BACTERIAL CELL MEMBRANE

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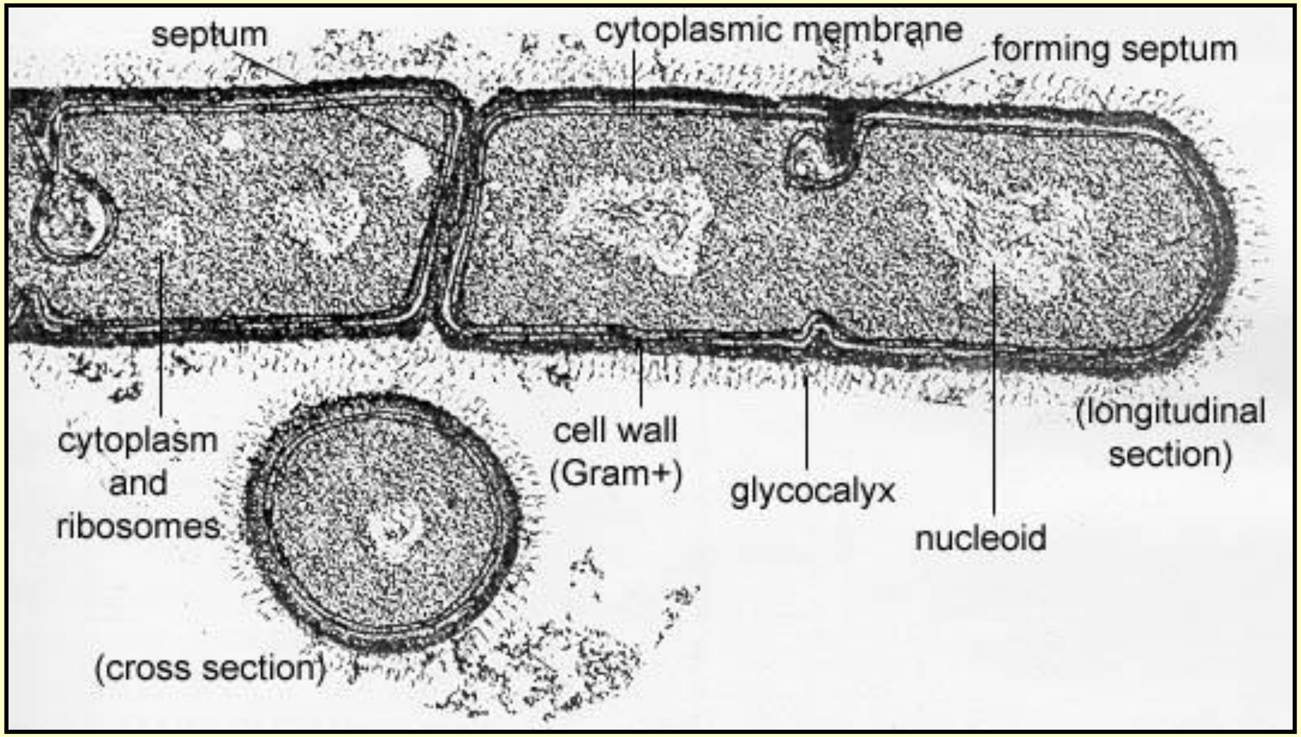
CYTOPLASMIC MEMBRANE

