Module: Human Development and tissue Differentiation (HDTD)

# Transport of materials across the cell membrane

## First Grade : 2024

## Ashur Medical College

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# Objectives:

- Mechanisms of transport across plasma membrane .
- The role of transport across plasma membrane in Homeostasis.
- Types and classification of Transport Across Cell Membranes.

# Homeostasis

- Homeostasis is the body's natural ability to maintain a stable and balanced internal environment despite external changes.
- Cell membrane one important function is to maintain homeostasis through:

1. separation the components of a cell from its environment—surrounds the cell. The spaces created by the membrane's fluidity are incredibly small ,so it is still an effective barrier.

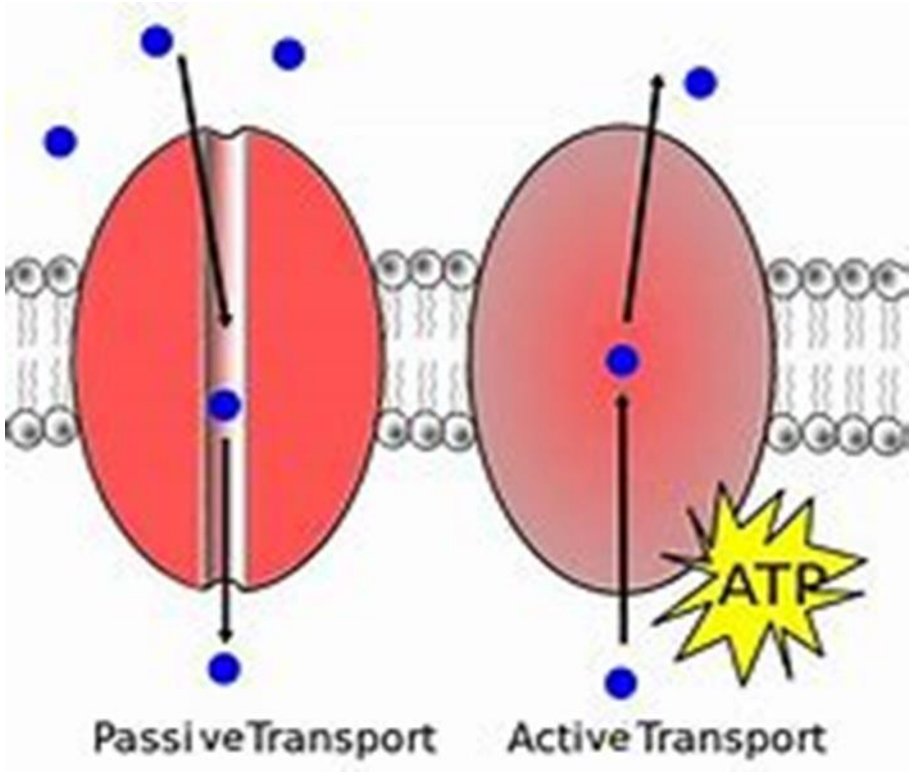
2.Transport mechanisms (facilitated diffusion and active transport ):

By these mechanisms cell membrane play a role in regulating the pH, temperature, glucose ,H2O balance.

- The plasma membrane is Gatekeeper" of the cell exhibits selective permeability, allowing some substances to cross it more easily into or out of the cell. The cell membrane is semi-permeable because of its phospholipid arrangement. The hydrophobic tails of phospholipid do not allow polar molecules to cross through.

# Cell membrane transport

- A. Passive Transport
  - A.1. Diffusion
    - A.1.1 Simple Diffusion
    - A.1.2 Facilitated Diffusion
  - A.2 Osmosis
- B. Active transport
  - B.1. Protein pumps
  - B.2. Vesicle Transport
    - B.2.1.Exocytosis
    - B.2.2. Endocytosis
      - B.2.2.1.Pinocytosis
      - B.2.2.2 Phagocytosis
      - B.2.2.3.Receptor-mediated endocytosis



