Cellular transport mechanisms

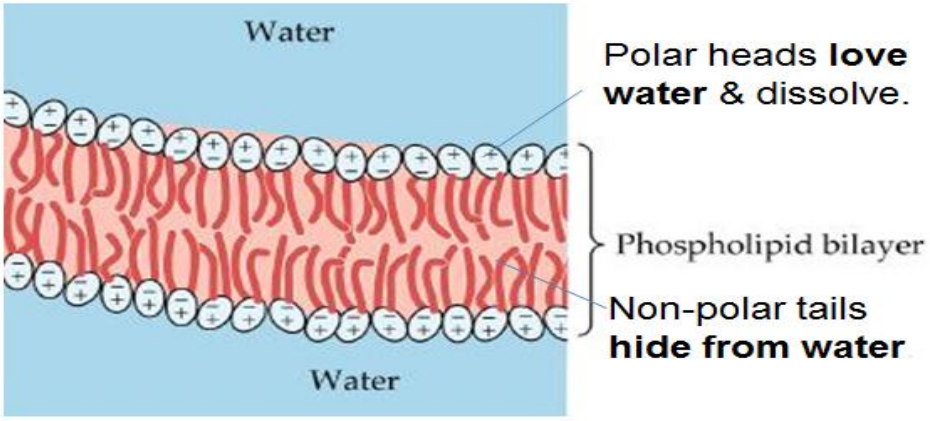
About cell membranes

1. All cells have a cell membrane.
2. Functions: Controls what enters and exits the cell to maintain an internal balance called **homeostasis**.
3. Provides protection and support for the cell structure of the cell membrane.

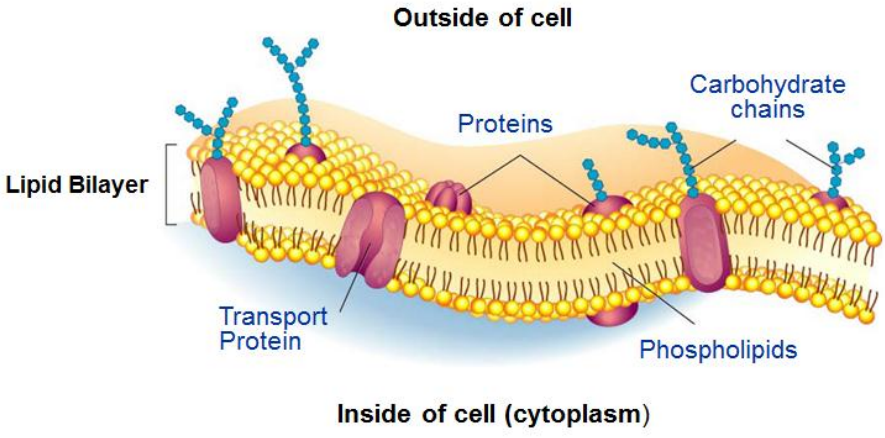
Lipid Bilayer: two layers of phospholipids

   a. The phosphate head is *polar* (water-loving).
   b. Fatty acid tails are *non-polar* (water-fearing).
   c. Proteins embedded in the membrane.

4. Cell membranes have pores (holes) in it
   a. **Selectively permeable**: Allows some molecules in and keeps other molecules out.
   b. The structure helps it be selective.



Structure of the cell membrane



Types of cellular transport

There are two ways in which substances can enter or leave a cell:

1. **Passive transport:** Cell doesn't use energy.
   - Diffusion

- Facilitated diffusion
- Osmosis

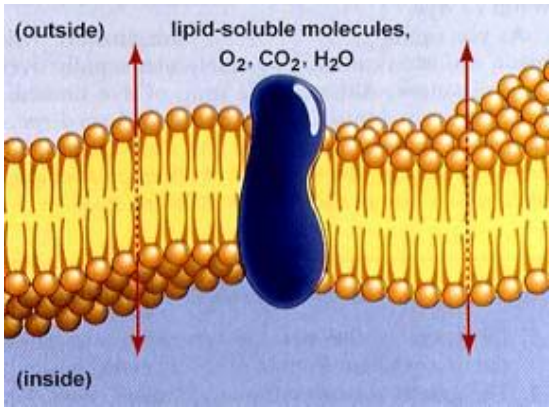
2. **Active transport:** Cell does use energy.
   - Protein pumps
   - Endocytosis
   - Exocytosis

A. Passive transport mechanisms

- The cell uses no energy.
- Molecules move randomly.
- Molecules spread out from an area of high concentration to an area of low concentration (High→Low).
- **Three types:**
  1) Diffusion
  2) Facilitative diffusion: Diffusion with the help of transport proteins.
  3) Osmosis: Diffusion of water.

