A study material for M.Sc. Biochemistry (Semester: IV) Students
on the topic (EC-1; Unit II)

Structure of Bacteria

Except the Cell Wall

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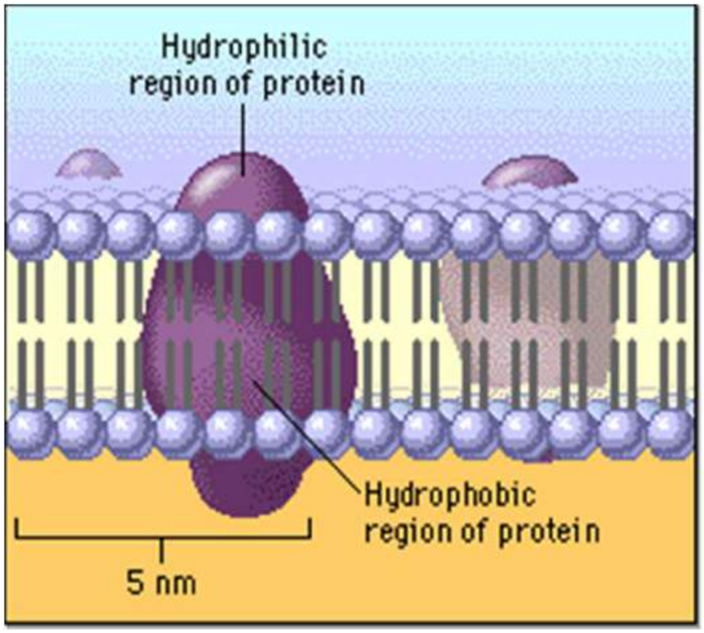
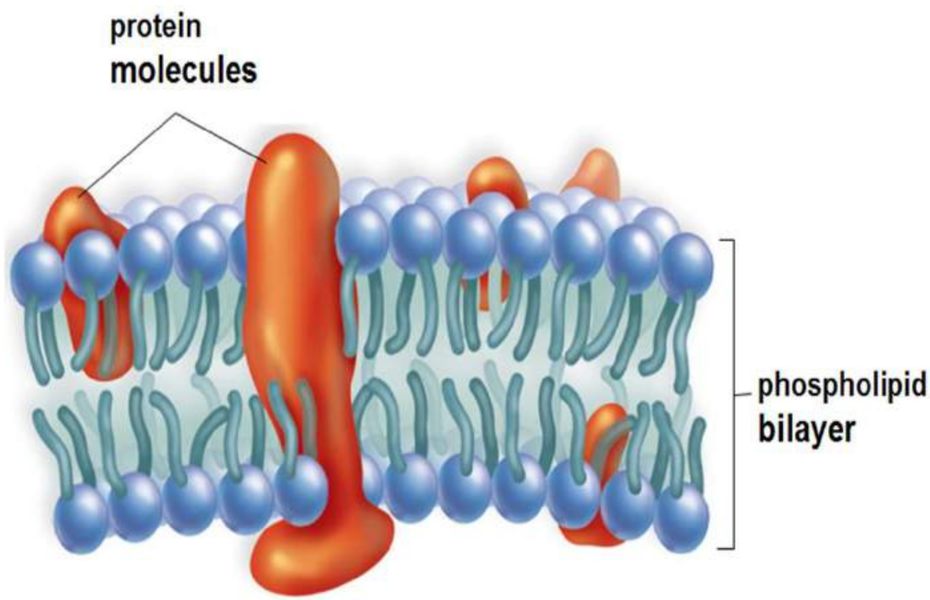
Cell Membrane

- **Boundary layer of cytoplasm**
- **Provide rigidity,**
- **Selectively permeability barrier**
- **Location of many metabolic processes (Respiration, Photosynthesis)**
- **It contains special receptor molecules that respond to chemical in their surroundings.**
- **Help in Phagocytosis**
- **Electron transport and oxidative phosphorylation**
- **Excretion of hydrolytic exoenzymes**