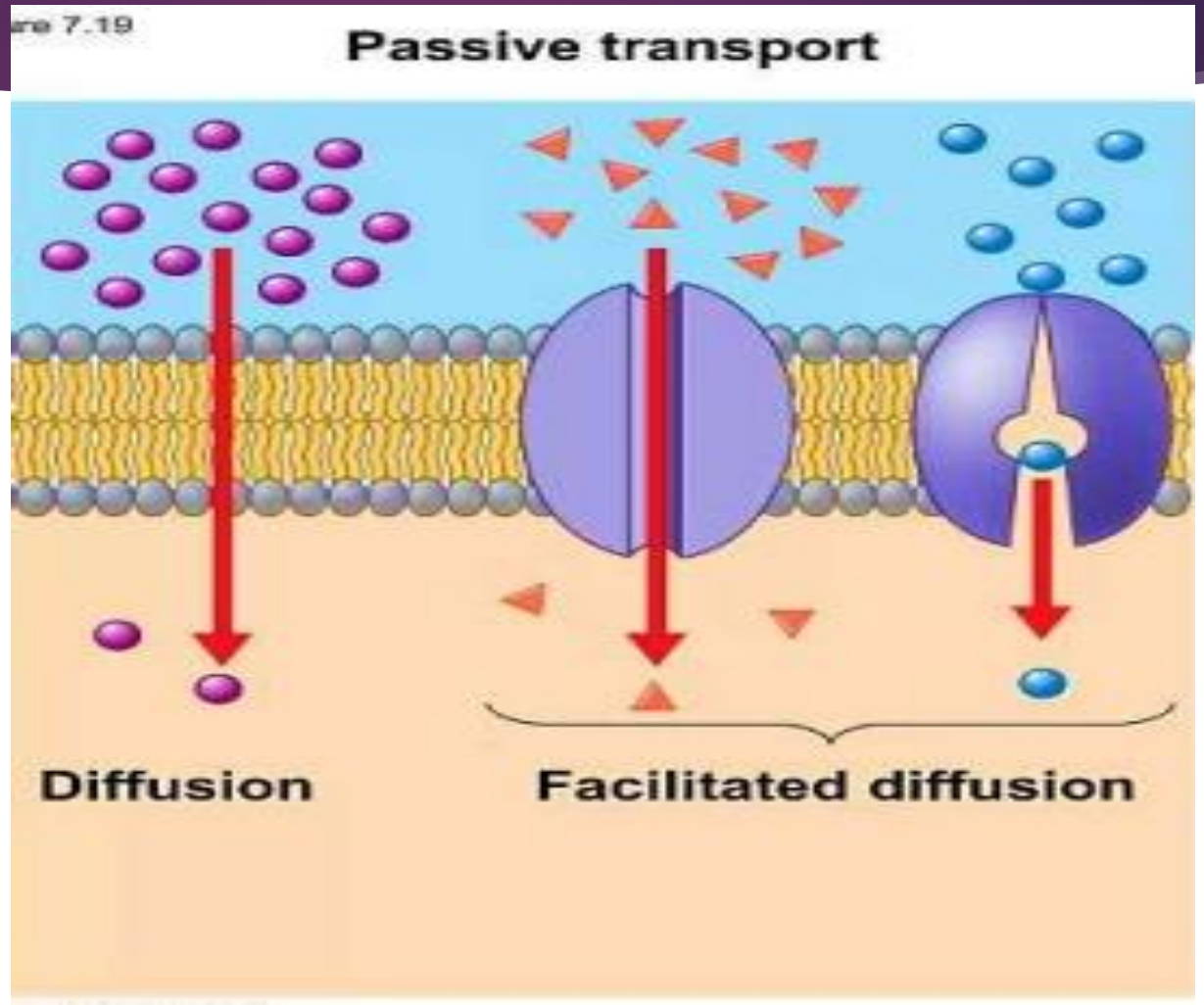
# A. Passive Transport

- A. Passive transport across cell membranes : Molecules have a natural kinetic energy to move & cells do not use energy to move the molecules.
- A.1.Diffusion: Is the movement of small particles across the cell membrane until equilibrium is reached. Particles move from a high concentration to a low concentration area.
- There are two types of diffusion :
- A.1.1.Simple Diffusion: Substances pass directly through the cell membrane from high to low concentration.
- The cell membrane has limited permeability to polar molecules, water, and ions.
- Non polars (< 0.5 polarity ) such as Oxygen and CO2 diffuses very quickly.
- **The electrical charges of nonpolar molecules are evenly distributed across the molecule.**

# A.1.2. Facilitated Diffusion

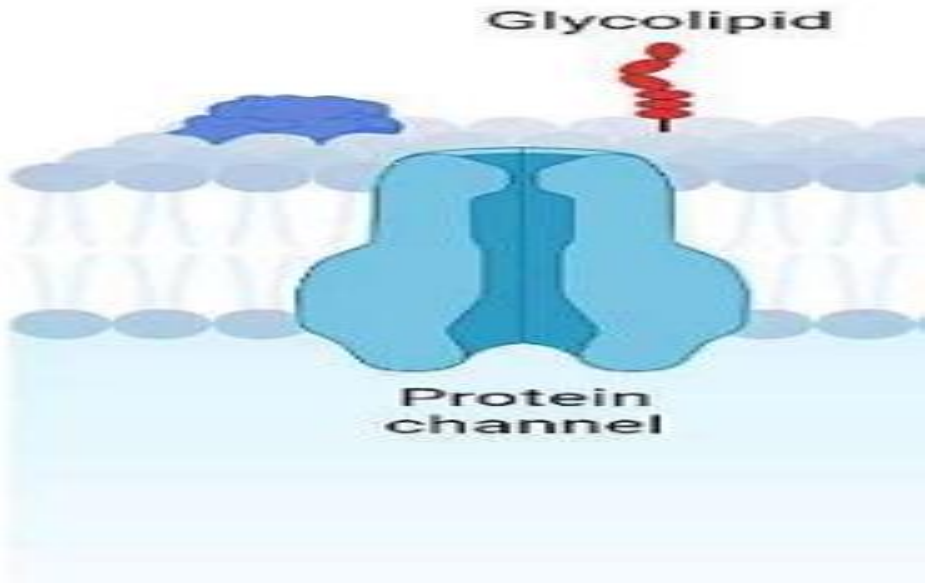
- Is the movement of larger & polar molecules like glucose through the cell membrane .
- Larger & polar molecules must be “helped” by Transport Proteins.

# Simple VS Facilitated diffusion



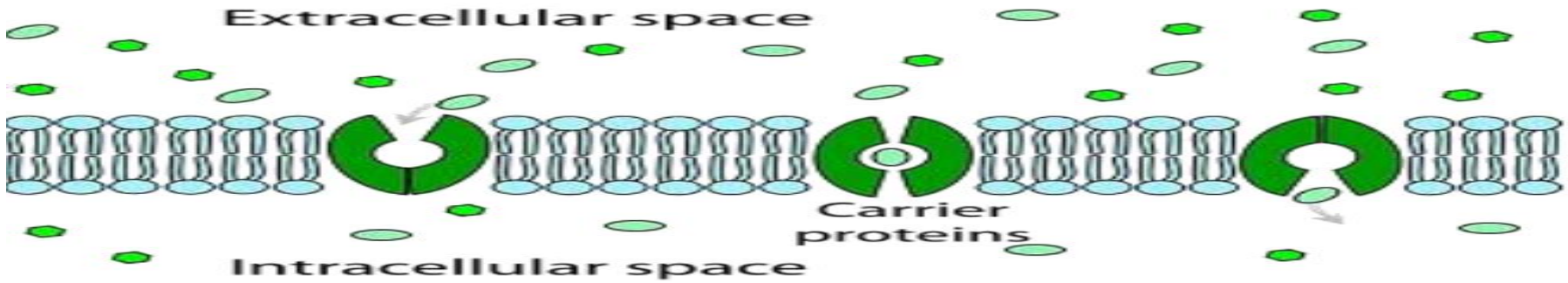
# Transport Proteins:
# a-Channel proteins
# b- Carrier proteins

**a- Channel proteins in the cell membrane form channels (pores) for large molecules to pass through. Channel proteins are embedded in the cell membrane & have a pore for materials to cross. Molecules will randomly move through the pores in Channel Proteins.**



# b- Carrier proteins:

- 1-Carrier proteins can change shape to move material from one side of the membrane to the other.
- 2-Some Carrier proteins do not extend through the membrane. They bond and drag molecules through the phospholipid bilayer and release them on the opposite side.



