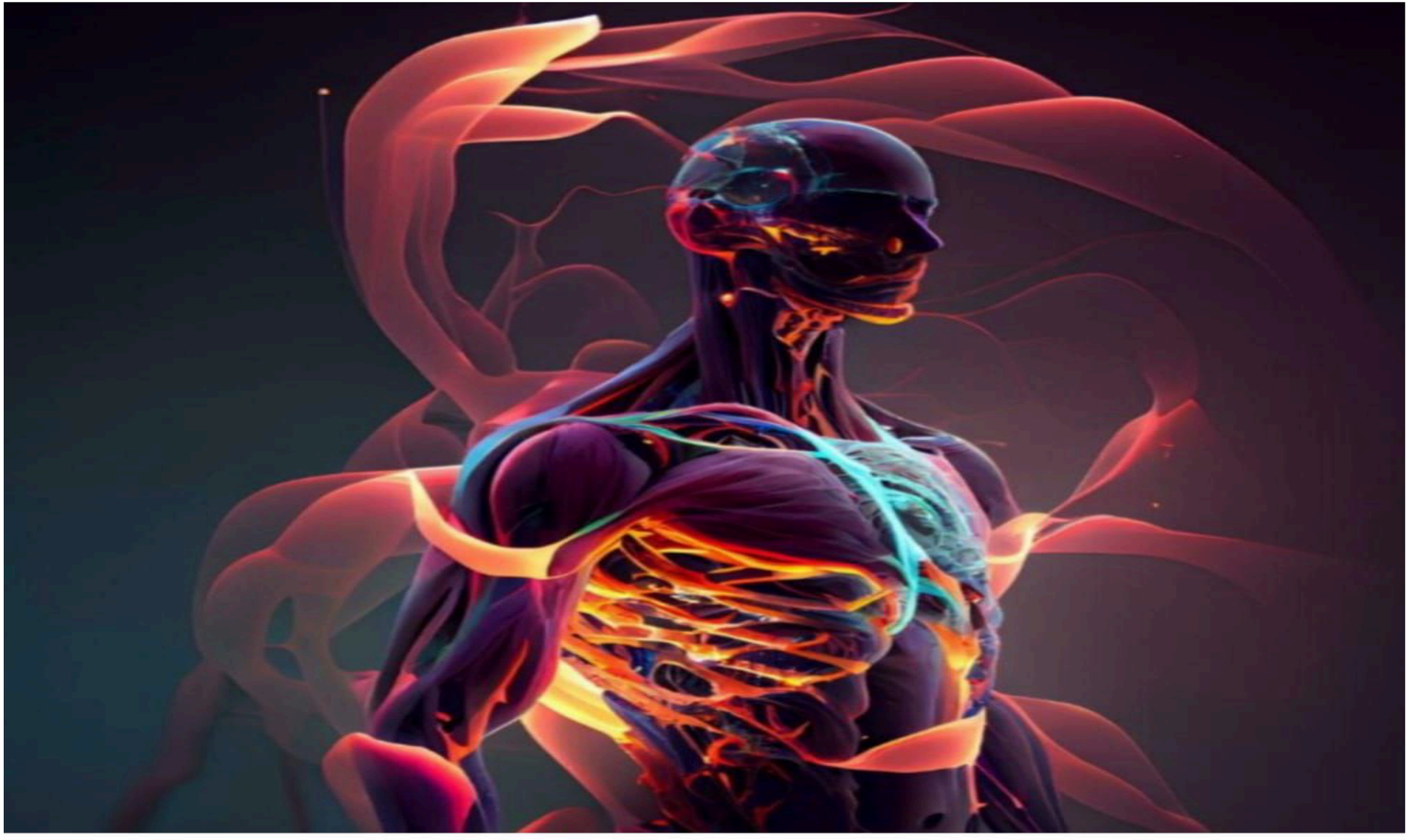


Lecture: 4

Done By: Abdulrahman Ehsan 🐸

Physiology Lecture 4

Transport of substances through cell membranes

Dr. Waleed R. Ezzat

Lecture Objectives:

- Define diffusion and describe the factors that affect the rate of diffusion of substances across cell membranes.
- Describe facilitated diffusion.
- Compare and contrast facilitated diffusion and simple diffusion.
- Explain characteristics of carrier mediate transport, (specificity, saturation, and competition).
- Define and explain primary active transport, using the Na^{+}-K^{+} pump, and proton pump as examples of primary active transport.
- Discuss the characteristics of primary active transport.
- Define and explain the mechanism of secondary active transport.
- Explain how glucose is transported across epithelial cells in the kidney and the gut by secondary active transport.
- Define vesicular transport, transcellular transport, and their functions.
- Define osmosis and explain how osmosis takes place.
- Define osmotic pressure and explain the determinants of osmotic pressure.
- Understand how to calculate osmotic pressure.
- Describe water movement across the plasma membrane and explain the role of water channels.