1. **Diffusion:** Random movement of particles from an area of high concentration to an area of low concentration (High to Low).
   - Diffusion continues until all molecules are evenly spaced (equilibrium is reached) - Note: Molecules will still move around but stay spread out.

Diffusion through a plasma membrane

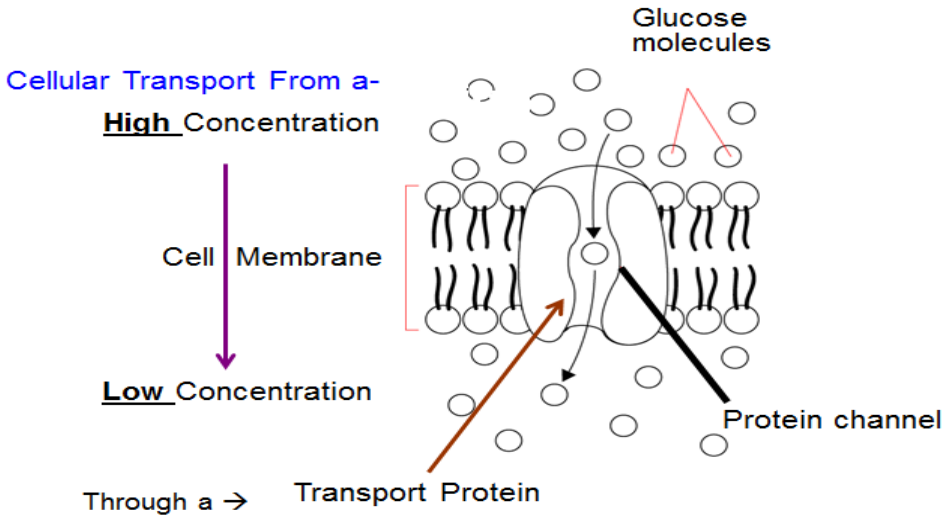


Equilibrium

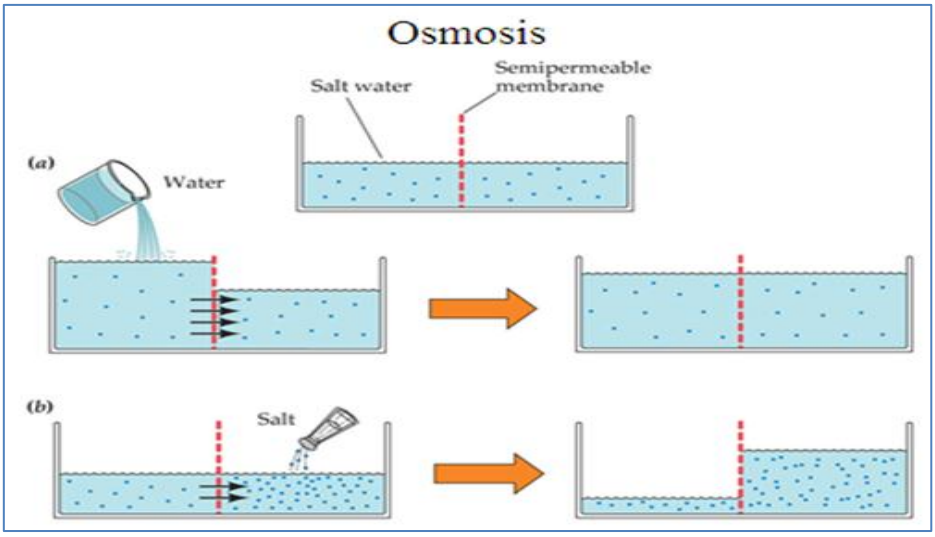
- Diffusion stops at equilibrium (when the concentrations across a membrane are equal).
- The movement of molecules continues at equilibrium but the # of molecules moving across the membrane remains the same.
- The rate of transport is dependent on:
  1. If the material is solid, liquid, or gas.
  2. The size of the molecules.
  3. Temperature

- Examples of molecules that can diffuse through the bilayer: carbon dioxide, oxygen, water but very, very slowly.