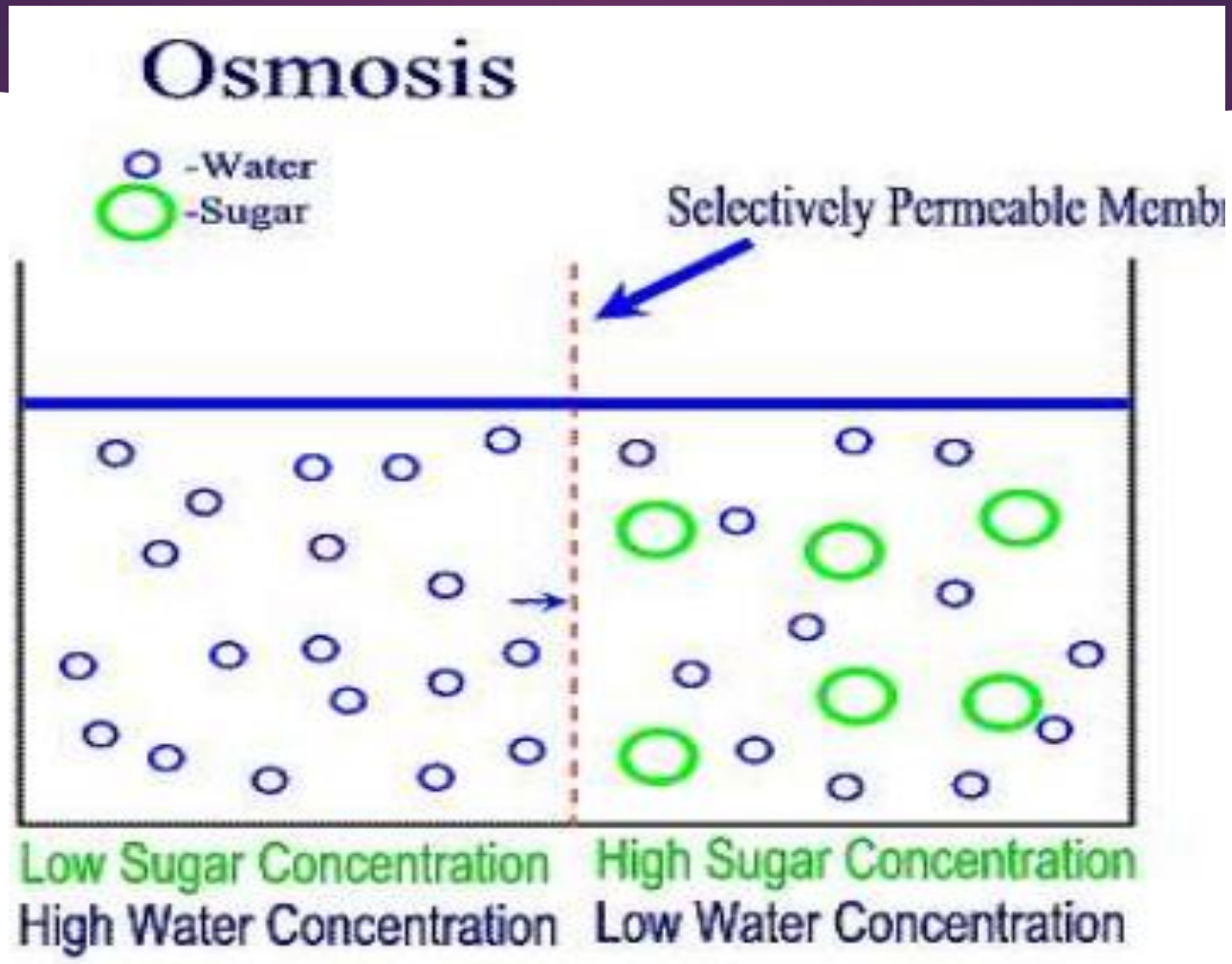
# 1.2. Osmosis

- Diffusion of water across a plasma membrane through a semi-permeable plasma membrane .
- Water moves from HIGH water potential (low solute) to LOW water potential (high solute).

The diffusion of water from an area of high concentration of water molecules (high water potential) to an area of low concentration of water (low water potential) across a partially permeable membrane.

- Water diffuses across a membrane from the region of lower solute concentration to the region of higher solute concentration until the solute concentration is equal on both sides.

# In osmosis a semi-permeable membrane is permeable to (solvent) water, but not to solute (sugar)



- Osmotic concentration is determined by the concentration of all solutes in the solution.

Tonicity is the ability of a surrounding solution to cause a cell to gain or lose water.

- Hypertonic Solutions: contain a high concentration of solute relative to another solution (e.g. the cell's cytoplasm). When a cell is placed in a hypertonic solution, the water diffuses out of the cell, causing the cell to shrivel.

Plasmolysis: water leaves the cell due to the hypertonic surrounding.

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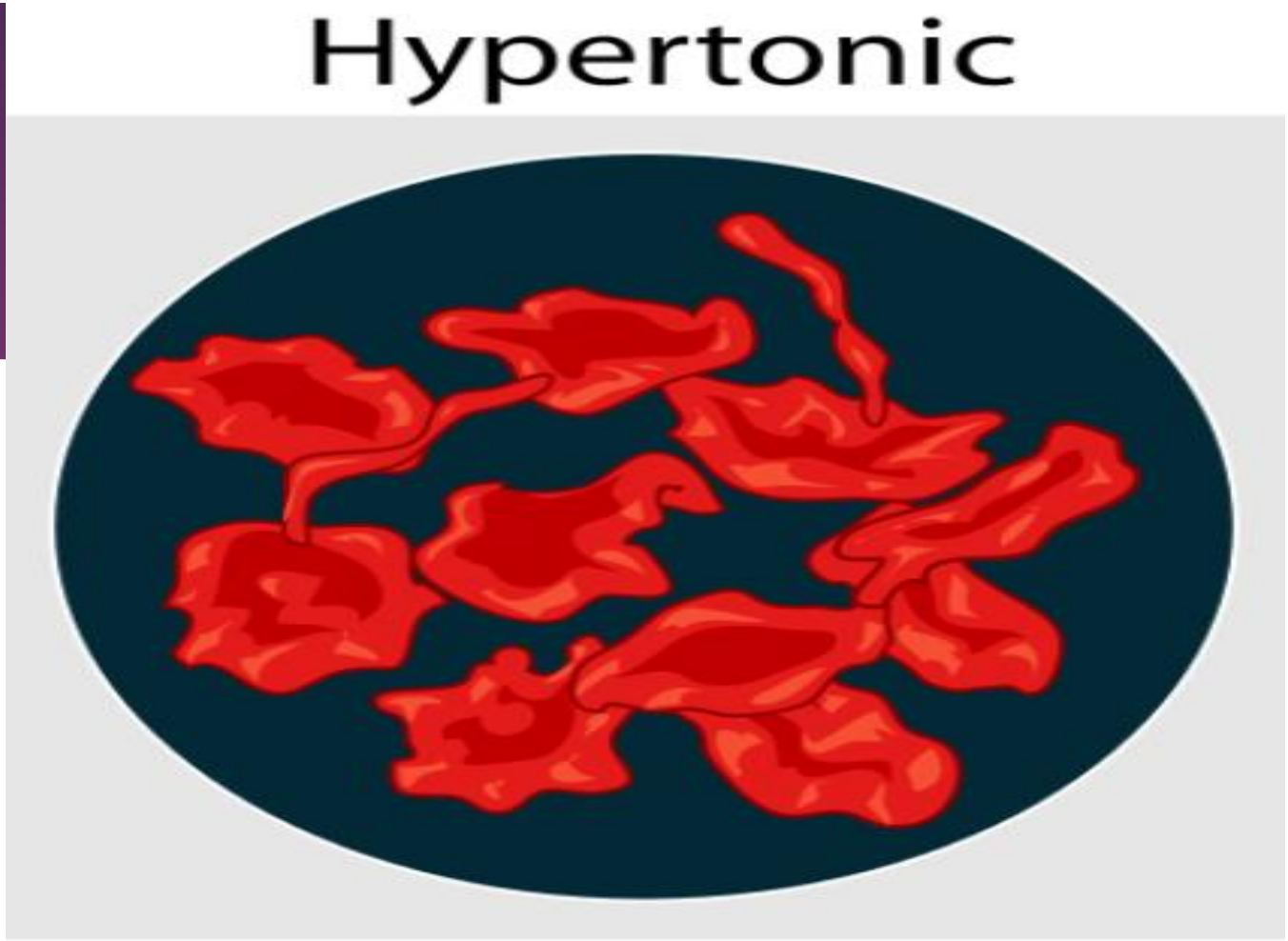
# Hypertonic solution& Plasmolysis

