Biochemistry of Extracellular& Intracellular Communication

Membranes: Structure & Function:

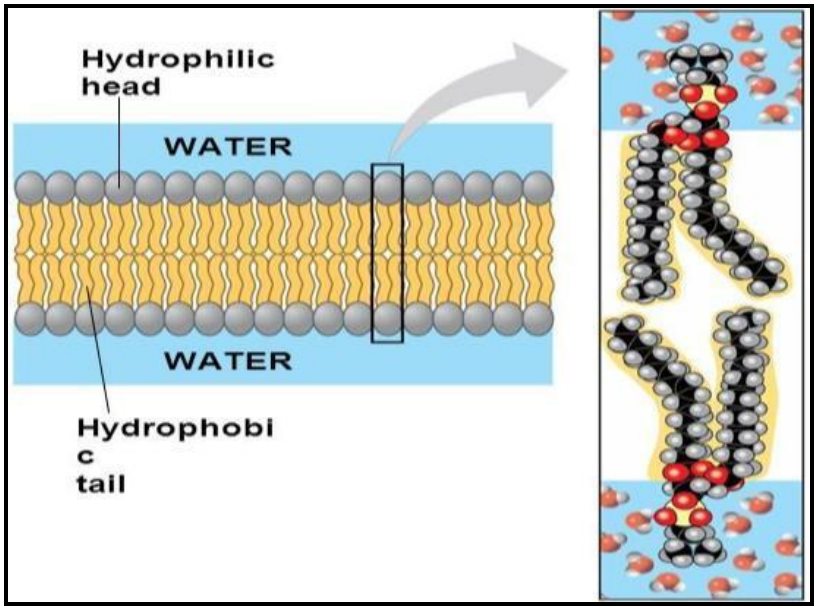
- The plasma membrane is the boundary that separates the living cell from its surroundings
- The plasma membrane exhibits selective permeability , allowing some substances to cross it more easily than others

Cellular membranes are fluid mosaics of lipids and proteins :

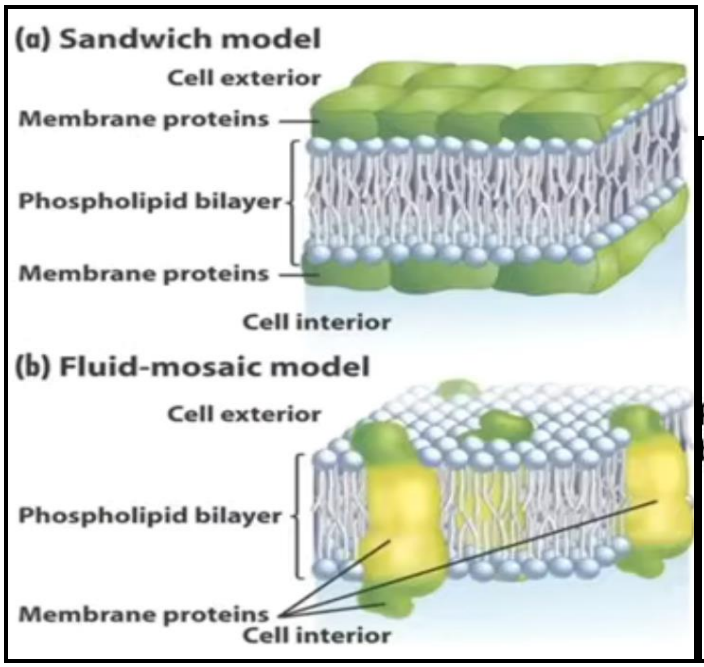
- Phospholipids are the most abundant lipid in the plasma membrane
- Phospholipids are amphipathic molecules containing hydrophobic and hydrophilic regions
- The fluid mosaic model states that a membrane is a fluid structure with a " mosaic " of various proteins embedded in it.