Cell membrane





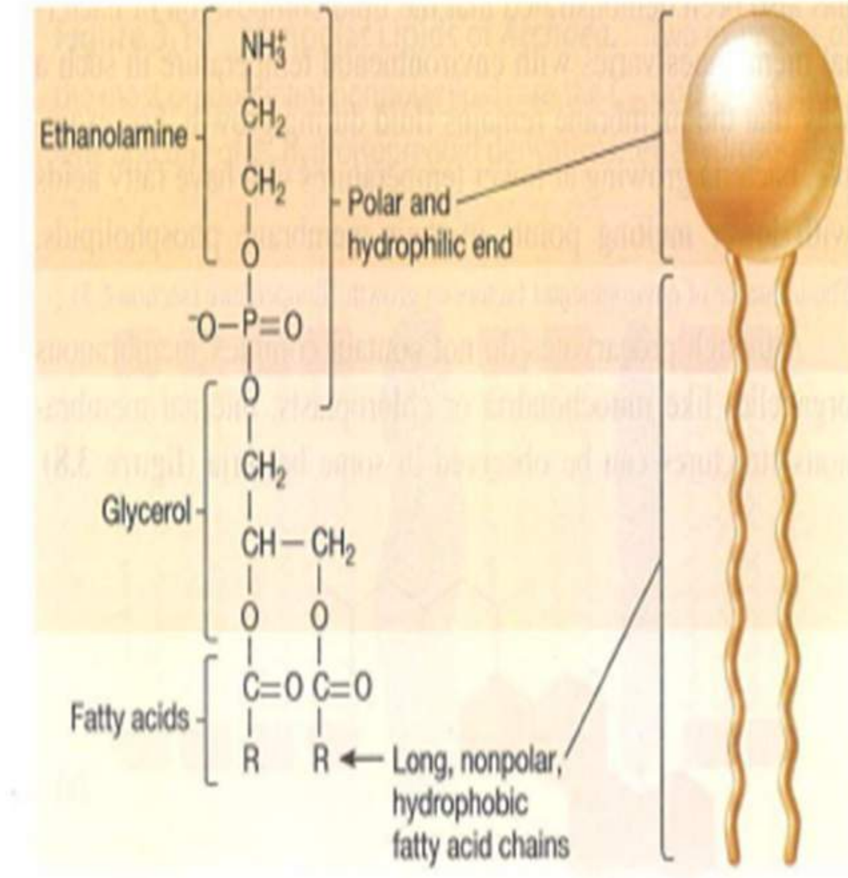


Figure 3.6 The Structure of a Polar Membrane Lipid. Phosphatidylethanolamine, an amphipathic phospholipid often found in bacterial membranes. The R groups are long, nonpolar fatty acid chains.

