BALAJI COLLEGE OF PHARMACY

TRANSPORT PROCESS ACROSS THE CELL MEMBRANE

Subject: Medicinal Biochemistry
PHARM D I YEAR

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HISTORY

Year	Scientist	Discovery
1877	Pfeffer	Proposed membrane theory of cell physiology
1889	Hamburger	Used hemolysis of erythrocytes to determine permeability of solutes
1935	Karl Lohman	Discovered ATP and its a role as a source of energy
1939	Harvey and Danielli	Proposed a lipid bilayer membrane
1941	Boyle and Conway	Membrane of resting frog muscle was permeable to both K+ and Cl-
1972	Singer and Nicolson	Fluid mosaic model
1997	Jens Shou	Nobel prize winner for Na+ - K+ pump

INTRODUCTION

- Cell membrane is the thin outer layer of the cell.
- It is composed mainly of phospholipids and protein molecules.
- Transport across cell membrane underlies a variety of physiological processes , from the beating of an animal's heart to the opening of tiny pores in leaves that enables gas exchange with the environment.

- Various processes involved in the transport of substances across the cell membrane may be grouped as under:

  1)Passive Transport

  2)Active Transport and

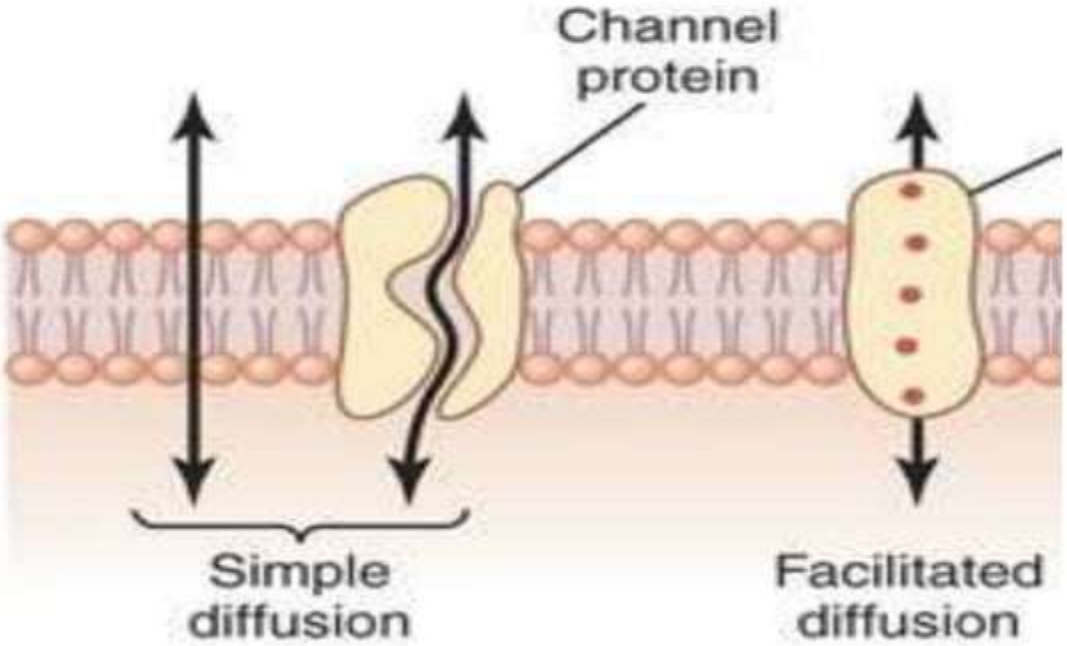
  3)Vesicular Transport

PASSIVE TRANSPORT

- Passive transport refers to the mechanism of transport of substances along the gradient without any energy expenditure.
- “Down-hill” movement.

SIMPLE DIFFUSION

- Movement from higher concentration to lower concentration.
- No carrier protein required.
- No energy required.
- Very small(O_2,CO_2) and lipid soluble molecules(steroids) can be transported.