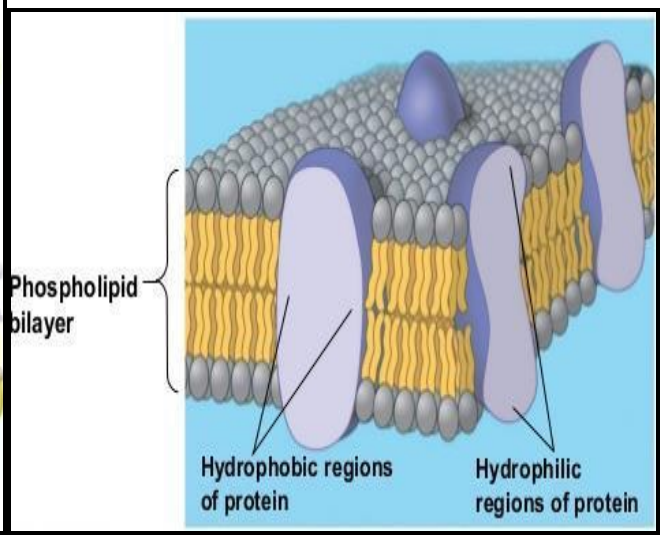
Membrane Models : Scientific Inquiry

- Membranes have been chemically analyzed and found to be made of proteins and lipids
- Scientists studying the plasma membrane reasoned that it must be a phospholipid bilayer

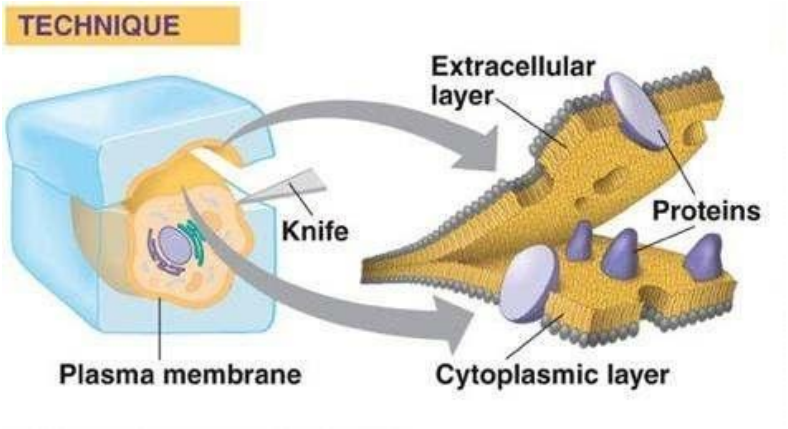


- In 1935, Hugh Davson and James Danielli proposed a sandwich model in which the phospholipid bilayer lies between two layers of globular proteins.
- Later studies found problems with this model ,particularly the placement of membrane proteins .which have hydrophilic and hydrophobic regions
- In 1972, J. Singer and G. Nicolson proposed that the membrane is a mosaic of proteins dispersed within the bilayer, with only the hydrophilic regions exposed to water



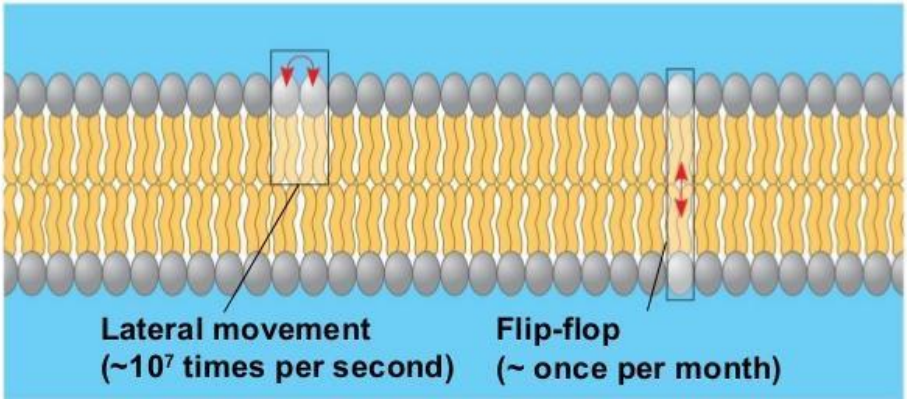


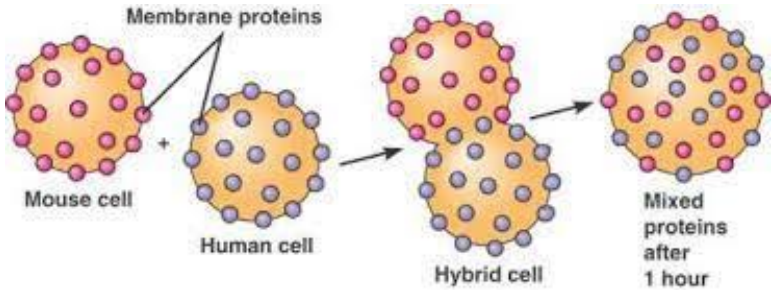
- **Freeze - fracture studies of the plasma membrane supported the fluid mosaic model**
- **Freeze - fracture is a specialized preparation technique that splits a membrane along the middle of the phospholipid bilayer**



