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Number

3

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❖ Functions of membrane proteins

- Ion channels, transporter, receptors, enzymes, cell identity and linker all of them is integral membrane protein

1) Ion channels:

- The protein channels are distinguished by two important characteristics:
  - ✓ They are often selectively permeable to certain substances
  - ✓ Many of the channels can be opened or closed by gates
- Such as Sodium channels passage only sodium ions across the cell membrane
  Potassium channels passage only potassium ions across the cell membrane

- **These channels have a gate:**
  A. **Voltage gated channels**: open or close by electrical signals
  B. **Ligand gated channels**: open or close by chemicals that bind to it
  C. **Diffusion channels:** open always (for specific substances)

2) Transporter ''carrier'':

- Selectively move substances through the membrane by changing shape
- Such as glucose and amino acids

3) Receptors:

- For cellular recognition
- All receptors have hormones and All hormones binds with receptors
- Such as peptide hormones that do not easily penetrate the cell membrane
- A ligand is molecule that binds to the receptor

4) Enzymes:

- Catalyze chemical reactions
- For example: disaccharidases (enzymes that breakdown certain types of sugar)
  Disaccharidases such as lactase, maltase and sucrase

5) Cell identity:

- Distinguish your cells from anyone else's
- Such as antigen and histocompatibility (MHC)
  - ✓ Antigen: For example blood groups (A,B,AB,O) meaning there is an antigen on the cell membrane called A and **it is specific for cells**
  - ✓ Histocompatibility (MHC): when you transport organ to another person

6) Linkers

➢ Summary for structure of a membrane

- Consists of lipid bilayer which made of phospholipids, cholesterol and glycolipids
- Contains lipids, proteins and carbohydrates
- Membrane proteins: integral, transmembrane and peripheral proteins

- Membrane carbohydrates:

✓ **Glycoproteins:** carbohydrates combination with proteins

✓ **Glycolipids:** carbohydrates combination with lipids

In fact, most of the integral proteins are glycoproteins, and about one tenth of the membrane lipid molecules are glycolipids. The "glyco" portions of these molecules almost invariably protrude to the outside of the cell, dangling outward from the cell surface.

✓ **Glycocalyx (the sugar coating):** the entire outside surface of the cell surrounding by a loose carbohydrate coat called the glycocalyx

The glycocalyx portions of the glycolipids and glycoproteins

✓ **Proteoglycans:** which are mainly carbohydrate substances bound to small protein cores are loosely attached to the outer surface of the cell as well

❖ Membrane permeability

- The cell is either permeable or impermeable to certain substances
- The lipid bilayer is permeable to oxygen, carbon dioxide, water and steroids, but impermeable to glucose
- Transmembrane proteins act as channels and transporters to assist the entrance of certain substances, for example, glucose and ions

❖ Transport through the membrane

- From ECF (extracellular fluid) to ICF
- Transport through the cell membrane, either directly through the lipid bilayer or through the proteins, occurs via one of two basic processes:

✓ **Passive transport:** substances move across cell membranes **without** the input of energy (that mean it transport from higher level to lower level) Downhill & with concentration gradient by using the kinetic energy of individual molecules or ions

✓ **Active transport**: using energy from the breakdown of ATP to move substances across the membrane (from lower to higher) & against a concentration gradient

- Types of passive transport

1) **Simple diffusion**: the simplest passive transport

A. **Diffusion through lipid bilayer**: If the substance is **lipid soluble** it can diffuse through the membrane since the membrane is lipid bilayer

- The best Lipid soluble: all gases (CO2, O2, N2…) and alcohols and lipids (steroids)

- Note: more concentration means more kinetic energy and more diffusion
  e.g perfume in the room and ink in water

B. Diffusion through channels: other substances are **lipid insoluble** and **water** pass through the channels but the channels must be open

- Components of lipid soluble

A. Gases: all gases are lipid soluble, there for all gases diffuse through the membrane but they differ in **the diffusion rate**
the permeability of the membrane to CO2 is 24 times more than O2 that is why **we need less CO2 gradient to pass the same amount of O2**

Ex: O2 gradient between lung (100mHg) and the blood (40mHg) is 60mHg
CO2 gradient between lung (40mHg) and the blood (45mHg) is 5mHg
the permeability of the membrane to CO2 is higher than O2 so we need less CO2 gradient to pass the same amount of O2 from the blood to lung

B. Lipids: such as steroids
C. Alcohols

note: we use in anaesthesia nitrogen gas instead of chemical materials because it is diffuse through the membrane rapidly