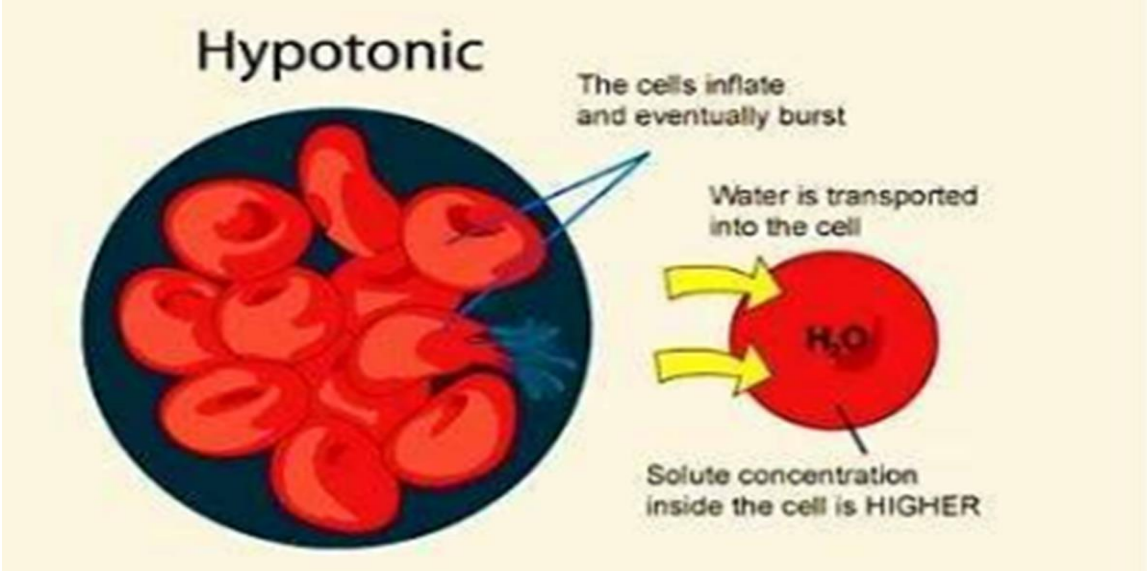




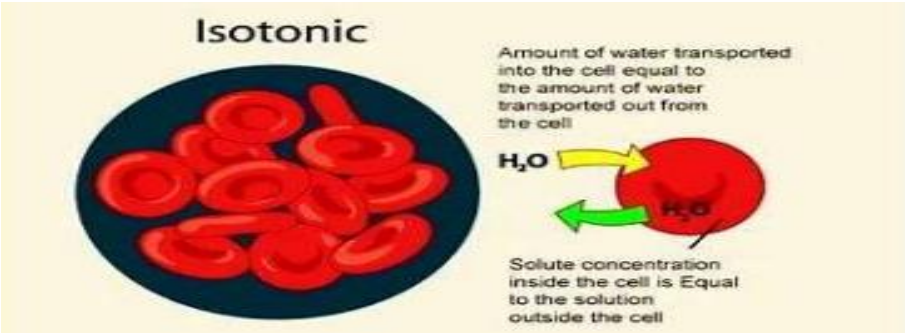

# Hypotonic Solutions & cytolysis

- The solution contain a low concentration of solute relative to another solution (e.g. the cell's cytoplasm). When a cell is placed in a hypotonic solution, the water diffuses into the cell, causing the cell to swell and possibly explode.

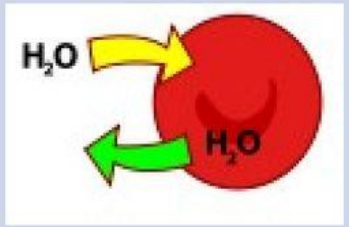
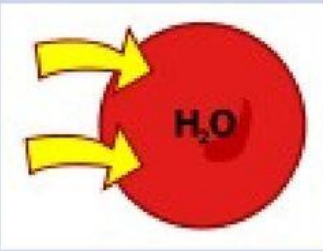
In cytolysis, water moves into the cell due to the hypotonic surrounding .



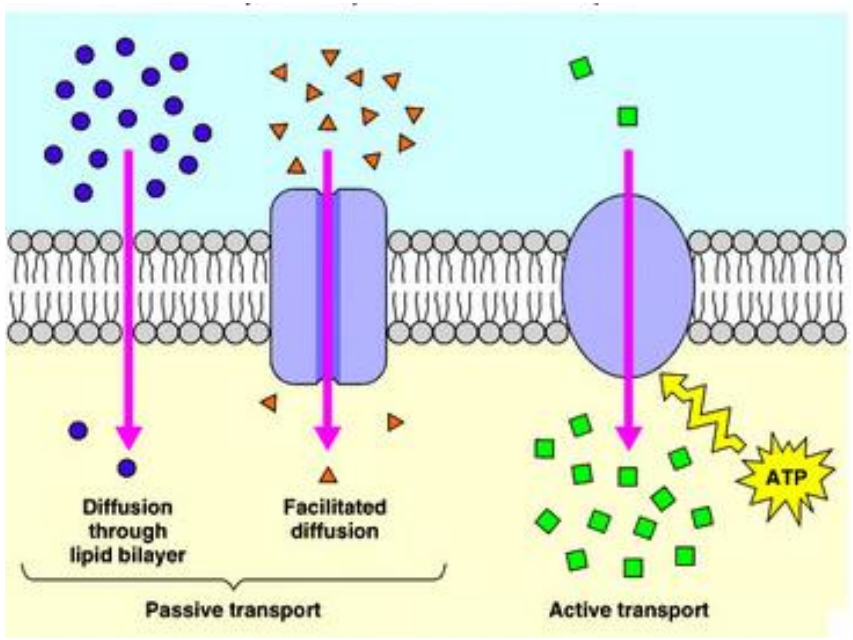
# Isotonic Solutions: The water diffuses into and out of the cell at the same rate.