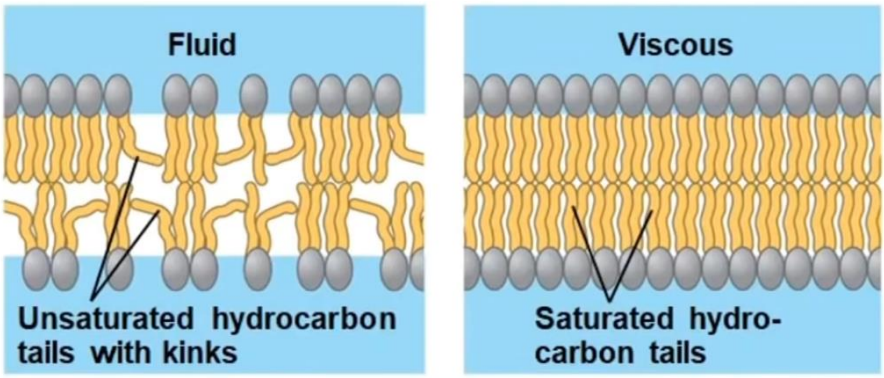
The Fluidity of Membranes

- **Phospholipids in the plasma membrane can move within the bilayer.**
- **Most of the lipids, and some proteins, drift laterally**
- **Rarely does a molecule flip - flop transversely across the membrane**



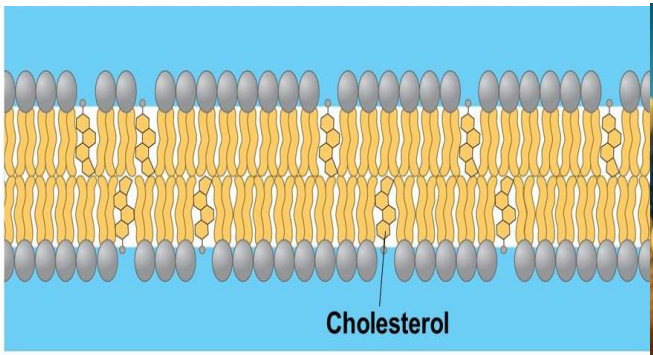


- As temperatures cool , membranes switch from a fluid state to a solid state
- The temperature at which a membrane solidifies depends on the types of lipids
- Membranes rich in unsaturated fatty acids are more fluid that those rich in saturated fatty acids
- Membranes must be fluid to work properly ; they are usually about as fluid as salad oil

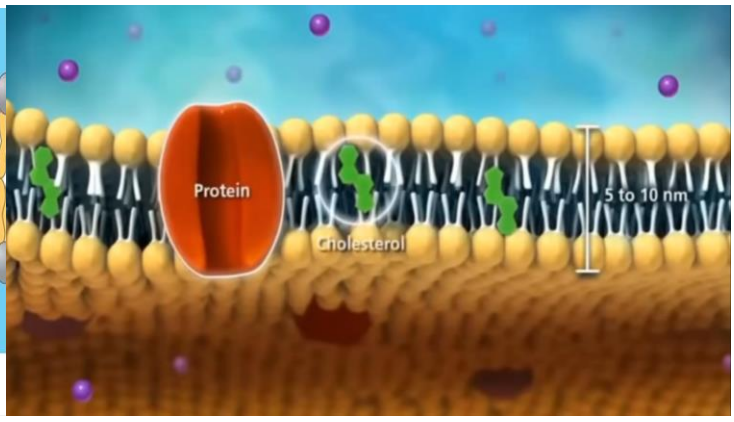


(b) Membrane fluidity

- The steroid cholesterol has different effects on membrane fluidity at different temperatures
- At warm temperatures (such as 37 ° C) , cholesterol restrains movement of phospholipids
- At cool temperatures , it maintains fluidity by preventing tight packing

