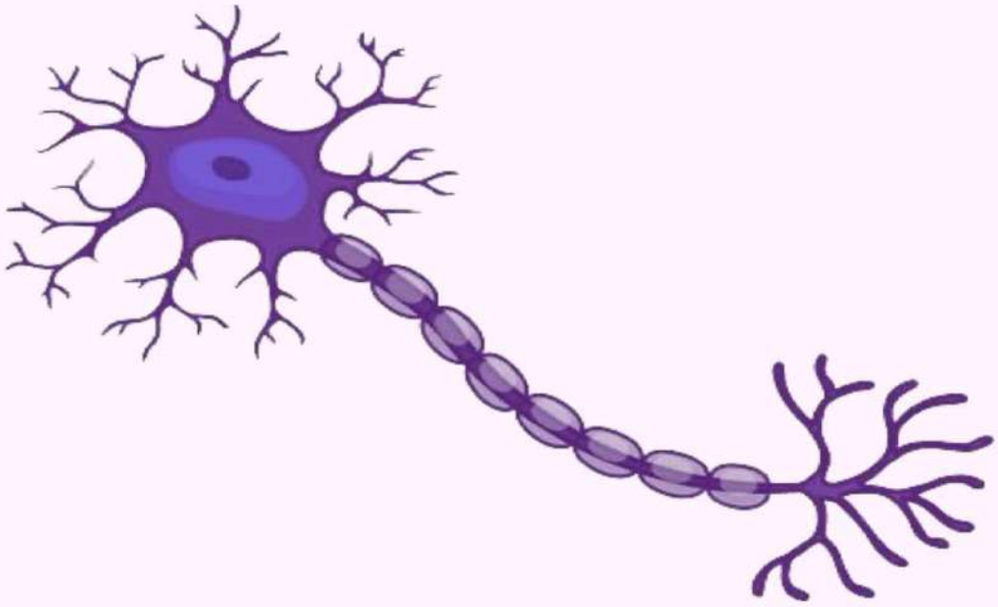
PHYSIOLOGY



LEC NO. : Lecture 2

DONE BY : Asia Al-wedyan.

وقل رب زدني علماً

Introduction to Celluar Physiology

Course: Destistry
Hashemite University

Lecture No. 1

1. **Levels of organization in the body**
2. **Levels of Homeostasis and body fluids**

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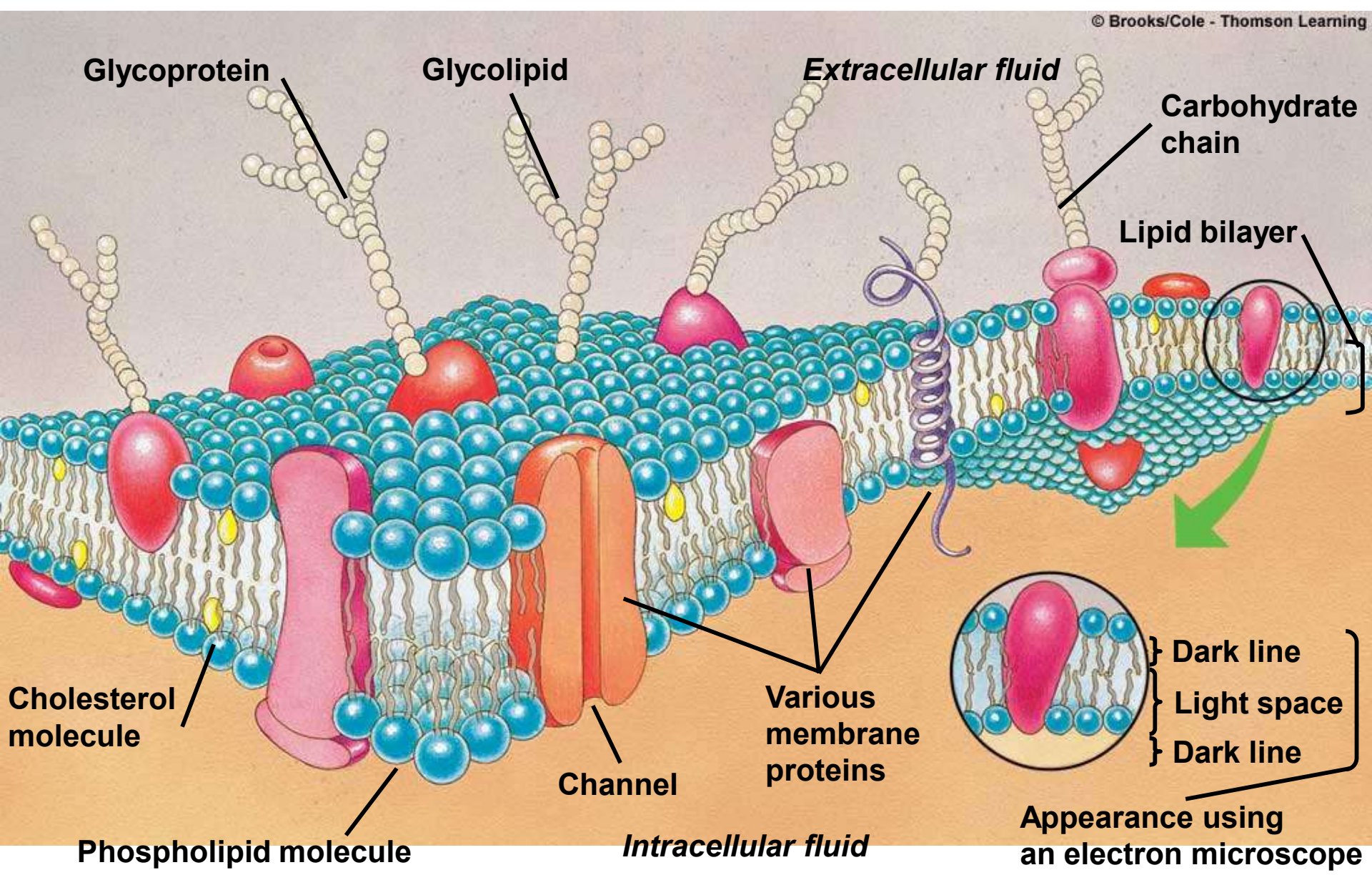


- Composition
  - Proteins 55%
  - Lipids 42%
  - carbohydrates 3%

Fig. 3-3, p. 45

The membrane is the structure which separates the internal enviroment inside the cell from the external enviroment (extracellular space)

The structure of the membrane is a bylayer of lipids / fatty acids(the hydrophobic tails inside and the hydrophilic head outside) .
There are so many structures are embedded in the membrane (some of them have access to the outside , some inside and some from outside to the inside) these can be receptors for hormones , for chemicals inside the blood etc . It can be ion channels for sodium , potassium , calcium etc . It can be channels to transport glucose , amino acids .

