Department of biology

2025-2026

((MICROBIOLOGY))

Stage (-2-)

LEC- ((5))

(Bacterial cell structure - Gram positive & Gram negative)

By

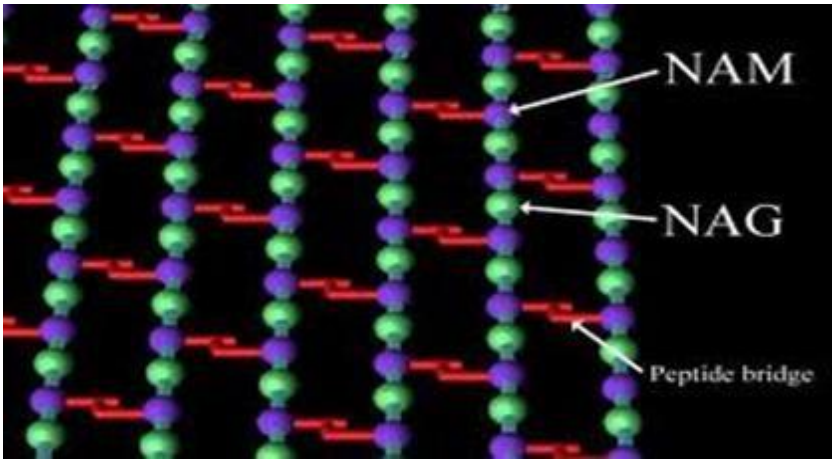
Asst. Lecturer ALI ALAWADI

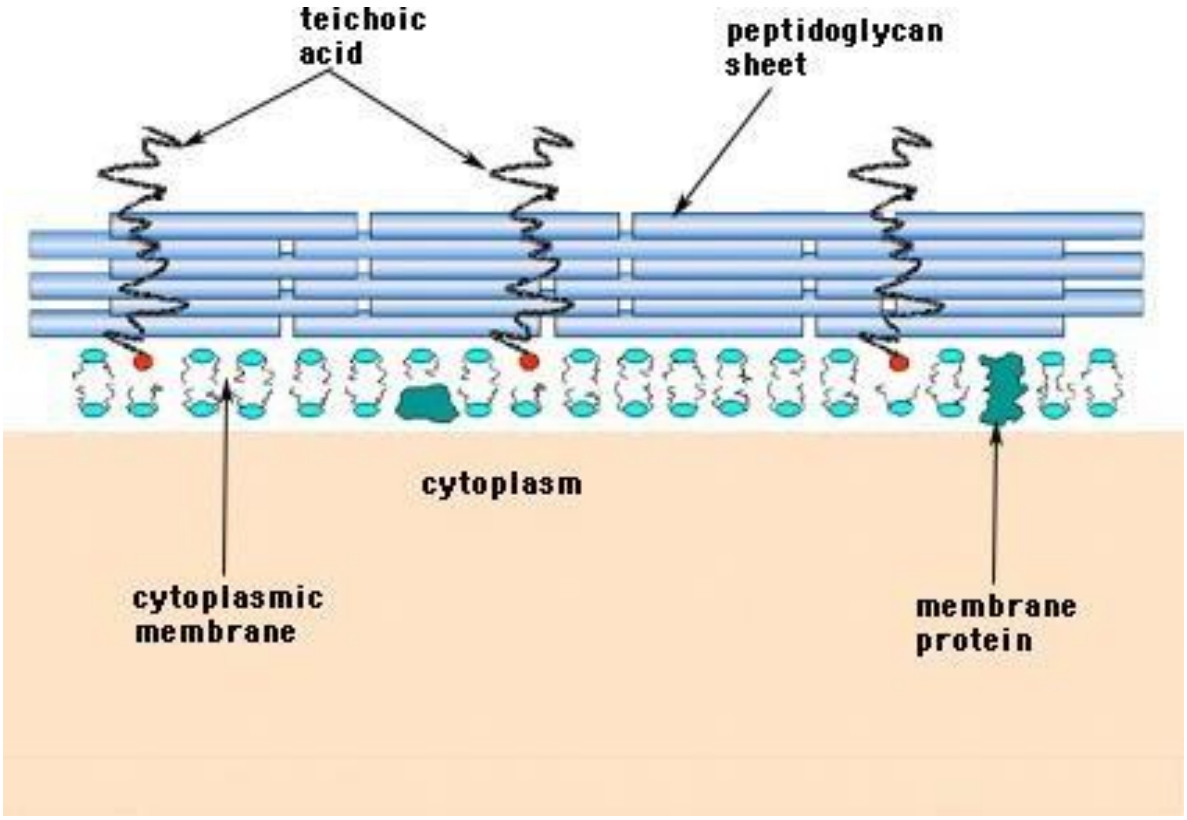
Cell wall

- Outer covering of most cells that protects the bacterial cell and gives it shape (spherical, rod and spiral).
- Composed of peptidoglycan (polysaccharides + protein)
- Mycoplasma are bacteria that have no cell wall and therefore have no definite shape.
- Peptidoglycan - molecule found only in bacterial cell walls.
- The rigid structure of peptidoglycan gives the bacterial cell shape, surrounds the plasma membrane and provides prokaryotes with protection from the environment
- From the peptidoglycan inwards all bacterial cells are similar.
- Going further out, the bacterial world divides into two major classes: **Gram-positive** and **Gram-negative** .