2. **Facilitated diffusion:** Diffusion of specific particles through transport proteins found in the membrane.
   a. Transport proteins are specific – they "select" only certain molecules to cross the membrane.
   b. Transports larger or charged molecules.
      - Particles always move with (down) a concentration gradient.
      - Uses transport/channel proteins.
      - Passive transport.
      - Usually for specific molecules such as glucose.
      - Facilitated diffusion stops at equilibrium.



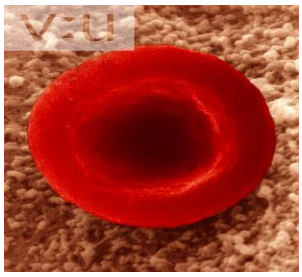
3. **Osmosis:** Diffusion of water through a selectively permeable membrane. Water molecules move from a higher concentration of **water** to a lower concentration of **water**.
   Water will move to where there is a greater amount of solute because there is less water there

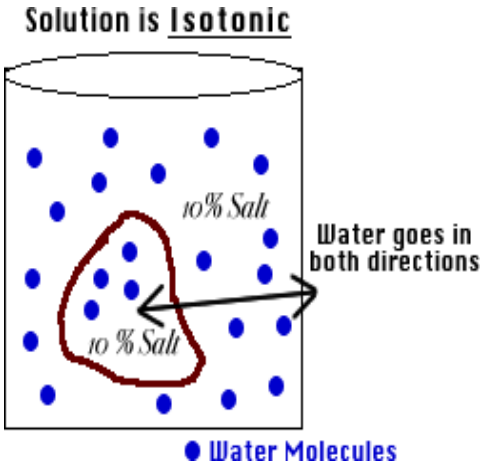


3.1. Isotonic solution

Isotonic: The concentration of solutes in the solution is equal to the concentration of solutes inside the cell.

Result: Water moves equally in both directions and the cell remains the same size! (Dynamic Equilibrium)

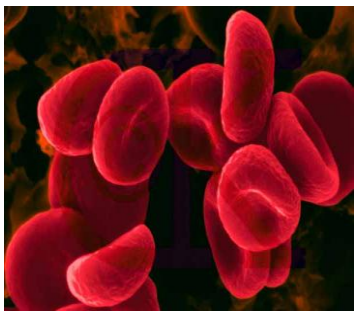


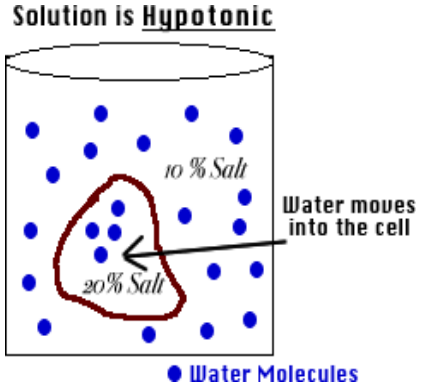


3.2. Hypotonic solution

Hypotonic: The solution has a lower concentration of solutes and a higher concentration of water than inside the cell (Low solute; High water).

Result: Water moves from the solution to inside the cell): Cell Swells and bursts open (cytolysis)!

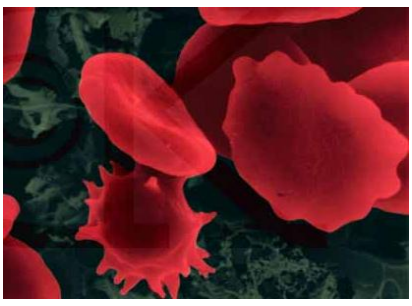


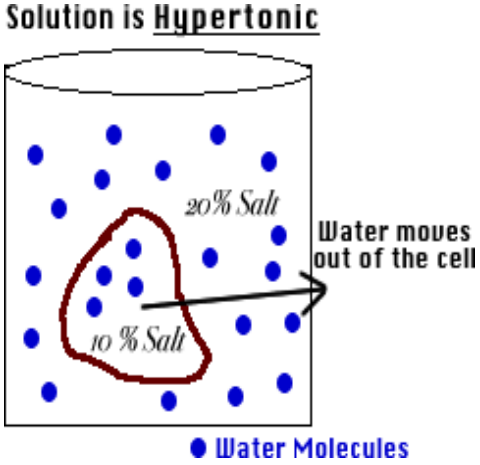


3.3. Hypertonic solution

Hypertonic: The solution has a higher concentration of solutes and a lower concentration of water than inside the cell (High solute; Low water).