Channel
protein
Simple
diffusion
Facilitated
diffusion

FACTORS AFFECTING NET RATE OF DIFFUSION

1) Cell membrane permeability

2) Concentration gradient

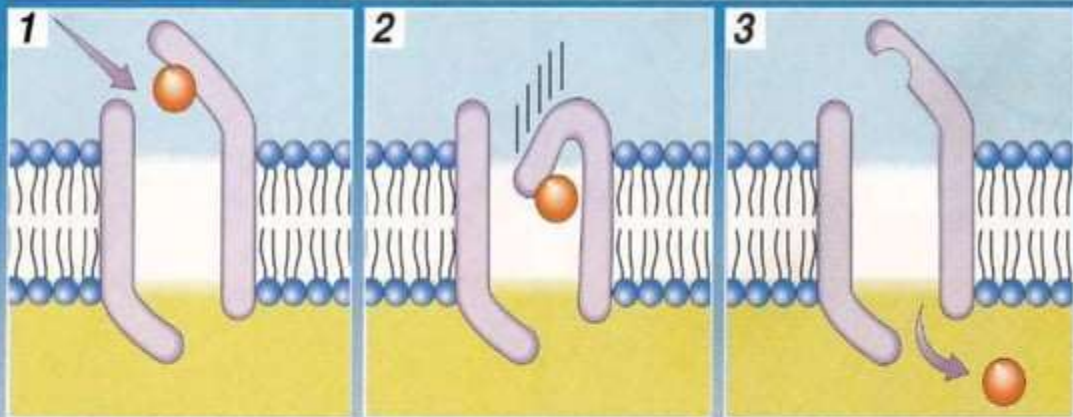
3) Electrical potential gradient

4) Pressure gradient

FACILITATED DIFFUSION

- Movement from higher concentration to lower concentration.
- Carrier protein required.
- No energy required.
- Large (glucose) and charged molecules(ions).

FACILITATED DIFFUSION

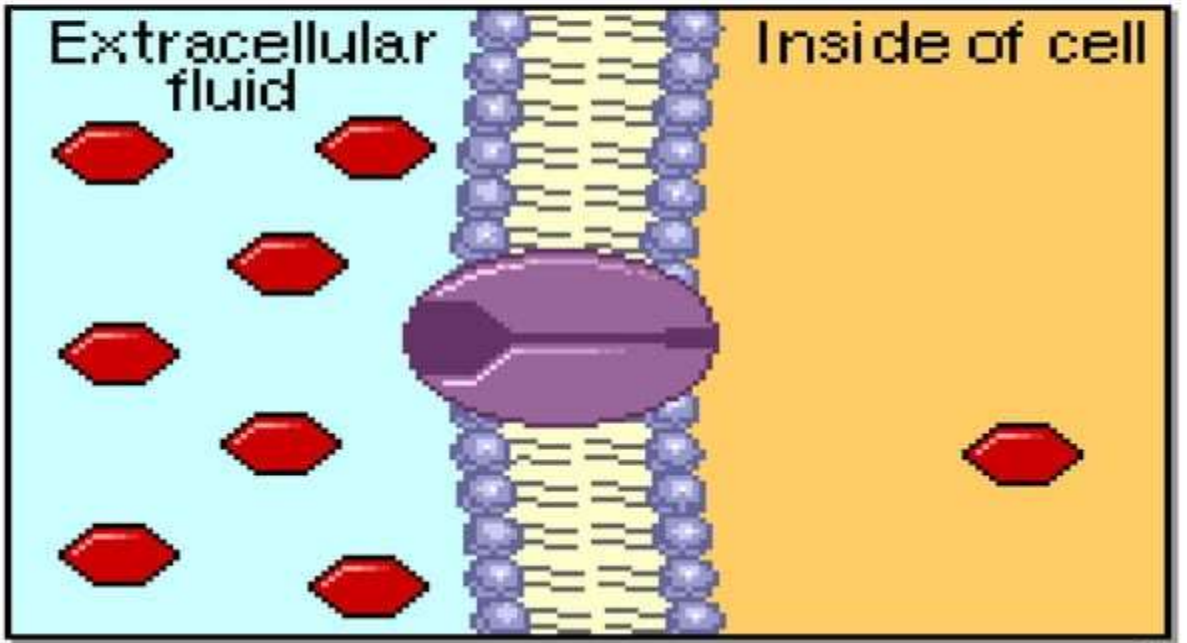


Particular molecules can bind to special protein channels in the plasma membrane.

The protein channel helps (facilitates) the diffusion process and does not require energy.