- Amount and location of peptidoglycan in the cell wall determines whether a bacterium is G+ve or G-ve

Peptidoglycan = (polysaccharides + protein)

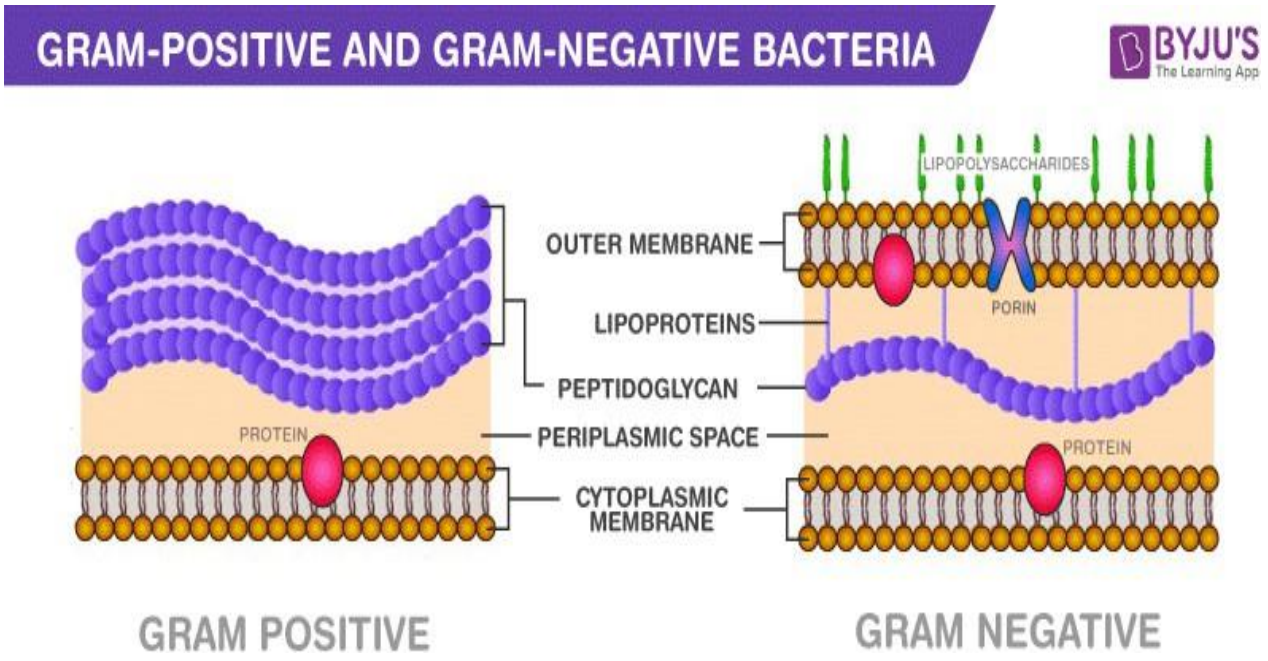
- Peptidoglycan (murein)- huge polymer of interlocking chains composed of similar monomers.
- **peptidoglycan** is made from polysaccharide chains cross- linked by peptides containing D-amino acids
- The backbone of the peptidoglycan molecule is composed of two derivatives of glucose:
- N-acetylglucosamine (NAG)
- N-acetlymuramic acid (NAM).
- The NAG and NAM strands are connected by inter peptide bridges.





Gram-positive Cells

- **G+ve bacteria** possess thick cell wall containing many layers of peptidoglycan and **teichoic acids**.
- In G+ ve cells, peptidoglycan is the outermost structure and makes up as much as 90% of the thick compact cell wall.