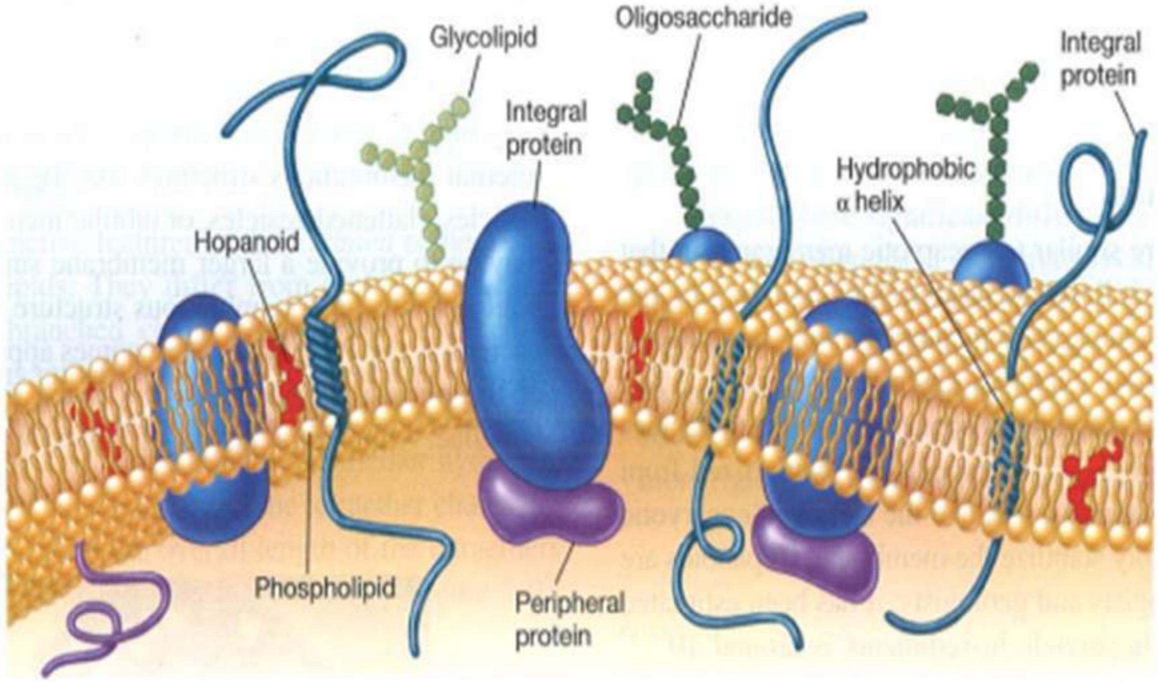


Figure 3.5 Bacterial Plasma Membrane Structure. This diagram of the fluid mosaic model of bacterial membrane structure shows the integral proteins (blue) floating in a lipid bilayer. Peripheral proteins (purple) are associated loosely with the inner membrane surface. Small spheres represent the hydrophilic ends of membrane phospholipids and wiggly tails, the hydrophobic fatty acid chains. Other membrane lipids such as hopanoids (red) may be present. For the sake of clarity, phospholipids are shown in proportionately much larger size than in real membranes.

Bacterial membranes usually differ from euckryotic membranes in lacking sterols such as cholesterol (figure 3.6a). However, many bacterial membranes do contain pentacyclic sterol-like molecules called hopanoids

Mesosomes

- A large invaginations of the plasma membrane, irregular in shape.
- Increase in membrane surface, which may be useful as a site for enzyme activity in respiration and transport.
- It may participate in cell replication by serving as a place of attachment for the bacterial chromosome.

Cytoplasm

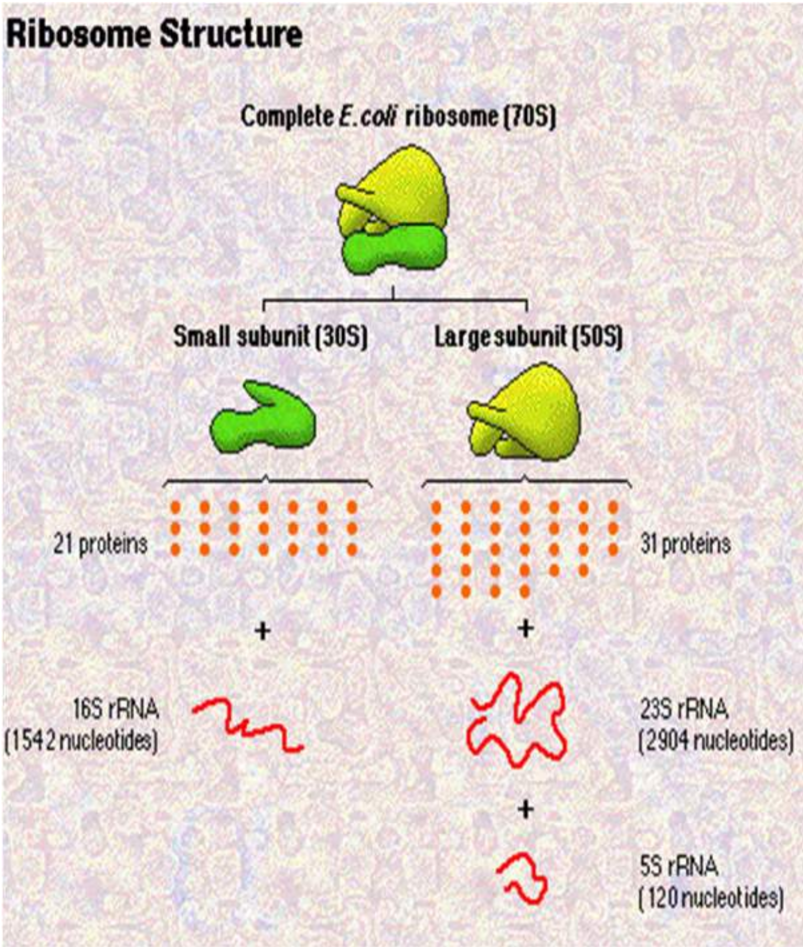
- Composed largely of water, together with proteins, nucleic acid, lipids and small amount of sugars and salts
- Ribosomes: numerous, 15-20nm in diameter with 70S; distributed throughout the cytoplasm; sensitive to streptomycin and erythromycin site of protein synthesis

- Plasmids: extra chromosomal genetic elements
- Nucleoid:

•Lacking nuclear membrane, absence of nucleoli, hence known as nucleic material or nucleoid.