Diffusion

أبسط واحد

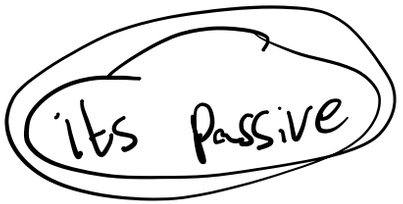
- It is the random movement of substances molecules, ions, or suspended colloid particles either through membrane openings or through intermolecular spaces in the membrane, or in combination with a carrier protein.
- Diffusion through cell membrane is either *simple* or *facilitated*
- **Simple diffusion** is passive process (no energy is required) by which particles in solution flow down a concentration gradient. Diffusion rate is determined by the (1) concentration gradient, (2) electrical gradient, and by (3) membrane permeability. It is the only form of transport that is **not carrier-mediated**.
- Lipid-soluble particles can diffuse easily, their permeability is proportional to (1) their lipid solubility and (2) the size of the particle.
- The **selective** rapid passage of water through the membrane is achieved through *aquaporins,* which are channels used for the passage of water.

النفاذية

يتنقل بسرعة

* الانتشار بشتغل على هيئة المواد بتكون متركزة بمنطقة معينة ثم تتوزع

حتى تملأ كل حيز.



① simple :- لا يحتاج إي طاقة من الخلية للأقل تركيز وحمل

الانتشار يتم تحديده بواحدة من :-

① concentration gradient
② Electrical gradient
③ membrane permeability

وهو النوع الوحيد من ال transportation الي لا يعتمد على Carrier protein

* المواد التي تكون (Lipid-S) تعبر بسهولة عبر الغشاء .

* النفاذية تزداد كلما : ① كانت المواد ذائبة في الدهون .

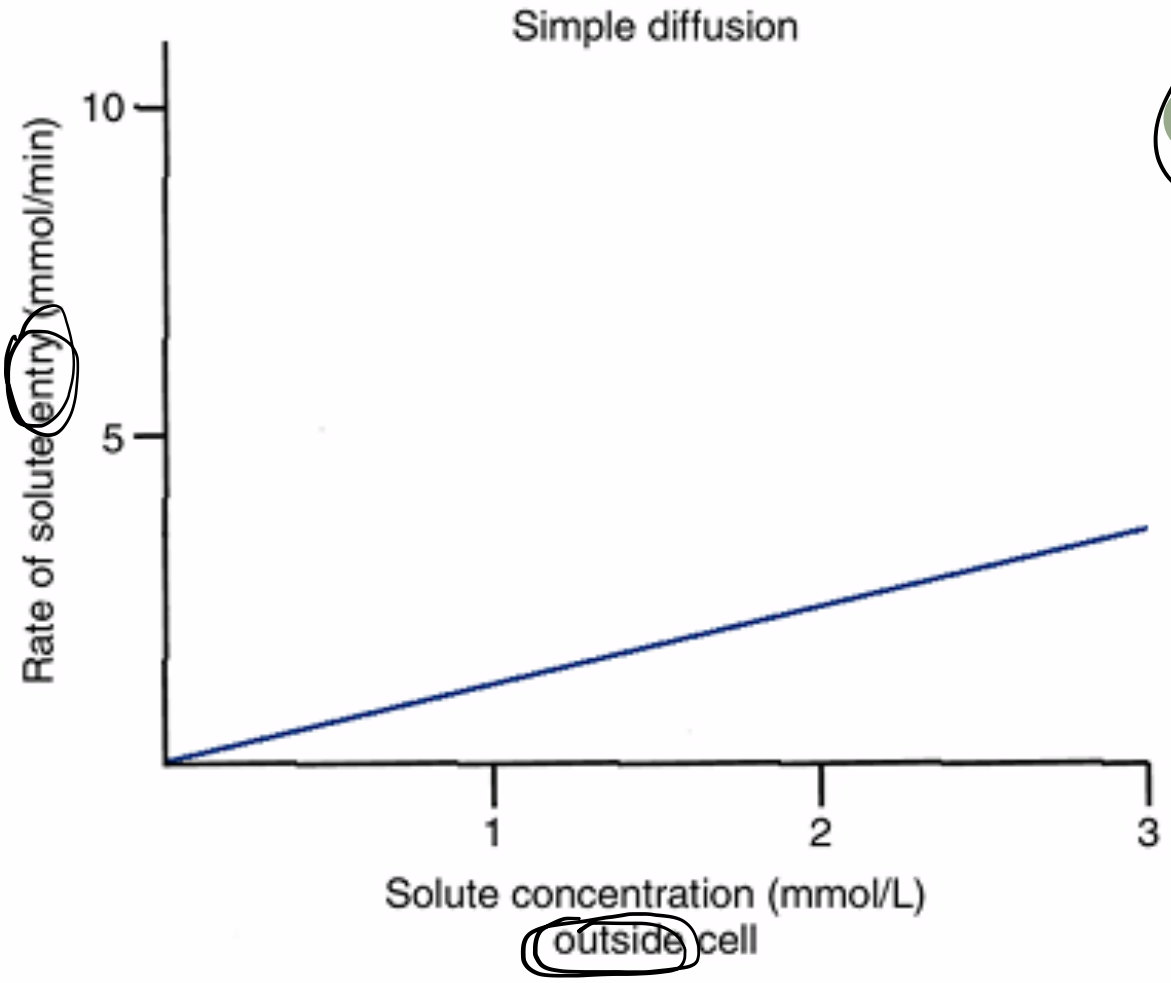
② كان حجمها أصغر. (أو طرها أصغر)