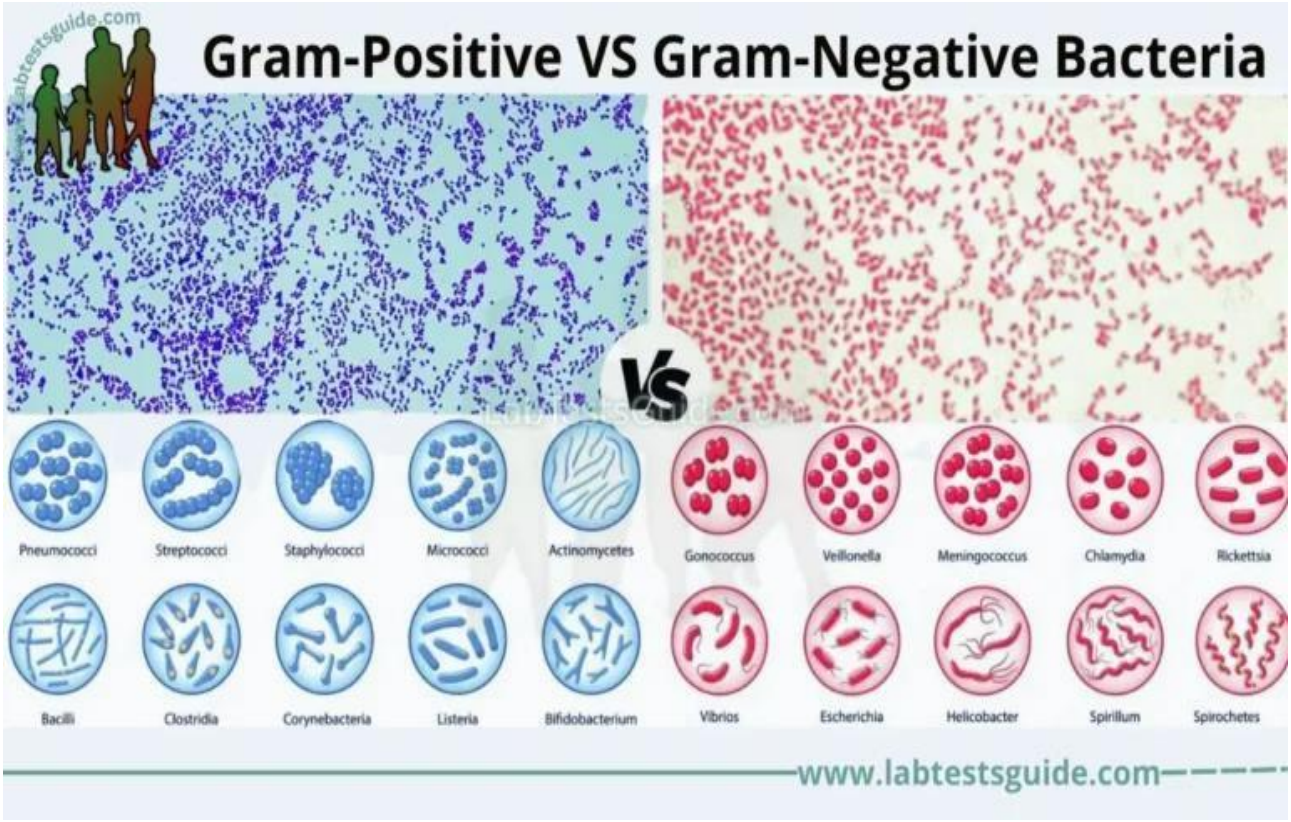
Gram-negative

- **G-ve bacteria** have relatively thin cell wall consisting of few layers of peptidoglycan surrounded by a second lipid membrane containing **lipopolysaccharides** and lipoproteins
- Peptidoglycan makes up only 5 – 20% of the cell wall and is not the outermost layer, but lies between the plasma membrane and an outer membrane.