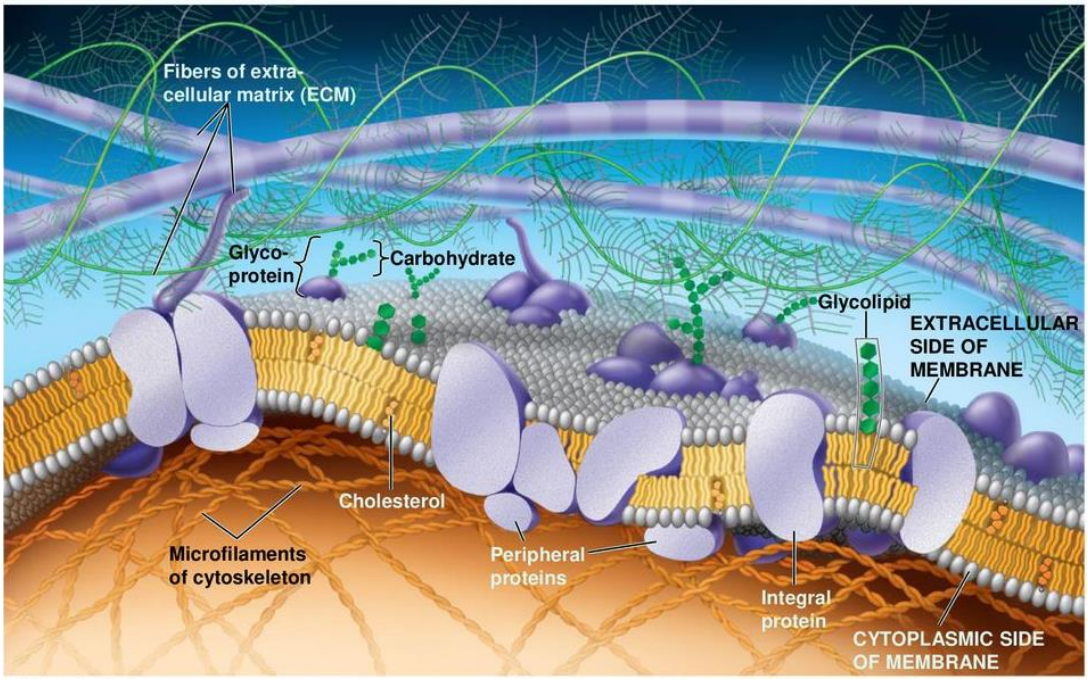


(c) Cholesterol within the animal cell membrane

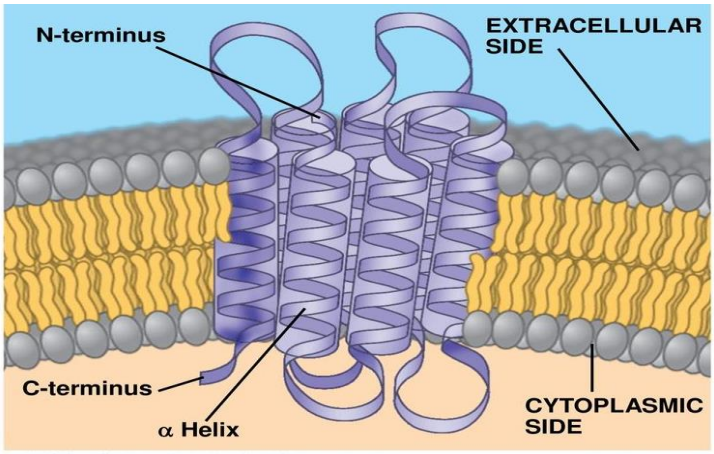


Membrane Proteins and their Functions

- A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer
- Proteins determine most of the membrane's specific functions