③ كان الغشاء رقيق

* الماء يعبر مثل الصاروخ عن طريق الـ diffusion عن طريق الـ

((Aquaporins))

وهي قنوات لعبور الماء .



A graph of solute transport across a plasma membrane by simple diffusion

Diffusion (cont.)

- ***Permeability*** describes the ease with which a solute diffuses through a membrane. It depends on the characteristics of the solute and the membrane.
- The permeability increases if:
  1. Solute is lipid soluble
  2. The radius of the solute is small
  3. The membrane thickness is small
- Uncharged or nonpolar molecules such as O_2, N_2, CO_2, fatty acids, and alcohols can diffuse through lipid membrane because of their high lipid solubility.
- Water-soluble ions less than 0.8 nm in diameter diffuse through protein pore channels. Their permeability is proportional to their size, shape, and charge; as well as the number of channels through which they can diffuse.

* اطوار الغشاء الخلوية مثل (Alcohols / fatty-A / O_2 / N_2 / CO_2)

تعبر خلاله مباشرة عن طريق الغشاء وفق آلية الانتشار البسيط

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* الأيونات المحبة للماء التي قطرها أقل من (0.8 nm) تمر عن طريق قنوات البروتين . ويعتمد نفاذيتها على :-

1. حجمها
2. شحنتها
3. شحنتها
4. عدد القنوات التي تسمح لها بالتحرك

* Passive

الـ CM يمرر الموجب فقط بسبب السالب.

Diffusion (cont.)

- Some lipid-insoluble molecules (such as urea) can use less selective water channels to pass.
- In **facilitated diffusion** carrier protein aids passage of too large molecules or ions by binding chemically with the molecule or ion and shuttling them through the membrane in this form down an electrochemical gradient (e.g. *glucose* and *amino acids*). It does not require metabolic energy (i.e. *passive*) and is more rapid than simple diffusion.
- As facilitated diffusion is carrier-mediated, therefore, it displays three important characteristics that determine the kind and amount of material that can be transferred across the membrane: ***stereospecificity***, ***saturation***, and ***competition***.
- **Stereospecificity:** Each carrier protein is specialized to transport a specific substance or, at most, a few closely related chemical compounds. Example, amino acids cannot bind to glucose carriers.

* بعض المواد الكبيرة مثل (urea) تمر عبر الـ ((aquaporins))

↳ ((less selective aquaporins))

وهي حالات قليلة جدًا.

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* أما في حالة كان القطر أكبر من 0.8nm في هذه الحالة سنحتاج إلى carrier وتصبح المادة Carrier-mediated.

وهذا يسمى بال facilitated-diff

* وتكون أسرع مثال Simple diffusion وهي أيضًا Passive .

* يتحكم في نقل هذه المواد عن طريق هذه الطريقة ③ أمور:

① Stereospecificity ⟶ أي أن البروتين ينقل مواد خاصة لها شكل ثابت ولو كانت متشابهة مثل D-Glucose و L-Glucose

② Saturation أي شكل الجسم في الفراغ

③ Competition

Diffusion (cont.)

- **Saturation:** A limited number of carrier binding sites are available within a particular plasma membrane for a specific substance. Therefore, there is a limit to the amount of a substance a carrier can transport across the membrane in a given time. This limit is known as the **transport maximum** (***Tm*** or ***Vmax***).

  This means that initially facilitated diffusion depends on the concentration gradient until all binding sites are filled (saturated); at this point, the rate of diffusion can no longer rise with increasing the concentration gradient.

- **Competition:** Closely related compounds may compete for a ride across the membrane on the same carrier. Example the amino acid ***glycine*** can compete with ***alanine*** for the same carrier. The rate of transport of each amino acid is less when both amino acid molecules are present than when either is present by itself.

② Saturation ⟶ لا حد معين للنقل وإذا أضفنا مايستقبل كمان

لحد ما ينقل الحوية مثل (ناقلات حاملات) بياخد عدد معين أو أقل منه.