•It is made up of 60% DNA, 30% RNA, and 10% protein by weight.

•Bacteria do not use histone proteins to package their DNA



Plasmid

- Plasmids are small, circular/linear, extrachromosomal, double-stranded DNA molecules.
- They are capable of self-replication and contain genes that confer some properties, such as antibiotic resistance, virulence factors.
- Plasmids are not essential for cellular survival.
- Plasmid are inherited stably during cell division , but they are not always equally apportioned in to daughter cells and some time lost. The lost of plasmid is called **curing**

Types of plasmid

- Conjugative plasmid (F factor):
- R Plasmid:
- Col plasmid
- Virulence plasmid
- Metabolic plasmid

Fertility Factors

A plasmid called the fertility or **F factor** plays a major role in conjugation in *E. coli* and was the first to be described (**figure 13.5**). The F factor is about 100 kilobases long and bears genes responsible for cell attachment and plasmid transfer between specific bacterial strains during conjugation. Most of the information required for plasmid transfer is located in the *tra* operon, which contains at least 28 genes. Many of these direct the formation of sex pili that attach the F^+ cell (the donor cell containing an F plasmid) to an F^- cell (**figure 13.6**). Other gene products aid DNA transfer. Sex pili (p. 63)

The F factor also has several segments called insertion sequences (p. 298) that assist plasmid integration into the host cell chromosome. Thus the F factor is an episome that can exist outside the bacterial chromosome or be integrated into it (**figure 13.7**).

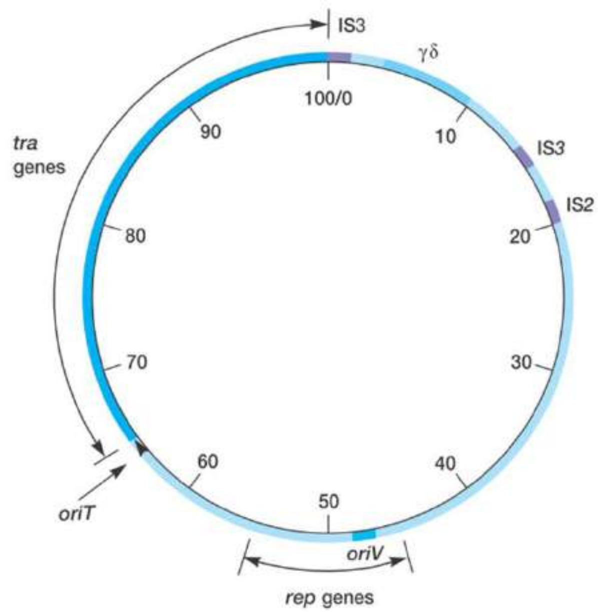


Figure 13.5 The F plasmid. A map showing the size and general organization of the F plasmid. The plasmid contains several transposable elements. IS2 and IS3 are insertion sequences; γδ is also called transposon Tn*1000*. The *tra* genes code for proteins needed in pilus synthesis and conjugation. The *rep* genes code for proteins involved in DNA replication. *OriV* is the initiation site for circular DNA replication and *oriT*, the site for initiation of rolling circle replication and gene transfer during conjugation.

Resistance Factors

Plasmids often confer antibiotic resistance on the bacteria that contain them. **R factors** or plasmids typically have genes that code for enzymes capable of destroying or modifying antibiotics. They are not usually integrated into the host chromosome. Genes coding for resistance to antibiotics such as ampicillin, chloramphenicol, and kanamycin have been found in plasmids. Some R plasmids have only a single resistance gene, whereas others can have as many as eight. Often the resistance genes are within a transposon (p. 298), and thus it is possible for bacterial strains to rapidly develop multiple resistance plasmids. R factors and antibiotic resistance (p. 819)