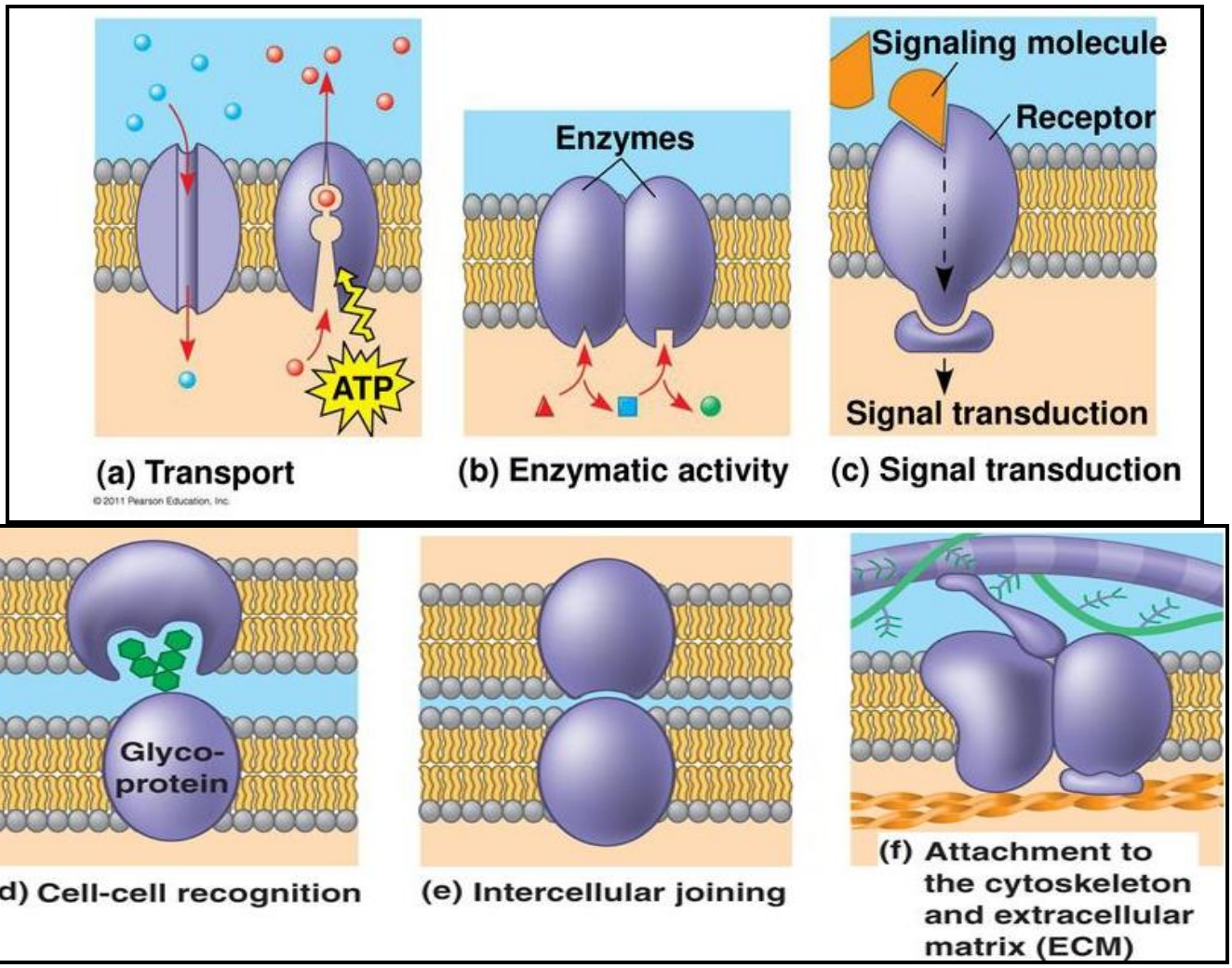


- **Peripheral proteins are bound to the surface of the membrane**
- **Integral proteins penetrate the hydrophobic core**
- **Integral proteins that span the membrane are called trans membrane proteins**
- **The hydrophobic regions of an integral protein consist of one or more stretches of nonpolar amino acids , often coiled into alpha helices**



❖ *Six major functions of membrane proteins :*

1. **Transport**
2. **Enzymatic activity**
3. **Signal transduction**
4. **Cell - cell recognition**
5. **Intercellular joining**
6. **Attachment to the cytoskeleton and extracellular matrix (ECM)**