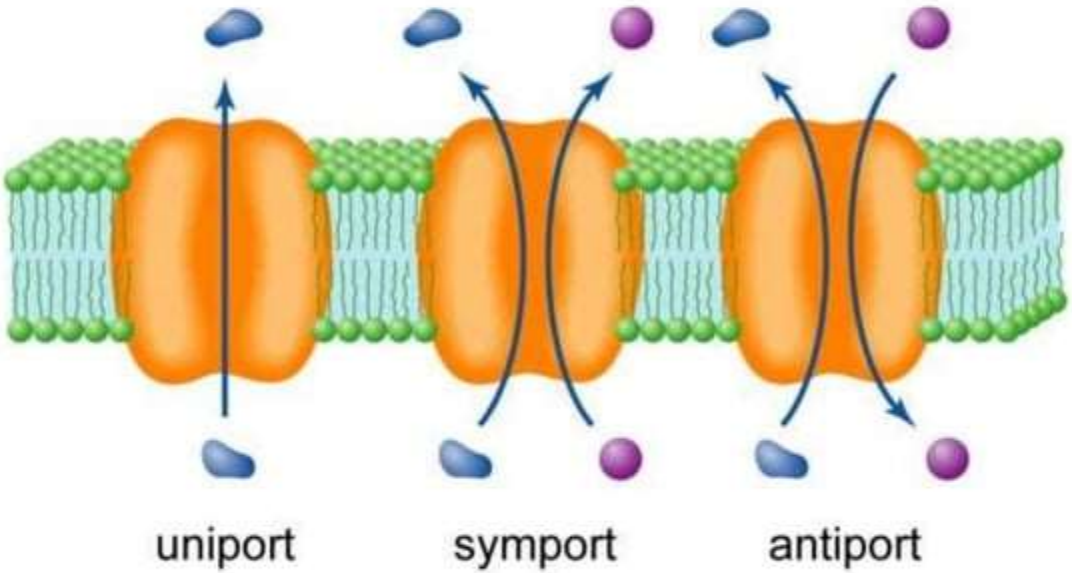
The molecule is released on the far side of the membrane. Protein channels transport only certain molecules across the membrane but will take them in either direction.

Facilitated Diffusion



Types of carrier protein synthesis

1) **Uniport** - transports one solute at a time.
2) **Symport** - transports the solute and a cotransported solute at the same time in the same direction.
3) **Antiport** -transports the solute in (or out) and the co-transported solute in the opposite direction. One goes in the other goes out or vice-versa.

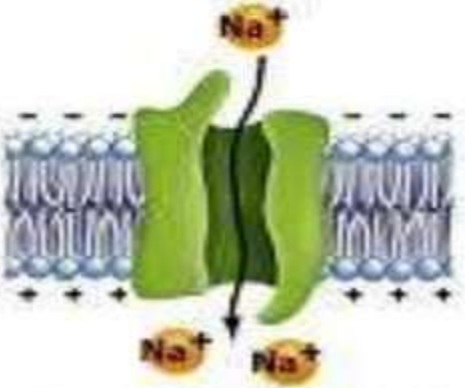

uniport
symport
antiport

Gating mechanisms in protein channels

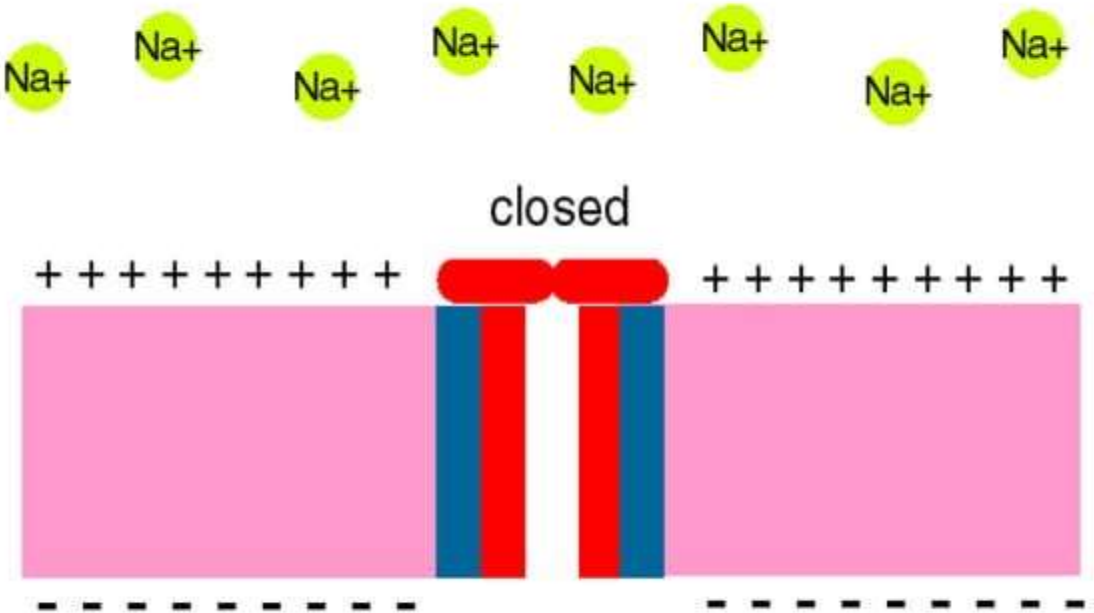
- Voltage – gated channels
- Ligand – gated channels
- Mechanical – gated channels

How voltage-gated channels work

At the resting potential, voltage-gated Na^+ channels are closed.