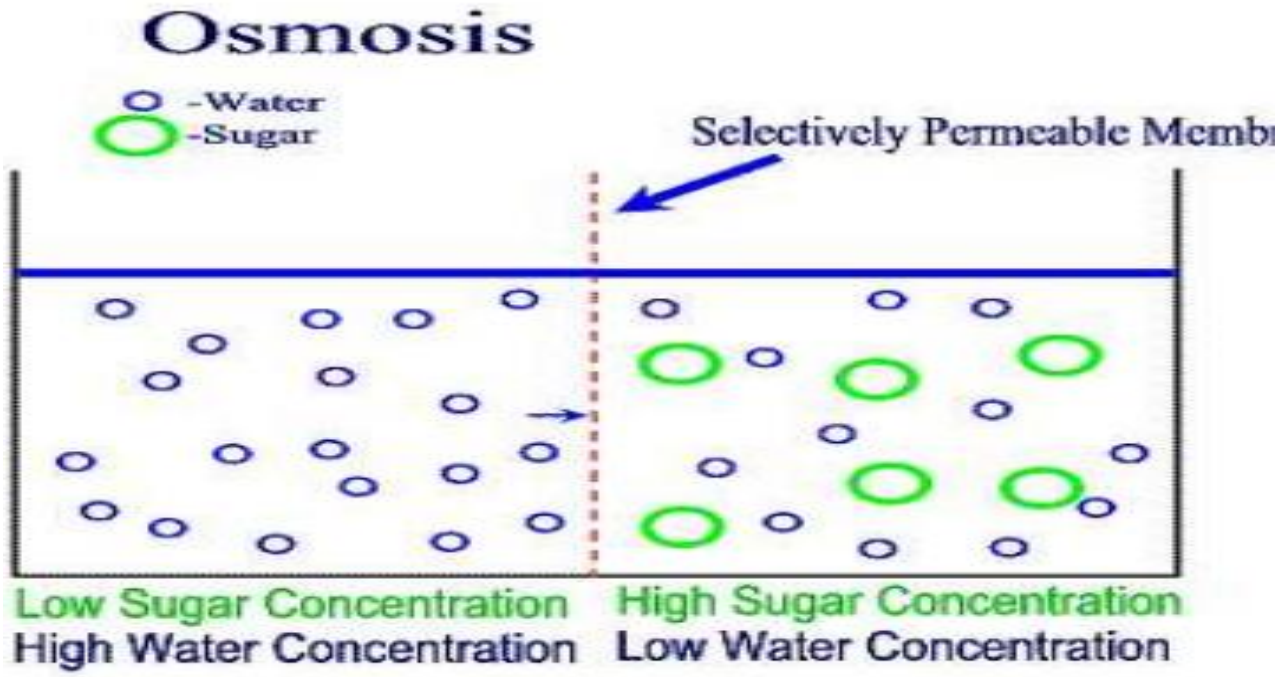



## Hypertonic vs. Isotonic vs. Hypotonic Solutions

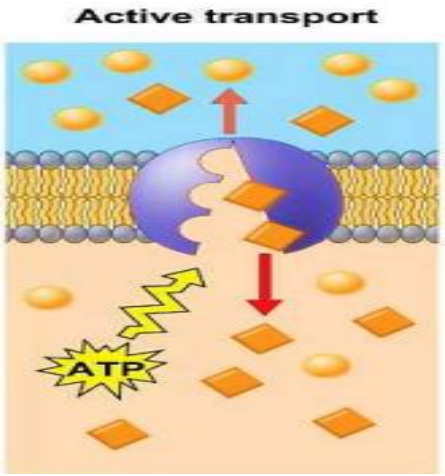
| Hypertonic | Isotonic | Hypotonic |
|---|---|---|
| Higher solute OUTSIDE | Equal solute | Higher solute INSIDE |
| Higher water INSIDE | Equal water | Higher water OUTSIDE |
| Water moves OUT | No net movement | Water moves IN |
| Cell SHRINKS | Normal | Cell SWELLS |
|  |  |  |

# Summary : Passive diffusion



# B. Active Transport

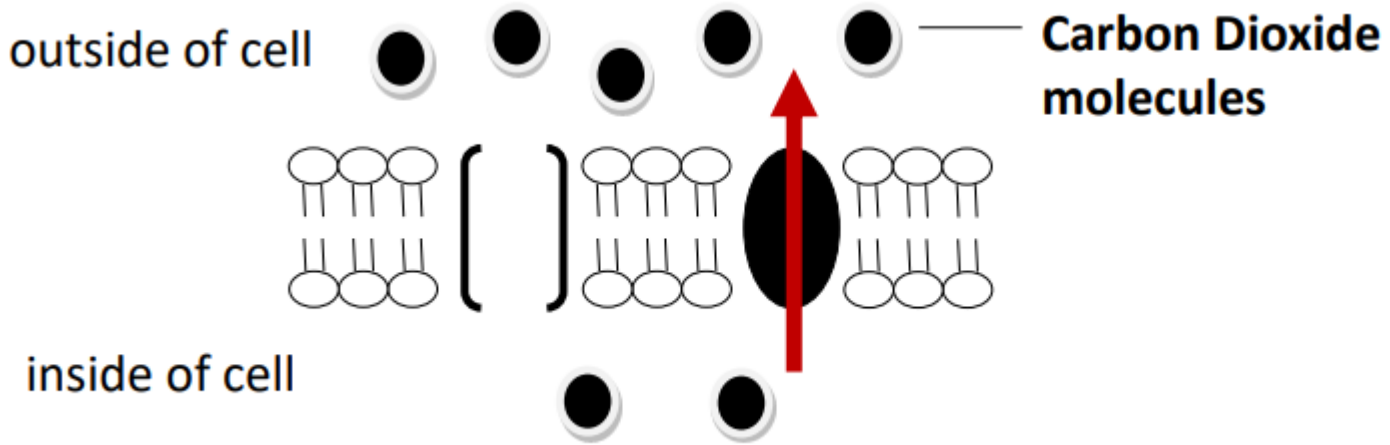



**It is the movement of molecules from LOW to HIGH concentration. Energy is needed (mostly ATP):**

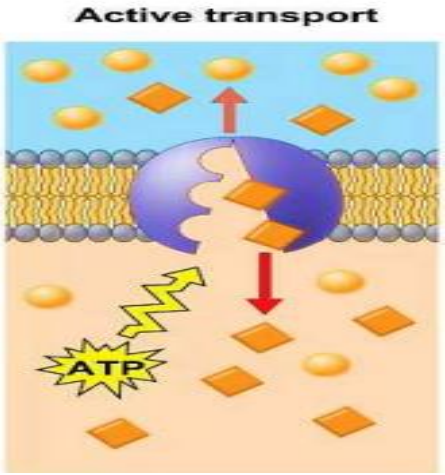
- **B.1. Protein pumps**
- **B.2. Vesicle Transport**
  - **B.2.1.Exocytosis**
  - **B.2.2. Endocytosis**
    - **B.2.2.1.Pinocytosis**
    - **B.2.2.2.Receptor-mediated endocytosis**
    - **B.2.2.3. Phagocytosis**

- **Active transport allows cells to maintain concentration gradients that differ from their surroundings.**

