PHYSIOLOGY Team 433

Lecture 2:

Cell membrane structure and transport across cell membrane.

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Color Index

Blue = Main Topic
Violet = sup topic
Red = important
Orange = Explanation
White &Black = Addition

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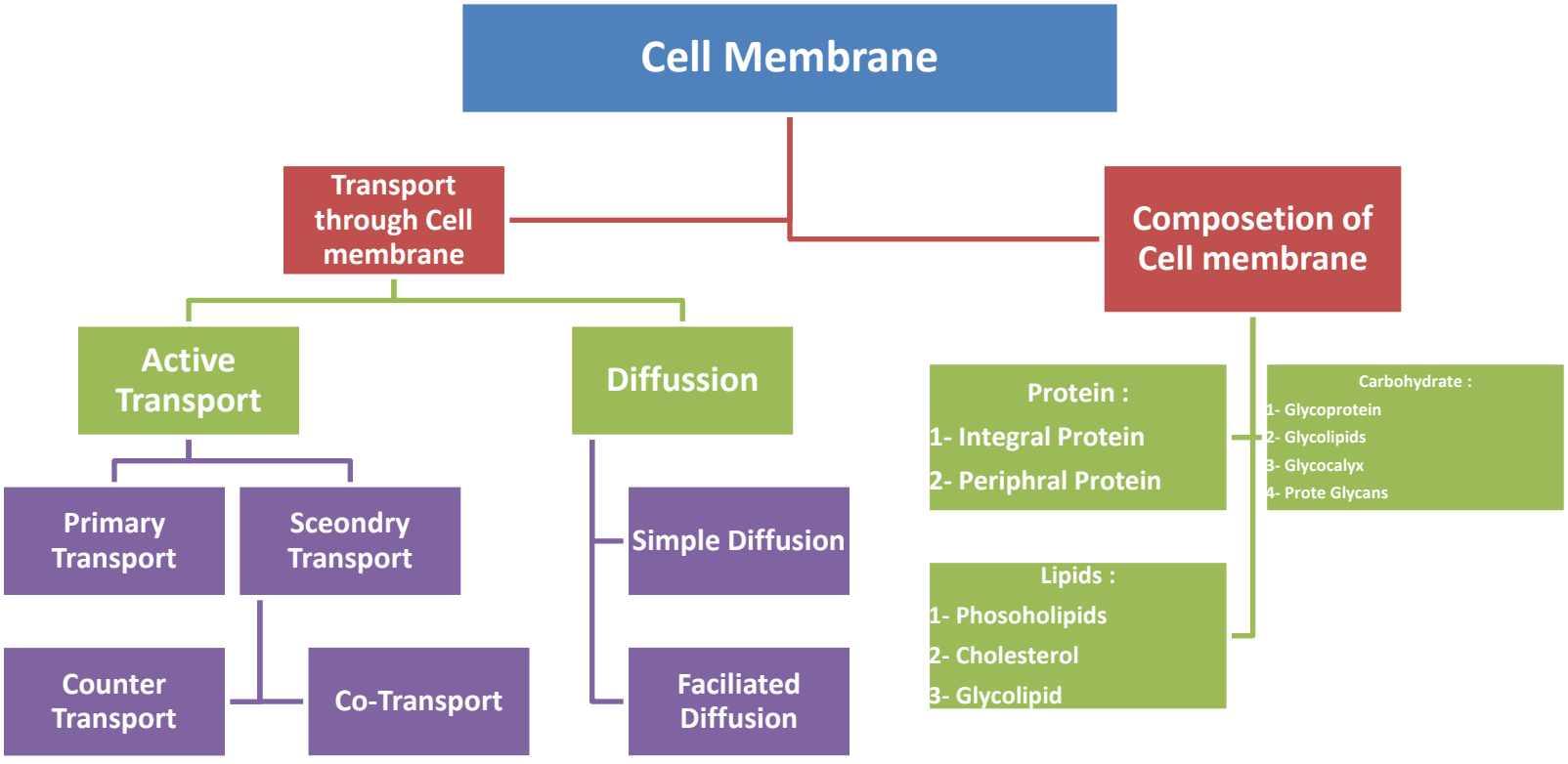
Objectives:

At the end of this session, the students should be able to:

- Describe the fluid mosaic model of membrane structure and function.
- Define permeability and list factors influencing permeability.
- Identify and describe carried-mediated transport processes: Primary active.
  transport, secondary active transport, facilitates diffusion.