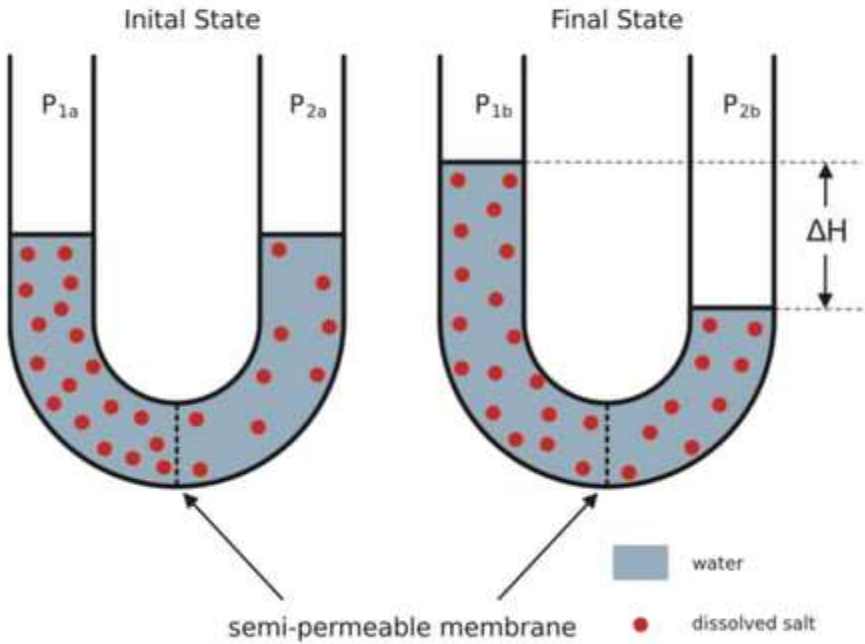


When the membrane is depolarized, conformational changes open the voltage-gated channel.

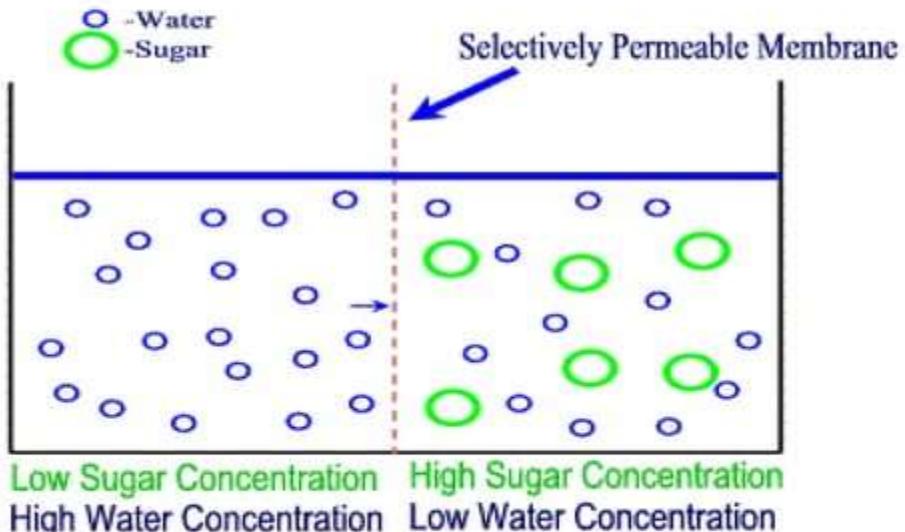

Na+
Na+
Na+
Na+
Na+
Na+
Na+
closed
+ + + + + + + + + +
+ + + + + + + + + +
- - - - - - - - - -
- - - - - - - - - -

OSMOSIS

- Diffusion of water or any other solvent molecules through a semipermeable membrane from a solution containing lower concentration of solutes towards the solution containing higher concentration of solutes.