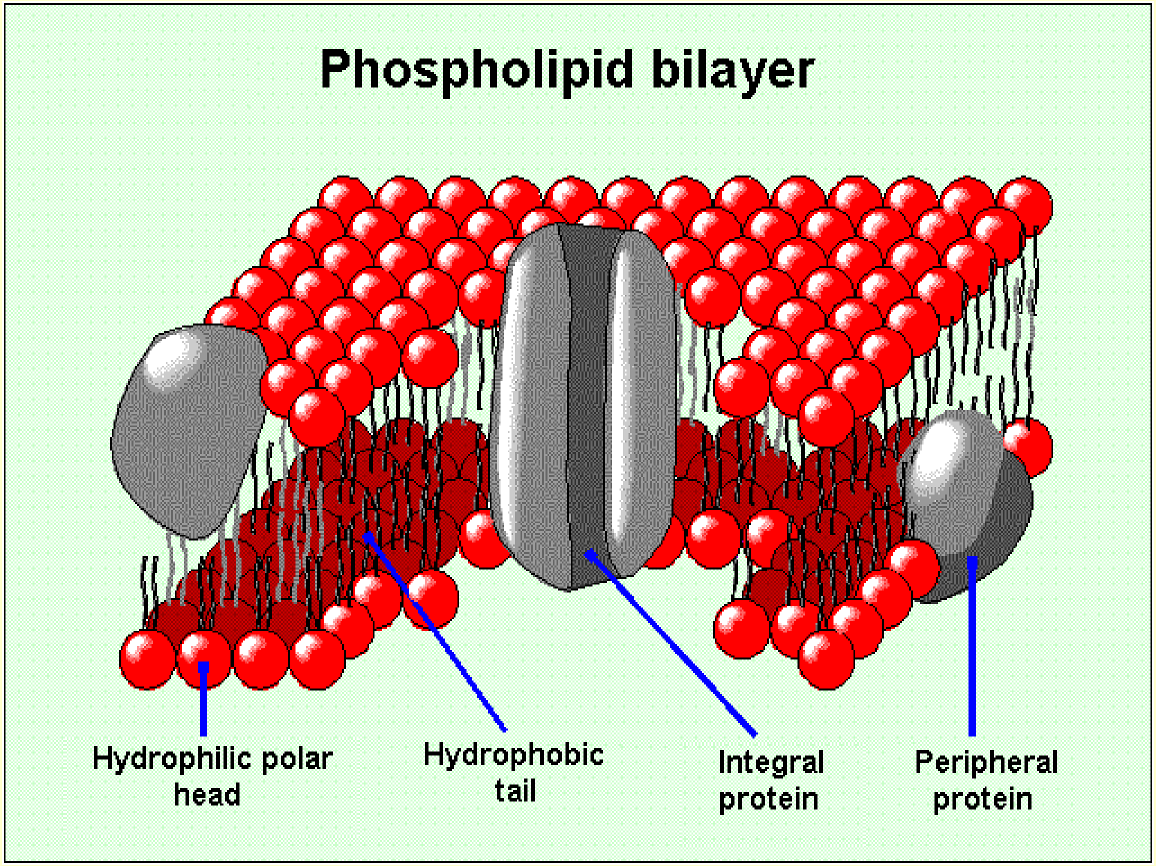
- **The cytoplasmic membrane, also called a cell membrane or plasma membrane, is about 7 nanometers (nm; 1/1,000,000,000 m) thick.**
- **It lies internal to the cell wall and encloses the cytoplasm of the bacterium.**
- **It is the most dynamic structure of a prokaryotic cell.**