Mind map

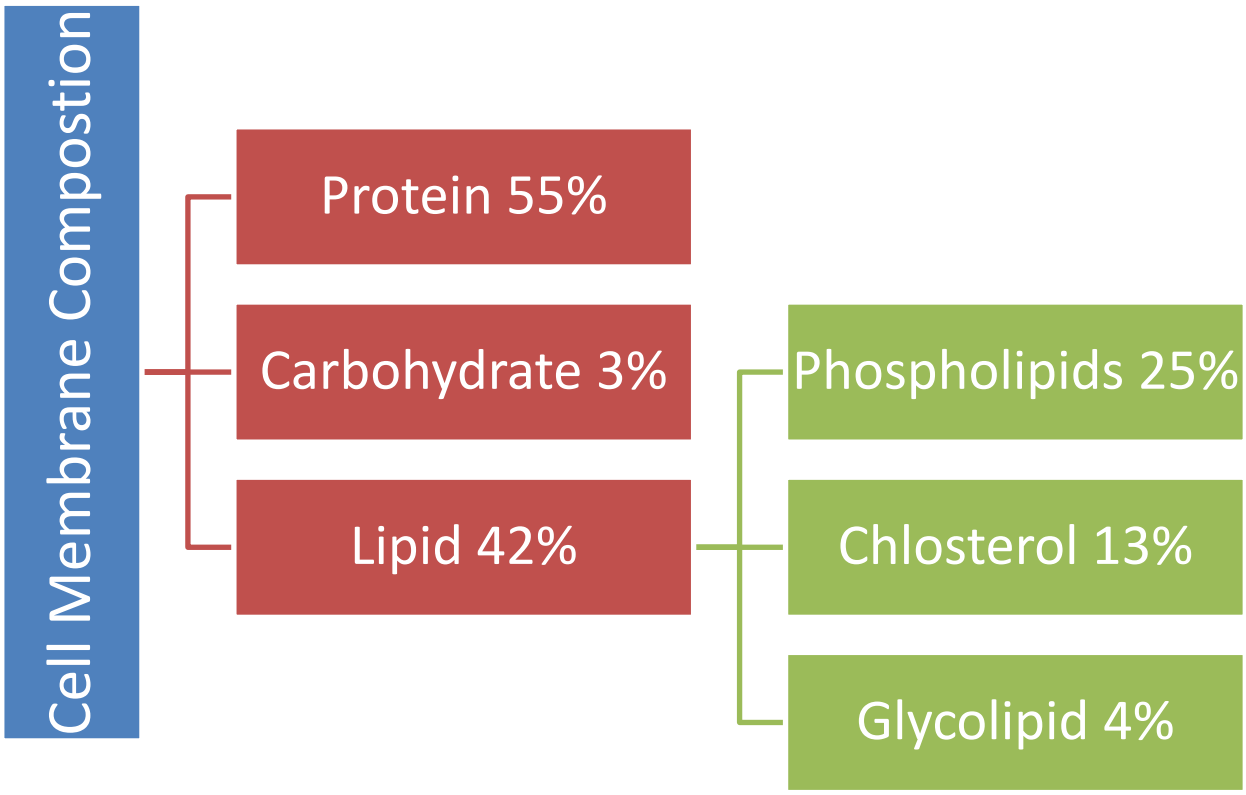


Cell Membrane

(The Plasma Membrane)

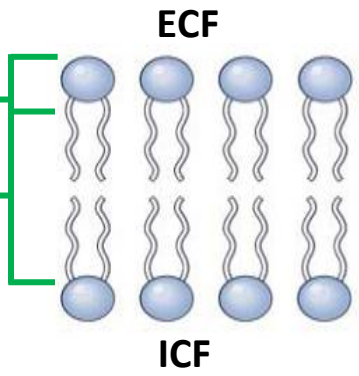
General characteristics of Cell membrane:

- **Lipid bilayer (phospholipids)**
- **Envelops the cell (covers the cell).**
- **Thin, pliable and elastic (fluid not solid).**
- **7 - 10 nanometer thick.**



❖ Phospholipids (Amphipathic) :

1. **Glycerol head** (hydrophilic).
2. **Two fatty acid** ''tails'' (hydrophobic).



