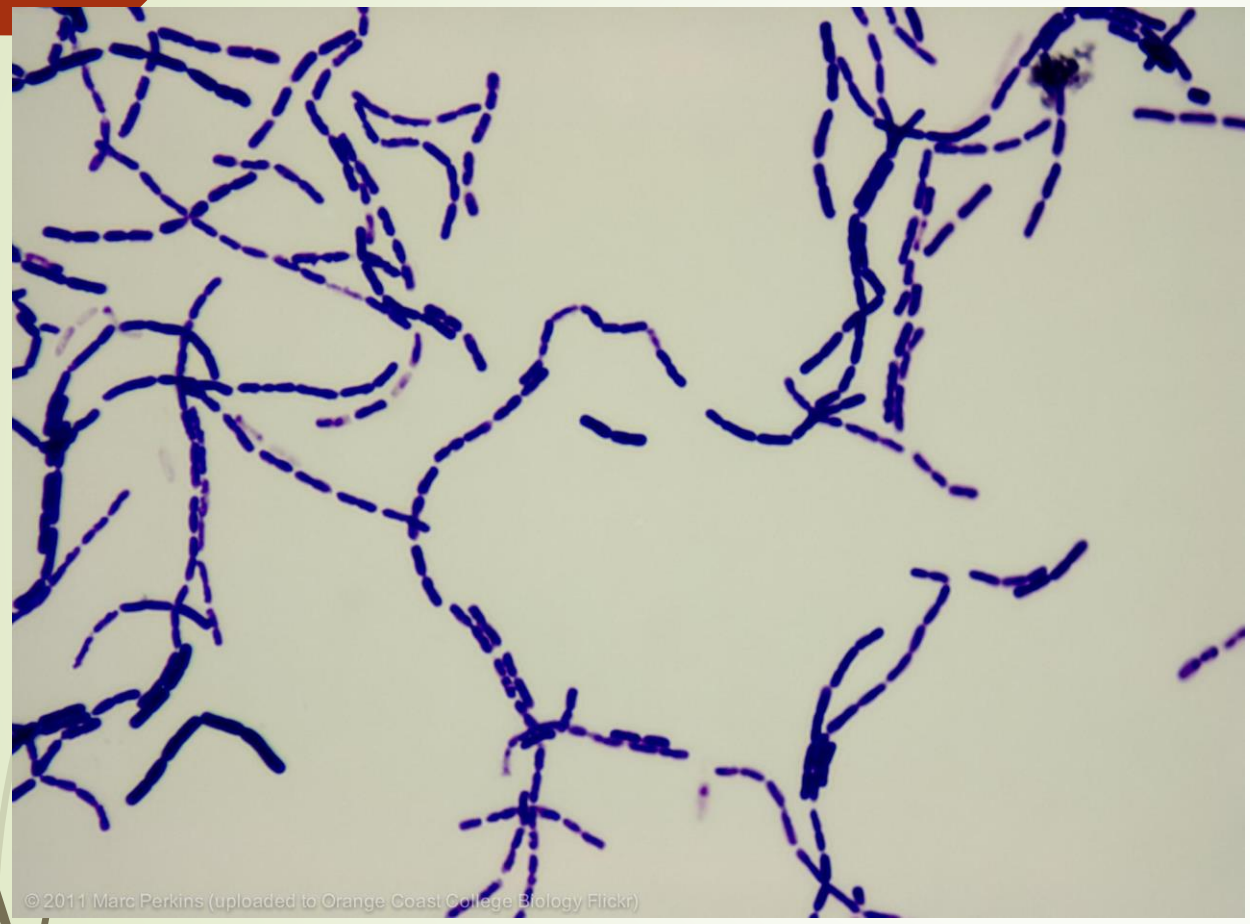
Comparison of Gram +ve and Gram –ve cell walls

Gram negative	Gram positive
	
Thin layer of Peptidoglycan	Thick layer of peptidoglycan
Periplasmic space presents	No periplasmic space
Outer membrane presents	No outer membrane
No teichoic acids	Teichoic Acids present
Lipopolysaccharide present	No Lipopolysaccharide

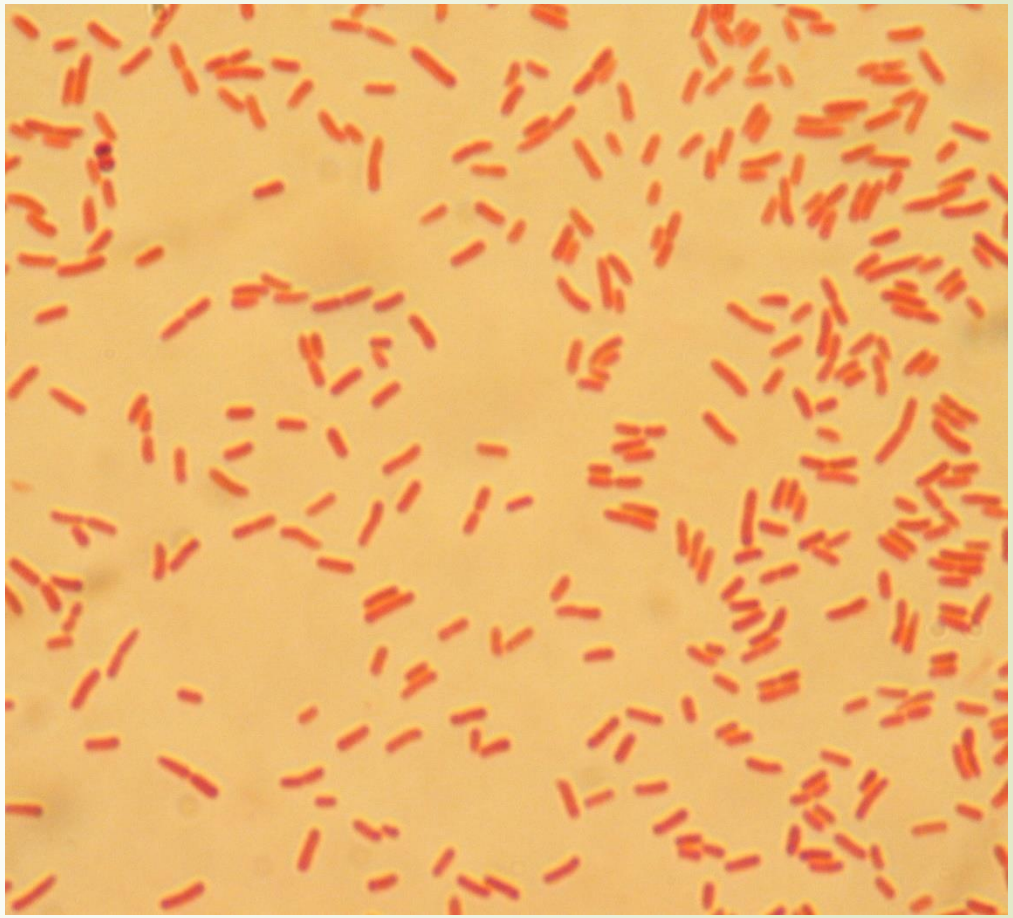
Function of the cell wall

- Determines the **shape** of the bacterial cell.
- Protection of bacterial cell against **osmotic lysis**.
- Responsible for **staining properties** of bacteria.

Cell wall determines the **staining properties** of the bacterial cell



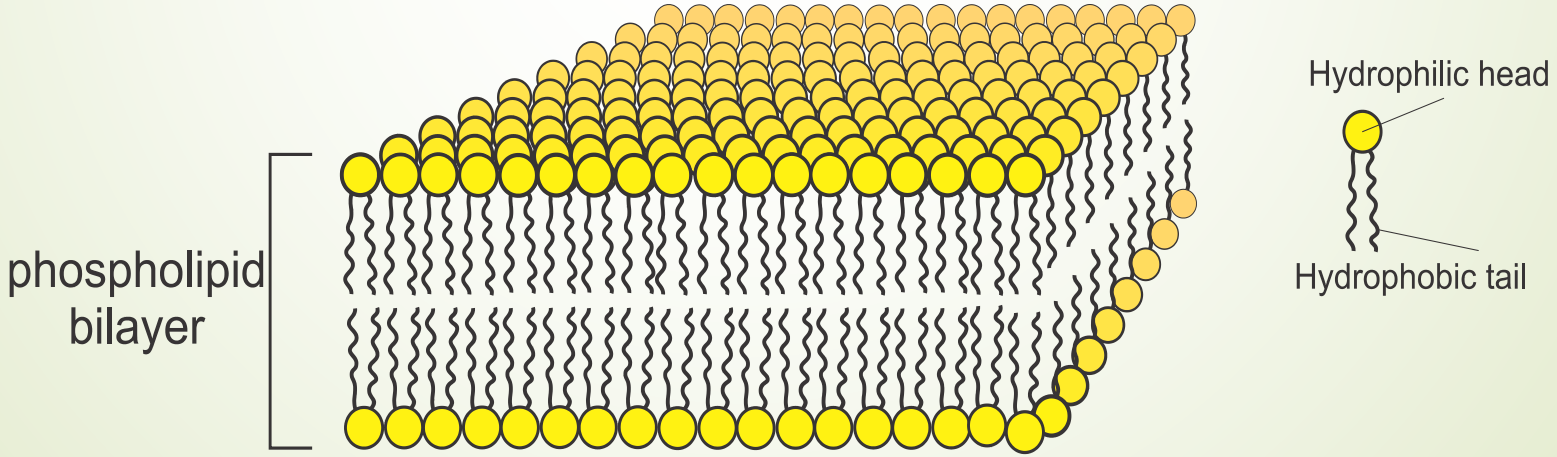
Gram Positive Bacteria (Blue)