Structure of cell membrane

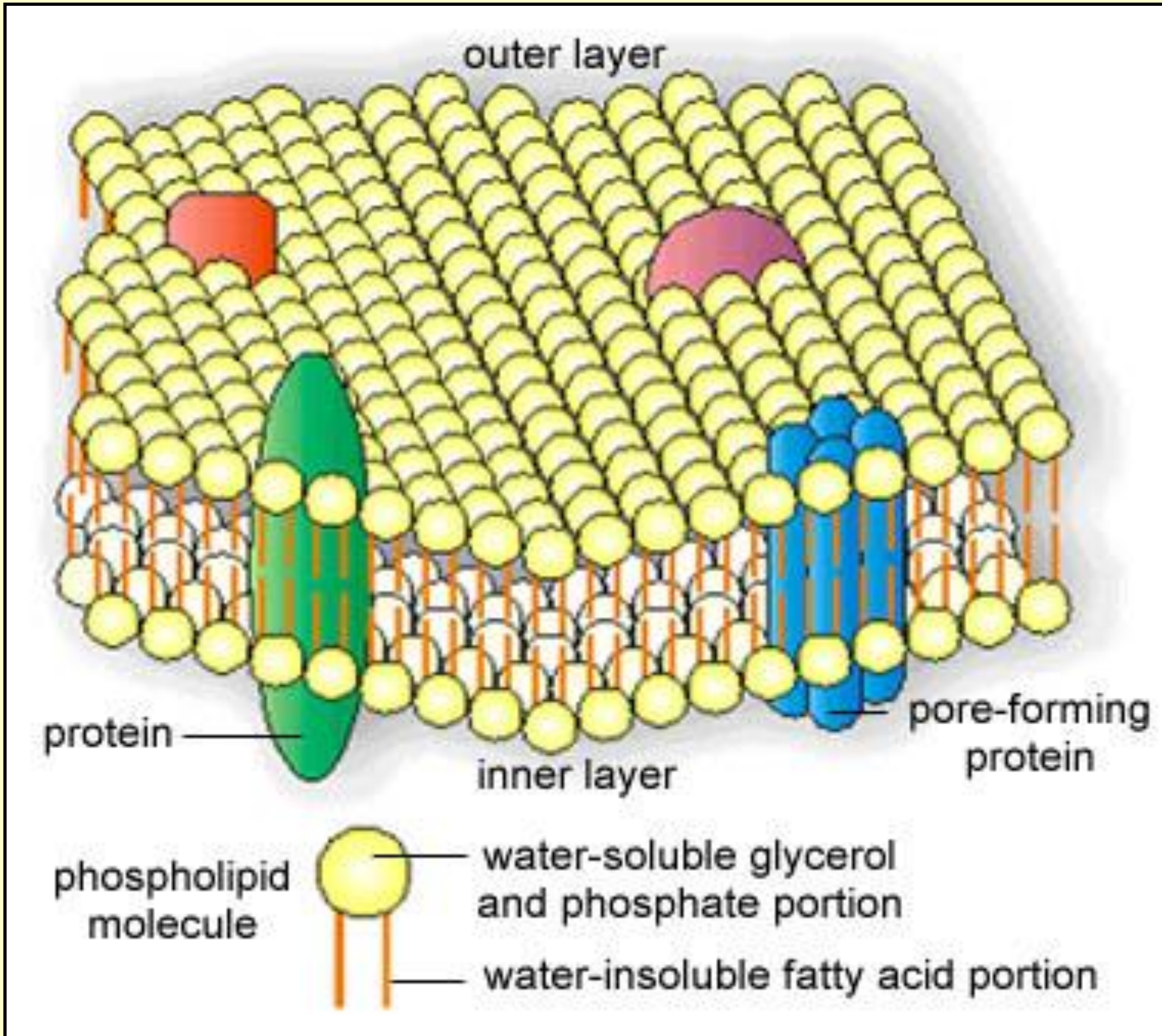
- **The structure of bacterial plasma membrane is that of unit membrane, i.e., a fluid phospholipid bilayer, composed of phospholipids (40%) and peripheral and integral proteins (60%) molecules.**
- **The phospholipids of bacterial cell membranes do not contain sterols as in eukaryotes, but instead consist of saturated or monounsaturated fatty acids (rarely, polyunsaturated fatty acids).**
- **Many bacteria contain sterol-like molecules called hopanoids.**
- **The hopanoids most likely stabilize the bacterial cytoplasmic membrane.**

- The **phospholipids are amphoteric molecules** with a polar hydrophilic glycerol "head" attached via an ester bond to two non-polar hydrophobic fatty acid tails.
- The phospholipid bilayer is arranged such that the polar ends of the molecules form the outermost and innermost surface of the membrane while the non-polar ends form the center of the membrane



Fluid mosaic model

- **The plasma membrane contains proteins, sugars, and other lipids in addition to the phospholipids.**
- **The model that describes the arrangement of these substances in lipid bilayer is called the fluid mosaic model**
- **Dispersed within the bilayer are various structural and enzymatic proteins, which carry out most membrane functions.**
- **Some membrane proteins are located and function on one side or another of the membrane (peripheral proteins).**
- **Other proteins are partly inserted into the membrane, or possibly even traverse the membrane as channels from the outside to the inside (integral proteins).**
- **Lipids are capable of rapid diffusion within their layer, but "flip-flopping" from one layer to the other is rare .**


outer layer
protein
inner layer
pore-forming protein
phospholipid molecule
water-soluble glycerol and phosphate portion
water-insoluble fatty acid portion

Functions of cell membrane

- The cytoplasmic membrane is a selectively permeable membrane and act as a osmotic or permeability barrier.
- Location of transport systems for specific solutes (nutrients and ions).
- Energy generating functions - respiratory and photosynthetic electron transport systems, proton motive force, and transmembranous ATP-synthesizing ATPase.
- Synthesis of phospholipids (including membrane lipids and lipopolysaccharide of Gram-negative cells).
- Synthesis of murein, both in the growing cell wall and in the transverse septum that divides the bacterium during bacterial division.
- Assembly and secretion of extracytoplasmic proteins.