- The water can easily penetrate any cell of the body throygh channels which is specialized for water that called Aquaporins (AQP) channels

- The fats does not need a transport systems , because fat can dissolve in fat (لانو الmembrane is a bylayer of fats)

- Brain is impermeable to almost all substances except 3 types :

1-- glucose / لانه معظم العمليات الي بتصير بالدماغ تعتمد على ال glucose
و بروح الجسم بصير ساخد طاقة عن. ريق ال brain عشان يوفرلها الجسم لل glucose فخلال الصيام بصير يتسكر عندي كل البوابات الي ممكن تحرقلي ال fats

2-- ketone bodies are acidic . When their production are increased بصير عندي اغماء لانو بقلل من ال pH for the body as what happens in diabetes

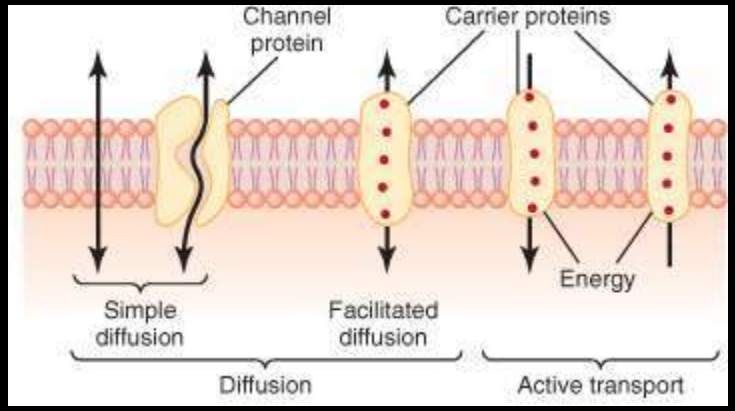
3-- urea / in malfunction of kidneys the urea level will increase وهاد الاشي ما بصير يصير لانو high levels of urea could enter the brain cell and cause damage in the brain cell

Cont. cell membrane composition →

- Proteins
  - Integral; penetrate cell membrane.
  - peripheral; attached to integral protein, don't penetrate the cell M.

Actions:

a) Forming channels (pores)
b) Carrier proteins.
c) enzymes.



- Carbohydrates

Actions:

- With proteins (glycoproteins)
- With lipids (glycolipids)

→ Glycocalyx

a) receptors.
b) Share in immune reaction.
c) Help in attachment of one cell to another.
d) Provide negative charge to the cell.

Responsible for antigenic properties of the cells

Why do we care about cell membranes?

- The concentration of Calcium has a big effect on the central nervous system and on the stability of the nervous system

- If the cell membrane breaks, the cell dies.!
- Cell membrane creates and maintains concentration differences between the intracellular and extracellular solutions.
- Contrast concentration and conditions

Inside and outside the cell..:

1- much higher K+ conc. Inside than outside.

2- much higher Na+ conc. outside than Inside.

3- much higher Cl- conc. outside than Inside.

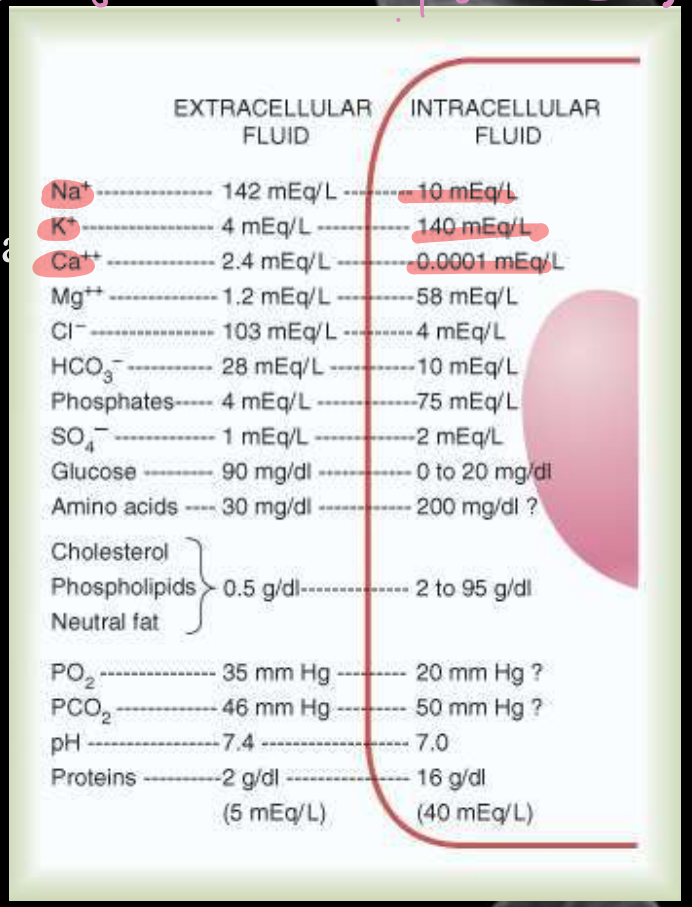
4- much higher Ca++ conc. outside than inside.

5- higher protein conc. inside than outside.

6- outside is slightly alkaline (PH=7.4) while inside is neutral (PH=7).

7- osmolarity of solutions inside and outside is similar

*only this 3 ions (حفظ ترا كيزهم)



	EXTRACELLULAR FLUID	INTRACELLULAR FLUID
Na^+	142 mEq/L	10 mEq/L
K^+	4 mEq/L	140 mEq/L
Ca^{++}	2.4 mEq/L	0.0001 mEq/L
Mg^{++}	1.2 mEq/L	58 mEq/L
Cl^-	103 mEq/L	4 mEq/L
HCO_3^-	28 mEq/L	10 mEq/L
Phosphates	4 mEq/L	75 mEq/L
SO_4^-	1 mEq/L	2 mEq/L
Glucose	90 mg/dl	0 to 20 mg/dl
Amino acids	30 mg/dl	200 mg/dl ?
Cholesterol, Phospholipids, Neutral fat	0.5 g/dl	2 to 95 g/dl
PO_2	35 mm Hg	20 mm Hg ?
PCO_2	46 mm Hg	50 mm Hg ?
pH	7.4	7.0
Proteins	2 g/dl (5 mEq/L)	16 g/dl (40 mEq/L)

- Three ions that are very important :

-Sodium / potassium because they play in the osmolarity of the intracellular and extracellular fluid
-Calcuim it effect on the nervous system

Diffusion is the passege of a substance from place to place

How do substances (particles) cross cell membranes?

1. Diffusion
   - Simple
   - Facilitated
2. Osmosis
3. Active transport
   - Primary
   - Secondary
4. In vesicles
   - Endocytosis
   - Exocytosis.

- Simple diffusion : it means that it does not need a carrier , so the substance will go from one place to another place without the use of energy or the use of a carrier , so the substance can diffuse very easly like water

Water movement is a simple diffusion . The only driving force for the movement of water 1-- ((the osmotic pressure, osmolarity)) 2-- ((the concentration of solutes))

- Facilitated means there is a carrier which the substance will move from place to a place carried by a carrier . These carrier could be protiens but without the using of energy (يعني فيو انتقال للمواد من مكان لمكان مع وجود diffusion هوه ناقل ينقل المواد بس يشرط انو الموضوه يعتمد على الفرق في التركيز و ليس استخدام الطاقه)

The driving force will be the concentration difference from the inside and outside

- Osmosis is the movement of water and solutes from side to other side
(water will move from high content of water to low content of water) or we can say (water will move from low concentration of solutes to high concentration of solutes) . There is no meed for ATP or any energy and move passivly down and usually there is no membrane so it move passivly

Active transport system is the most important system we have in our body and it is present on almost in every cell of the body .

- primary active transport system , where the ATP is used to transfer the substance from low concentration to high concentration

- secondary active transport system , we do need ATP but not directly to transport specific substance

Endocytosis and exocytosis transport are much much less than the other.

-Endocytosis , it is used to absorb large molecules as waht happens in infancy (الطفل حديث الولادة)

-Exocytosis , it refers to the release of a substance from inside the cell to the outside as what happened in the neuromuscular transmission ((هيه ال joints between the neuron و العضلة)) (فبحكي انو في وساع بين هاي العضلة و النيورون فيو fluid بحكيلك ف hoe would the action potential go fron the neuron to the muscle by first releasing a substance which is called ACYTYLCHOLIN by exocytosis and the acytucholin in the cliff it go to the receptor then the signal will be transferred from the neuron to the muscle) example.