- Some factors enhance the simple diffusion

A. Concentration gradient: higher concentration gradient means higher diffusion and faster transport
B. Surface area: the higher surface area the faster transport
C. Solubility of lipids: as we have already said
D. Thickness: the higher thickness the less transport and less permeability **(inversely with diffusion)**

- Fick's law of diffusion

Diffusion coefficient reflects the amount of substance that diffusing and **depends** on the molecular weight, **so the higher molecular weight the slower diffusion** because diffusion is inversely proportions with the square root of the molecular weight

- Fick's law of diffusion

J = P(C2-C1)*S where P=permeability in lipid (C2-C1)=concentration gradient, S=surface area.
Or J=DA*(ΔC/ΔX), ΔC=concentration gradient, A=Area, ΔX=Thickness of the membrane, D=diffusion coefficient (depends on the solubility in lipids, molecular weight)

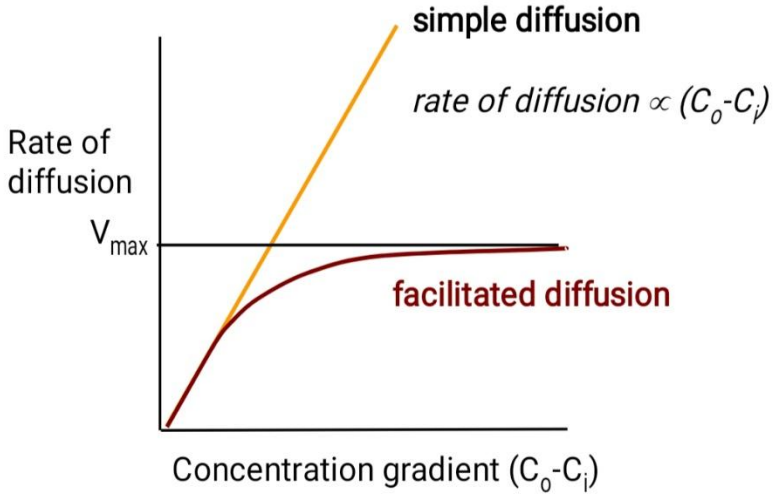
2) Carrier mediated diffusion (facilitated diffusion)

- Carrier is a membrane protein and it is specific like the receptor
- Characteristics of carriers
  - ✓ Specificity binding: for Na means only for Na and so on
  - ✓ The carriers can transport a specific no.of molecule through it like receptor

  Ex: we have 500 receptors and 1000 substances, so it will pass 500 substances and 500 will not pass
- So, facilitated diffusion is saturable because the binding sites are limited and has transport maximum (T max) or velocity maximum (V max)

➢ **Summary**

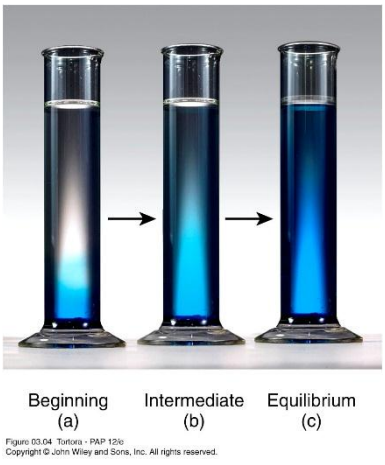
- ✓ Simple diffusion: the higher concentration the higher transport
- ✓ Diffusion through channels: the channel must be open
- ✓ Carrier mediated: the higher concentration the higher transport until we reach T max and any thing above T or V max does not pass

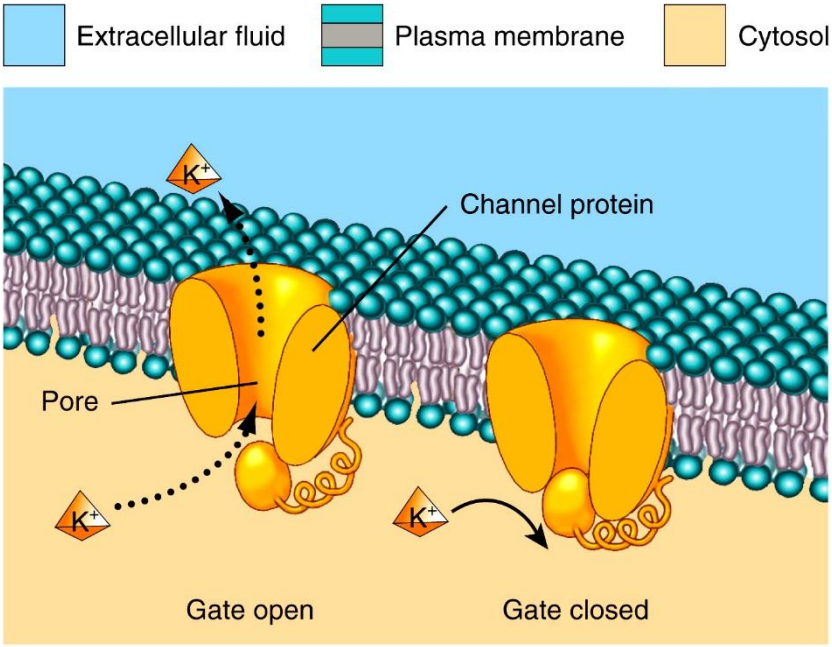


What limits maximum rate of facilitated diffusion?