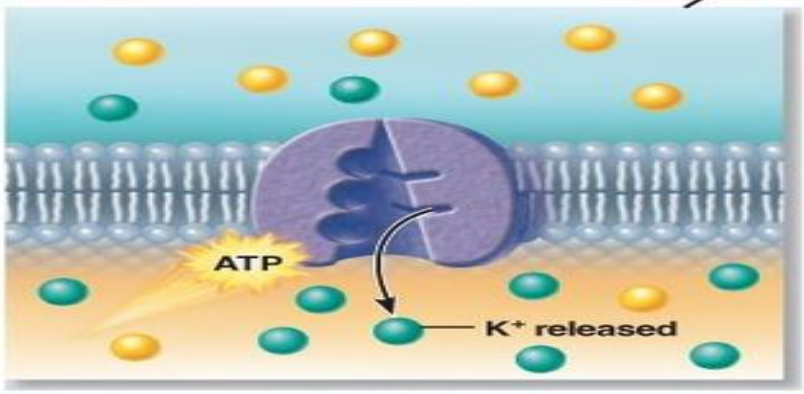
**E.g. Body cells must pump carbon dioxide out.**



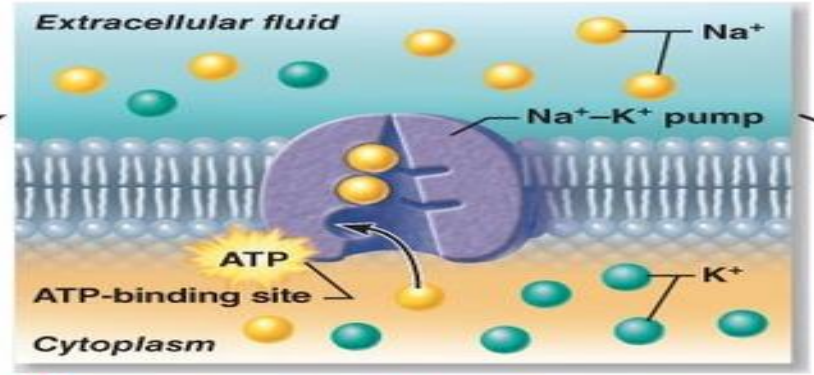
# B.1. Protein pumps



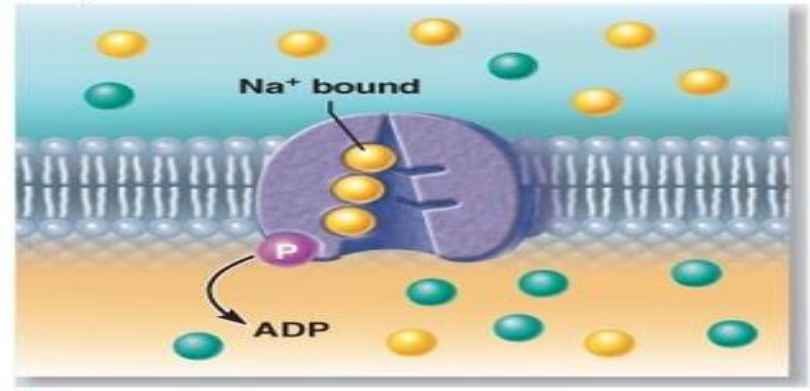

- **Proteins that work as pumps are called protein pumps. E.g. the sodium-potassium pump, which exchanges sodium ions for potassium ions across the plasma membrane.**
- **ATP powers active transport by transferring a phosphate group directly to a carrier protein. This may cause the carrier protein to change its shape, which moves the molecule or ion to the other side of the membrane.**
- **There are several drugs inhibiting the $Na^+$ $K^+$ pump e.g. digoxin.**



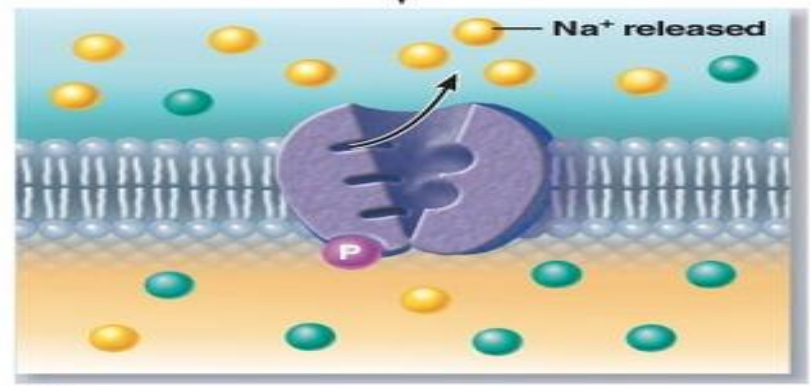

6 Pump protein binds ATP; releases $K^+$ to the inside, and $Na^+$ sites are ready to bind $Na^+$ again. The cycle repeats.



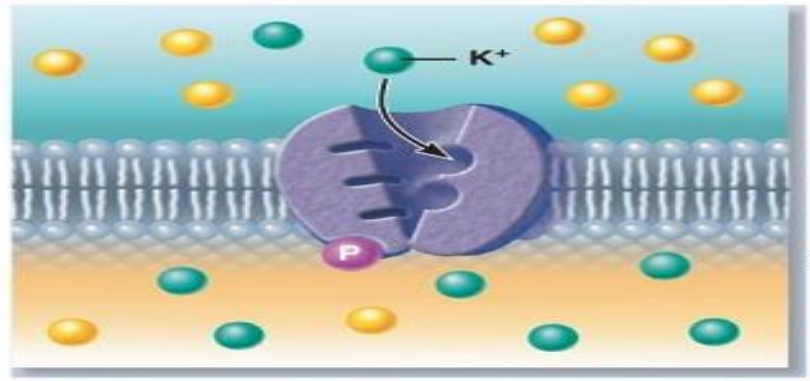

1 Three cytoplasmic $Na^+$ bind to pump protein.



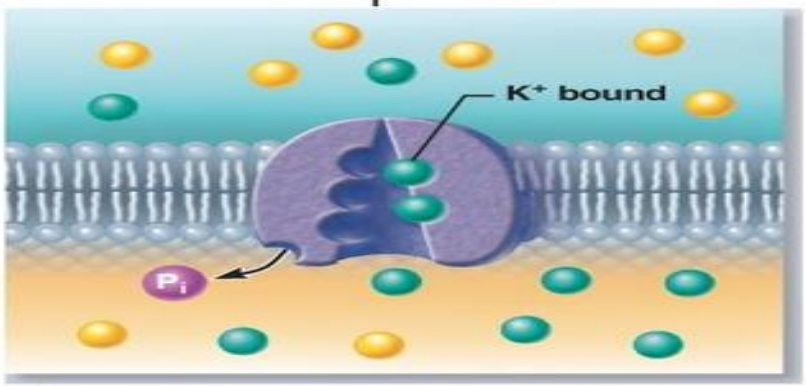

2 $Na^+$ binding promotes hydrolysis of ATP. The energy released during this reaction phosphorylates the pump.