	Gram-Positive bacteria	Gram-Negative bacteria
Cell Wall	A single-layered, smooth cell wall	A double-layered, wavy cell-wall
Cell Wall thickness	The thickness of the cell wall is 20 to 80 nanometres	The thickness of the cell wall is 8 to 10 nanometres
Peptidoglycan Layer	It is a thick layer/ also can be multilayered	It is a thin layer/ often single-layered.
Teichoic acids	Presence	Absence
Outer membrane	Absent	The outer membrane is present (mostly)
Porins	Absent	Present
Mesosome	It is more prominent.	It is less prominent.
Morphology	Cocci or spore-forming rods	Non-spore forming rods.
Flagella Structure	Two rings in basal body	Four rings in basal body
Lipid content	Very low	20 to 30%
Lipopolysaccharide	**Absent**	**Present**
Toxin Produced	Exotoxins	Endotoxins or Exotoxins
Resistance to Antibiotic	More susceptible	More resistant
Examples	Staphylococcus, Streptococcus, etc.	Escherichia, Salmonella, etc.
Gram Staining	These bacteria retain the crystal violet colour even after they are washed with acetone or alcohol and appear as purple-coloured when examined under the microscope after gram staining.	These bacteria do not retain the stain colour even after they are washed with acetone or alcohol and appear as pink-coloured when examined under the microscope after gram staining.

Gram Staining

- Developed in 1884 by Danish scientist Christian Gram.
- It is a differential stain.
- In this, bacteria are first stained with crystal violet, then treated with a mordant - a solution that fixes the stain inside the cell.
- Bacteria are then washed with a decolorizing agent, such as alcohol, and counterstained with safranin, a light red dye.



Gram Staining

- **Gram-positive bacteria** are those that are stained dark blue or violet by Gram staining.
- **Gram-negative bacteria** cannot retain the crystal violet stain, instead take up the counterstain and appearred or pink.
- The walls of gram-positive bacteria have more peptidoglycans than do gram-negative bacteria. Thus, gram- positive bacteria retain the original violet dye and cannot be counterstained.

Cell wall

- If the bacterial cell wall is entirely removed, it is called a **protoplast** while if it's partially removed, it is called a **spheroplast**.
- Antibiotics such as penicillin inhibit the formation of peptidoglycan cross-links in the bacterial cell wall.
- The enzyme **lysozyme**, found in human tears, also digests the cell wall of bacteria and is the body's main defense against eye infections.

outer membrane

- Similar to the plasma membrane, but is less permeable.
- This membrane has tiny holes or openings called **porins**.
- **Porins** block the entrance of harmful chemicals and antibiotics, making G-ve bacteria much more difficult to treat than G+ve cells.
- Composed of lipopolysaccharides (LPS).
- **LPS** is a harmful substance classified as an **endotoxin.**

outer membrane

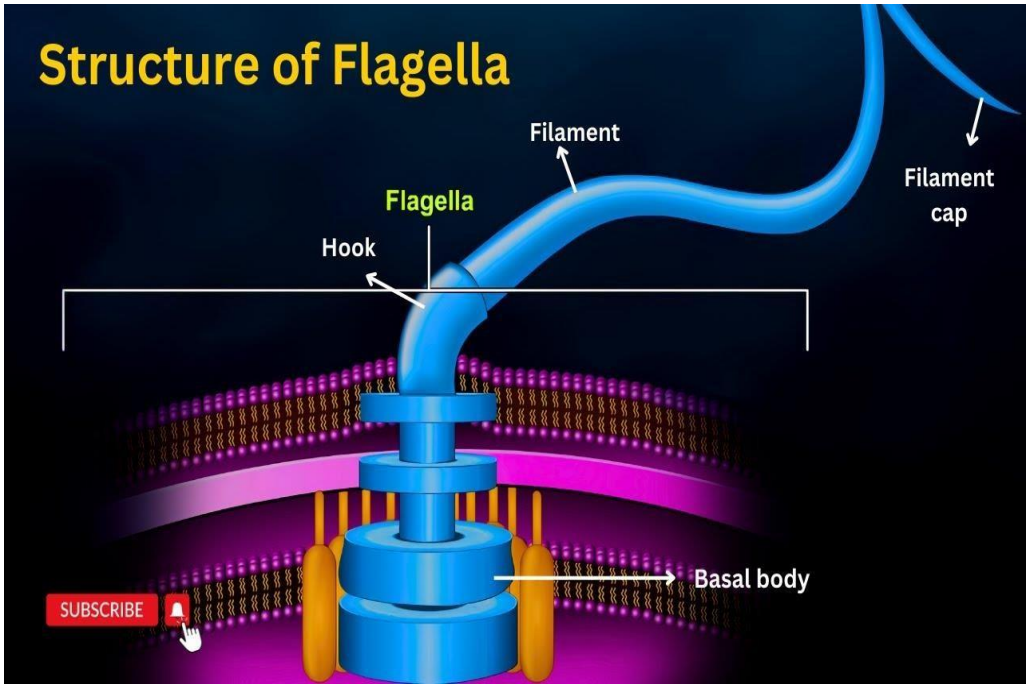
- Lipopolysaccharides, which acts as an **endotoxin**, are composed of **polysaccharides** and **lipid A** (responsible for much of the toxicity of G- ve bacteria).
- These differences in structure can produce differences in antibiotic susceptibility
- Ex: vancomycin can kill only Gram +ve bacteria and is ineffective against Gram -ve pathogens, such as *Haemophilus influenzae* or *Pseudomonas aeruginosa.*