- **Coordination of DNA replication and segregation with septum formation during binary fission**
- **Site of insertion for flagella.**
- **Chemotaxis (both motility per se and sensing functions)**
- **Waste removal.**
- **Formation of endospores.**

Besides transport proteins that selectively mediate the passage of substances into and out of the cell, prokaryotic membranes may contain sensing proteins that measure concentrations of molecules in the environment or binding proteins that translocate.

A very few antibiotics, such as polymyxins and tyrocidins as well as many disinfectants and antiseptics, such as orthophenylphenol, chlorhexidine, hexachlorophene, zephiran, alcohol, triclosans, etc., used during disinfection alter the microbial cytoplasmic membranes and cause leakage of cellular needs.

Transport of substances across the bacterial cell membrane by transport (carrier) proteins

For the majority of substances a cell needs for metabolism to cross the cytoplasmic membrane, specific transport proteins (carrier proteins) are required. This is because the concentration of nutrients in most natural environments is typically quite low. Transport proteins allow cells to accumulate nutrients from even a sparse environment.

Examples of transport proteins include channel proteins, uniporters, symporters, antiporters, and the ATP-binding cassette (ABC) system. These proteins transport specific molecules, related groups of molecules, or ions across membranes through either facilitated diffusion or active transport.

Types of Transport Systems

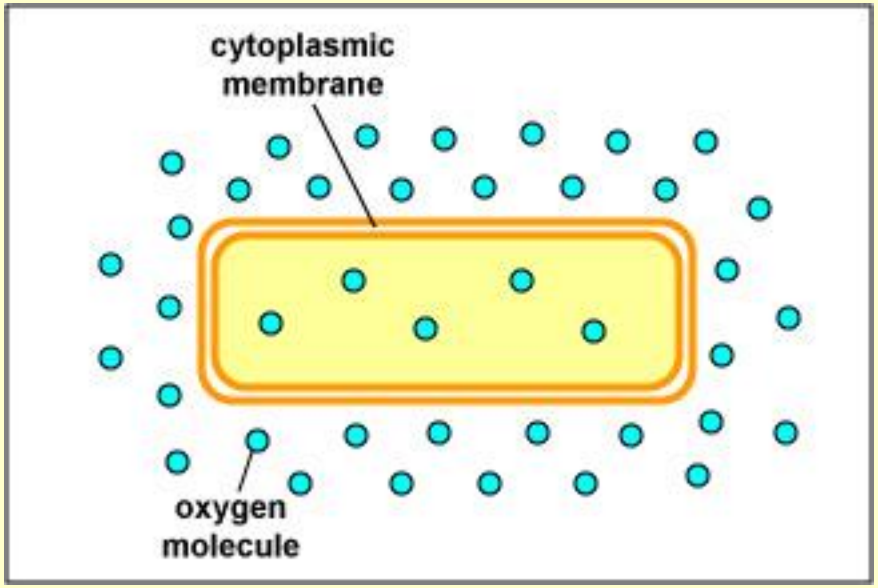
Mechanisms by which materials move across the prokaryotic cytoplasmic membrane are:

- **PASSIVE DIFFUSION (*including osmosis*)**
- **FACILITATED DIFFUSION**
- **ACTIVE TRANSPORT**
  - ***Ion driven transport (IDT)***
  - ***Binding-protein dependent transport (BPDT)***
- **GROUP TRANSLOCATION**