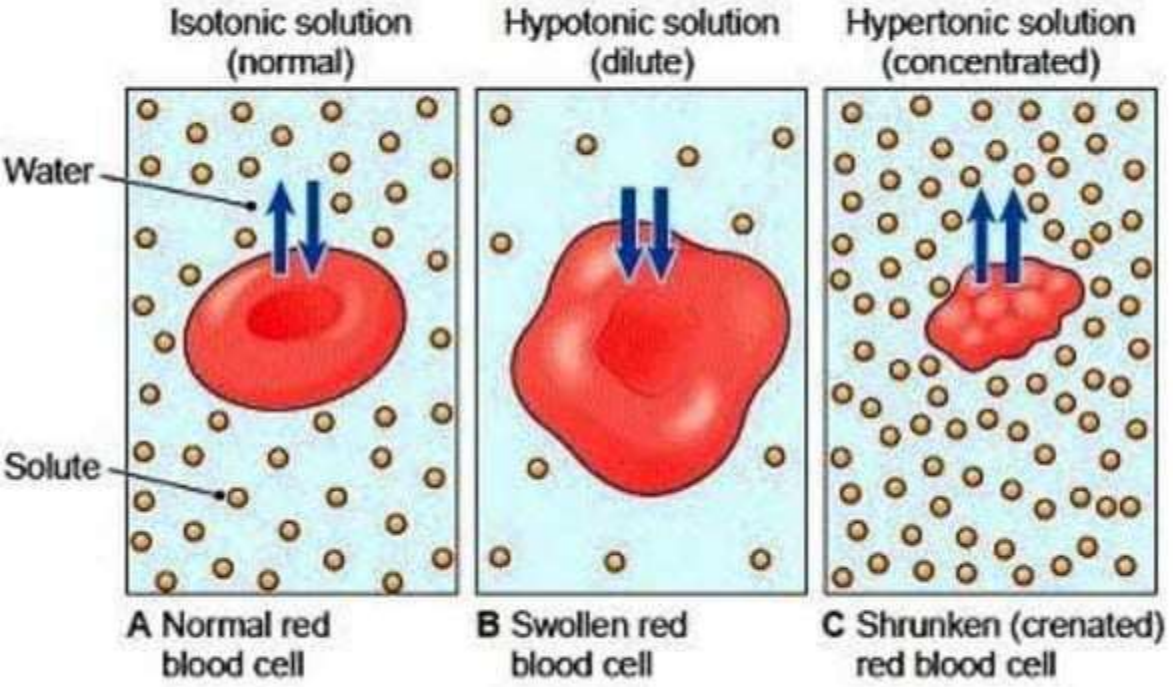

Inital State
Final State
P1a
P2a
P1b
P2b
ΔH
water
dissolved salt
semi-permeable membrane

Osmosis


-Water
-Sugar
Selectively Permeable Membrane
Low Sugar Concentration
High Water Concentration
High Sugar Concentration
Low Water Concentration

TONICITY

- **Hypotonic Solution -** One solution has a lower concentration of solute than another.
- **Hypertonic Solution -** one solution has a higher concentration of solute than another.
- **Isotonic Solution -** both solutions have same concentrations of solute.


Isotonic solution (normal)
Hypotonic solution (dilute)
Hypertonic solution (concentrated)
Water
Solute
A Normal red blood cell
B Swollen red blood cell
C Shrunken (crenated) red blood cell
Direction of osmotic water movement

ACTIVE TRANSPORT

- Cells use energy (ATP) to move large molecules or ions through a cell membrane
- Usually, these substances are moved "uphill" or against the concentration gradient. In other words, the substances are moved in the opposite direction of diffusion (passive transport)
- The embedded proteins involved are often called PUMPS.

- Active transport are of 2 types :

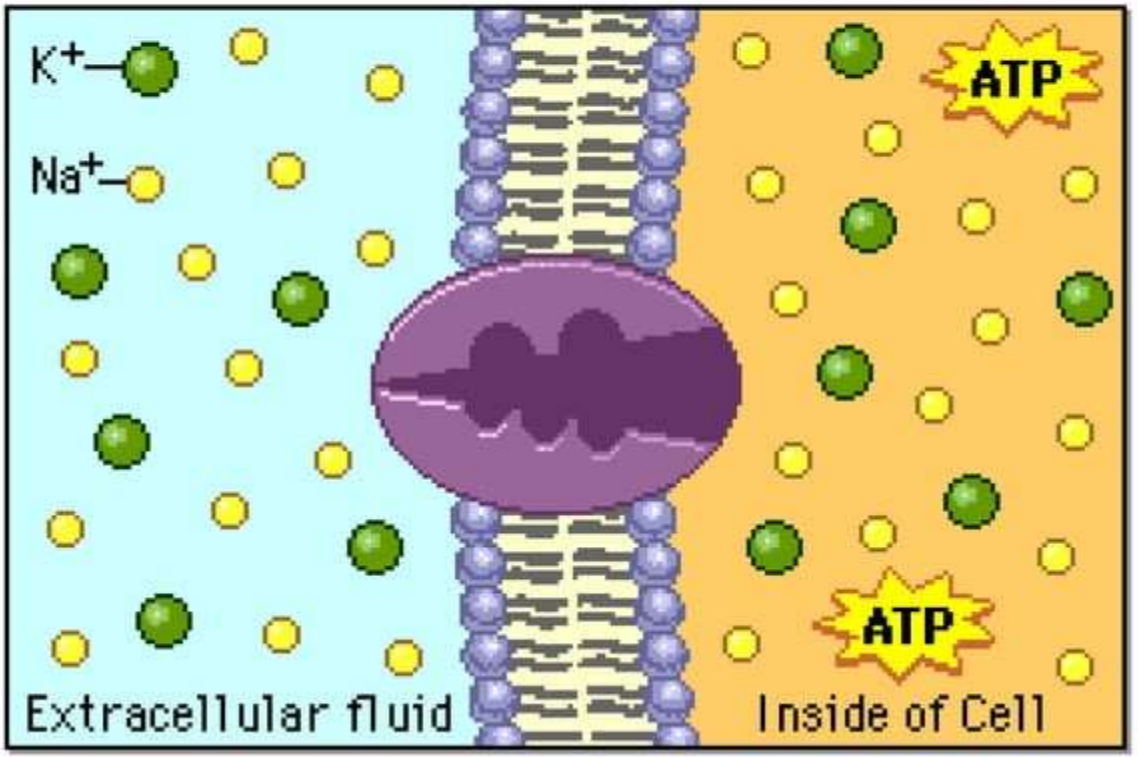
- 1) Primary active transport: ATP is used directly, and the energy comes from the breakage of a high energy phosphate bond.