Gram Negative Bacteria (Pink)

CYTOPLASMIC MEMBRANE

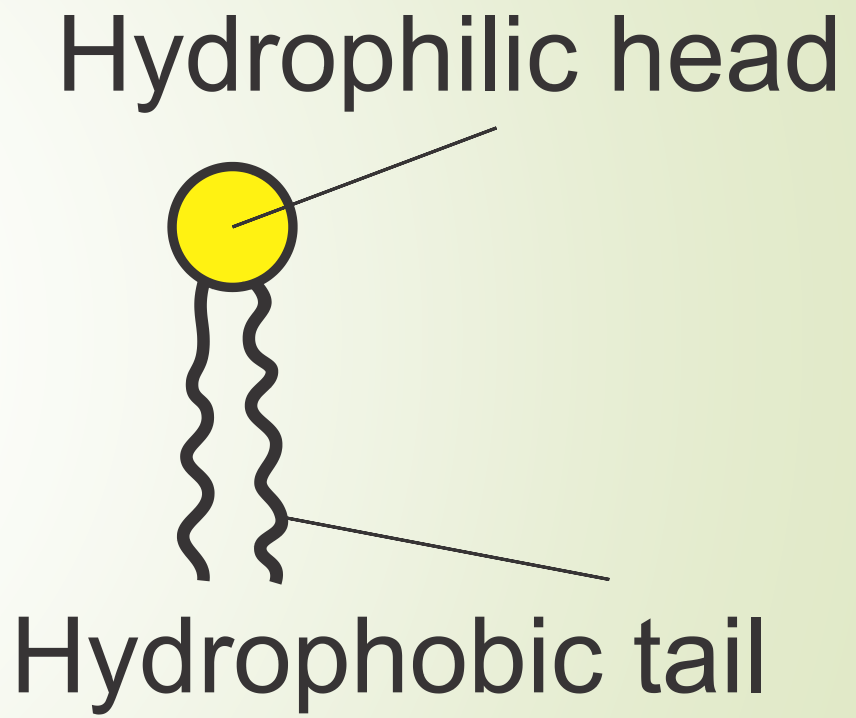
- Surrounds the cytoplasm
- The cytoplasmic membrane is a **bilayer** of **phospholipids**



Phospholipid molecule

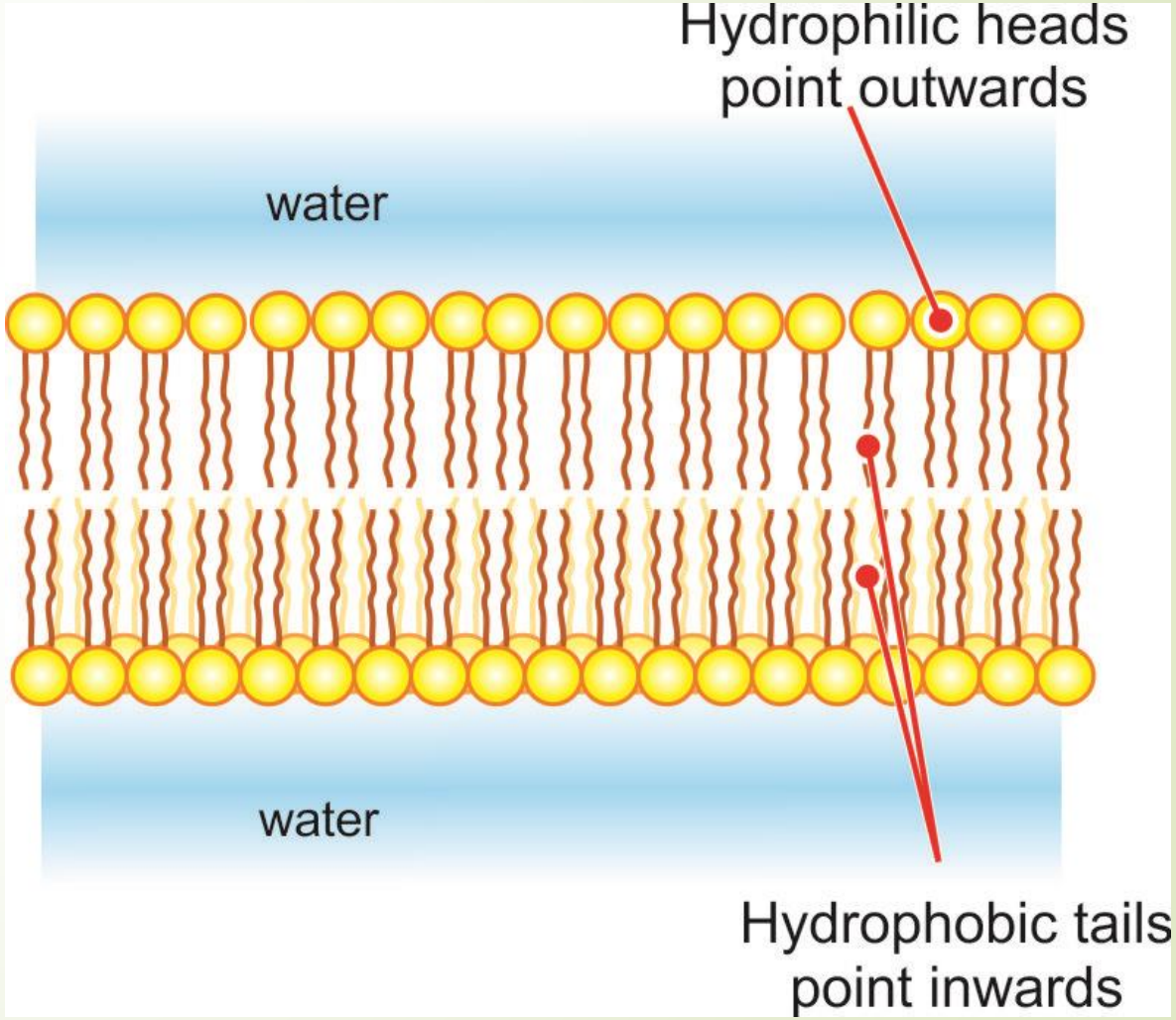
Phospholipids are composed of two parts:

- Hydrophilic head ("water-loving").
- Hydrophobic tails ("water-fearing").



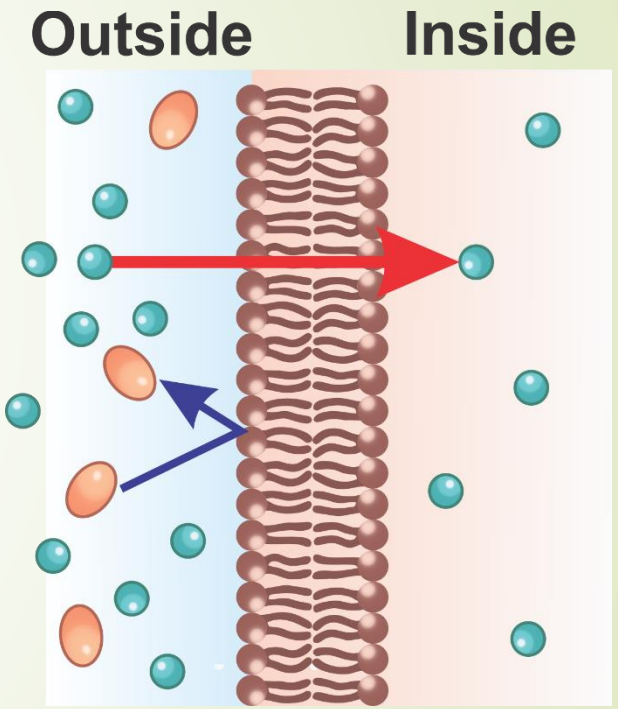
Bilayers of phospholipids

- The cytoplasmic membrane is a **bilayer** of **phospholipids**
- The **Hydrophilic heads** points outwards (facing the aqueous medium on both sides of the bilayer).
- The **hydrophobic Tails** points inwards.



Some functions of cell membrane

- **Selective permeability** = selectively **allows particular** ions and molecules to pass through the membrane, while **preventing** the movement of **others**.