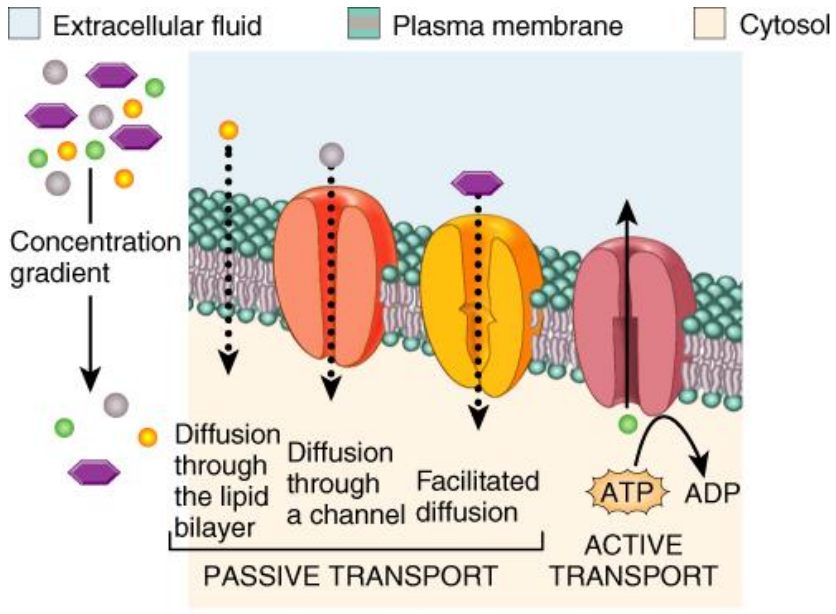
Figures for passive transport

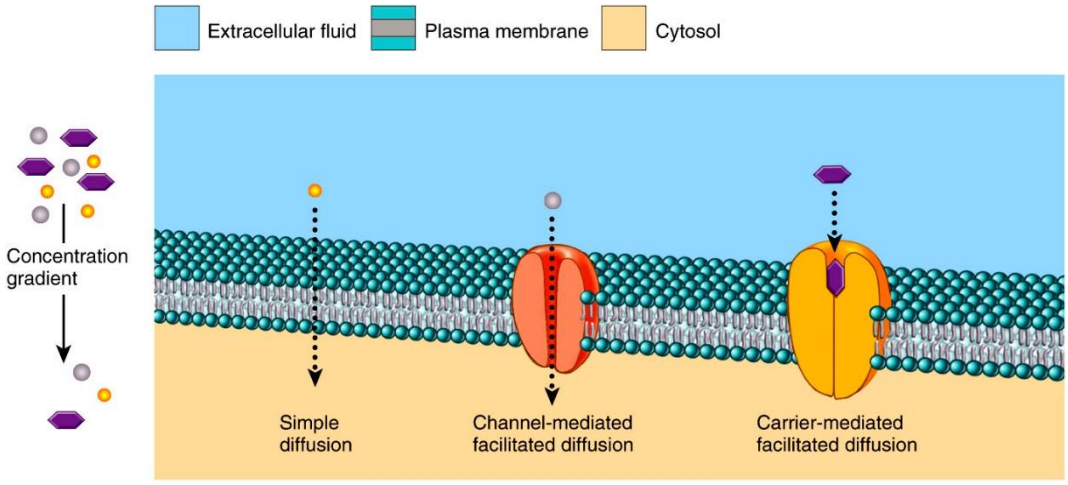
- Steepness of
- concentration gradient
- Temperature
- Mass of diffusing substance
- Surface area
- Diffusion distance