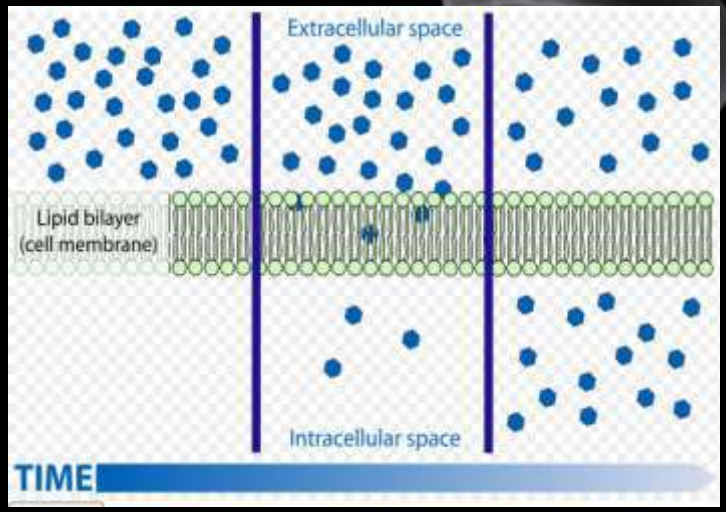
* Diffusion is the simple movement of the substance from ↑ con to ↓ con.
* The driving force for the movement of the particles is the con difference

* Simple Diffusion → no carrier
Facilitated → ✓ carrier.

(summary).

Diffusion

- Is the random movement of particles in a solution. This movement depends on the temperature.
- The process of diffusion causes particles to move from an area of high concentration to an are of low concentration. Finally the concentration of particles becomes equal through out the solution.
- The net diffusion is always from high Conc. to low.



Diffusion tries to reach equilibrium Where the conc. are the same everywhere. No energy source is needed, the random movement of the particles is all what is needed.

*when the is equilibration this the transport system will stopped.

Cont. simple diffusion →

- Two types of simple diffusion

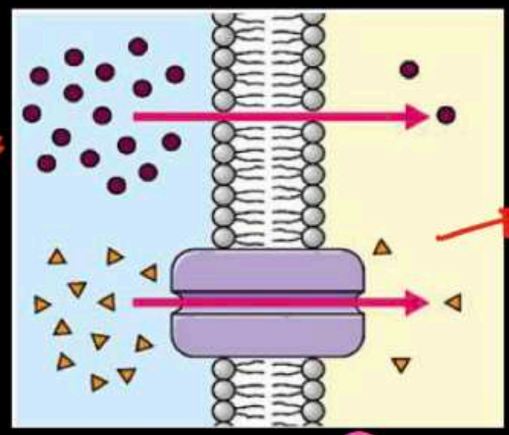
a) Through intermolecular spaces of the membrane

"lipid soluble substances"

Vitamin A/ K/E/D are fat soluble so they can cross the membrane easly easly driven by the concentration difference

b) Through membrane channels

"water and lipid insoluble molecules"



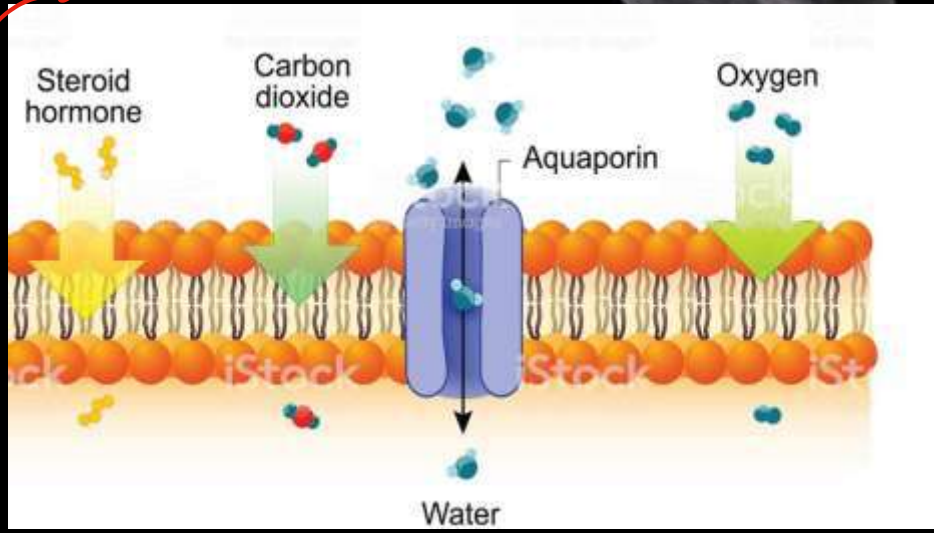
99% of channels are protenis , so they allow the transport of the compounds without the need of energy

Why i need a carrier ?
Bec the compound transporting are not solube , or maybe it has a charge

Simple diffusion (Cont.)

- Lipid-soluble molecules like oxygen and CO2 cross the cell membrane by simple diffusion. The degree of diffusion of these substances is determined mostly by their lipid solubility.

Do not need a carier to transfer



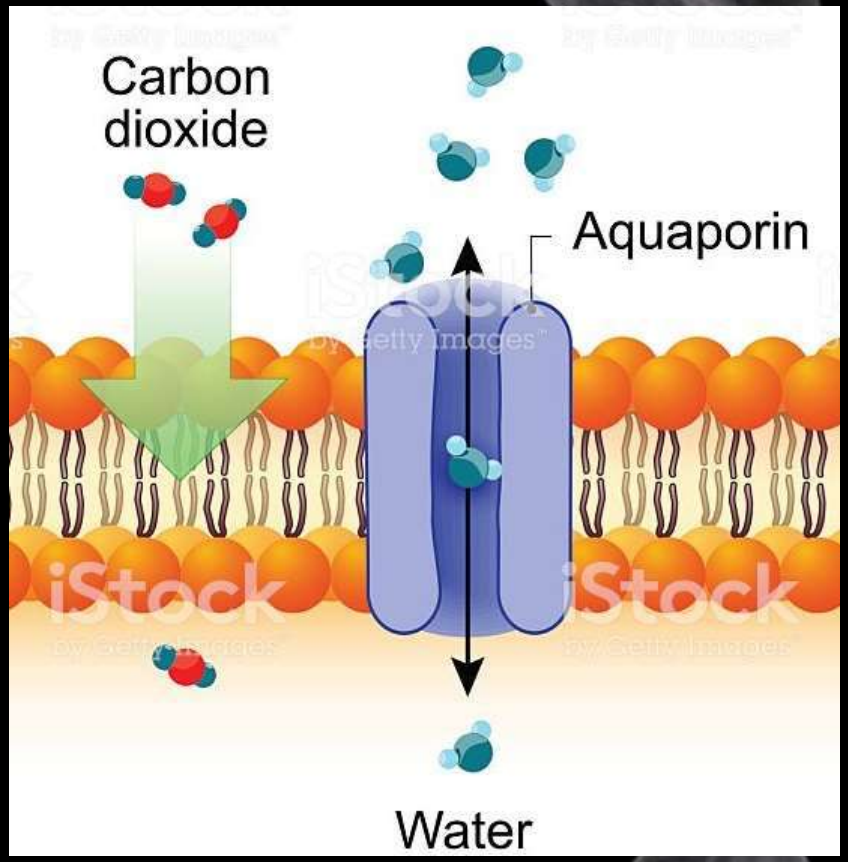
- Hydrophobic, lipophilic substances like fatty acids, fat-soluble vitamins and drugs can dissolve in the lipid bilayer of the cell membrane and diffuse across the membrane.

* O_2 / CO_2 / H_2O are the 3 main compounds that can cross cell membrane by simple diffusion.

Simple diffusion (Cont.)

- **Diffusion of water is through membrane channels. Water penetrates very rapidly the cell membrane through protein channels (aquaporins).**

- **Urea can cross the cell membrane by simple diffusion through protein channels. Urea molecule is 20% larger than water molecule and thus → its rate of diffusion is less than water.**



Aquaporins they do not need any force to open them , and they allow movement of water from high con to low spcon

Simple diffusion (Cont.)