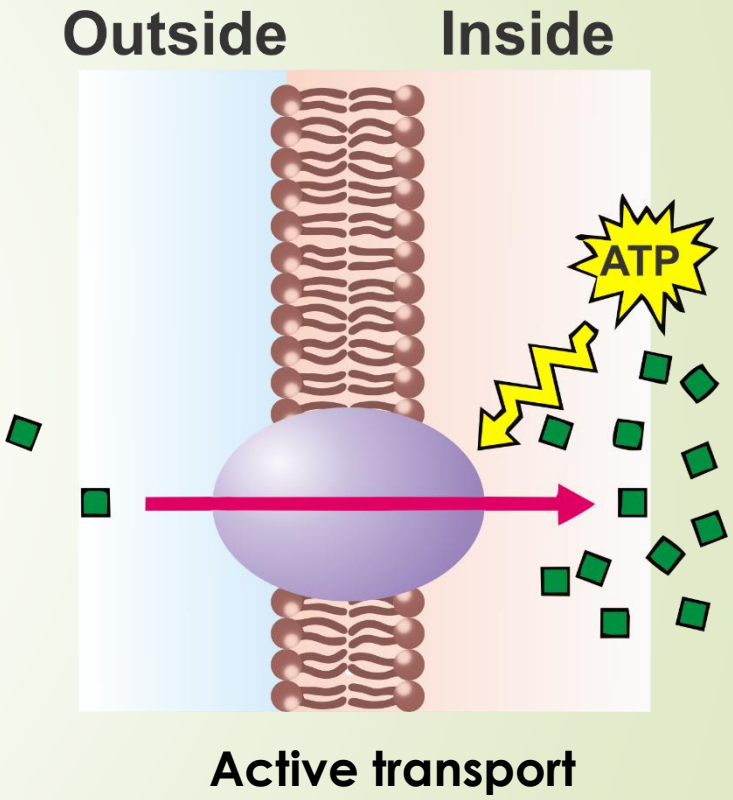


Selective permeability

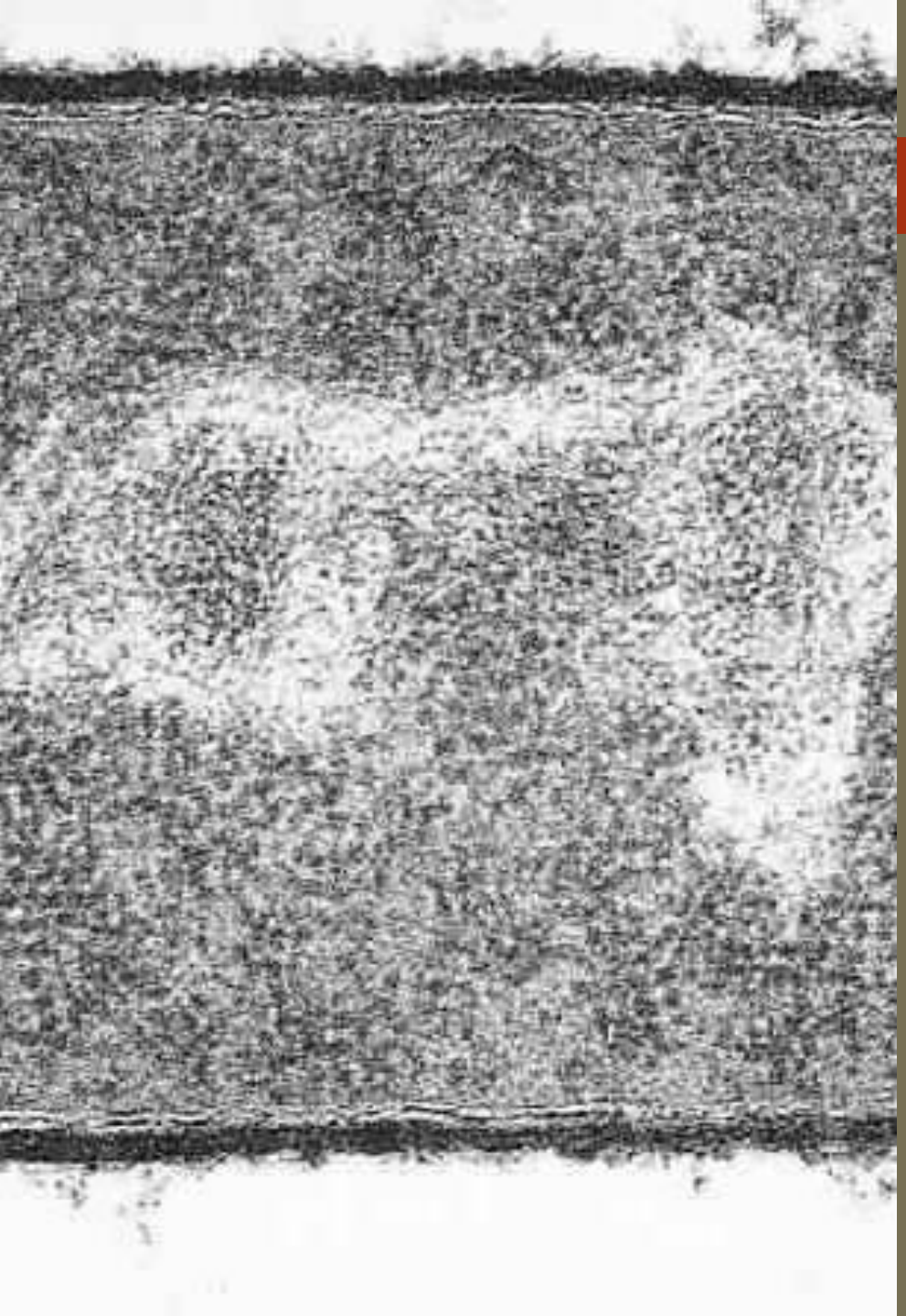
Some functions of cell membrane

- **Active transport (using energy)** of ions and molecules to the inside of cells.

- **Excretion** e.g. hydrolytic exoenzymes



Active transport

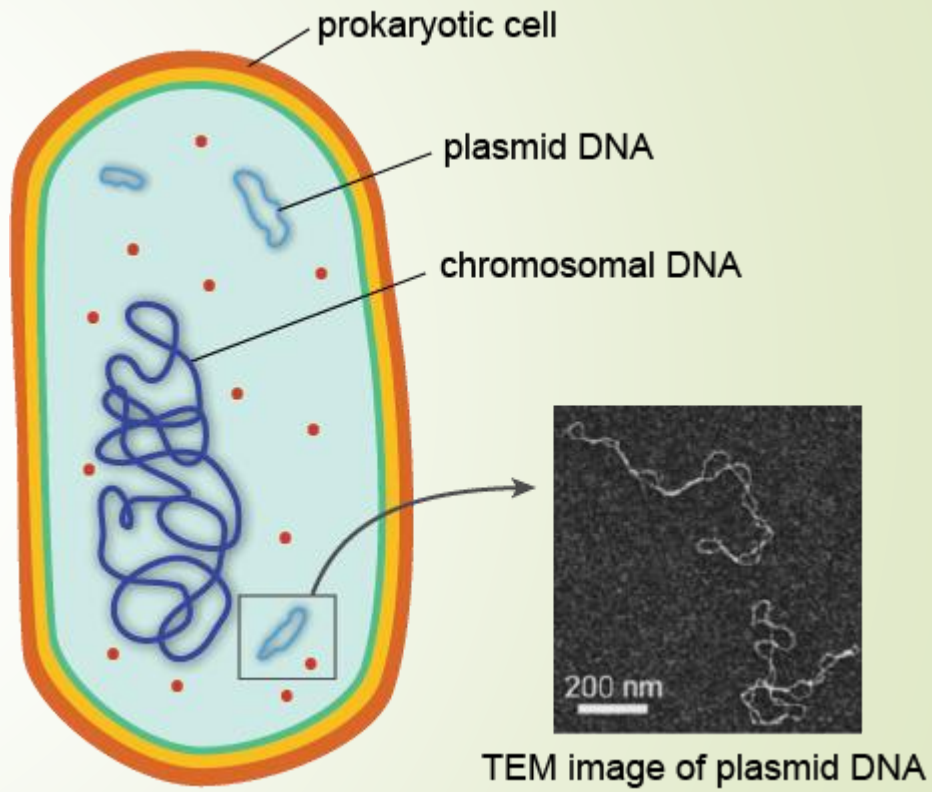


Cytoplasm

- A homogeneous soft gel mass inside the cell.
- The cytoplasm of prokaryotes has **no membrane bound organelles**.
- It contains:
  - **Nuclear body.**
  - Plasmids**.**
  - **Ribosomes**.
  - Enzymes.
  - Storage granules

THE NUCLEAR BODY

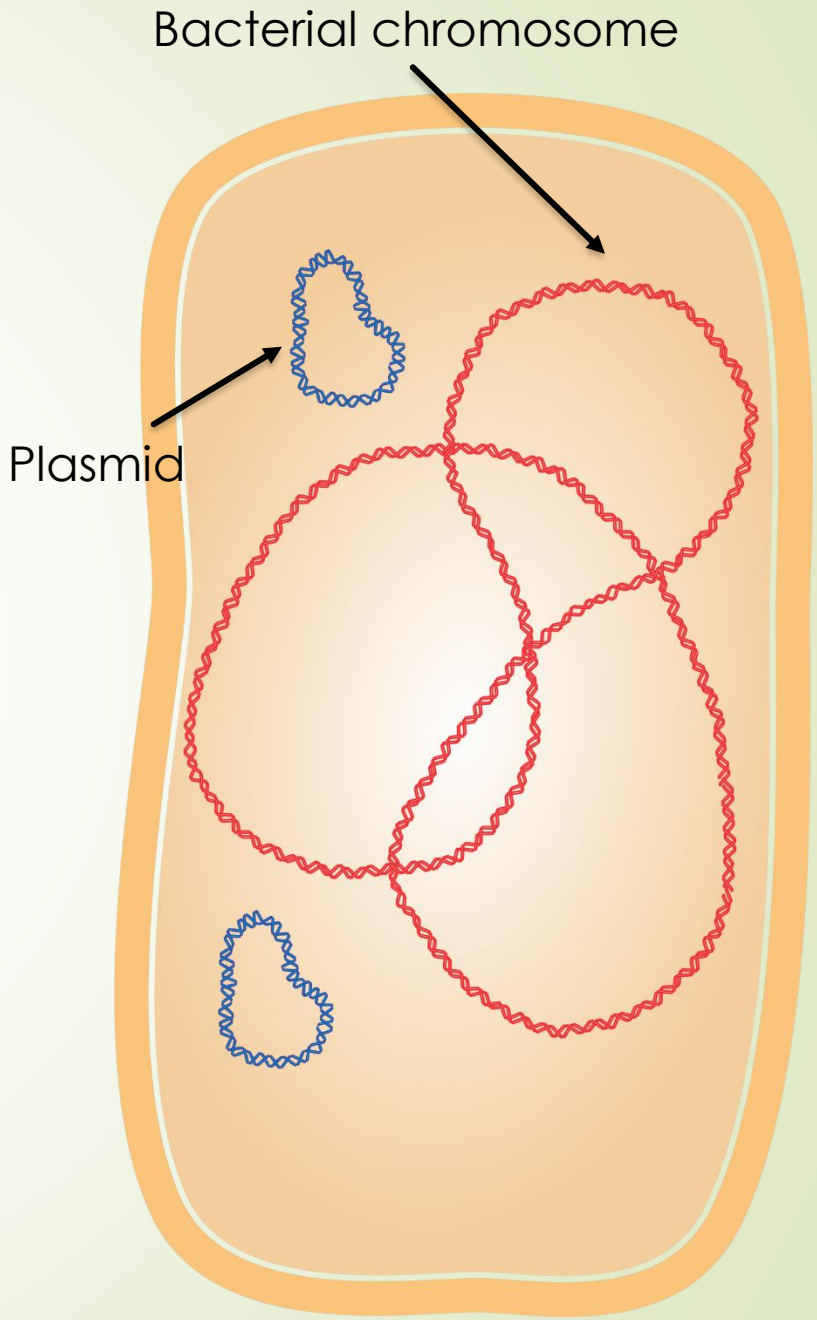
- The bacterial chromosome consists of **single circular** DNA molecule.
- Bacterial chromosome carries **all essential** genetic information of the cell.
- The bacterial chromosome is coiled to form a **mass** called the **nucleoid**.
- There is no nuclear membrane and no nucleolus.