- **Heads (hydrophilic) facing ICF and ECF and tails (hydrophobic) face each other in the interior of the bilayer**

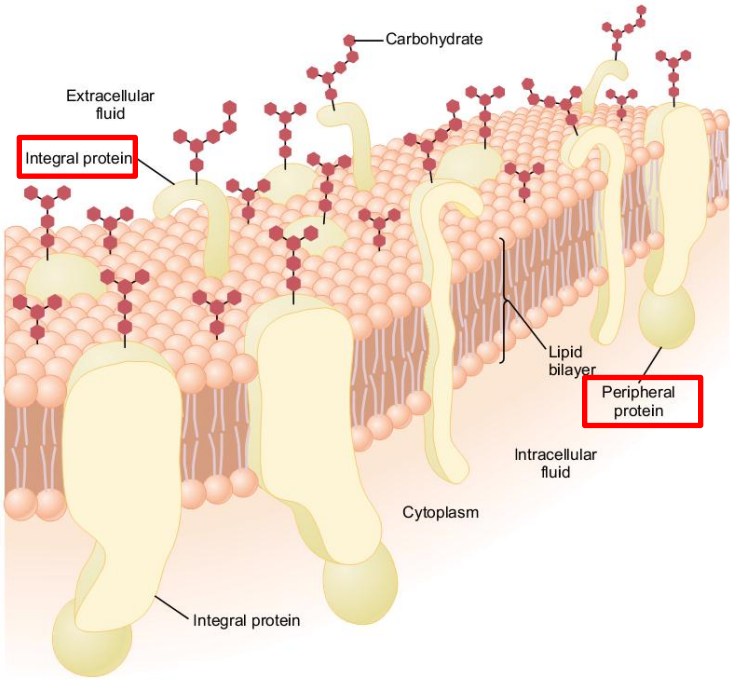
❖ Proteins :

1- Integral proteins:

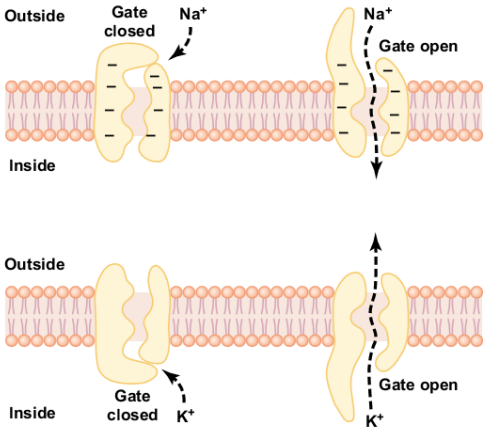
- **Span the membrane.**
- **Proteins provide structural channels or pores.**
- **Carrier proteins.**

2- Peripheral protein:

- **Present in one side.**
- **Hormone receptors.**
- **Cell membrane antigens**



This an example of how protein works as a channel for ions



❖ Carbohydrate :

1- Glycoproteins

(Most of integral proteins are glycoproteins).