Result: Water moves from inside the cell into the solution: Cell shrinks (*Plasmolysis*)!



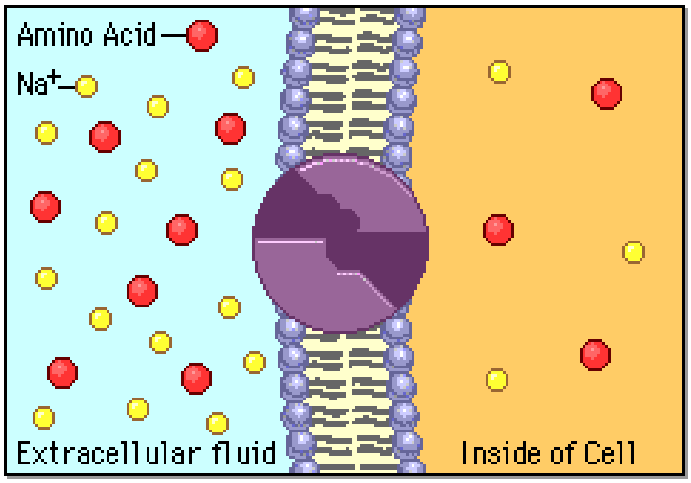


B. Active transport mechanisms

- The cell uses energy in the form of ATP. Active Transport: requires Capable of moving solute particles against the conc. gradient (from low conc. to high conc.)
  - Uses transport/carrier proteins (protein pumps) embedded in the plasma membrane.
  - Carrier proteins are specific for the molecules that they allow through. The carrier protein changes shape which requires energy (ATP).
- **Three Types:**

a. Protein Pumps: Transport proteins that require energy to do work**.**

- Example: Sodium / Potassium pumps are important in nerve responses.

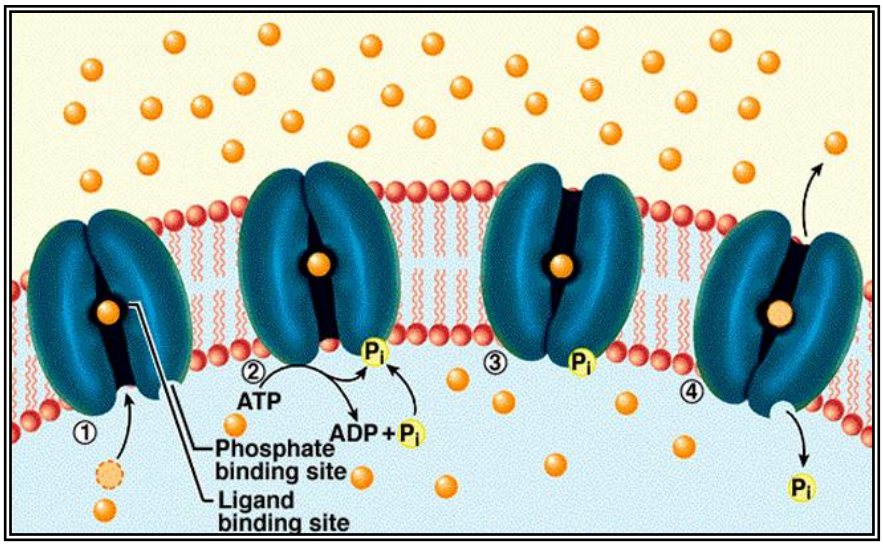


Protein changes shape to move molecules: this requires energy!

How does this happen?