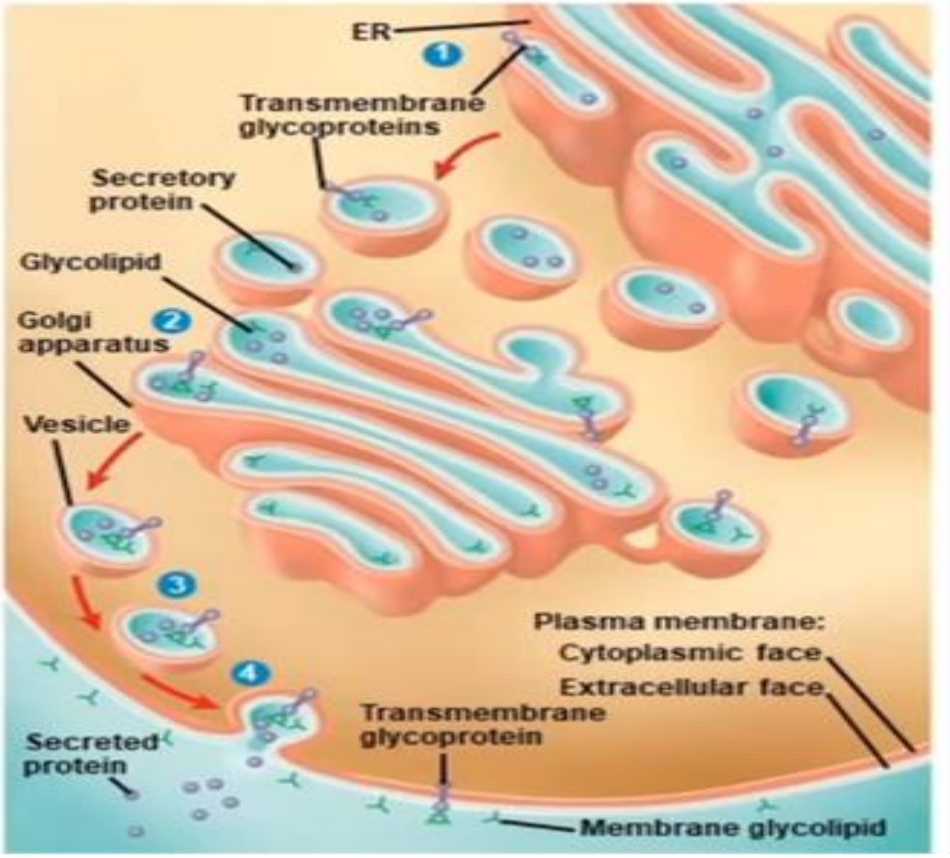


The Role of Membrane Carbohydrates in Cell - Cell Recognition

- **Cells recognize each other by binding to surface molecules, often carbohydrates, on the plasma membrane**
- **Membrane carbohydrates may be covalently bonded to lipids (forming glycolipids) or more commonly to proteins (forming glycoproteins).**
- **Carbohydrates on the external side of the plasma membrane vary among species, individuals, and even cell types in an individual**

Synthesis and Sidedness of Membranes

- **Membranes have distinct inside and outside faces**
- **The asymmetrical distribution of proteins , lipids , and associated carbohydrates in the plasma membrane is determined when the membrane is built by the Endoplasmic reticulum (ER) and Golgi apparatus**



Membrane structure results in selective permeability

- **A cell must exchange materials with its surroundings , a process controlled by the plasma membrane**
- **Plasma membranes are selectively permeable , regulating the cell's molecular traffic.**

The Permeability of the Lipid Bilayer

- **Hydrophobic (nonpolar) molecules, such as hydrocarbons, can dissolve in the lipid bilayer and pass through the membrane rapidly**
- **Polar molecules, such as sugars, do not cross the membrane easily**

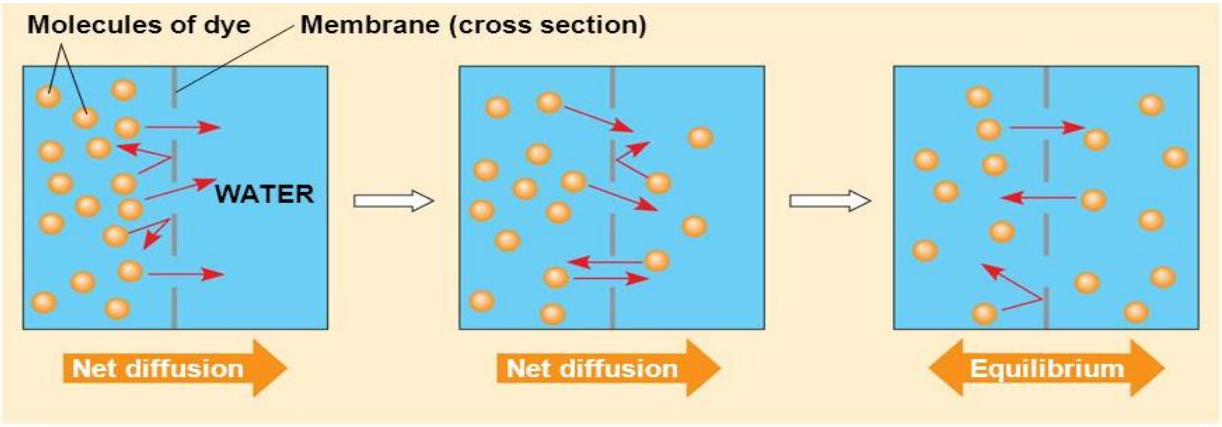
Transport Proteins

- **Transport proteins allow passage of hydrophilic substances across the membrane**