- 2)Secondary active transport: ATP is not used directly, and the energy comes from a gradient that was created by a primary active transport system that used ATP.

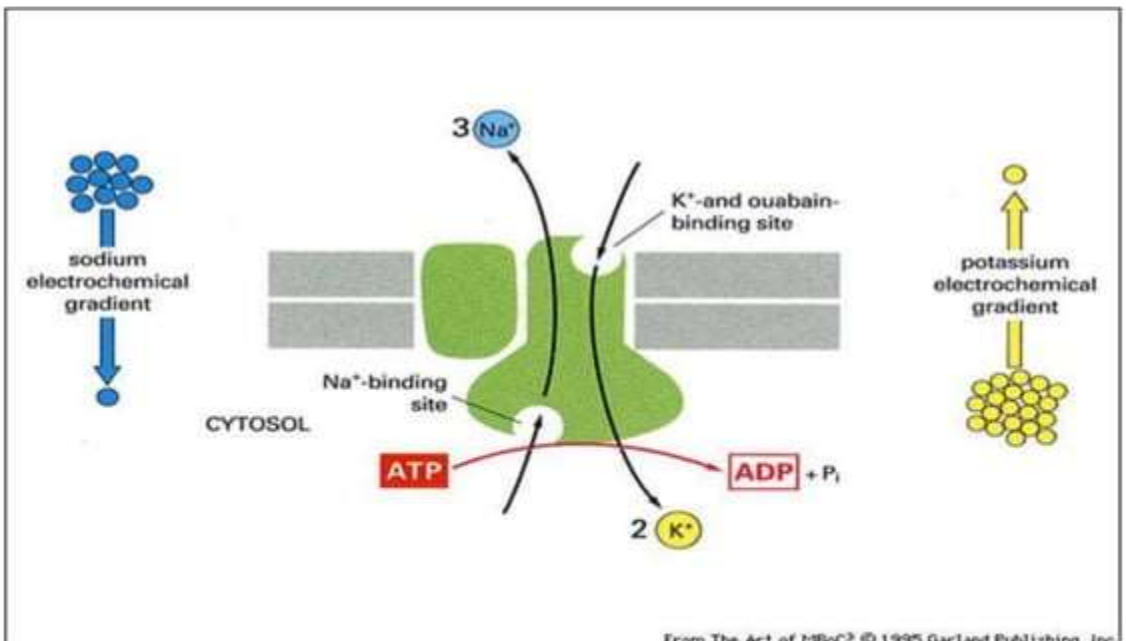
➢ Examples:

- Primary active : Sodium-potassium pump , calcium pump and potassium-hydrogen pump
- Secondary: Co transport (sodium co-transport of glucose and amino acids) and counter transport (sodium-calcium and sodium-hydrogen)