Protein Pumps

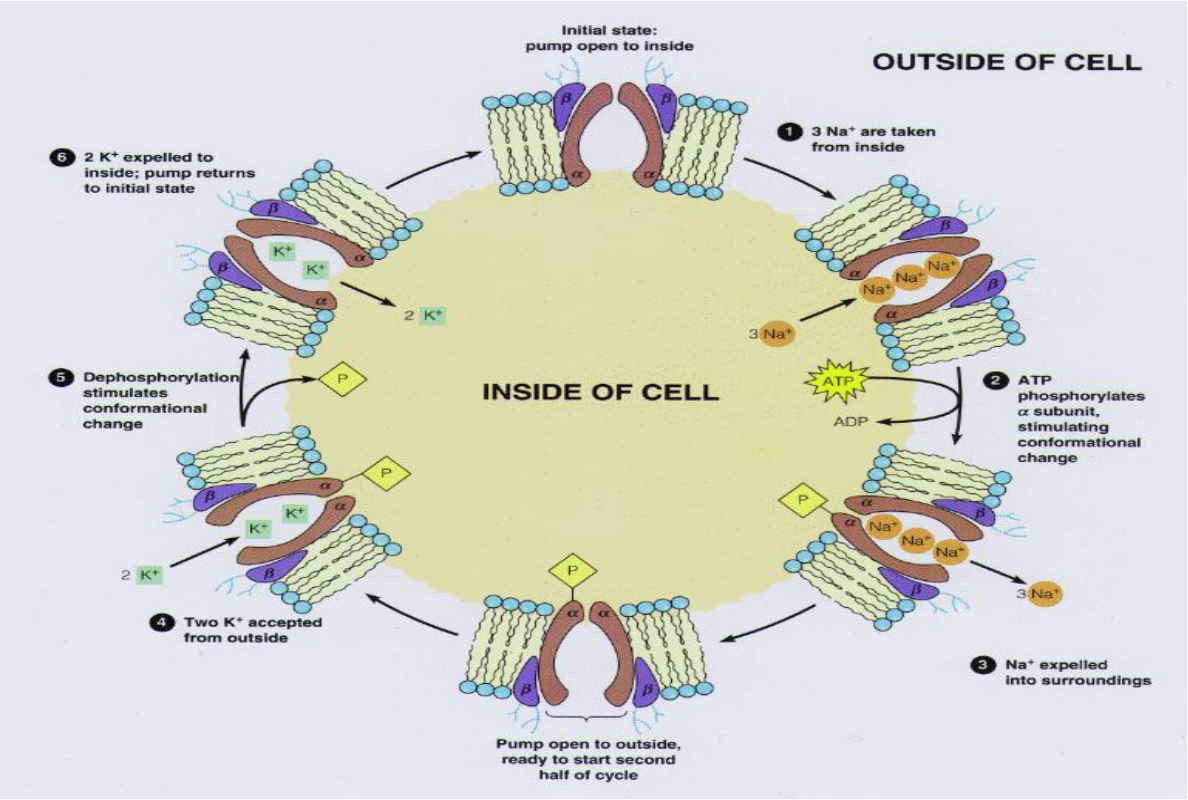
- Solute binds to the protein
- Mitochondria provide energy that changes the shape of the protein
- Change in shape allows solute to be moved across the membrane
- System resets



Operation of the Sodium Potassium Pump

1. Three Na^+ in the cytosol bind to the pump protein.
2. Na^+ binding triggers the splitting of ATP into ADP plus a phosphate group which attaches to the pump protein. This causes a change in the shape of the pump protein.
3. 3 Na^+ are expelled into the extracellular fluid.
4. The changed shape allows 2 K^+ in the extracellular fluid to bind to the protein.
5. The binding of the K^+ causes the phosphate group to be released which causes the pump protein to return to its original shape.
6. As the pump protein returns to its original shape, it releases the 2 K^+ into the cytosol.