- Transport of ions (Na+ and K+) is by simple diffusion through protein channels. → these channel are closed, we can open it by stimuls (بخض النفزات تو س).

>> these channels are:

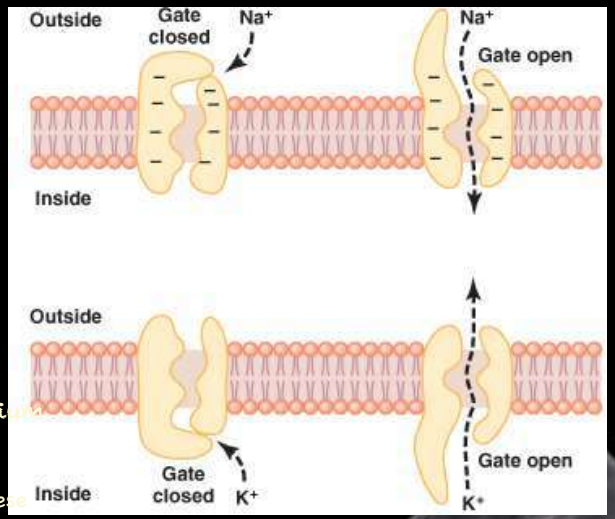
a) Selectively permeable to certain substance.

b) Opened or closed by gates.

- The presence of gates in these channels controls the movement of ions through these channels.
- The opening and closing of these gates are controlled by:

a) Changing the potential of the cell "voltage gating".

b) Binding chemical substances To the gate "chemical or ligand gating".



- We can force the potassium ,, calcuim channel to open .

So when we open for exanple potassium channel , all potassi ions will go out the cell .

What determines the movement of the ions ?

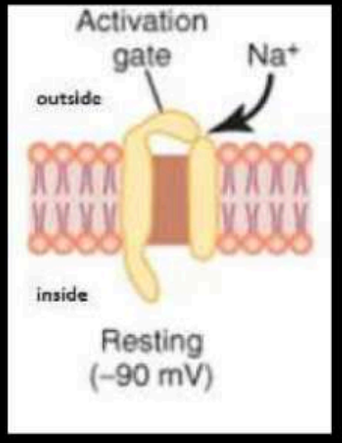
Resting membrane potential (رح نخوض فيها بالليكتشر الجاي)

- Voltage gated channels are the channels that depend on the the difference in voltage between inside and outside which means the force that open tha (Na+) gates is the voltage difference between inside and outside

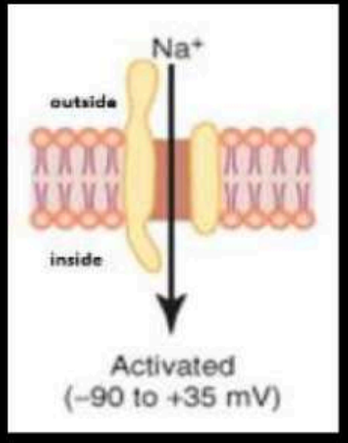
- Voltage gated channels it means : Channels open and closes by a voltage change in the resting membrane potential

Voltage-gated channels

Closed Na+ channel



open Na+ channel



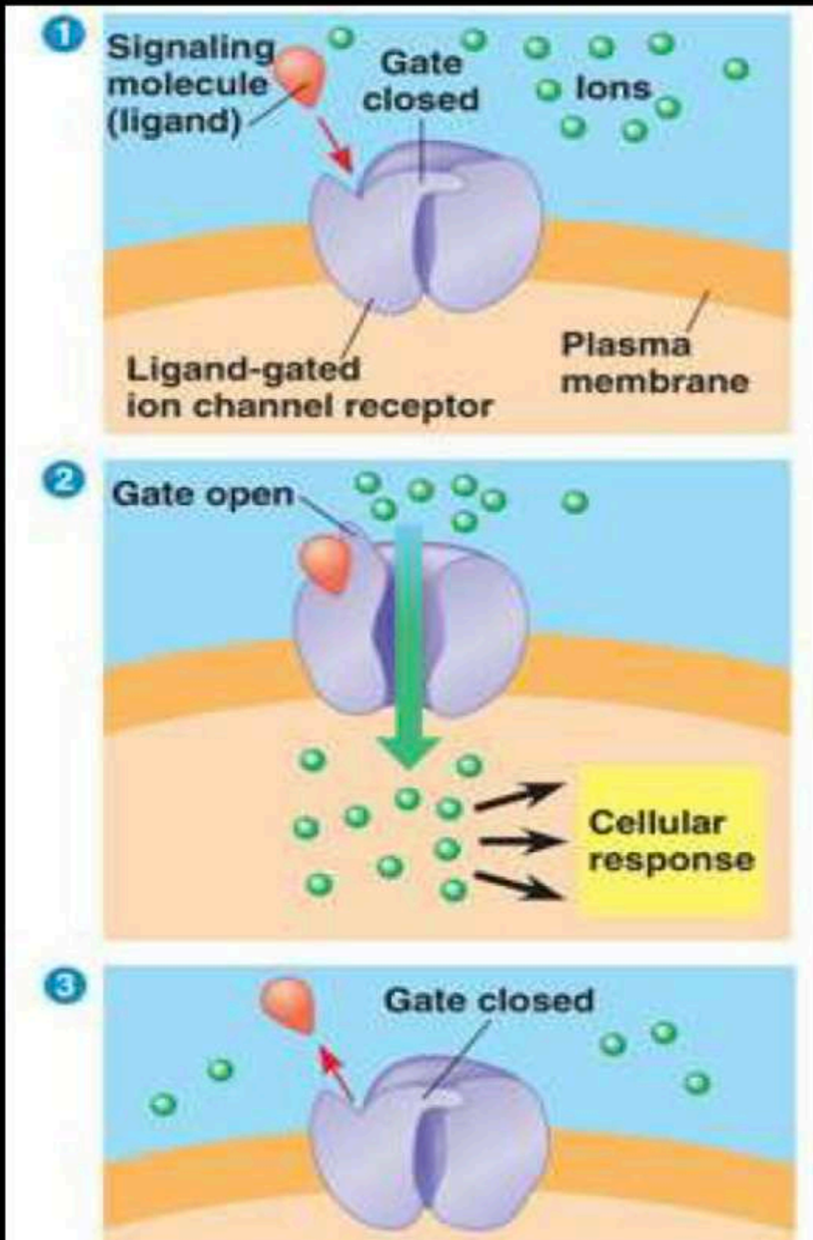
Less negative

- Na+ voltage gated channels are open when the inside of the membrane becomes less negative, allowing Na+ to pass from outside to inside the cells.
- Conversely, these Na+ channels are closed when inside of the membrane is highly negative

- K+ voltage gated channels are open when inside the membrane becomes positively charged.

- Once the cell the ability to mantain nagative intracellular the cell will die

Ligand (chemical) gated



- Example: ↗ between the neuron and the Joint.
- Acetylcholine chanels (they open when Ach binds with its receptor. These channels are 0.65 nm in diameter and negatively charged.)