2- Glycolipids

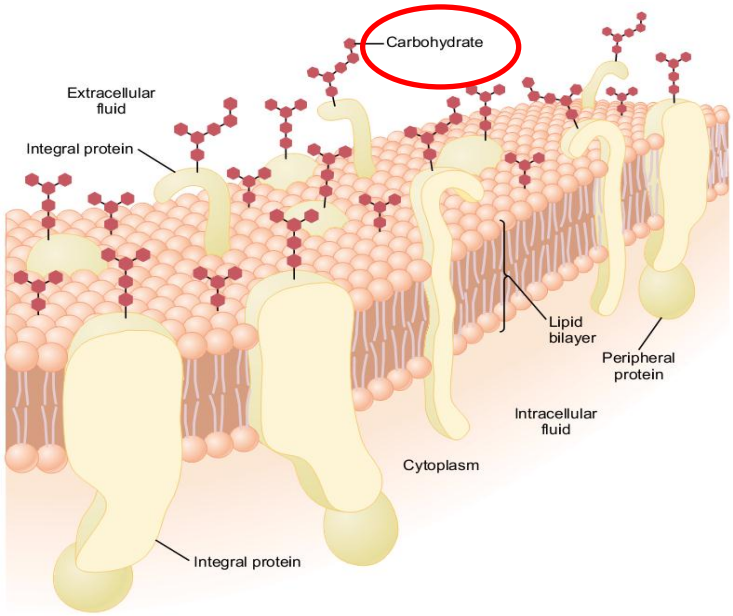
(Represent 1/10 of the membrane lipids)

3- Proteoglycans

(mainly carbohydrate substance bound together by protein)

4- Glycocalyx

(the entire outside surface of the cell often has a loose carbohydrate coat called the glycocalyx)



"glyco" part is in the surface forming.

The "glyco" portions of these molecules (glycoproteins & glycolipids) almost invariably protrude to the outside of the cell, dangling outward from the cell surface

أي أن الكربوهيدرات المرتبطة بالدهون والبروتينات تكون بارزة ومتدلية من سطح الخلية

Functions of Carbohydrates

- Attaches cell to each other's. (by glycoclyx)
- Act as receptors substances (help ligend to recognize its receptor).
- Some enter in to immune reactions.
- Give most of cells overall –ve surface. (to repelse other negetive object)

Transport Through The Cell

Cell membrane is
Selectively Permeable

Through the proteins
(Water -soluble substances e.g. ions, glucose)

Through the lipid bilayer
Fat -soluble substance (O2, CO2, N2, alcohol)

جميع المواد تدخل للخلايا إما عن طريق البروتين أو عن طريق طبقتي الدهون.

Types of membrane movement

Passive Transport
(No energy require)

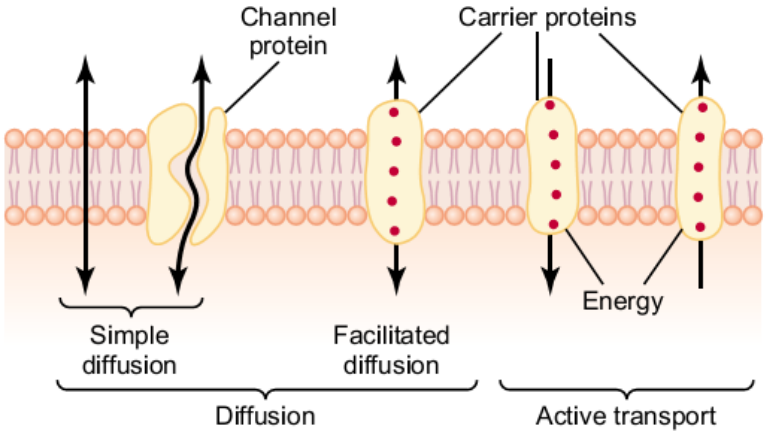
1. Simple Diffusion
2. Facilitated Diffusion
3. Osmosis

Active Transport
(Require energy)

1. Primary Active Transport
2. Secondary Active Transport

❖ Diffusion :

Random movement of substance either through the membrane directly or in combination with carrier protein down an electrochemical gradient.



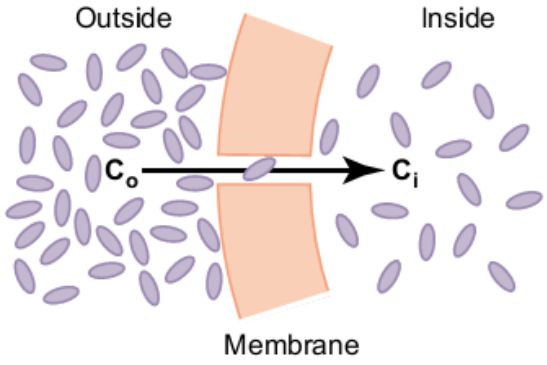
Simple diffusion & facilitated transport don ’t require input of energy = powered by Concentration gradient or electrical gradient
[Active transport = directly uses ATP]

Diffusion

- Simple Diffusion
  - **Non-carrier mediated** transport down an electrochemical gradient.
  - Diffusion of **nonelectrolytes** (uncharged) from high concentration to low concentration.
  - Diffusion of **electrolytes** (charged) depend on both **chemical as will as electrical potential difference.**
- Faciliated Diffusion
  - **Carrier mediated** transport down an electrochemical gradient.