The pump protein is then ready to bind Na^+ and the cycle can repeat

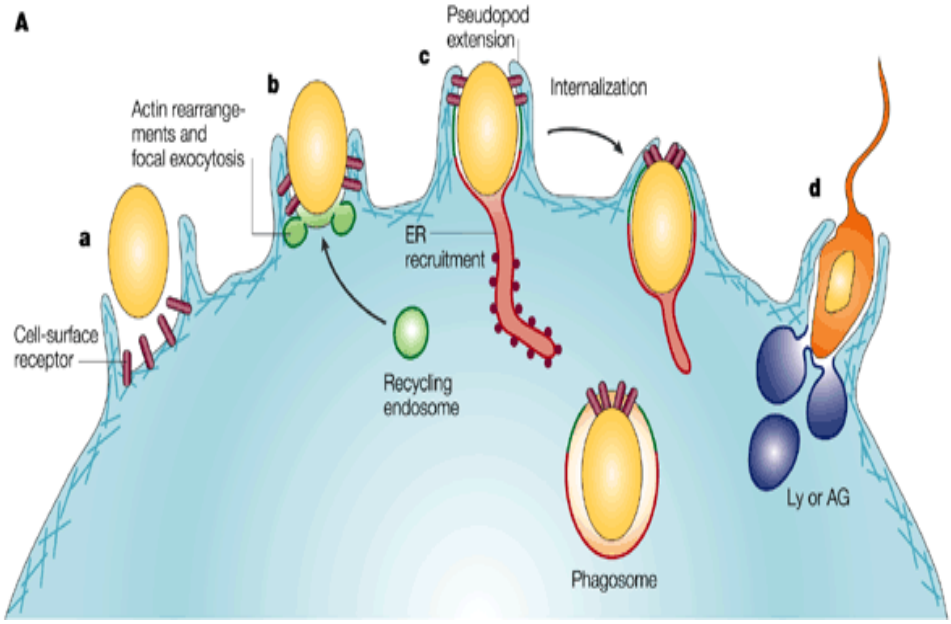


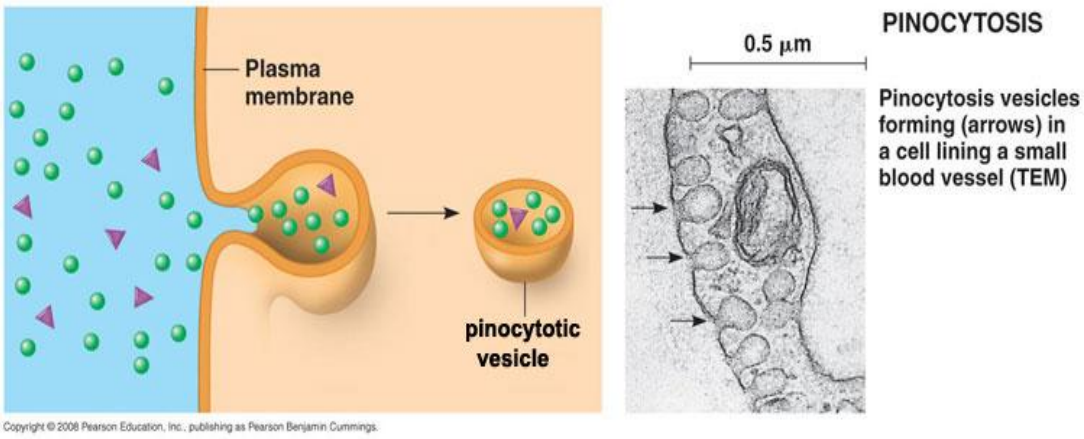
b. **Endocytosis:** a process of taking material into the cell by means of infoldings, or pockets, of the cell membrane (usually putting them into a vacuole).

- **Phagocytosis -"Cell eating"**
  - Nonspecific molecules
  - Intake of solids
- **Pinocytosis –" Cell Drinking"**
  - Nonspecific molecules
  - Intake of small droplets of liquid

Phagocytosis

- Phagocytosis occurs only in special cells called phagocytes.
- They are specialized cells used to engulf and destroy bacterial and other foreign substances.
- These cells include certain white blood cells and macrophages.
- Phagocytosis is one of the body's defense mechanisms against disease.
- Large solid particles (like whole cells) are taken in by the cell.
- The particle binds to the plasma membrane receptor, the cell extends projections called pseudopods that surround the particle, and then the membranes fuse to create a vesicle in the cytoplasm.
- Any undigested materials remain indefinitely in a vesicle called a residual body. Cells take up vesicles containing tiny droplets of extracellular fluid and any solutes dissolved in that fluid.
- The vesicle detaches from the membrane and enters the cytosol.
- The vesicle fuses with a lysosome where enzymes digest the solutes into smaller molecules.





c. Exocytosis

- Results in secretion – materials exiting the cell.
- Secretory cells give off digestive enzymes, hormones, mucus, or other secretions.
- Nerve cells give off neurotransmitters. Vesicle containing the substance to be secreted forms in the cytosol fuses with the plasma membrane then releases the contents into the extracellular fluid.