- Some transport proteins , called **channel proteins** , have a hydrophilic channel that certain molecules or ions can use as a tunnel
- Channel proteins called **aquaporin** facilitate the passage of water
- Other transport proteins, called **carrier proteins**, bind to molecules and **change shape** to shuttle them **across the membrane**
- A transport protein is specific for the substance it moves

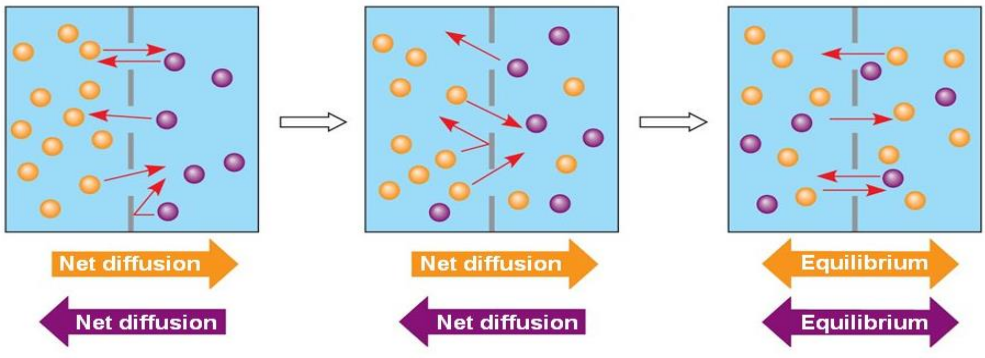
1. **Passive transport is diffusion of a substance across a membrane with no energy investment.**

- **Diffusion** is the tendency for molecules to spread out evenly into the available space
- Although each molecule moves randomly, **diffusion** of a population of molecules may exhibit a net movement in one direction
- At dynamic equilibrium, as many molecules cross one way as cross in the other direction



(a) Diffusion of one solute

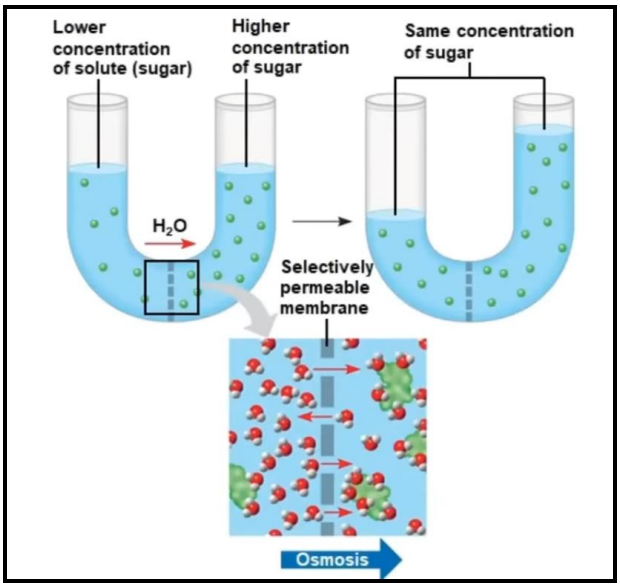
- Substances diffuse down their concentration gradient , the difference in concentration of a substance from one area to another
- No work must be done to move substances down the concentration gradient
- The diffusion of a substance across a biological membrane is passive transport because it requires no energy from the cell to make it happen