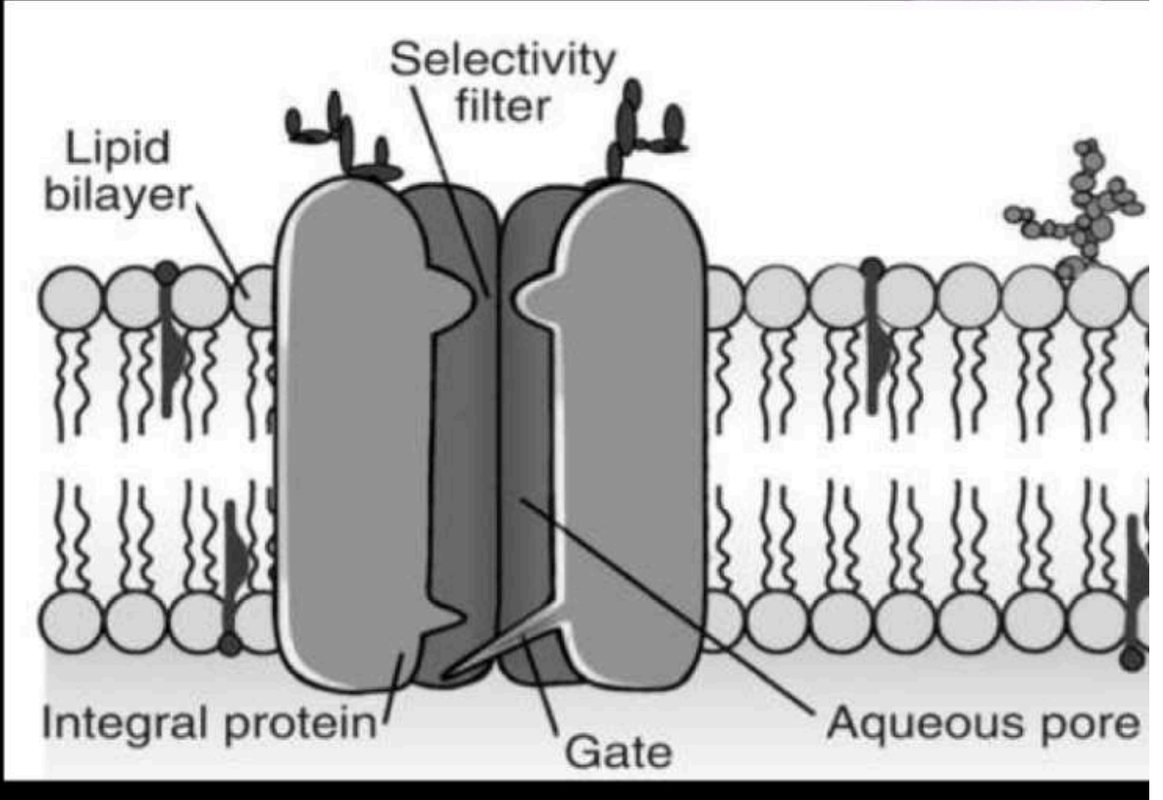
* الـ 2 سلايدة 8 .
اخر نقطة .

- The channel can be opened by either a chemical gate channel or by voltage change between inside and outside

usually the channels in our body are ⇉ selectivity channel.

Selectivity of protein channels

- These channels are selective for transport of one or more specific ions. لبه بتراوح حتى صغيرة كتير
- The selectivity depends on:
  1) Shape of the channel.
  2) Size of the channel.
  3) Nature of the electrical charges of the channel.

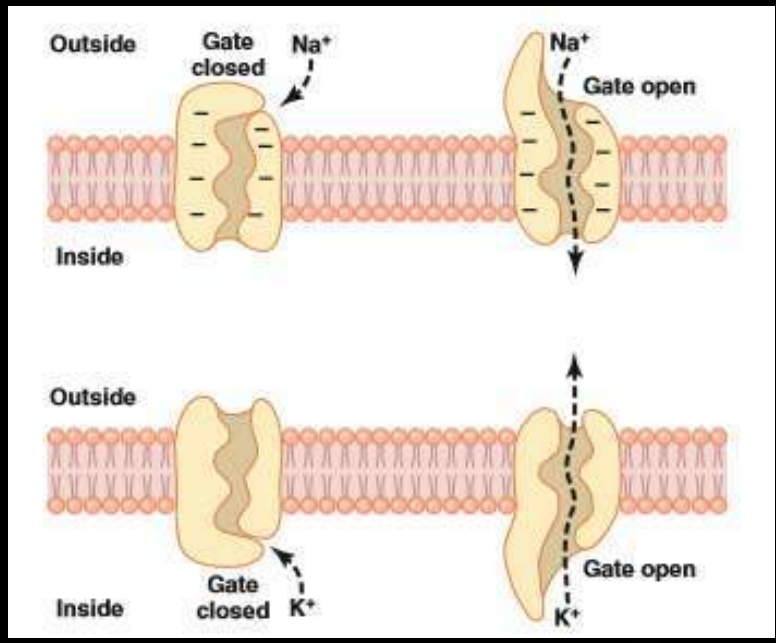


The channels are specific for particular ions .
So rarely you find in our body a channel which can allow two substance to move

Sodium carrier هيه الشانيل الوحيدة الي بتمسح للادتين يمرو ، فهيه بالاساس بتمرق جلوكوز لكن لما كل الجلوكوز يصيرلو امتصاص بتصير تمرق جالاكتوز و فيتم امتصاصه عن طريق تفس الكاريير

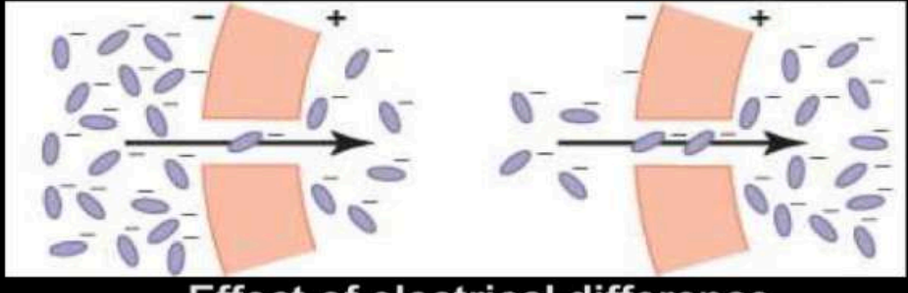
Gated sodium and potassium channels

- Sodium channels:
- Negatively charged → pull sodium ion from its water.
- Diameter 0.3 X 0.5 nm.
- Gate is found at the extracellular end of the channel.
- Potassium channels:
- Smaller than sodium channels (0.3 X 0.3 nm).
- Are not charged.
- Gate is found at intracellular end of the channel.

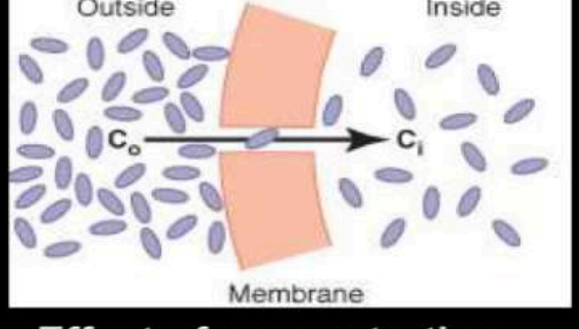


Other Factors affecting the net rate of diffusion:

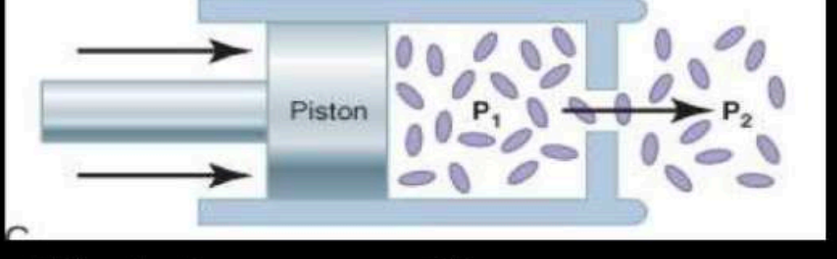
a) **Effect of concentration difference.**
b) **Effect of electrical difference.**
c) **Effect of pressure difference.**



Effect of electrical difference



Effect of concentration difference



Effect of pressure difference.

dynamic كا ما زادت الحرارة كل ما زادت ال movemnt of the molecules and increase s the movement • 3

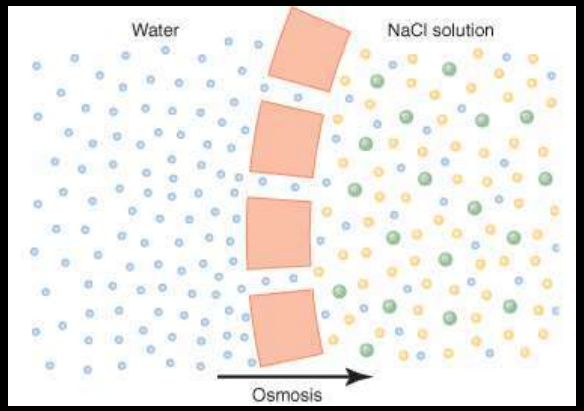
• 1 كل ما كان concentration difference اكبر كل ما كانت ال movement اسرع واكبر

• 2 كل ما زادت ال osmotic pressure كل ما زادت ال movement

Osmosis

- Osmosis is the flow of water across a semipermeable membrane cased by a difference in the concentration of the solutions on either side of the membrane.