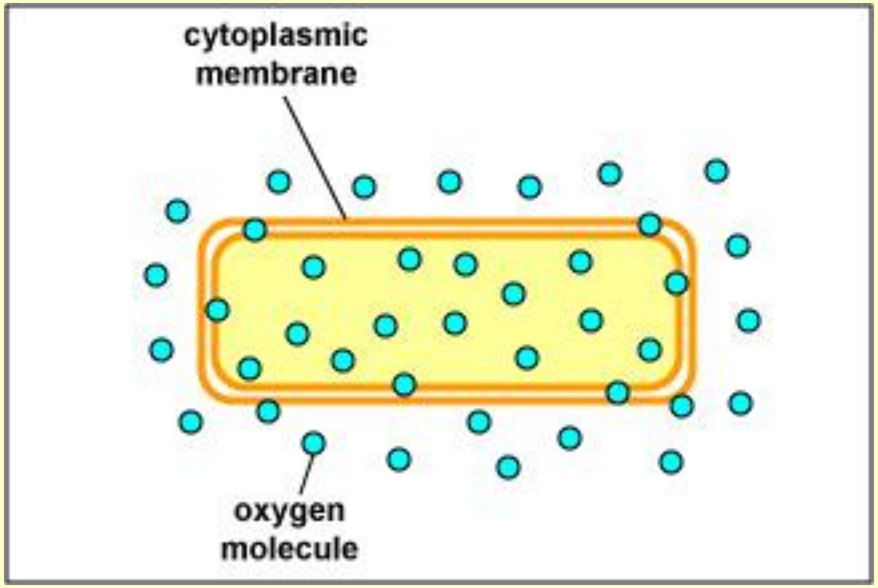
Passive Diffusion

- Net movement of gases or small uncharged polar molecules across a bacterial cell membrane from an area of higher concentration to an area of lower concentration.

- Examples of gases that cross membranes by passive diffusion include N_2, O_2, and CO_2; examples of small polar molecules include ethanol, H_2O, and urea.