3 Phosphorylation causes the pump to change shape, expelling $Na^+$ to the outside.




4 Two extracellular $K^+$ bind to pump.




5 $K^+$ binding triggers release of the phosphate. The dephosphorylated pump resumes its original conformation.

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# B.2. Vesicle Transport: B.2.1. Exocytosis

- In exocytosis, transport vesicles migrate to the membrane, fuse with it, and release their contents.
- Many secretory cells use exocytosis to export their products .

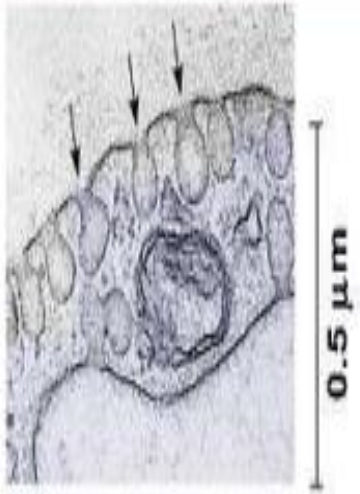
# B.2.2. Endocytosis

- Endocytosis is the process of engulfing macromolecules with the cell membrane and bringing it into the cell.
- In endocytosis, the cell takes in macromolecules by forming vesicles from the plasma membrane.
- Endocytosis is a reversal of exocytosis, different proteins involved in each one.

# 2.2.1.Pinocytosis

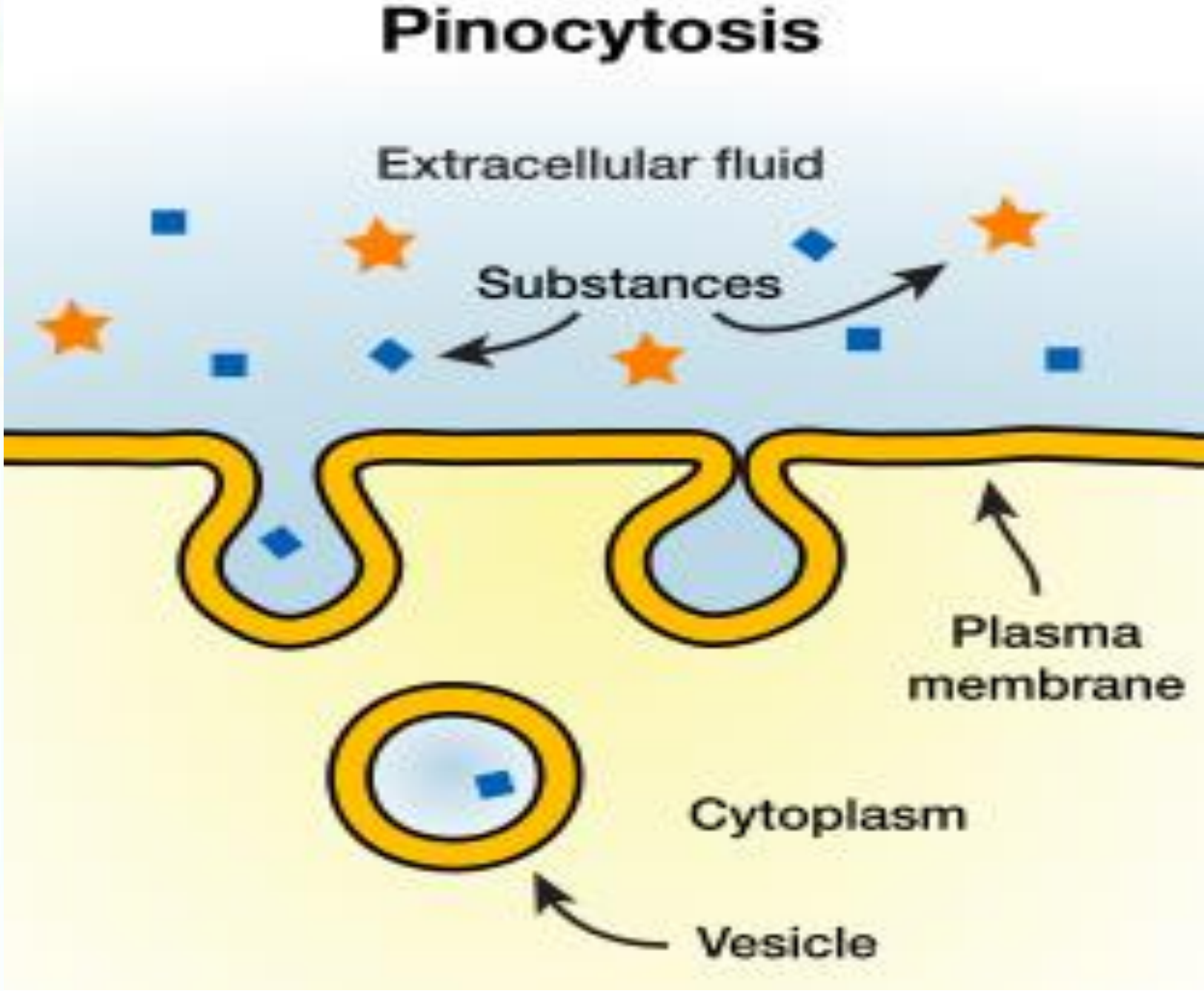
- In pinocytosis, the cell membrane invaginates (dimples inward) to form a pit containing a drop of extracellular fluid . The pit pinches off inside the cell when the cell membrane fuses and forms a pinocytotic vesicle containing the fluid. Pinocytosis represent (cellular drinking).
- Unlike receptor mediated endocytosis, pinocytosis is nonspecific in the substances that it transport: the cell takes in surrounding fluids, including all solutes present

Pinocytosis




Pinocytosis vesicles forming in a cell lining a small blood vessel (TEM).