TEM image of plasmid DNA

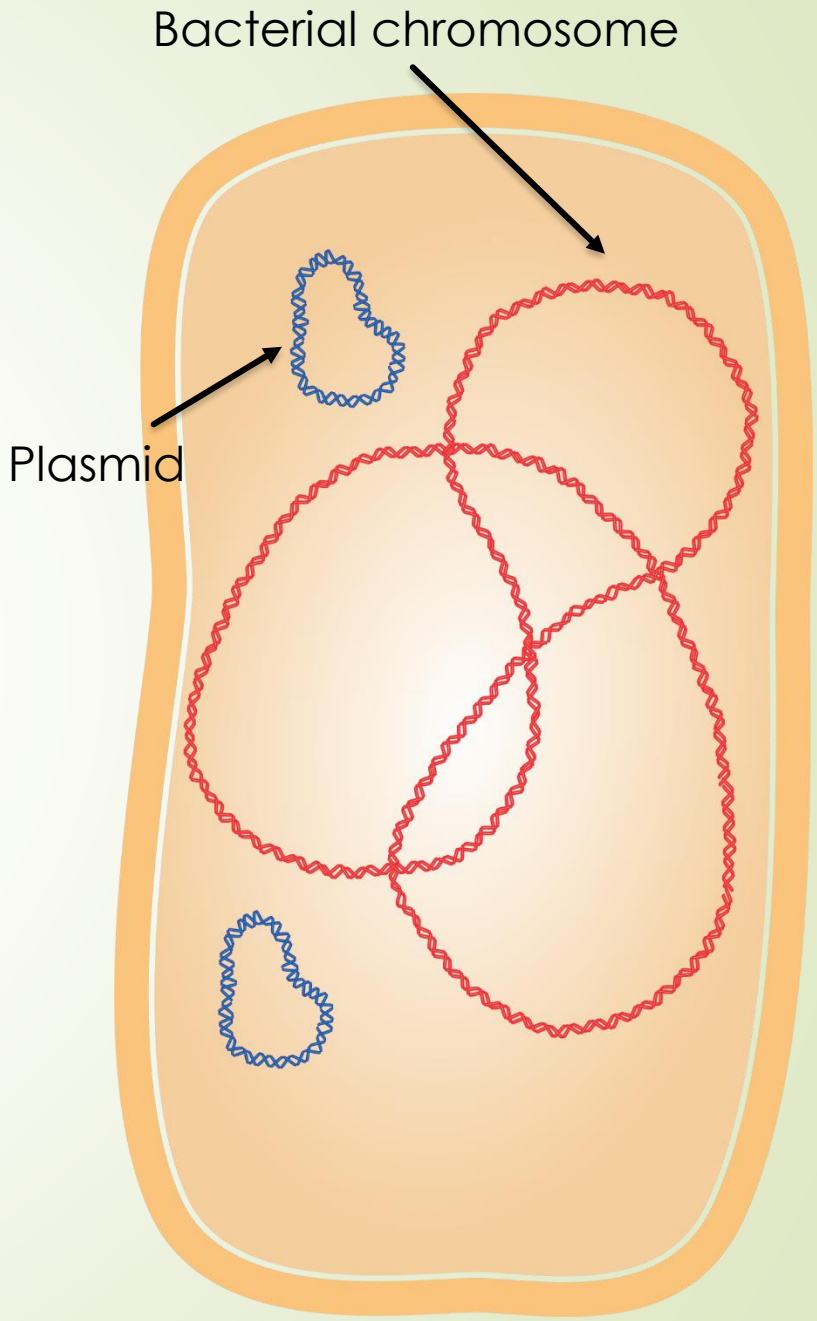
Plasmids

- Plasmids: are small **extrachromosomal** pieces of circular DNA.
- Some plasmids can be **transmitted** from one bacterium to another by various mechanisms.



Plasmids

- Plasmid possesses only a small number of genes.
- **Genes** carried by plasmids are **non-essential** to the host bacteria *such as antibiotic resistance genes*.



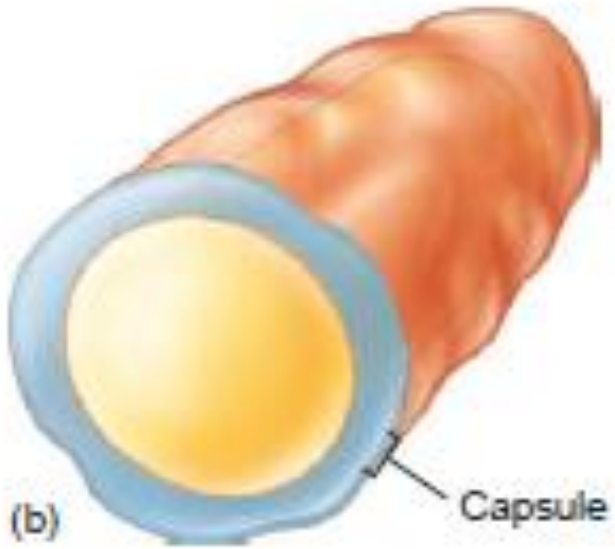
Capsule and slime layer

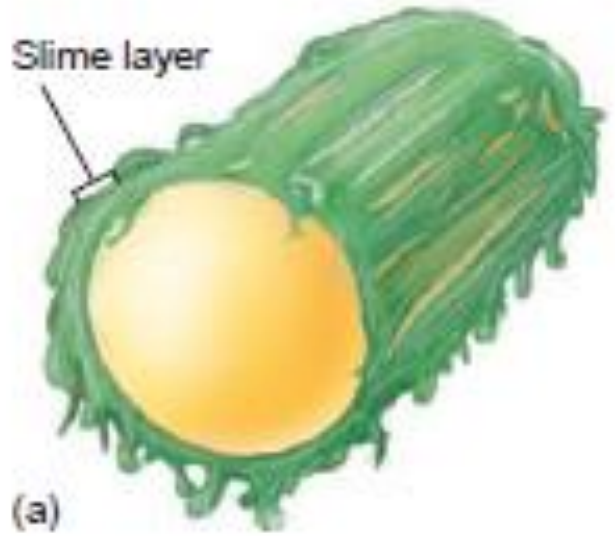
Capsule:

Capsule is a **well-defined** gelatinous protective outer covering surrounding and **firmly** attached to bacterial cell wall.

Slime layer:

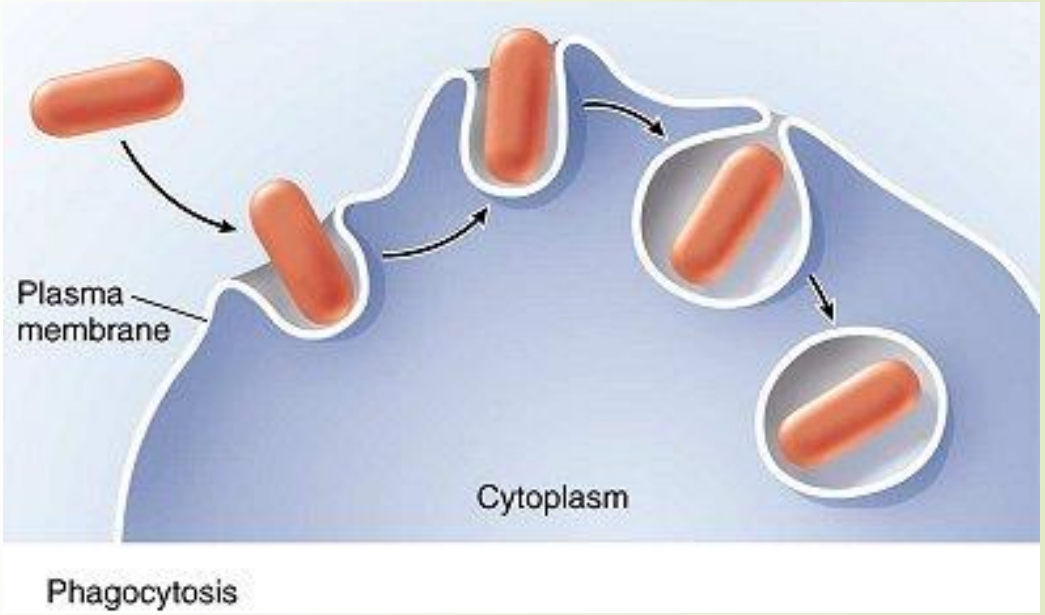
A slime layer is a zone of **diffuse**, unorganized material, **loosely associated** with the cell wall **and can be easily removed**.