  - **Water flows from the solution containing a low concentration of solute to the solution containing a high concentration of solute.**



Water conc. on this side is higher.

Water conc. on this side is lower

  - **The water is forced through the membrane by an osmotic pressure difference between the two compartments.**

Water conc. water in this side is lower in is higher. this side.

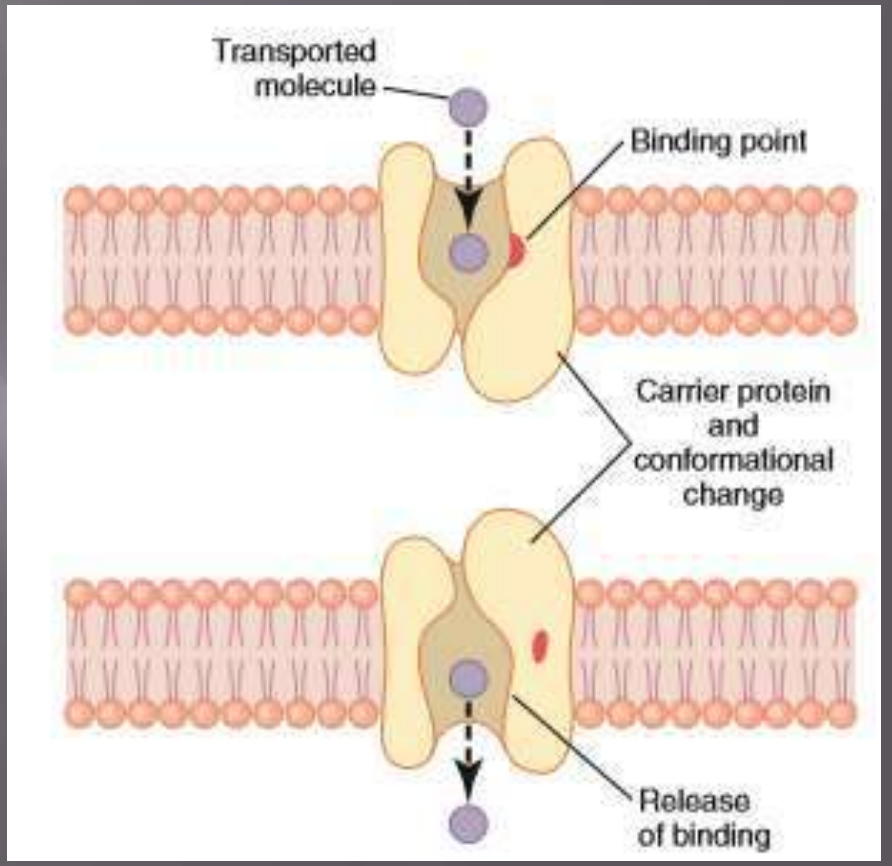
Measurements of solute concentraion

- Concentration of particles (molecules/ions) is measured in miliosmoles/Litre.
  - 1 molecular weight of undissociated solute like glucose = 1 osmol.
  - 1 molecular weight of dissociated solute:
    - into two ions like NaCl = 2 osmoles.
    - Into three ions like CaCl2 = 3 osmoles.

Facilitated diffusion

** It is passive transport which does not require energy to move the large molecules.

** Used carrier protein to move molecules across the membrane.
Example: transport of glucose and amino acids
into muscle or fat cells.
The hormone “insulin” can increase facilitated diffusion of glucose by 10-20 times.

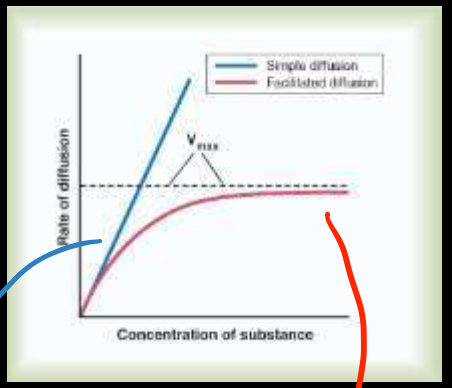


Facilitated Diffusion (carrier mediated diffusion)

- Only one solute is involved by specific carrier. (i.e. it shows specificity)
- The direction of transport is downhill (i.e from high concentration to low concentration).
- The carrier can be saturated.

(saturated means: has a capacity, can hold just A fixed amount of molecules)

- ATP energy is not required.
- They are specific each specific molecule has a certain carrier.

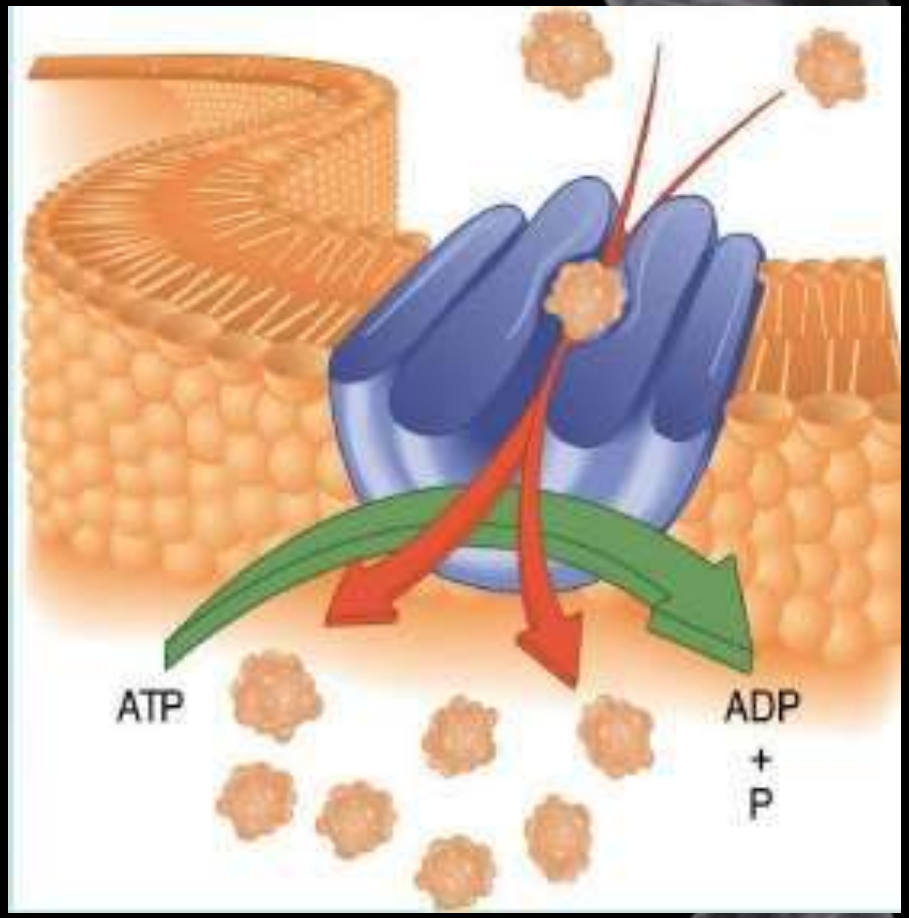


The high concentration of urea in the blood the more urea will apear in urean

It describes what saturation means (كل ما زاد ال concentration on thw x axis كل ما زاد ال absorbtion)
carriers are carrying يمثل لما يكون كل ال glocuse .