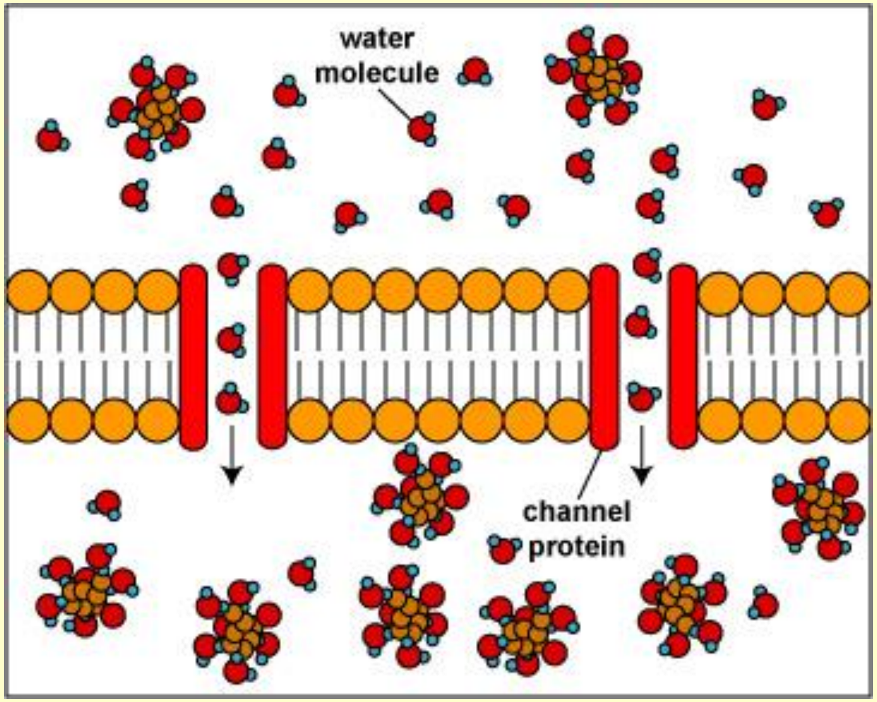
Step 1

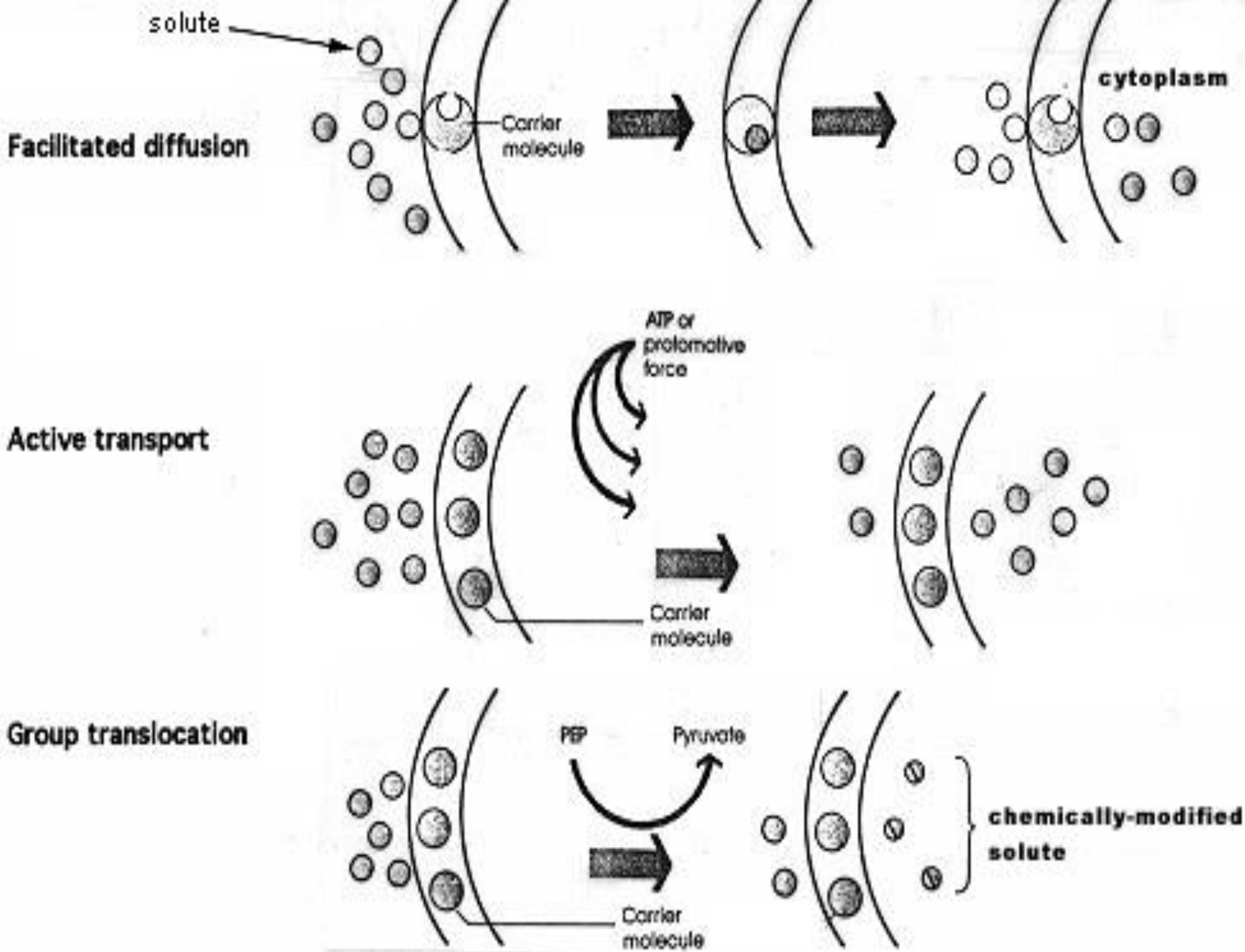


Step 2

Channel proteins

- **Transport water or certain ions down a concentration gradient from an area of higher concentration to lower concentration.**
- **While water molecules can directly cross the membrane by passive diffusion their transport can be enhanced by channel proteins called Aquaporins.**




solute
cytoplasm
Facilitated diffusion
Carrier molecule
Active transport
ATP or protomotive force
Carrier molecule
Group translocation
PEP
Pyruvate
chemically-modified solute
Carrier molecule