External structures

- Flagella
- Pili/fimbriae
- Capsule/slime layer

Flagella

- Singular: flagellum
- thin hair-like structures often much longer than the cell itself, and used for locomotion in many bacteria.
- It is rigid cylindrical filament made of the protein flagellin.
- Each flagellum is attached to cell membrane with the help of proteins other than flagellin.



- The basal region has a hook like structure and a complex basal body. The basal body consists of a central rod or shaft surrounded by a set of rings and is

more complex in Gram- negative than Gram-positive bacteria.

- Rotation of the flagellum is an energy-dependent process driven by the basal body, and the direction of rotation determines the nature of the resulting cellular movement.
- Bacterial spp differ in the number and arrangement of flagella on their surface.
- Bacteria may have one, a few, or many flagella in different positions on the cell.

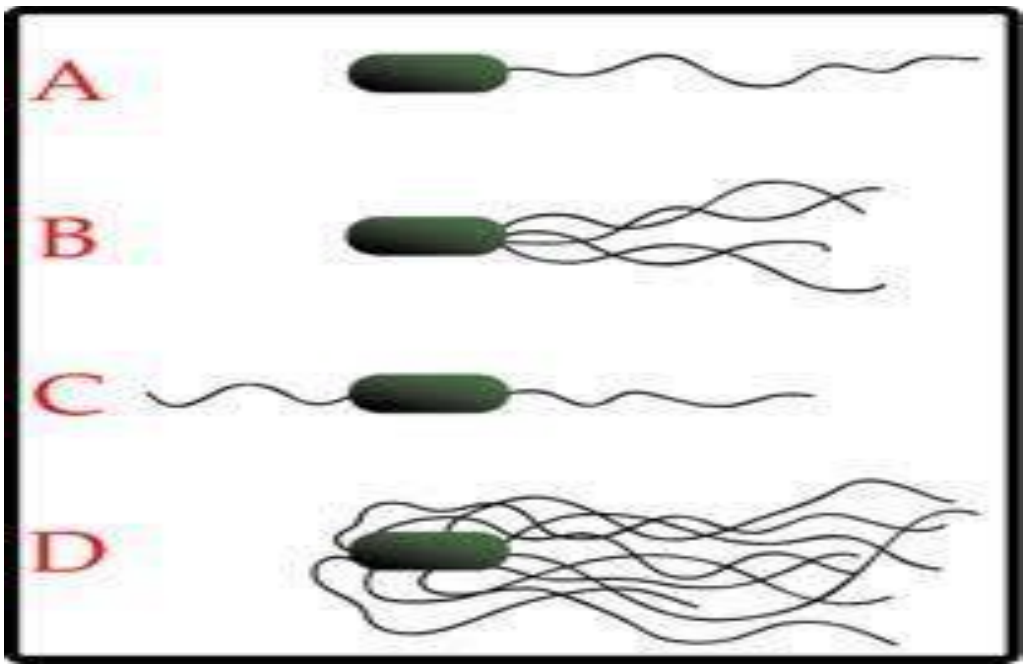
A. **Monotrichous** - single flagellum (polar)

B. **lophotrichous –** clusters of flagella at the poles of the cell

C. **amphitrichous** a flagellum at each end

D. **peritrichous** - flagella distributed over the entire surface of the cell .

Arrangement of flagella



- Motile bacteria are attracted or repelled by certain stimuli in behaviors called **taxis**: these include chemotaxis, phototaxis, and magnetotaxis.
- The flagella beat in a propeller-like motion to help the bacterium move toward nutrients; away from toxic chemicals; towards the light (photosynthetic cyanobacteria).
- Prokaryotes exhibit a variety of movements:

move , swim ,tumble ,glide, swarm in response to environmental stimuli.