Function of Capsule

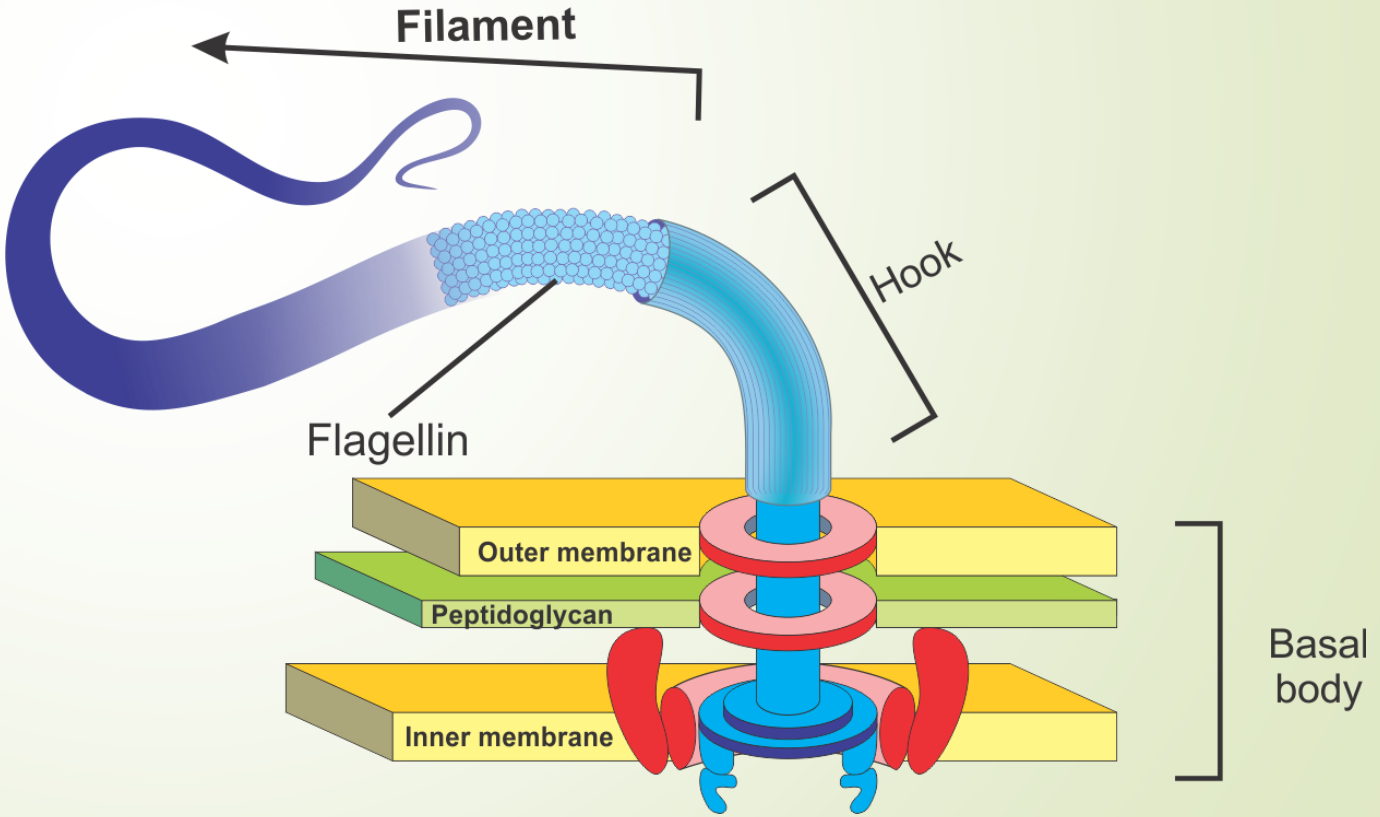
- Protection of bacteria against **phagocytosis**.
- Protect cells from **drying**.
- Help bacteria in **adherence** to surfaces.



Phagocytosis

Flagella (single Flagellum)

- Flagella are long helical appendages
- Flagella are composed of repeating protein subunits (flagellin).



Function of Flagella

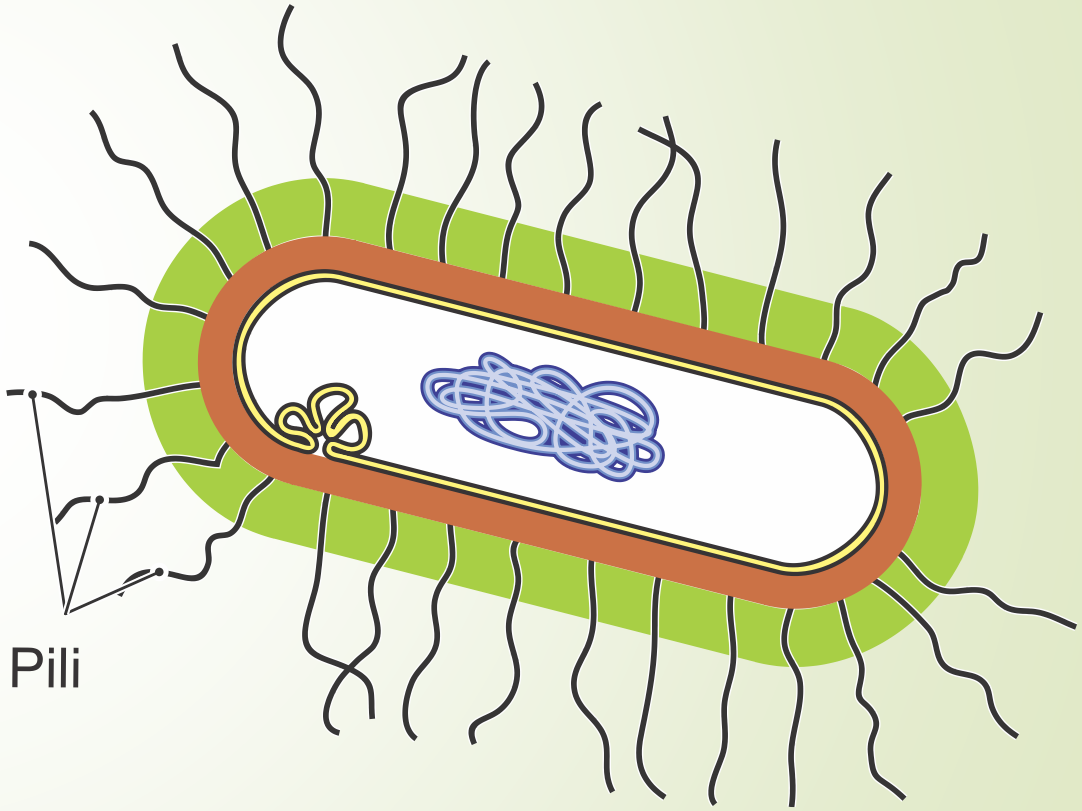
- Flagella are responsible for **motility**.
- The flagellum **rotates** and propel the bacterium through the surrounding fluid.

Pili (single → pilus)

Pili are short **hair-like** surface appendages.

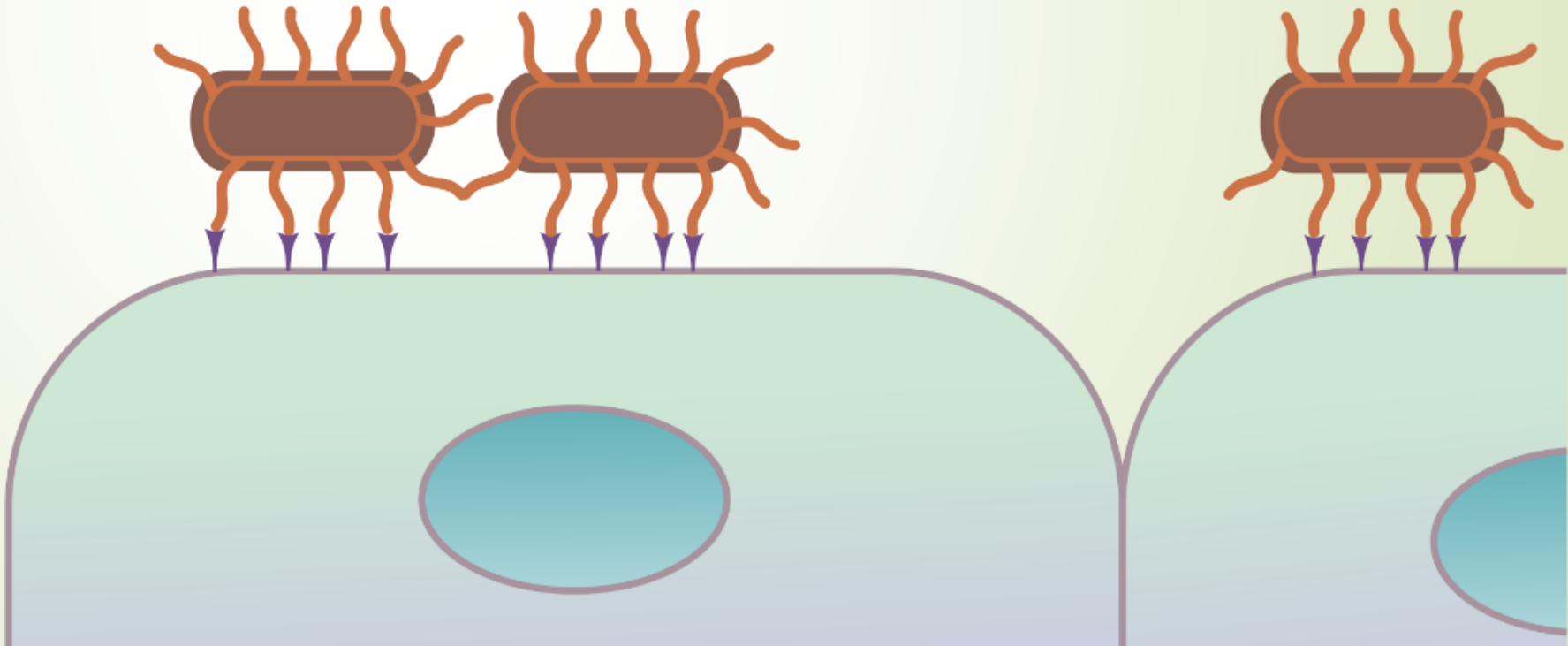
Pili exist in two classes:

- Ordinary pili
- Sex pili



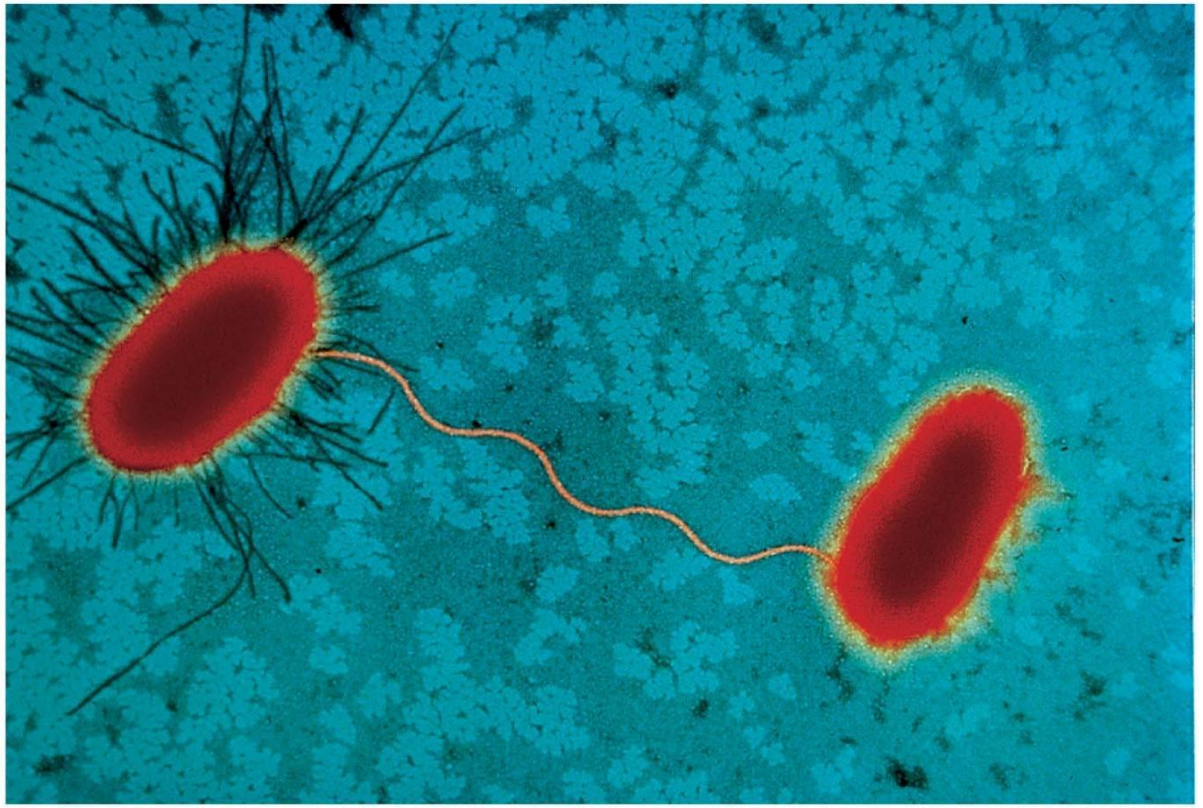
Function of Pili

- **Ordinary pili** are involved in bacterial **adherence.**



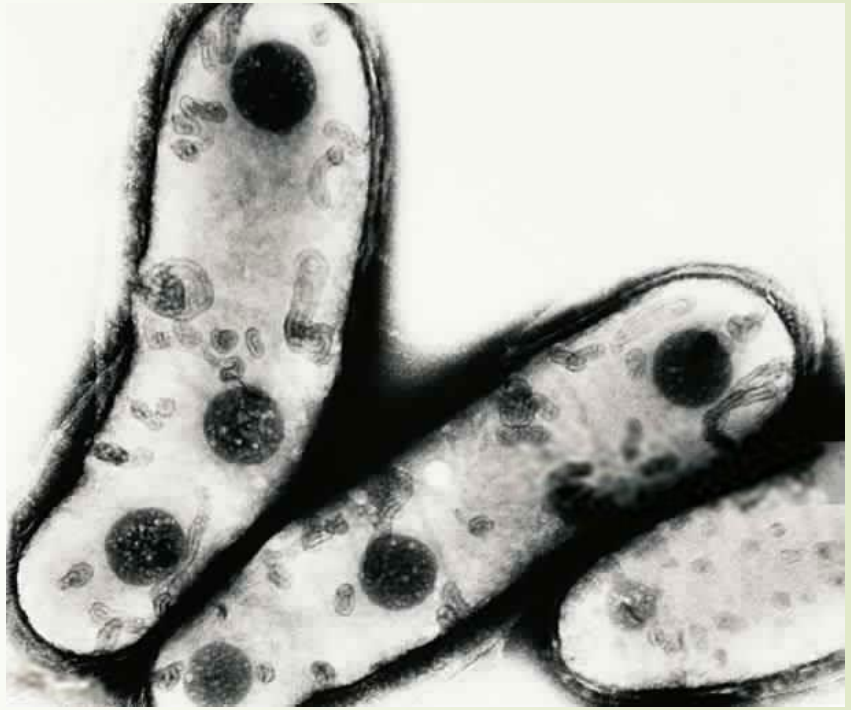
Function of Pili

- **Sex pili**, involved in transfer of genetic material (**conjugation).**



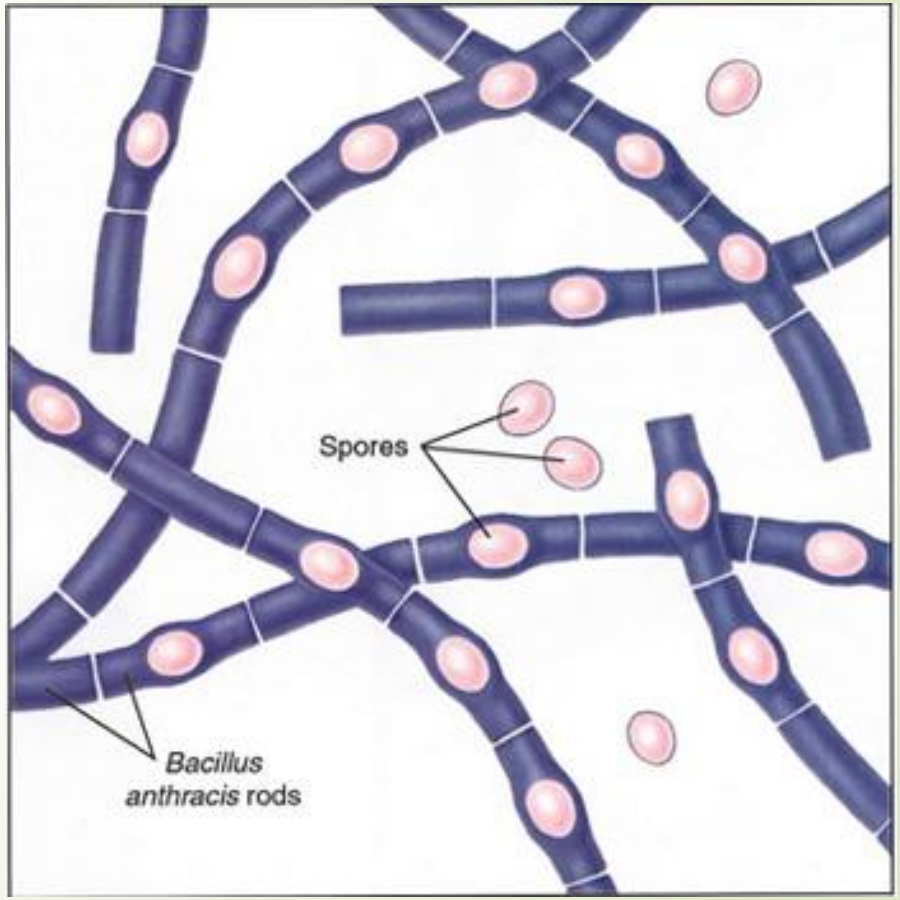
INCLUSION GRANULES

- **Function**: **Storage** of **energy** or structural **building blocks**.
- **Site:** In cytoplasm.
- **Example:** Volutin granules in diphtheria bacilli (reservoir of inorganic phosphate).