والتي تسمى بال (Vmax / Tm ...) . وإن زاد التركيز بالخارج لن تحصل أكثر من الحد.

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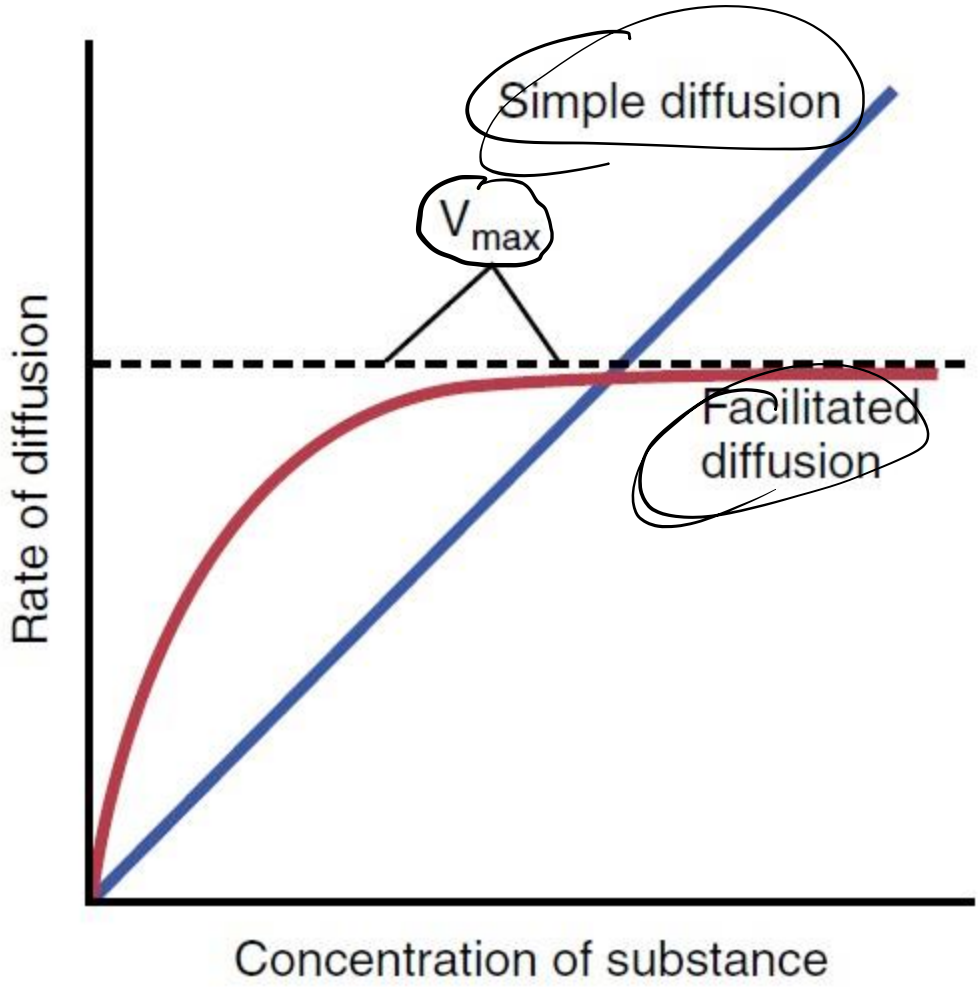
③ Competition ⟶ يمكن الناقل يتخدع ويستقبل مادة أخرى

مشابهة للمادة المطلوبة مثل (K^+ / Na^+) في حالات خاصة.

أو (alanine و glycine).



Effect of concentration of a substance on the rate of diffusion through a membrane by simple diffusion and facilitated diffusion. This graph shows that facilitated diffusion approaches a maximum rate, called the V_{max}.

Active transport

It is the movement of molecules or ions by a cell membrane (or intracellular membranes) uphill against a concentration or electrical gradient.

Ions actively transported are Na^+, K^+, Ca^{2+}, iron, H^+, I^-, and urate ions.

Molecules that are actively transported are different ***sugars*** and most of the ***amino acids***.

Transport depends on carrier proteins in cell membrane.

* في بعض الخلايا بالجسم نرى فيها تراكيز لمواد كيميائية تصل لحد الصفر

وهذا بسبب أن هناك قوى تحافظ على نسبة الصفر هذه الخلايا والأنسجة التي

تخلوا من الغلوكوز.

تحتاج الى طاقة عن طريق كسر الـ ATP

* المواد التي تنتقل عكس الـ gradient هي :-

* Ions like ⟵ K^+ // Na^+ // Ca^{+2} / H^+ / I^- / Urate ions.

(الخارج الخلايا) (بالمعدة كثير) (بالبرقية كالي)

(داخل الخلية كالي) (خارج الخلية كالي)

* Molecules like ⟵ Some Sugars // most of amino acids