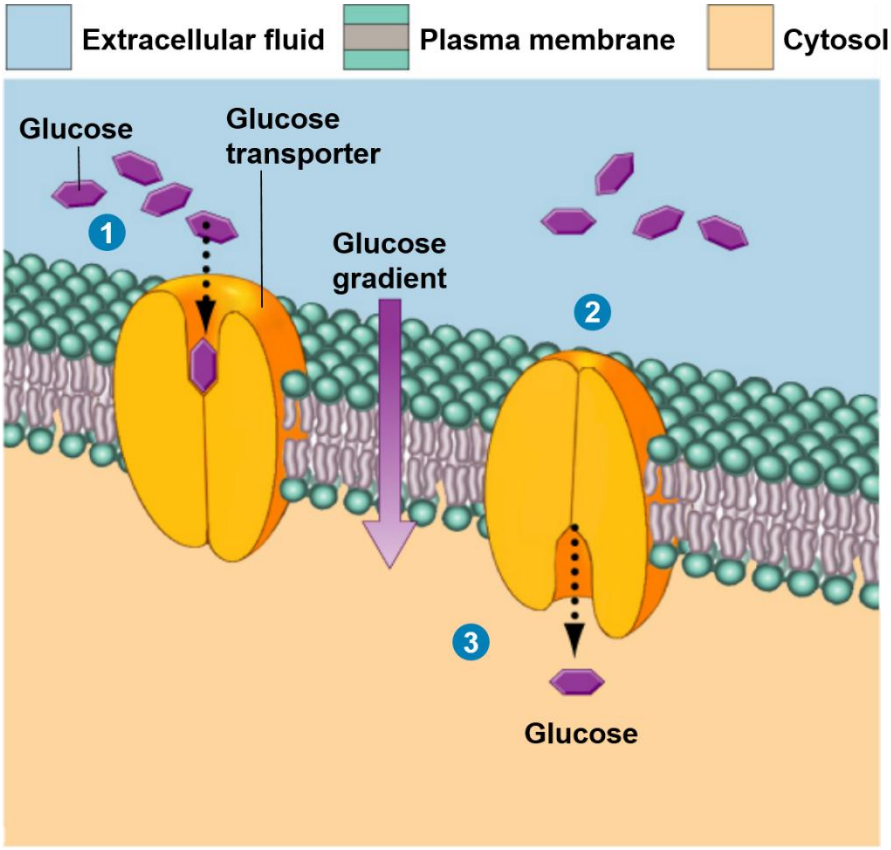




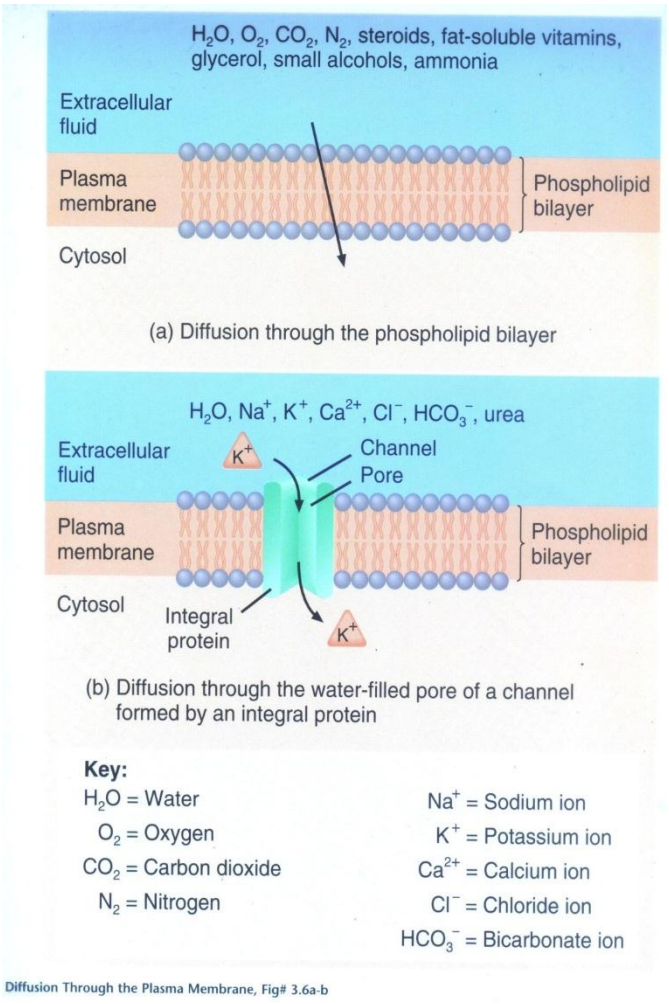
Details of the K^+ channel







Simple diffusion through the membrane of lipid soluble substances



Diffusion Through the Plasma Membrane, Fig# 3.6a-b

❖ Osmosis

- Another type of passive transport
- The net movement of water through a selectively permeable membrane from an area of high concentration of water (lower concentration of solutes) to one of lower concentration of water
- Water can pass through plasma membrane in 2 ways:
  - ✓ through lipid bilayer by simple diffusion
  - ✓ through aquaporins, integral membrane proteins