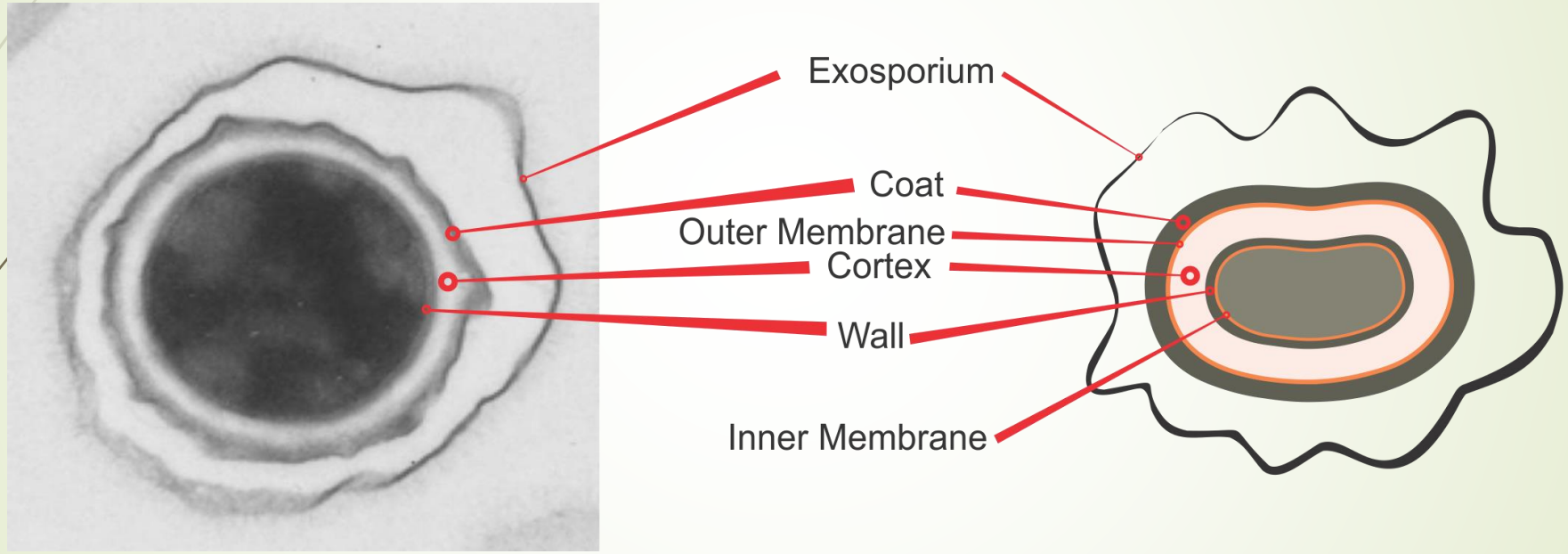


Spores

- ***Spores*** are highly **resistant** resting forms of some bacteria.
- Bacterial spores are highly **resistant to:**
  - Heat
  - Dehydration
  - Radiation and
  - Chemicals



Bacterial spore has multiple protective layers

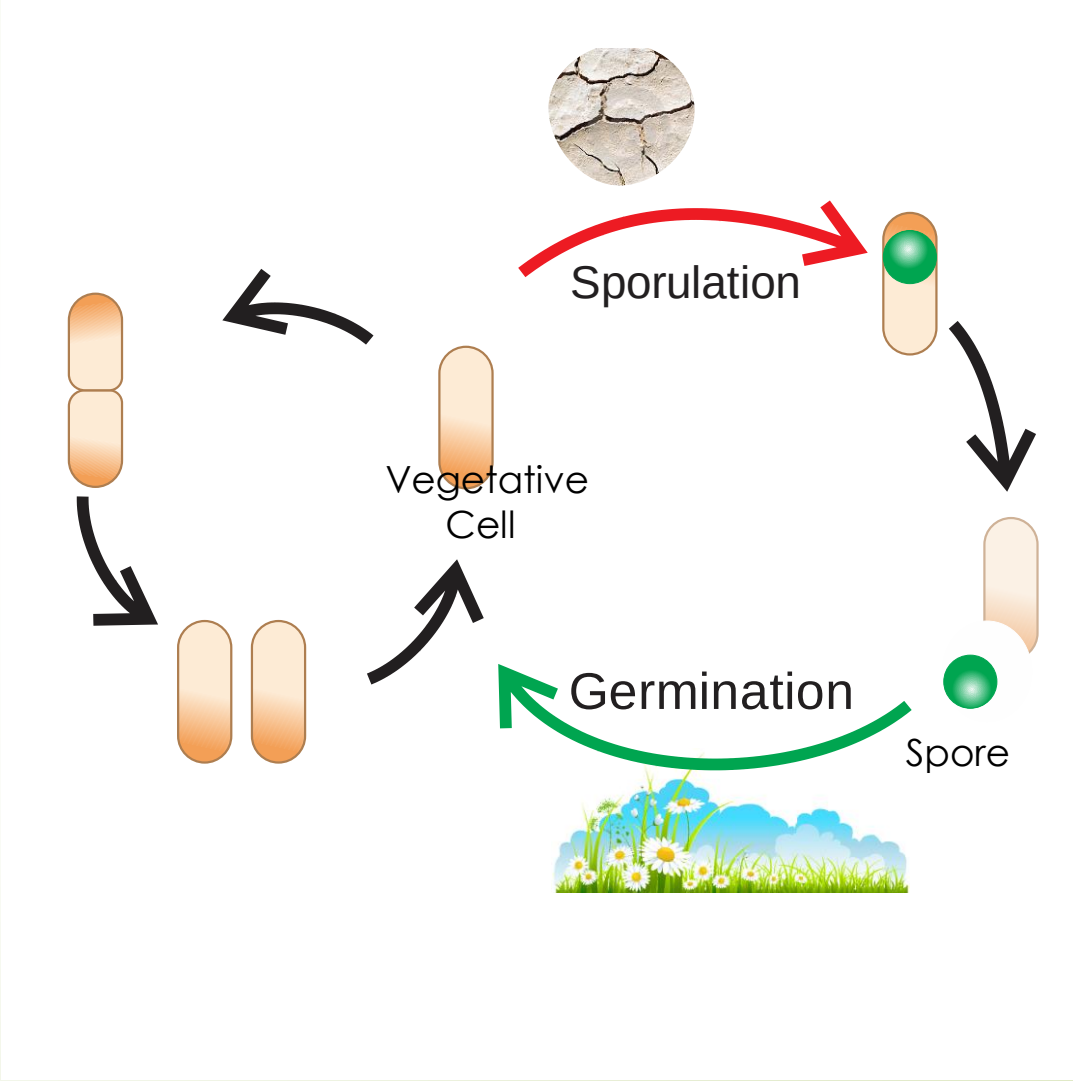


The multiple layers of the spore serve to protect the spore core which house the bacterial genome against adverse conditions.

Sporulation / Germination

Spores are formed on exposure to **unfavorable conditions** e.g. dryness, heat and depletion of nutrients.

- ***Sporulation (sporogenesis):*** *the process of formation of* ***spores from vegetative cells****.*
- ***Germination****: opposite to sporulation i.e. formation of* ***vegetative cells from spores*** *in favorable conditions.*



Medical Importance of spores

- The medical importance of spores lies in their **extraordinary resistance to killing by heat** and ***chemicals***.
- As a result of their resistance to heat, **sterilization** cannot be achieved by ordinary methods such as boiling.
- **Steam heating under pressure** (autoclaving) at 121°C, usually for 30 minutes, is required to ensure the sterility of products for medical use.

Quizzes

1. The bacterial structure responsible for motility is:

A. The nuclear body.
B. The cytoplasmic membrane.
C. The flagellum.
D. Pili.

2. The bacterial structure responsible for adhesion (attachment) to surfaces:

A. The nuclear body.
B. The cytoplasmic membrane.
C. The flagellum.
D. Pili.

3. The bacterial structure responsible for selective permeability:

A. The nuclear body.
B. The cytoplasmic membrane.
C. The flagellum.
D. Pili.

4. Short hair like surface appendages of bacteria are called:

A. Capsule.
B. The cytoplasmic membrane.
C. The flagellum.
D. Pili.

5. The bacterial structure responsible for cell shape and staining properties is:

A. The cell wall.
B. The cytoplasmic membrane.
C. The flagellum.
D. Pili.

6. Highly resistant resting from of Bacteria is called

A. Inclusion granule
B. Nucleoid
C. Flagellum
D. Spore

7. Staining properties of the bacterial cells is determined by _____?

A. The cell wall.
B. The cytoplasmic membrane.
C. The flagellum.
D. The capsule.

8. The toxic part of the bacterial cell wall is:

A. Peptidoglycan
B. Phospholipid
C. Lipopolysaccharide

9. The bacterial structure responsible for protecting bacteria against phagocytosis is:

A. Flagellum
B. Cell membrane
C. Capsule
D. Pilli.

10. The cell wall of Gram Positive bacteria:

A. Contains a periplasmic space
B. Contains a thick layer of peptidoglycan
C. Contains an outer membrane
D. Contains Lipopolysaccharide