Col Plasmids

Bacteria also harbor plasmids with genes that may give them a competitive advantage in the microbial world. **Bacteriocins** are bacterial proteins that destroy other bacteria. They usually act only against closely related strains. Bacteriocins often kill cells by forming channels in the plasma membrane, thus increasing its permeability. They also may degrade DNA and RNA or attack peptidoglycan and weaken the cell wall. Col plasmids contain genes for the synthesis of bacteriocins known as colicins, which are directed against *E. coli*. Similar plasmids carry genes for bacteriocins against other species. For example, Col plasmids produce cloacins that kill *Enterobacter* species. Clearly the host is unaffected by the bacteriocin it produces. Some Col plasmids are conjugative and also can carry resistance genes. Bacteriocins and host defenses (p. 712)

Other Types of Plasmids

Several other important types of plasmids have been discovered. Some plasmids, called **virulence plasmids,** make their hosts more pathogenic because the bacterium is better able to resist host defense or to produce toxins. For example, enterotoxigenic strains of *E. coli* cause traveler's diarrhea because of a plasmid that codes for an enterotoxin (**Box 13.1**). **Metabolic plasmids** carry genes for enzymes that degrade substances such as aromatic compounds (toluene), pesticides (2,4-dichlorophenoxyacetic acid), and sugars (lactose). Metabolic plasmids even carry the genes required for some strains of *Rhizobium* to induce legume nodulation and carry out nitrogen fixation.

Inclusion Bodies

- Not separate by a membrane but distinct .
- Granules of organic or inorganic material
- Used for storage i.e. carbon compound, inorganic substances, and energy

Granules of various kinds:

Organic inclusion bodies:

- Glycogen or polyhydroxybutyric acid droplets (PHB) . Glycogen and PHB inclusion bodies are carbon storage reservoirs providing material for energy and biosysnthesis.
- Gas Vacuoles: a structure that provides buoyancy to some aquatic prokaryotes.

Inorganic Inclusion bodies:

Polyphosphate or volutin granules and Sulphur granules

Polyphosphate or volutin granules

It is a linear polymer of orthophosphate joined by ester bond. Thus volutin granules function as storage reservoirs for phosphate, an important component of cell constituents such as nucleic acid. It also act as an energy reserve.

- These granules are also called metachromatic granules because they show the metachromatic effect; i.e. they appear red or a different shade of blue.

Sulphur granules: Store sulphur

Structures external to the Cell Wall: Glycocalyx, Flagella, Axial filaments, and Pili

1- Glycocalyx and Capsule:

- Many bacteria synthesize large amounts of extracellular polymers when growing in their natural environments.

- These polymers form capsules or glycocalyx. Its chemical nature may be polysaccharide as in the *Pneumococcus* or polypeptide as in *Bacillus anthracis* .

- When these polymers closely surrounding the cell; it is called Capsule, But if these polymers form a loose meshwork of fibrils extending outward from the cell; it is called glycocalyx.

- Function of capsule or glycocalyx is to protect bacterial cells from phagocytosis. It also help in attachment.

2-Flagella

- Motile bacteria possess filamentous appendages known as flagella, which act as organs of locomotion.
- Flagella are associated with chemotaxis process (chemical attraction)
- The flagellum is a long, thin filament, twisted spirally in an open, regular waveform.
- It is about 0.02 µm thick and is usually several times the length of the bacterial cell.
- According to the species, there may be one, or up to 20, flagella per cell.

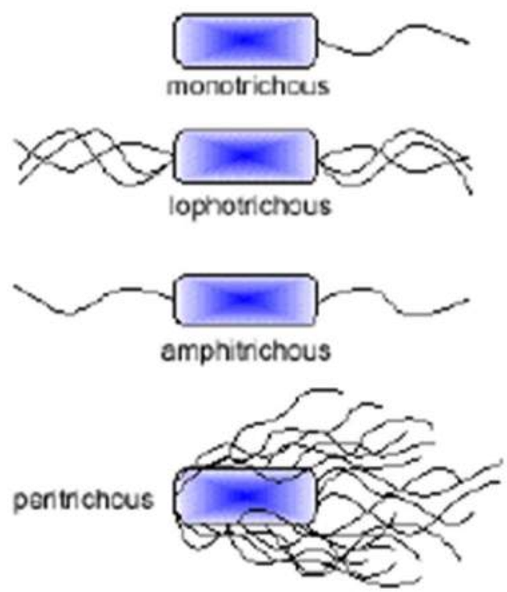
Flagella may be classified according to there arrangement as follow:

1- Monotrichous (single polar flagellum).