Facilitated Diffusion

- **Transport of substances across a membrane, along a concentration gradient from an area of higher concentration to lower concentration, by transport proteins, such as uniporters and channel proteins.**
- **Facilitated diffusion is powered by the potential energy of a concentration gradient and does not require the expenditure of metabolic energy.**
- **These are the least common type of transport system in bacteria.**
- **The glycerol uniporter in *E. coli* is the only well known facilitated diffusion system.**

Types of Active Transport

- **There are two types of active transports in bacteria: ion driven transport systems (IDT) and binding-protein dependent transport systems (BPDT)..**
- **IDT is a symport or antiport process that uses either proton motive force (pmf) or some other cation, e.g. lactose permease system of E. coli.**
- **BPDT involves ATP-binding cassette (ABC) system as binding proteins for and ATP as source of energy, e.g. histadine transport system in *E. coli*.**
- **IDT is used for accumulation of many ions and amino acids; BPDT is frequently used for sugars and amino acids**

Group translocation systems

- **In this case, a substance is chemically altered during its transport across a membrane so that once inside, the cytoplasmic membrane becomes impermeable to that substance and it remains within the cell.**

- **Example of group translocation in bacteria is the phosphotransferase system which phosphorylates the glucose and transports it across the membrane as glucose 6-phosphate.**

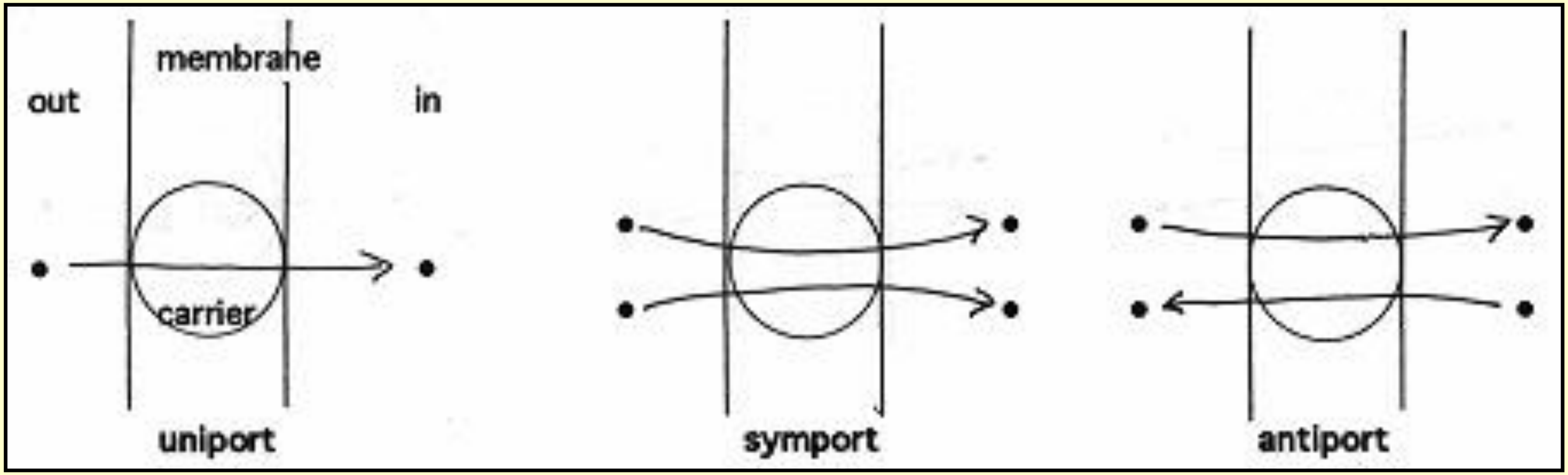
- **Other sugars that are transported by group translocation are mannose and fructose.**

- **It is more commonly known as the phosphotransferase system (PTS)**

Transport Processes

Transport systems operate by one of three transport processes

- **Uniport process** - a solute passes through the membrane unidirectionally.
- **Symport process** (also called co-transport) - two solutes are transported in the same direction at the same time.
- **Antiport process** (also called exchange diffusion) - one solute is transported in one direction simultaneously as a second solute is transported in the opposite direction.