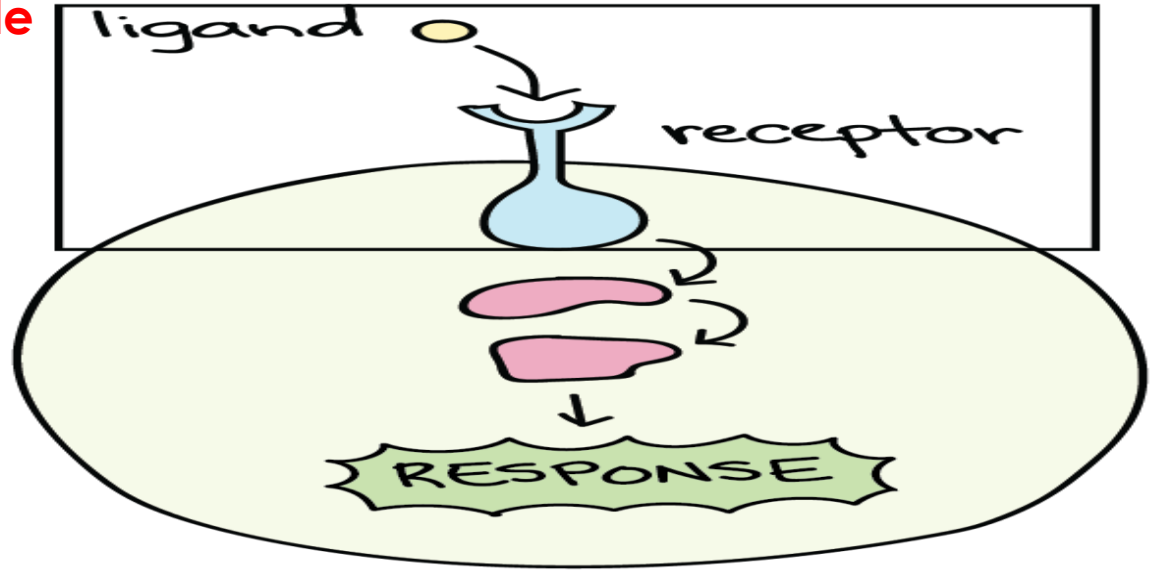
# Pinocytosis



# 2.2.2.Receptor-mediated endocytosis

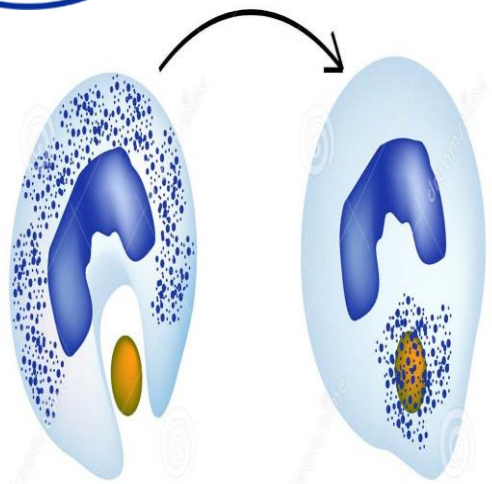
- **Includes membrane proteins called receptors that bind specific molecules (ligands). When many such receptors are bound by their ligands, they aggregate in one membrane region, which then invaginates and pinches off to create a vesicle or endosome containing both the receptors and the bound ligands. Examples of ligands include LDL via LDL receptors.**

**A ligand is any molecule or atom which binds reversibly to a protein.**



# ❖2.2.3 Phagocytosis

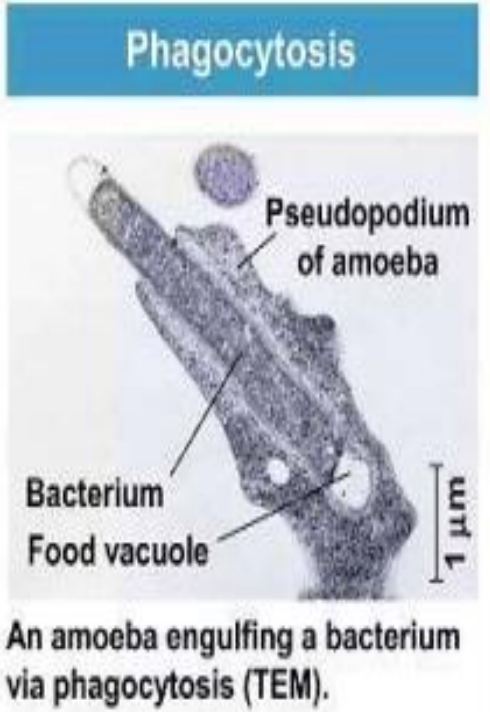
- In phagocytosis, a cell engulfs a particle in a vacuole.
- Involves the extension from the cell of large folds called pseudopodia that engulf particles, for example bacteria, and then internalize this material into a cytoplasmic vacuole or phagosome.
- The vacuole fuses with a lysosome to digest the particle



*Leukocyte absorbs bacteria*

*Leukocyte ingests bacteria*

# Phagocytosis




An amoeba engulfing a bacterium via phagocytosis (TEM).

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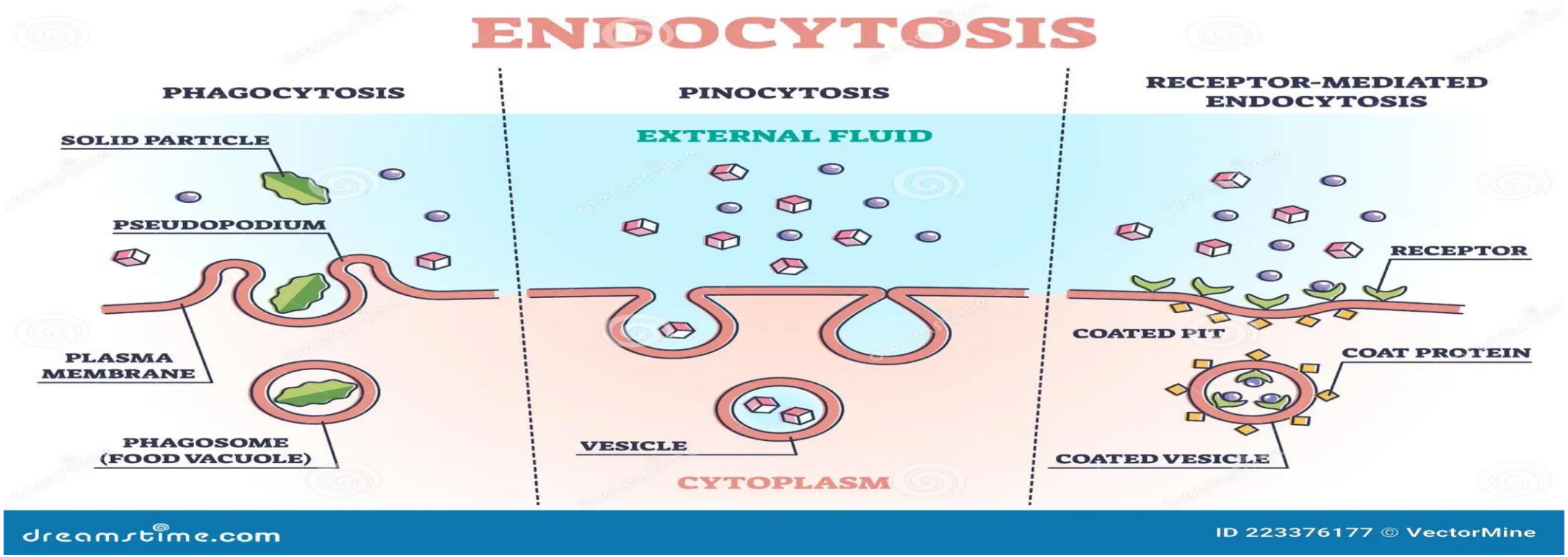
# Endocytosis :Summary



Dr Tareef Fadhil 24 Jan 2024