Sodium – potassium pump



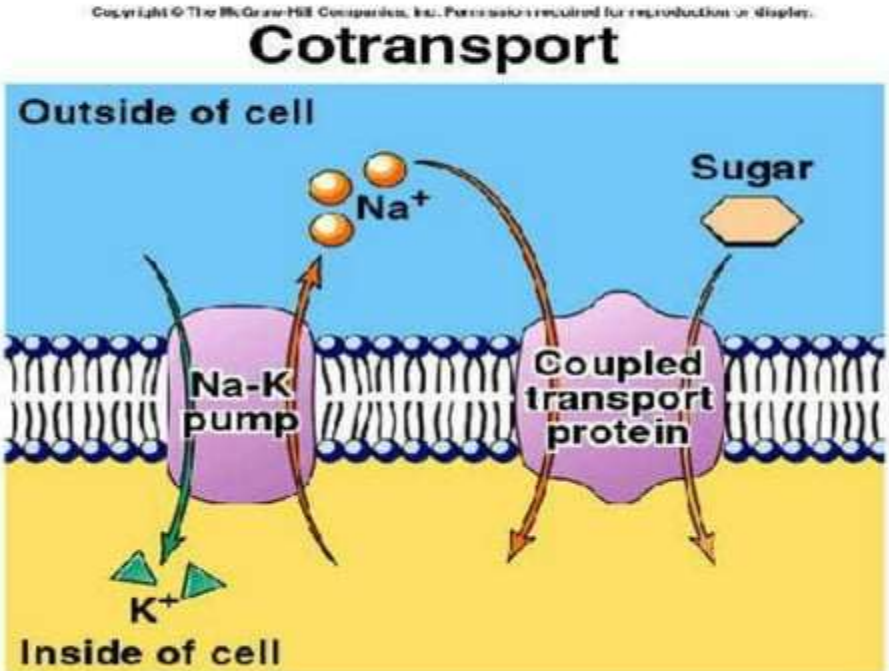
The Na^+-K^+ ATPase Pump



- **Functions of Na+ - K+ pump**:
  1) Controlling the cell volume
  2) Electrogenic activity

- **Regulation of Na+ - K+ pump**:
  1) Increased by cAMP ,diacylglycerol , thyorid hormone , insulin and G actin
  2) Inhibited by low temperature , oxygen lack , dopamine , ouabin and related glycosides used for the treatment of heart failure.

Sodium co-transport of glucose



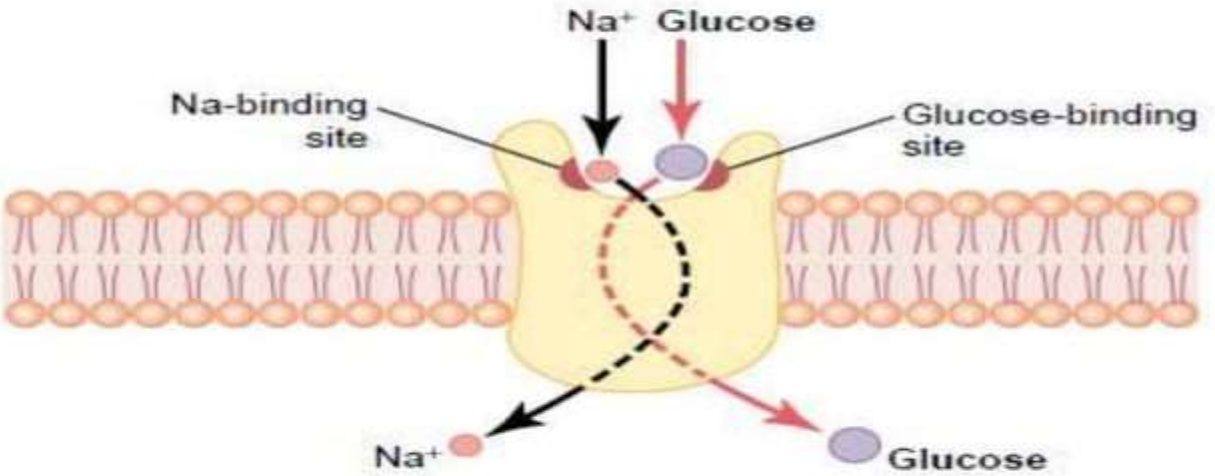


Figure 4–12

Postulated mechanism for sodium co-transport of glucose.