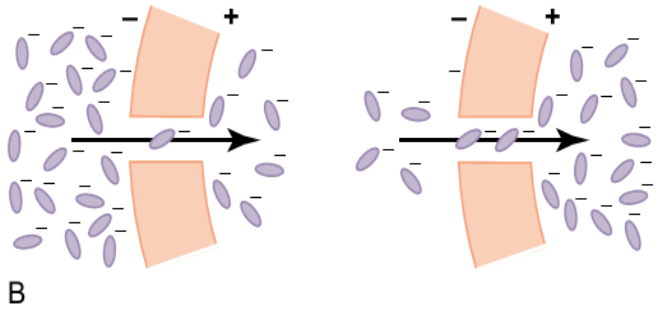
Rate Of Simple Diffusion

Amount of substance available	Increasing in diffusion due to increasing in amount
The number of opening pores in the cell membrane	Increasing in diffusion due to increasing in number of pores
Chemical concentration difference net diffusion= P x A (Co-Ci)	the rate of net diffusion into the cell is proportional to the concentration on the outside minus the concentration on the inside Co = Concentration Outside - Ci = Concentration Inside
Electrical potential difference. EPD=± 61 log C1/C2	the electrical charges of the ions cause them to move through the membrane even though no concentration difference exists to cause movement
Molecular size of the substance	Increasing in diffusion due to decreasing in molecular size
Lipid solubility	Increasing in diffusion due to increasing in lipid solublity
Temperature	Increasing in diffusion due to increasing in heat



A

Chemical concentration difference
net diffusion= P x A (Co-Ci)



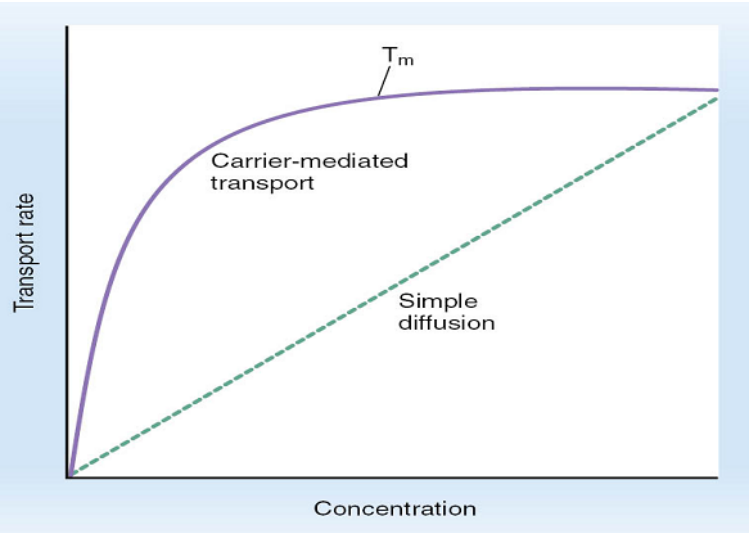
Electrical potential difference.
EPD=± 61 log C1/C2

Features Of Carrier Mediated Transport (Facilitaed diffusion)

Saturation	Stereopecificity	Competition
If all protein is occupied we achieve full saturation	The binding site recognize a specific substance e.g.D-glucose but not L-glucose.	Chemically similar substance can compete for the same binding site.

Substance → binding site → substance protein complex → conformational changes → release of substance.