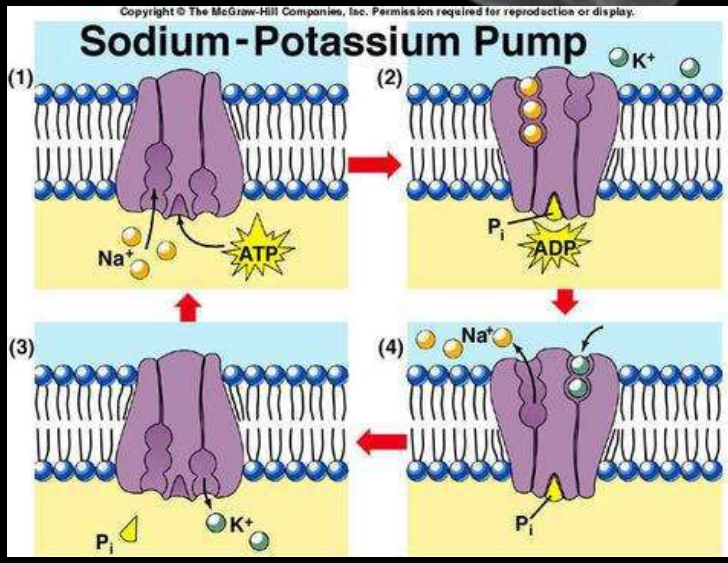
Active transport

- Transport of ions or molecules **against** their concentration gradient.
- It is **carrier-mediated** (needs carrier).
- Uses energy.
- Examples: transport of; **Na+ , K+, Ca++, H+, Cl-, I- Glucose, amino acids.**



Sodium/Potassium Pump

**Are proteins which can transport Na+ and K+ from low conc to high conc area, it needs ATP. Transport reaches maximum when all transporters are being used (saturated). Very specific..!



- 3 Na+ ions are removed from the cell as 2 K+ ions brought into cell, with 1 ATP molecule is used. (it is electrogenic pump).

- Na/K pump uses large amount of ATP produced by the cell (cells lining renal tubules use 90% of ATP for this pump).

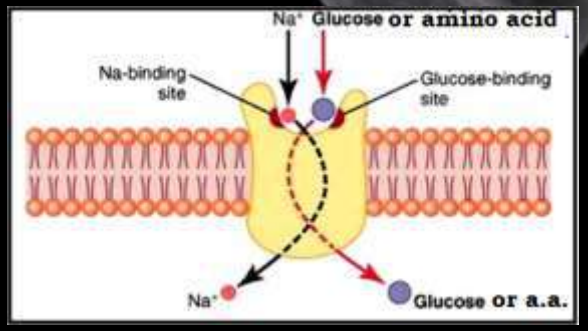
-Importance of Na+ /K+ pump

1. Responsible for creating and maintaining the high K+ and low Na+ in the cytoplasm. These concentrations make cell resting membrane potential and generation of action potential possible.

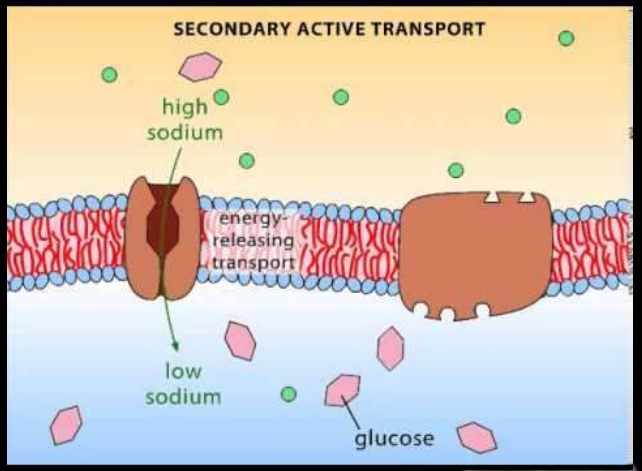
2. The low Na+ conc. inside the cell provides the energy needed for secondary active transport (discussed later).

3. Prevents cell swelling “i.e. keeps cell volume constant”.

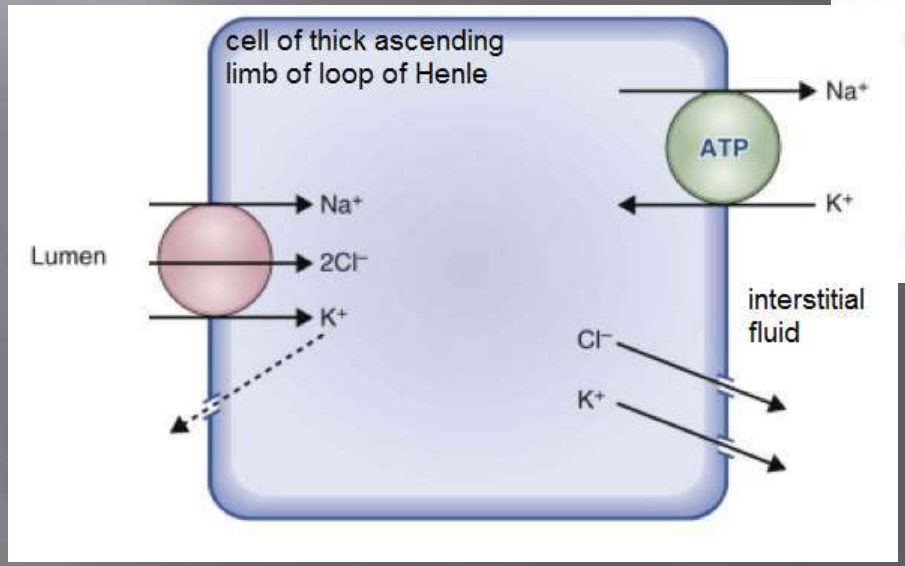
Secondary active co-transport

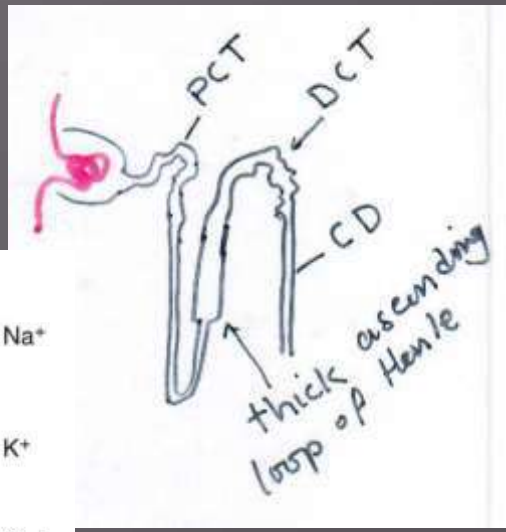


- Na Co-transport of glucose or amino acid:
- **Sometimes called symport.**
- **Both Na+ and Glucose (or amino acid) have to be present.**
- **The energy available from Na+ gradient is used as an energy source.**
- **Found in the epithelial cells of the intestine.**



** A co-transporter can carry more than 2 ions. For example, a co-transporter in cells of the ascending loop of Henle can carry 1 Na+, 2 Cl- and 1 K+.