Distinguishing characteristics of bacterial transport systems

Property	PD	FD	IDT	BPDT	GT
Carrier mediated	-	+	+	+	+
Concentration against gradient	-	-	+	+	NA
Specificity	-	+	+	+	+
Energy expended	-	-	Pmf	ATP	PEP
Solute modified during transport	-	-	-	-	+

PD – Passive Diffusion

FD – Facilitated Diffusion

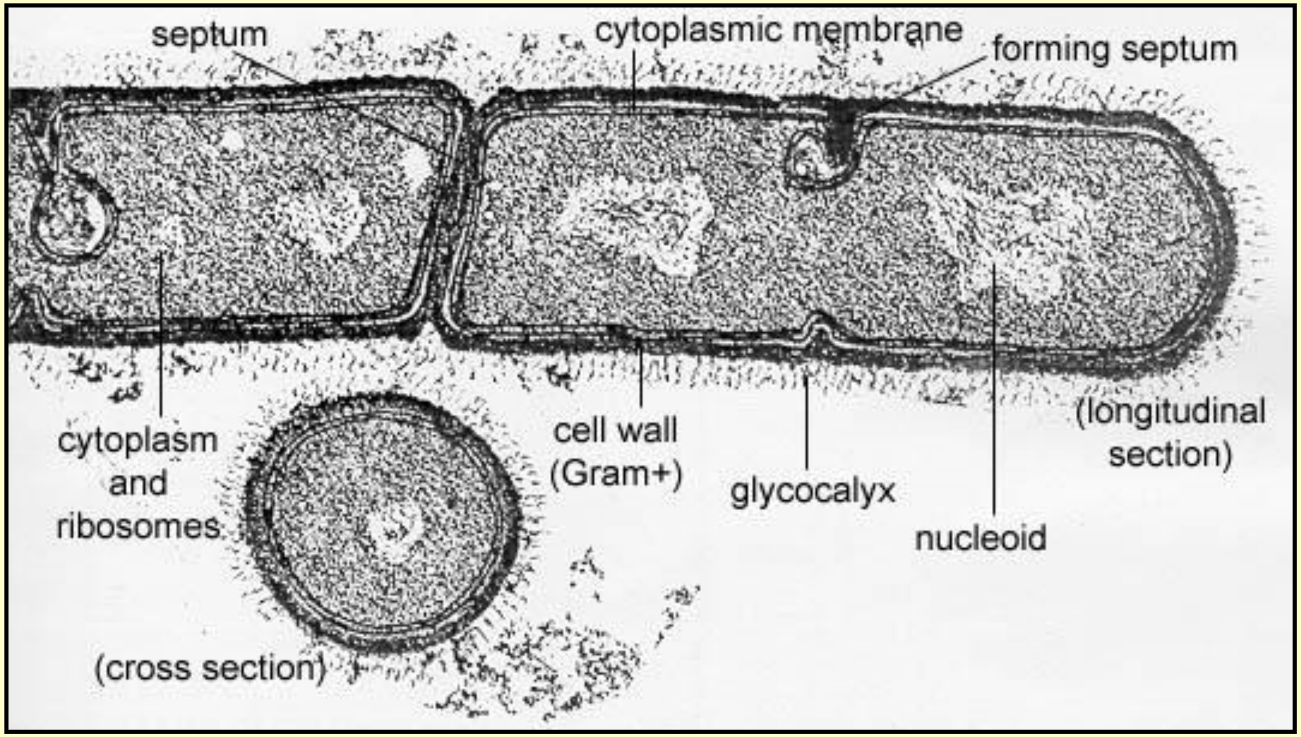
IDT - Ion Driven Transport

BPDT - Binding-protein Dependent Transport

GT – Group Translocation

MESOSOMES

Bacterial cell, especially Gram + ve, possess membrane invaginations in the form of systems of convoluted tubules and vesicles termed mesosomes



MESOSOMES

- **These are found in the center of the cell and also near the cytoplasmic membrane.**
- **Such internal membrane systems increase the surface area of membranes to which enzymes are bound for specific enzymatic functions.**
- **They are thought to be involved in the replication and cell division.**