Tm = Saturation



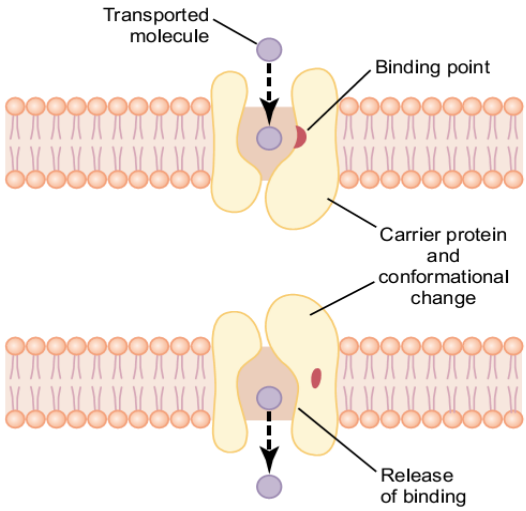
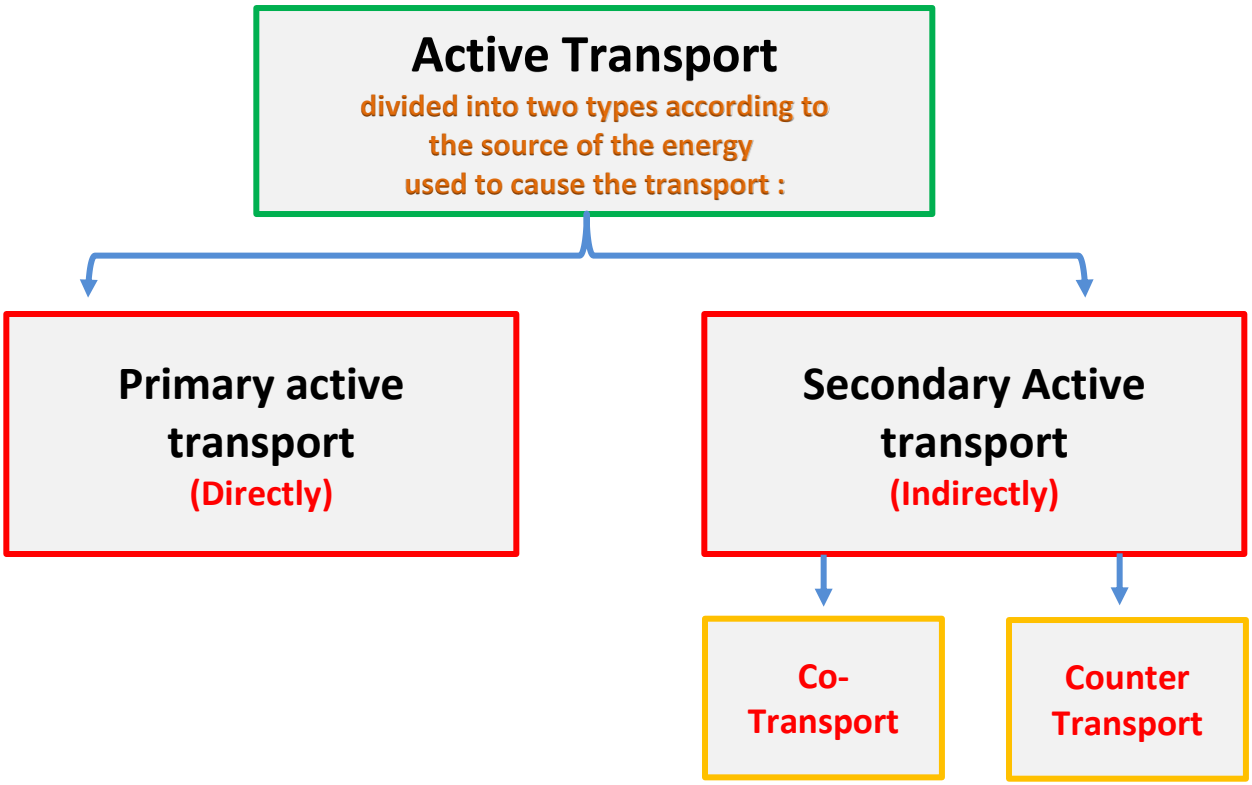


Figure 4–7

Postulated mechanism for facilitated diffusion.