2- Lophotrichous (tuft of polar flagella).

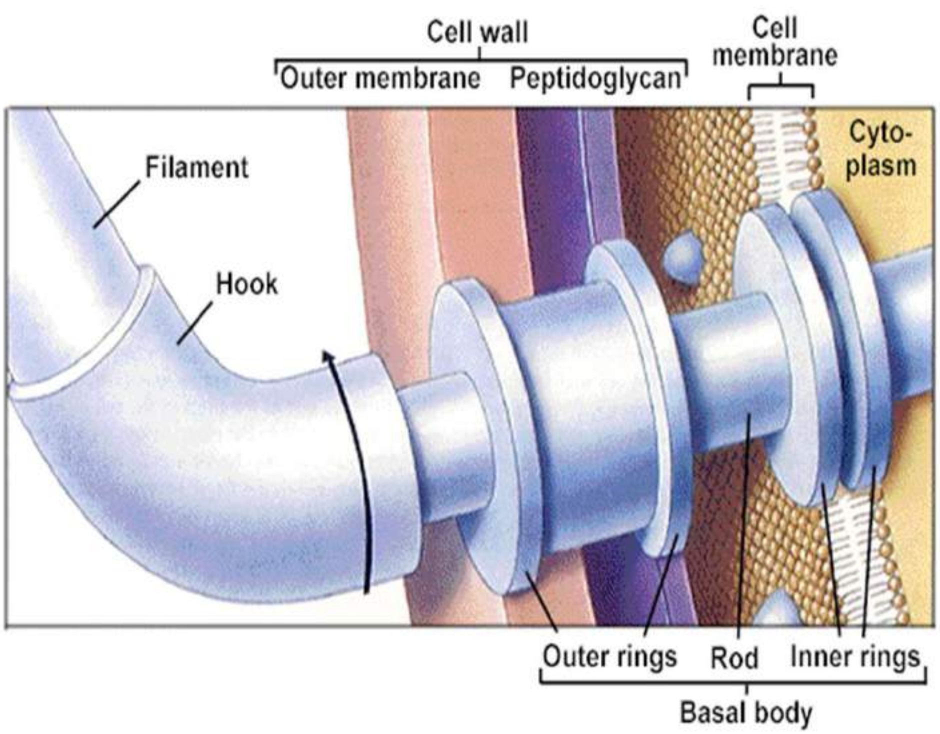
3- Perituichous (flagella distributed over the cell).

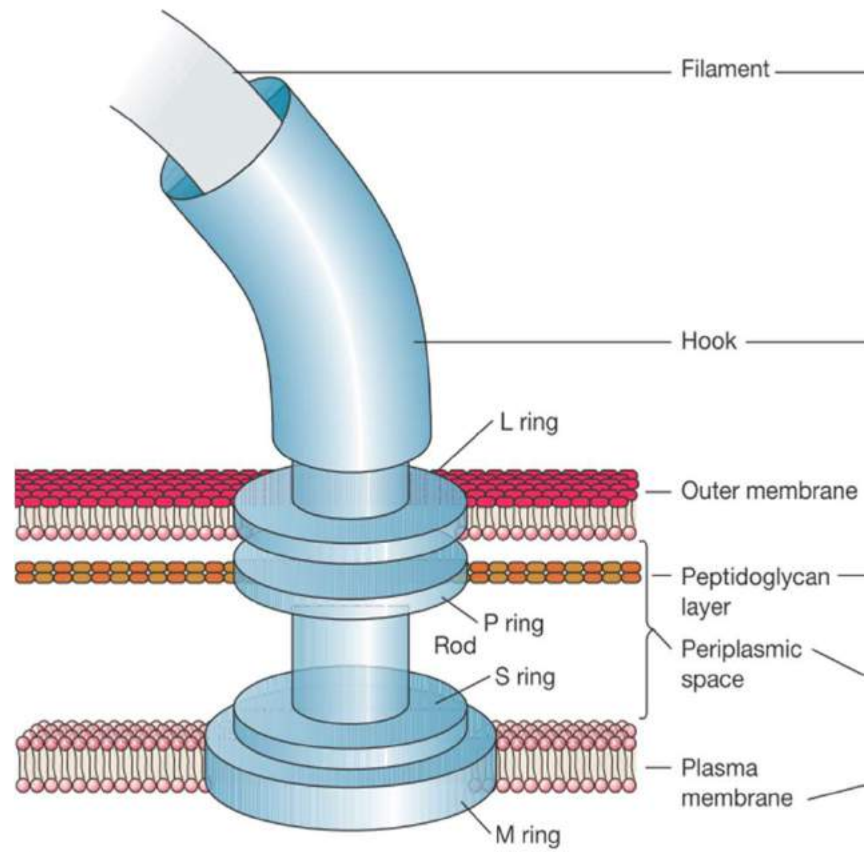
4- Amphitrichous (one flagellum at each side of cell).