(b) Diffusion of two solutes

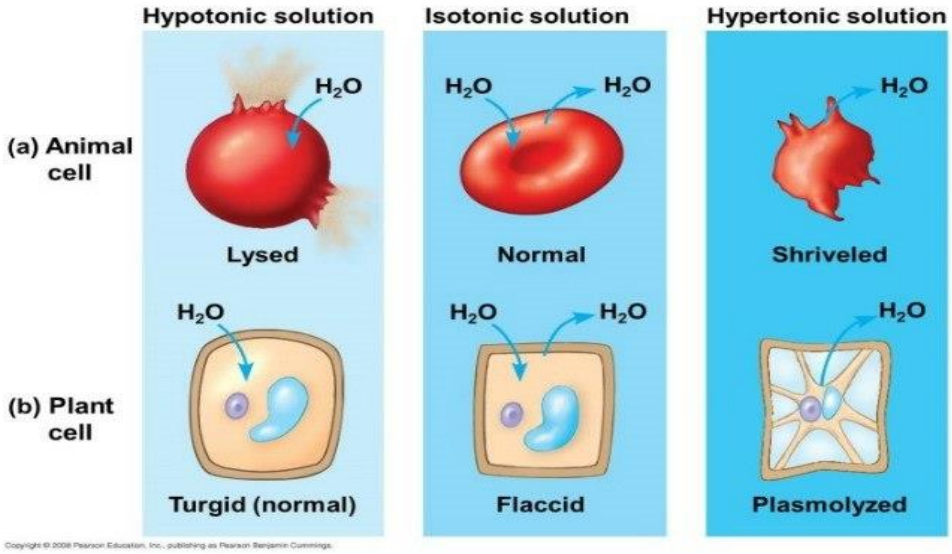
2. Effects of Osmosis on Water Balance

- **Osmosis is the diffusion of water across a selectively permeable membrane**
- **Water diffuses across a membrane from the region of lower solute concentration to the region of higher solute concentration**



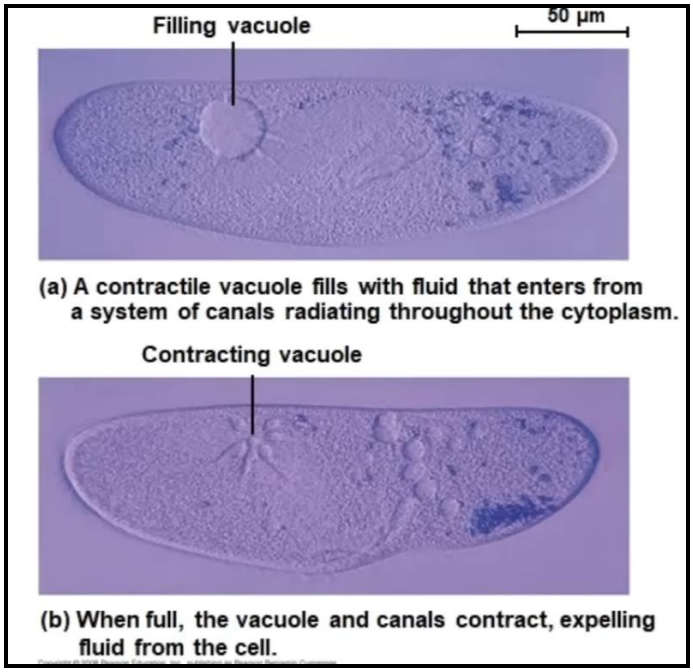
Water Balance of Cells Without Walls

- **Tonicity is the ability of a solution to cause a cell to gain or lose water**
- **Isotonic solution : Solute concentration is the same as that inside the cell ; no net water movement across the plasma membrane .**
- **Hypertonic solution : Solute concentration is greater than that inside the cell ; cell loses water**
- **Hypotonic solution : Solute concentration is less than that inside the cell ; cell gains water**



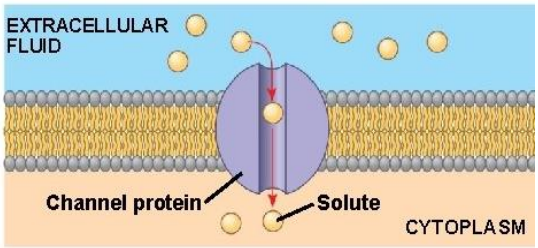
- **Hypertonic or hypotonic environments create osmotic problems for organisms**

- **Osmoregulation , the control of water balance , is a necessary adaptation for life in such environments**
- **The protist Paramecium , which is hypertonic to its pond water environment , has a contractile vacuole that acts as a pump**

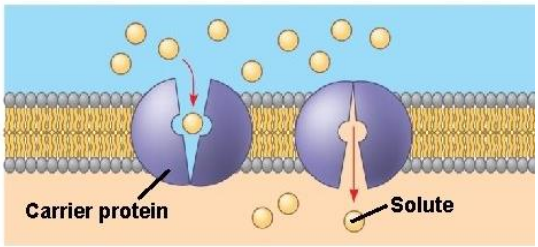


3. Facilitated Diffusion: Passive Transport Aided by Proteins

- **In facilitated diffusion , transport proteins speed the passive movement of molecules across the plasma membrane**
- **Channel proteins provide corridors that allow a specific molecule or ion to cross the membrane**
- **channel proteins include:**
  - ✓ **Aquaporin , for facilitated diffusion of water**
  - ✓ **Ion channels that open or close in response to a stimulus (gated channels)**



(a) A channel protein



(b) A carrier protein

- **Carrier proteins undergo a subtle change in shape that translocate the solute - binding site across the membrane**