11. Fill in the spaces

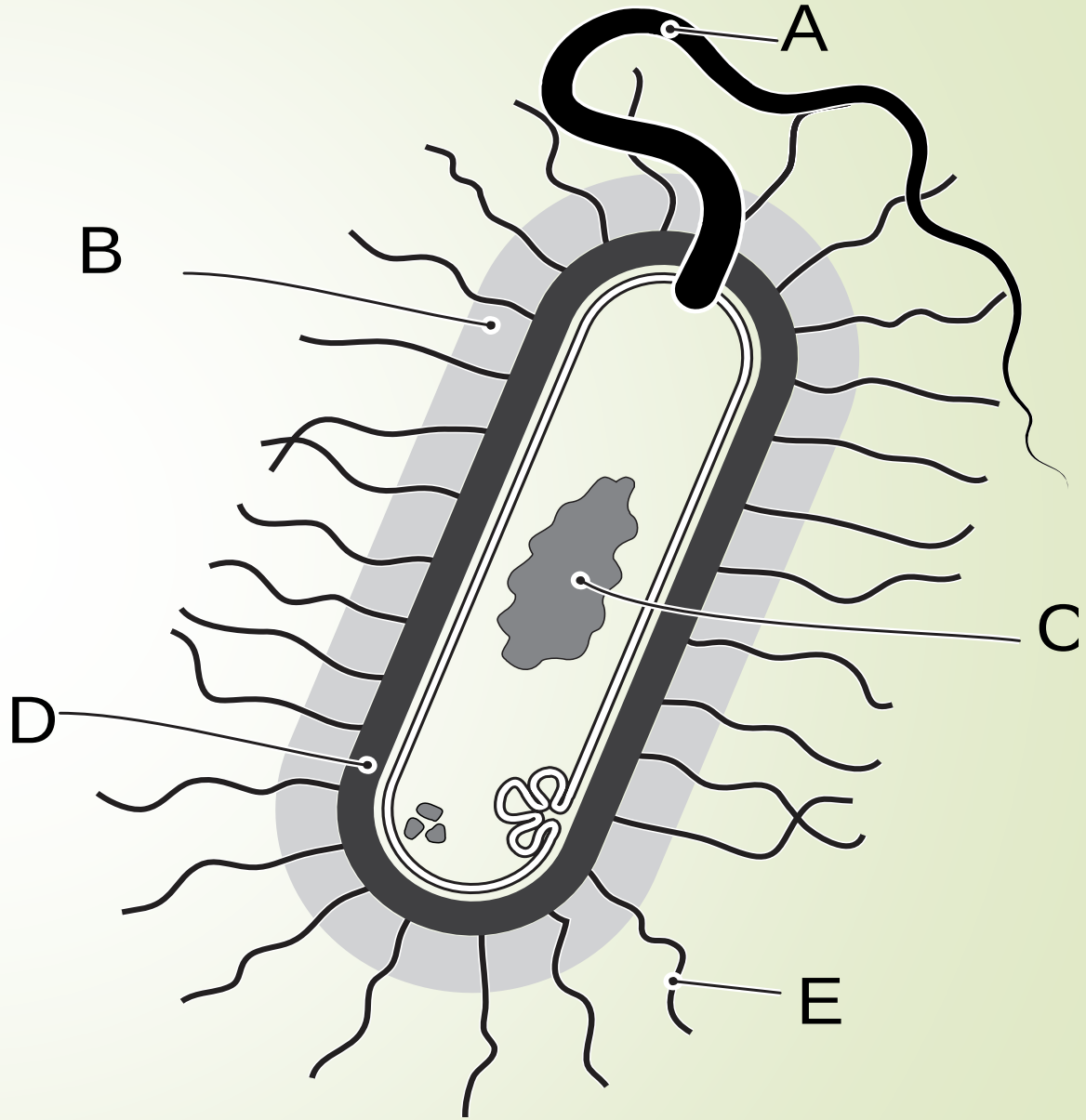
A:……

B:……

C:……

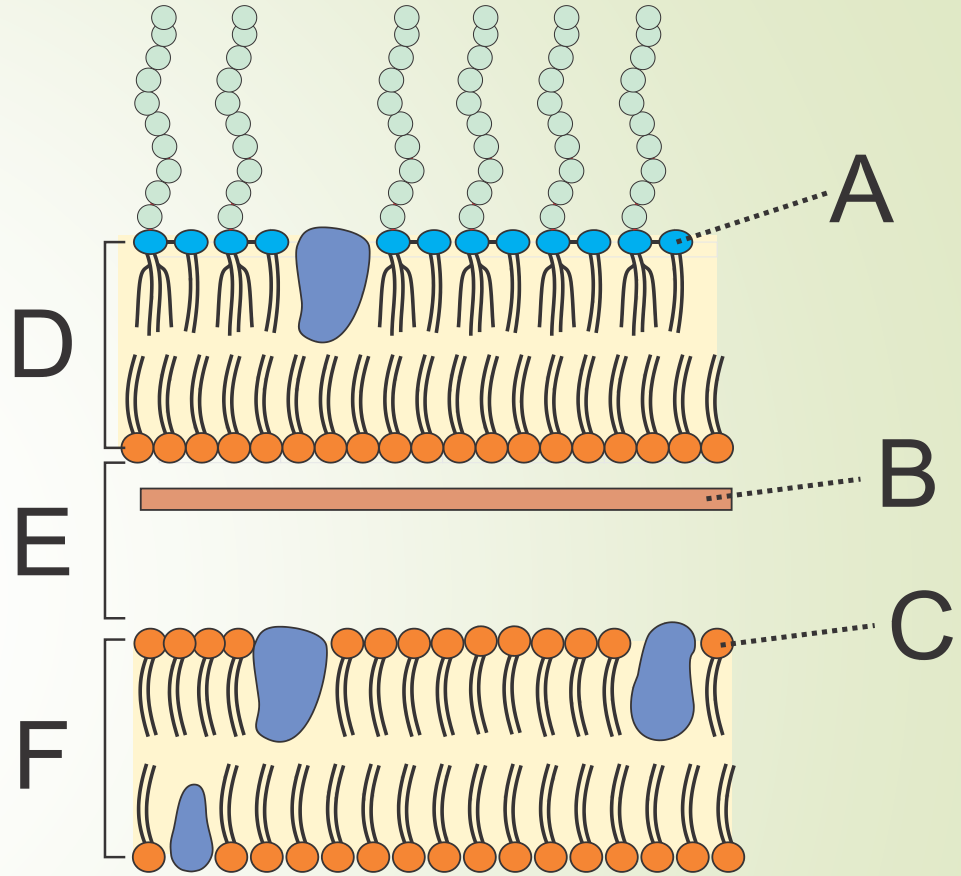
D:……

E:……



12. Fill in the spaces

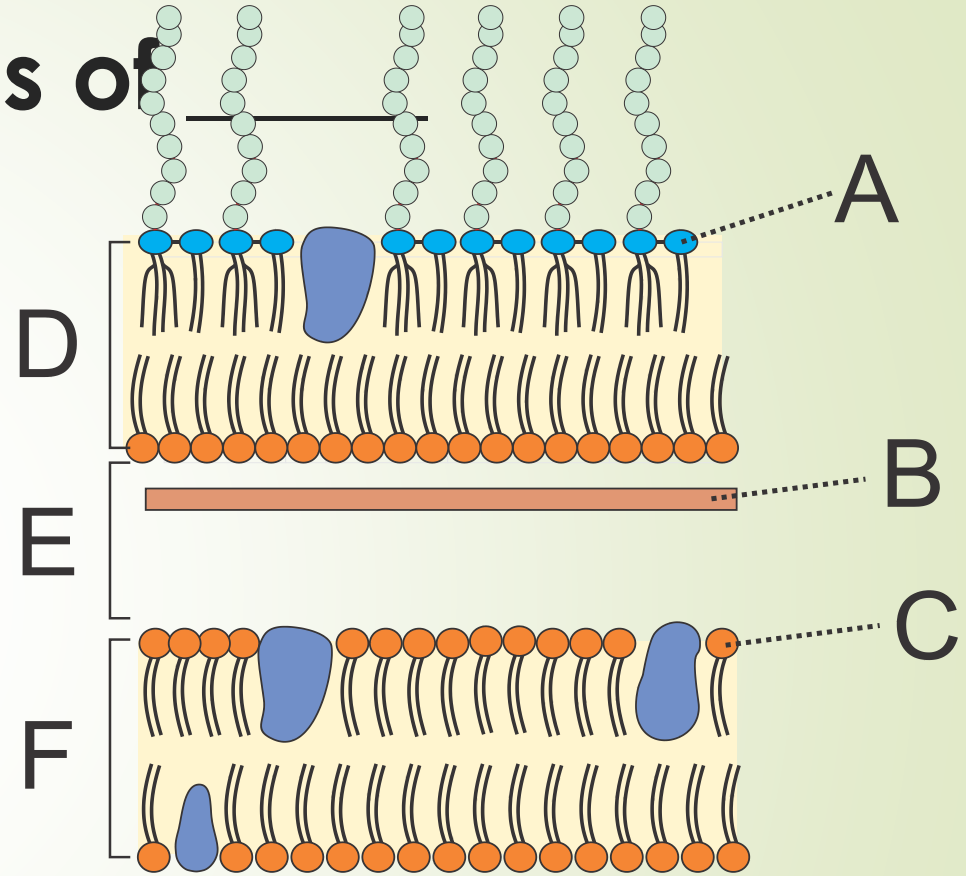
- A:……
- B:……
- C:……
- D:……
- E:……



13. This cell wall diagram is of Bacteria

A. Gram positive.

B. Gram negative.



14. True or False:

A. The toxic part of the cell wall is the peptidoglycan.

B. The toxic part of the cell wall is Lipopolysaccharide.

C. Plasmids carries essential genetic information of the cell.

D. Plasmids carries non-essential genes such as antibiotic resistance. genes.

E. Selective permeability is a function of bacterial cell wall.

F. Selective permeability is a function of bacterial cell membrane.