Ultra structure of Flagella

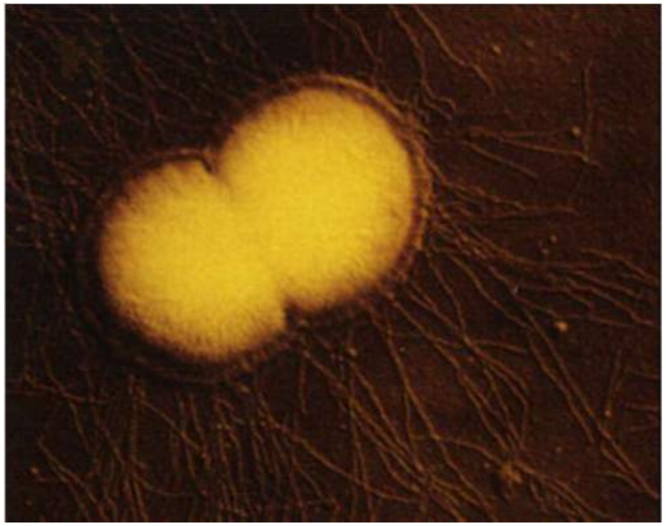
- Composed of filament, hook, and basal body
- Flagellin protein (filament) is deposited in a helix at the lengthening tip
- Base of filament inserts into hook
- Basal body anchors filament and hook to cell wall by a rod and a series of either two or four rings of integral proteins

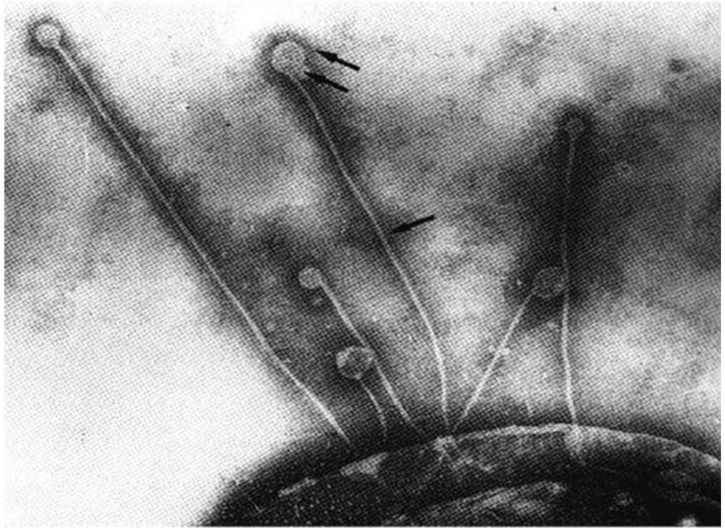




a)

3- Pili





- **Pili are hair-like projections of the cell , They are known to be receptors for certain bacterial viruses. Chemical nature is pilin**
- **Classification and Function**

a. Common pili or fimbriae: fine , rigid numerous, related to bacterial adhesion

b. Sex pili: longer and coarser, only 1-4, related to bacterial conjugation

Acknowledgement and Suggested Readings:

1. Microbiology, An Introduction; Tortora, Funke and Case; Pearson Publication
2. Microbiology; Prescott, Harley and Klein; The MacGraw-Hill Companies
3. Microbiology: Principles and Explorations; Jacquelyn G Black; John Wiley and Sons Inc.
4. Brock Biology of Microorganisms; Madigan, Martinko, Stahl and Clark; Benjamin Cummings (Pearson Publication)

Thanks