Active Transport:

- Transport (uphill) → against electrochemical gradient.
- Required energy (Direct & Indirect)
- Required carrier – protein.



What the difference? (Explanation Only)

1- In primary active transport, the energy is derived directly from breakdown of adenosine triphosphate (ATP) or of some other high-energy phosphate compound.
2- In secondary active transport, the energy is derived secondarily from energy that has been stored in the form of ionic concentration differences of secondary molecular or ionic substances between the two sides of a cell membrane, created originally by primary active transport.

❖ Primary Active Transport :

Energy is supplied directly from ATP.

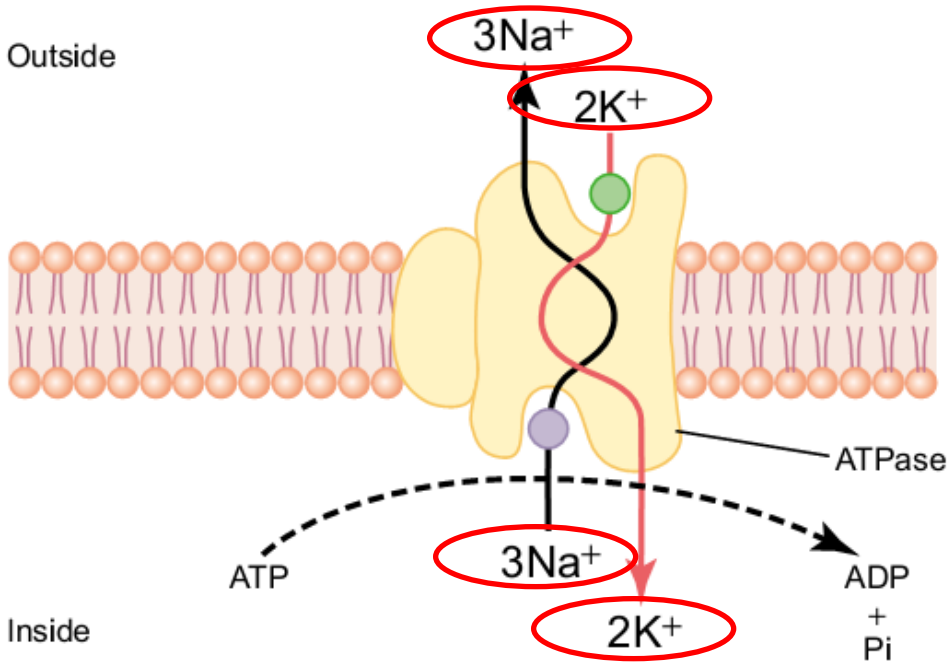
ATP → ADP +P+ energy.

A. Sodium-Potassium pump (Na+-K+ pump):

- Its present in all cell membranes.

- 3 Na^+ in → out.

- 2 K^+ out → in.



CHARACTERISTICS OF THE (NA^+- K^+ PUMP)

- Carrier protein.
- Binding site for Na inside the cell.
- Binding site for K outside the cell.
- It has ATPase activity.
- 3 Na out.
- 2 K in.

FUNCTIONS OF THE PUMP

A. Maintaining Na+ and K+ concentration difference .
B. Maintaining –ve potential inside the cell.
C. Maintains a normal cell volume.
D. It's the basis of nerve signal transmition .

B. primary active transport of calcium (Ca^{2}+ ATPase):

❖ Site:

- Sarcoplasmic reticulum (SR).
- Mitochondria.
- in some cell membranes.

❖ Function:

Maintaining a low Ca^{2}+ concentration inside the cell.

C. primary active transport of hydrogen ions H+-K+ ATPase:

❖ Site:

- Stomach.
- Kidneys.

❖ Function:

- pump to the lumen.
- H+-K+ ATPase inhibitors (treat ulcer disease). (omeprazol)

تمنع خروج H وبالتالي تعالج القرحة.