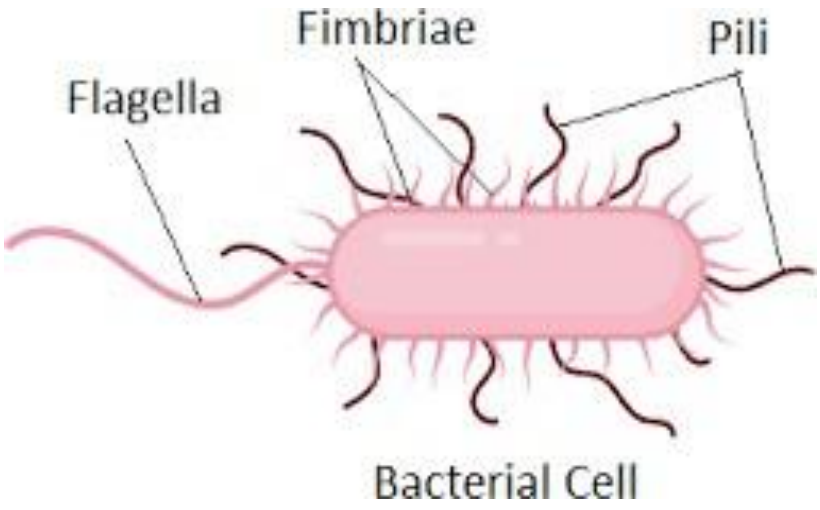
Fimbriae and Pili

- Hollow, hair like structures made of protein
- Pili (sing: pilus) are structures that superficially resemble short flagella.
- They differ from flagella, in that they:

  1. do not penetrate to the plasma membrane

  2. are not associated with motility.

- Their function, rather, is to anchor the bacterium to an appropriate surface. Pathogenic (disease-causing) bacteria have proteins called adhesins on their pili, which adhere to specific receptors on host tissues.



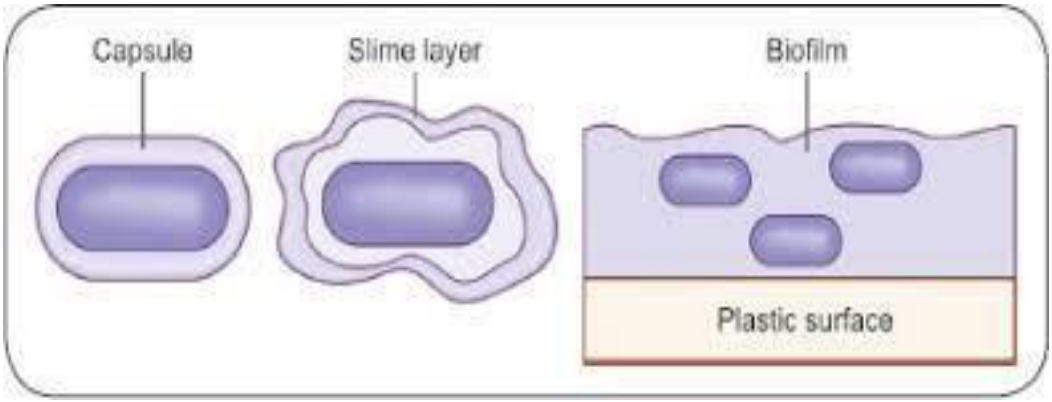
- **Fimbriae** fine filaments of protein. They are distributed over the surface of the cell, and resemble fine hairs when seen under the electron microscope.
- **Pili: (***sing*. pilus) are cellular appendages, slightly larger than fimbriae
- Involved in attachment to surfaces.
- Specialized pili, the sex pili, allows the transfer of genetic material from one bacteria to another in a process called conjugation where they are called **conjugation pili** or "sex pili".
- **type IV pili -** generate movement**.**

Helps in colonization and pathogenicity.

Glycocalyx

- **Glycocalyx** : sticky coating produced by many bacteria covering the surface of cell.
- The glycocalyx is composed of polysaccharides (sugars) and proteins.
- The bacterial glycocalyx has 2 forms

- a highly structured **rigid capsule**
- a disorganised **loose slime layer -**
- Capsules are found on many pathogenic bacteria



- Slime layer is a diffuse and loosely bound. It helps protect against desiccation and is instrumental in the attachment of certain bacteria to a substratum (the bacteria that stick to your teeth are a good example of this).
- Capsule is a better defined and generally thicker. It offers protection to certain pathogenic bacteria against the phagocytic cells of the immune system.