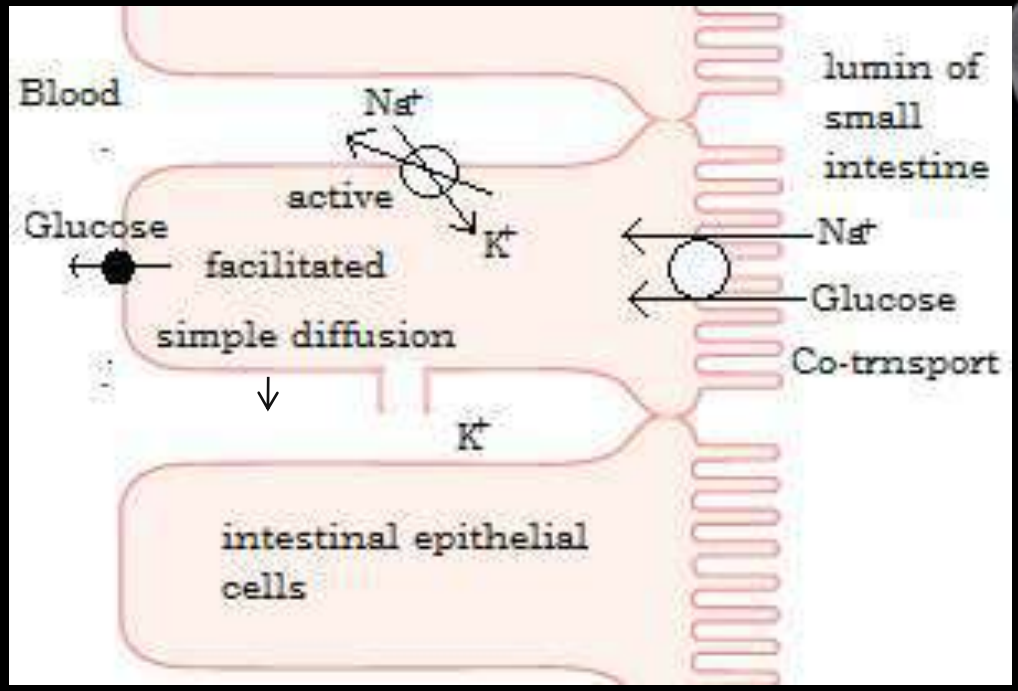




Comparison of simple diffusion, facilitated diffusion and active transport

Active transport	Facilitated diffusion	Simple diffusion	Property
yes	Yes	No	Requires special membrane protein
yes	yes	No	Highly selective
yes	yes	no	Transport saturation
yes	yes	no	Hormonal regulation
yes	no	no	Uphill transport “against concentration gradient”
yes	no	no	Requires ATP energy

Absorption of Glucose from small intestine needs all types of transportation

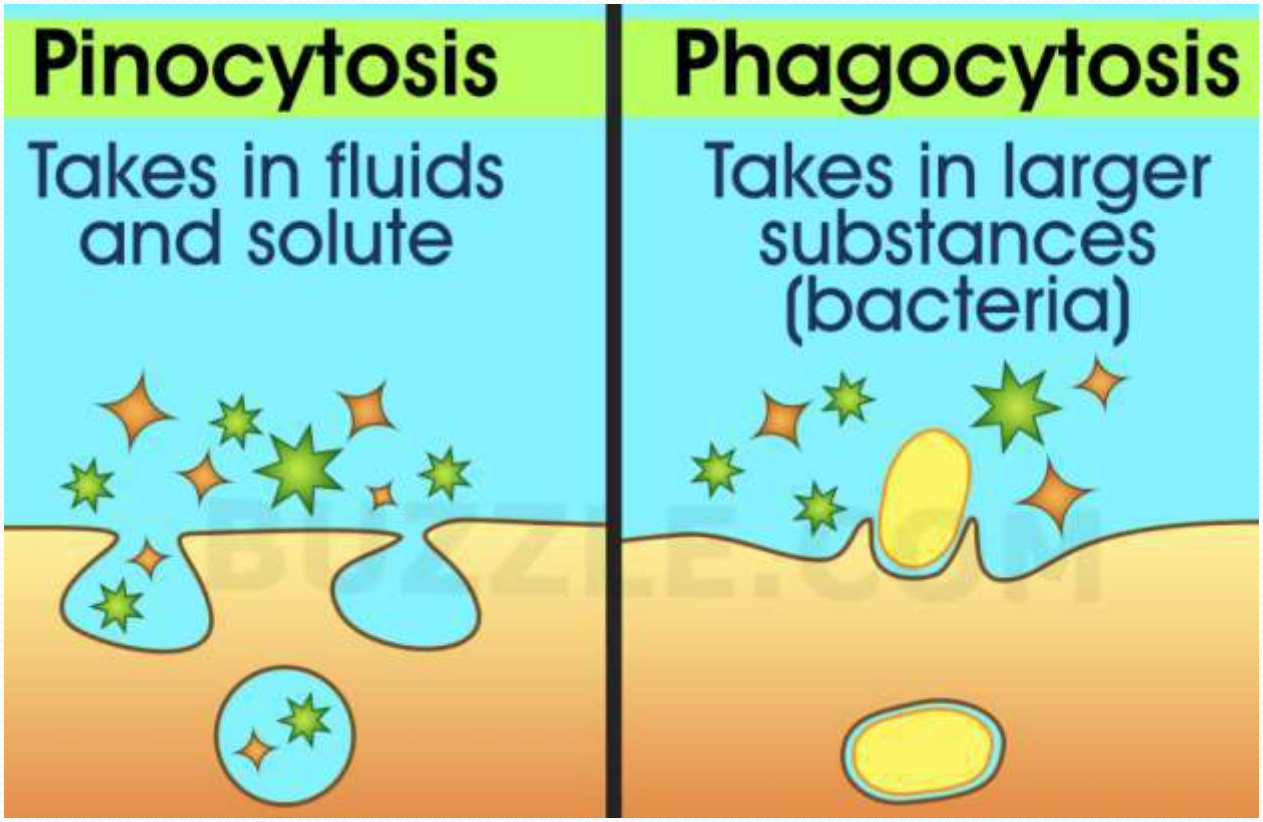


- Glucose transporters:

1- Sodium-Glucose transporter (SGLT) → found in the small intestine and renal tubules.

2- Facilitated diffusion glucose transporter (GLUT)

a. **GLUT 1 Found in RBCs.**
b. **GLUT 2 : transports glucose of intestinal cells.**
c. **GLUT 4 found in muscle and adipose tissue << insulin stimulates this type of transporters.**



Main transport system for immunoglobulins in infants since their immunity system is suppressed when born

Phagocytosis

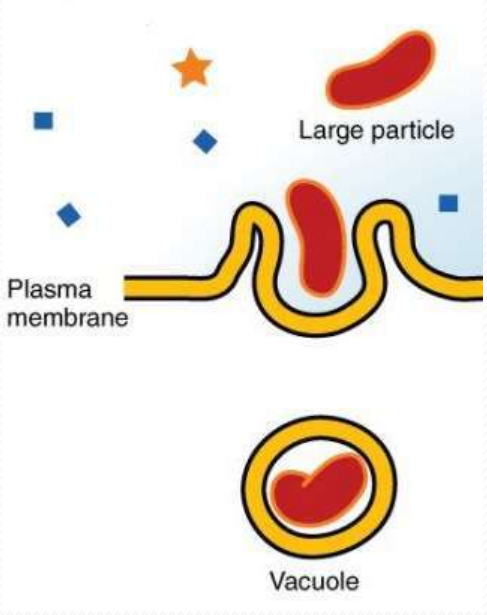
Phagocytosis involves large particles (bacteria, dead cells, or tissue debris) rather than molecules.

Tissue macrophages and some white blood cells have this ability

Bacterium is usually already attached to a specific antibody

Antibody attached to bacteria binds to the phagocyte receptors

The point of attachment invaginates inward forming vesicle inside the cell that contains the engulfed surround the bacteria.



End of lecture