❖ Secondary Active Transport:

- **Co- transport OR Countertransport:**

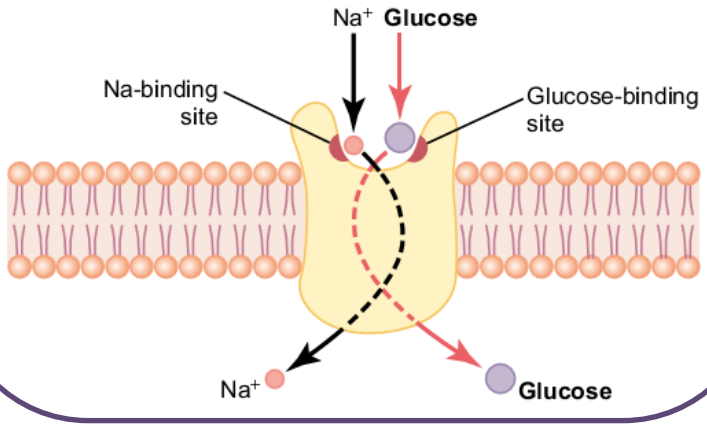
is transport of one or more solutes against an electrochemical gradient, coupled to the transport of another solute down an electrochemical gradient.

- **''downhill'' solute is Na.**
- **Energy is supplied indirectly form primary transport.**

Co-Transport

- All solutes move in the same direction to ''inside the cell''.

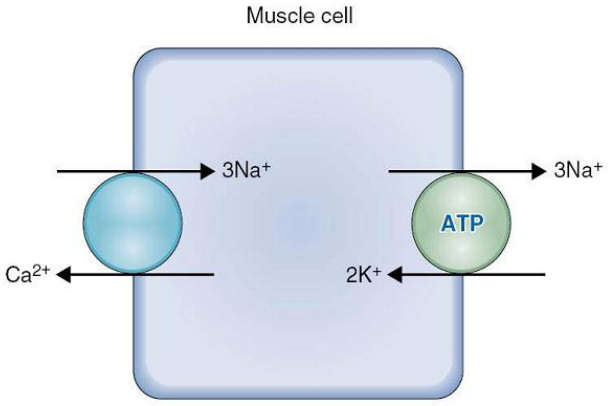
- Na+ - glucose Co-transport.
- Na+ - amino acid Co-transport.
- In the intestinal tract & kidney



Counter Transport

- **Na+ is moving to the interior causing other substance to move out.**

- **Ca^{2}+ - Na+ exchange.**
- **(Present in many cell membranes)**
- **Na+ - H+ exchange in the kidney**



Summary:

- the cell membrane consists of protein, lipid and carbohydrates .
- the cell membrane is selectively permeable.
- The solutes can enter the cell either with protein or lipid.
- Types of membrane transport are: diffusion, active transport and osmosis.
- In diffusion there is no need for energy, but in active transport we need energy, because it is against the electrochemical gradient.

Related videos:

1- https://www.youtube.com/watch?v=kfy92hdaAH0 **ACTIVE AND PASSIVE TRANSPORT**

2- https://www.youtube.com/watch?v=awz6lIss3hQ **NA^+K^+ PUMP**

Multiple Choice Questions

Q1: Which of the following statement is true about cell membrane?

A- It is a solid membrane
B- It is 11 nanometer thick
C- It is hydrophilic
D- It is Amphipathic

Answer is : D

Q2: The Cell membrane phospholipids consist of two fatty Acids which is "hydrophilic".

A- True
B- False

Answer is : B

Q3: In "Sodium – Potassium pump" which of these will happen?

A- 2Na+ in & 2K+ out
B- 2Na+ in & 3K+ out
C- 3Na+ in & 2K+ out
D- 3Na+ out & 2K+ in

Answer is : D

Q4: Which of the following act as receptor recognition in cell membrane?

A- Carbohydrates
B- Proteins
C- Lipids
D- Both A and C

Answer is : A

Q5: Simple Diffusion is a carrier mediated transport down its electrochemical graidant.

A- True
B- False

Answer is : B

Q6: Which of the following is an example for secondary active transport?

A- Na+ - Amino acid Co-transport
B- Na+ - K+ pump
C- Active transport of calcium (Ca2 + ATPase)
D- Active transport of hydrogen ions (H+ - K)

Answer is : A