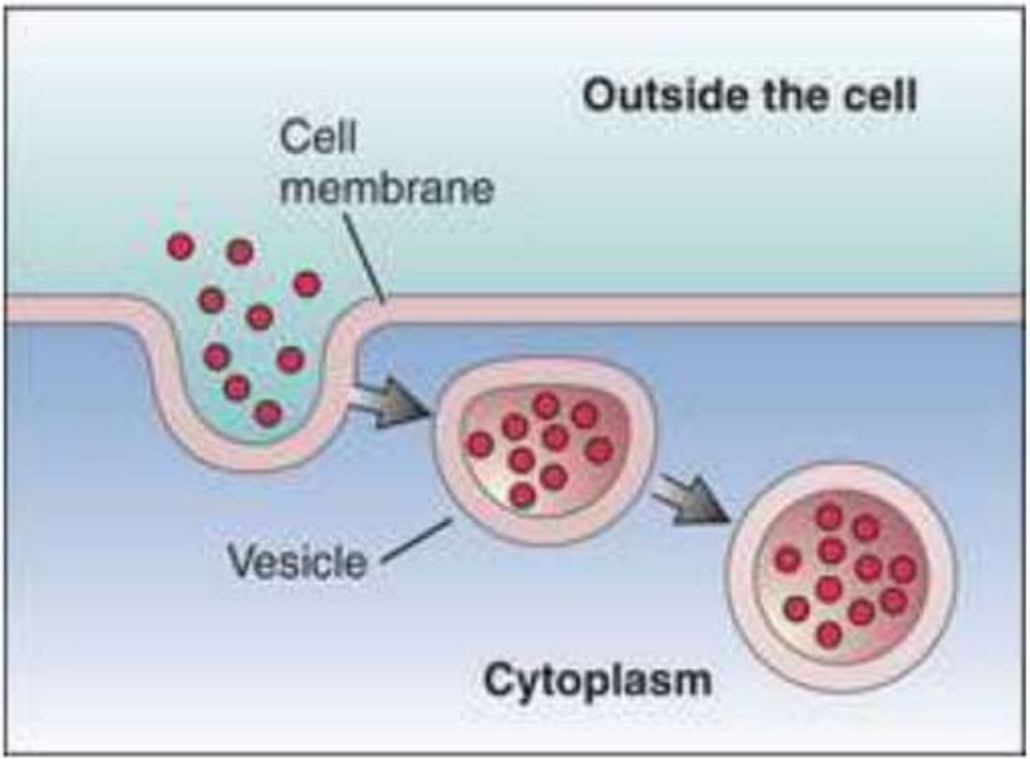
VESICULAR TRANSPORT

- Involved in the transport of macromolecules such as large protein molecules which can neither pass through the cell membrane by diffusion nor by active transport mechanisms.
- This includes: 1) Endocytosis
  2) Exocytosis
  3) Transcytosis

ENDOCYTOSIS

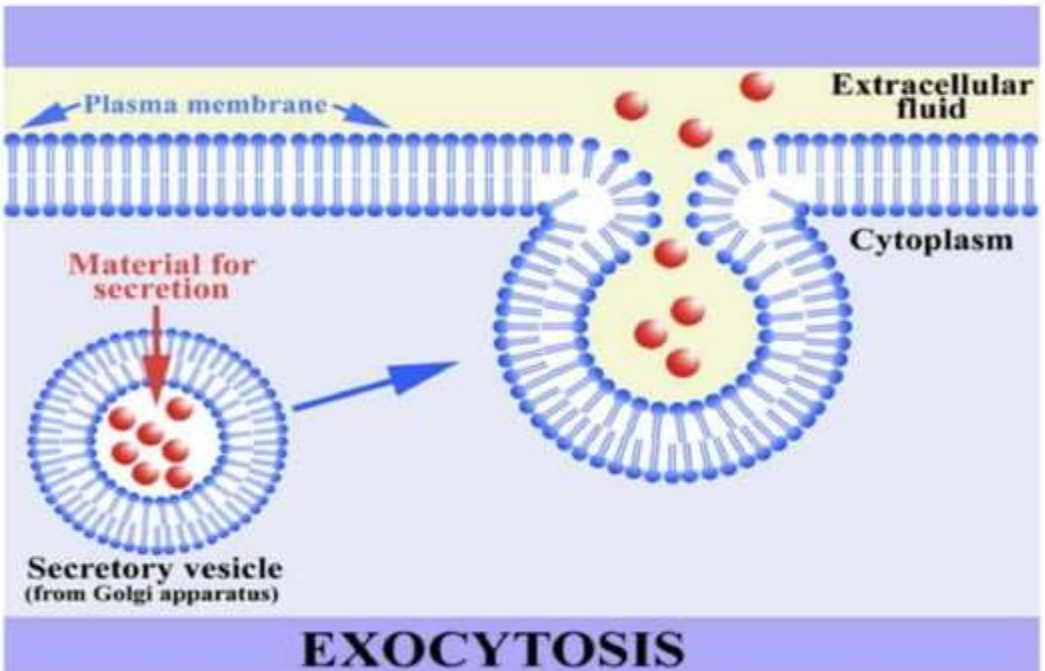
The process in which the substance is transported into the cell by infolding of the cell membrane around the substance and internalising it.

- Categorized into 3 types :
  - Pinocytosis (Cellular Drinking)
  - Phagocytosis (Cellular Eating)
  - Receptor-mediated endocytosis


Outside the cell
Cell membrane
Vesicle
Cytoplasm

EXOCYTOSIS

- The opposite of endocytosis is exocytosis. Large molecules that are manufactured in the cell are released through the cell membrane.
- For really large molecules, vesicles form and fuse to the plasma membrane & spills its contents out.


Plasma membrane
Extracellular fluid
Cytoplasm
Material for secretion
Secretory vesicle
(from Golgi apparatus)
EXOCYTOSIS

THANK YOU