PHYSIOLOGY

Lec: 4

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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.

Passive → لا يحتاج طاقة

Diffusion → الانتشار

- 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*. → carrier protein
- **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**.

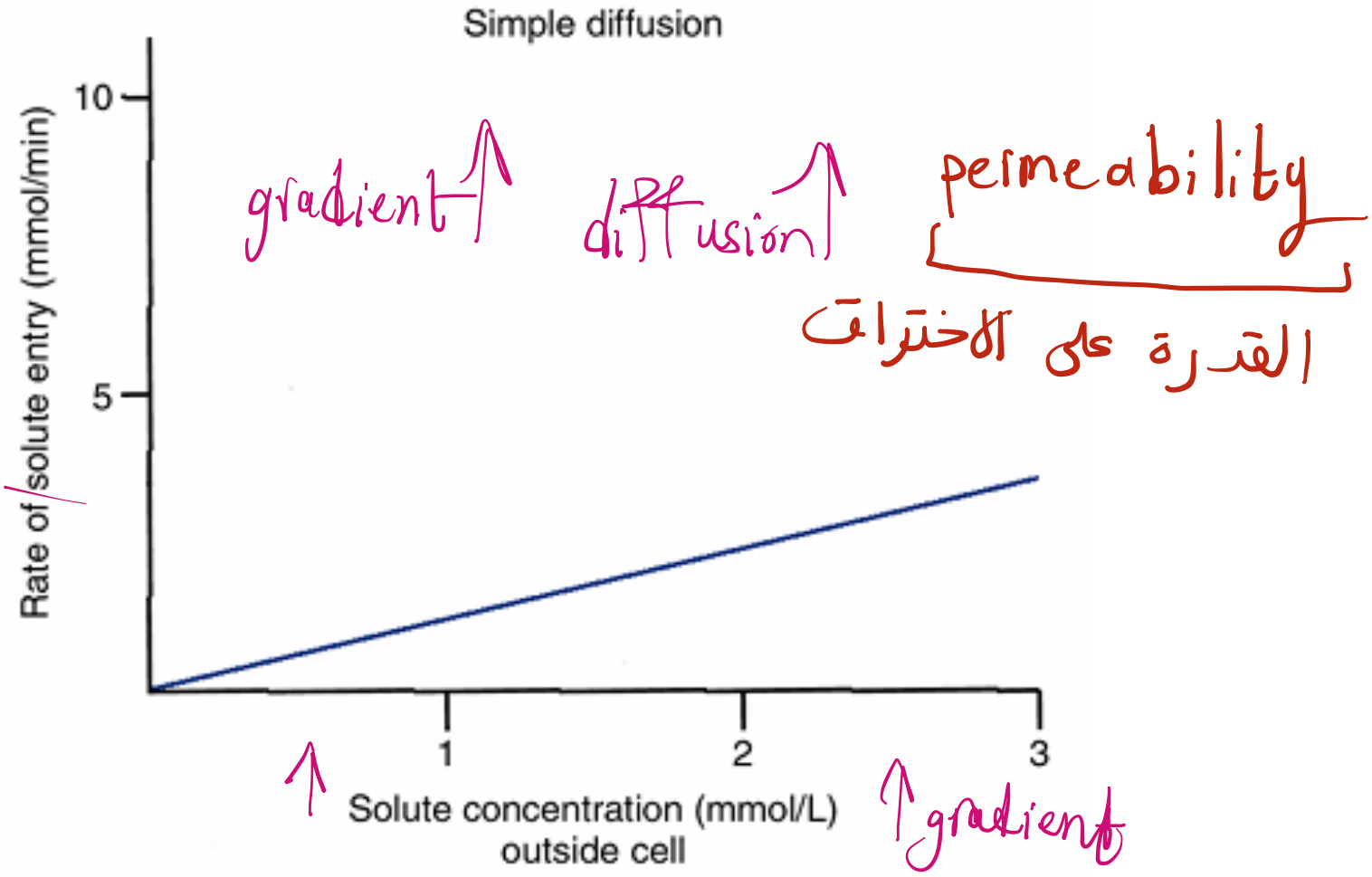
من التركيز الأعلى للأقل

سرعة الانتشار تكون حسب الحدث عوامل

- 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.

↳ channel protein for water

الانتشار البسيط ← النوع الوحيد اللي ما يحتاج أي ناقل



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

lipid soluble molecules → simple diffusion
go through the membrane

lipid soluble molecules العوامل اللي بتناسب معهم

وعلاقة كل واحد فيهم

1) lipid solubility → قدرتهم على الذوبان

علاقة طردية (بتزيد سرعة الانتشار)

2) size of the molecule → حجم الجزيء

علاقة عكسية (بتقل سرعة الانتشار)

قابلية الاختراق بتعتمد على المذاب

Diffusion (cont.)

قابلية الاختراق — المذاب

- ***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 → في مناطق سميكة ومناطق لأ

Solute → مذاب
Solution → المحلول
Solvent → مذيب

- 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.

1 2 3 4

4 → 100 قناة 100 ايون — 10 ممرات

3 → اللي شحنتهم موجبة بدخلو بسهولة اكبر

O_2 / N_2 / CO_2 / fatty acids / Alcohol

→ high lipid solubility → diffuse easily

Be careful !! (simple diffusion لسا احنا بنحكي عن ال)

water soluble ions —less daimeter than→ < 0.8 nm → channels

لكن في استثناء يحصل مرات

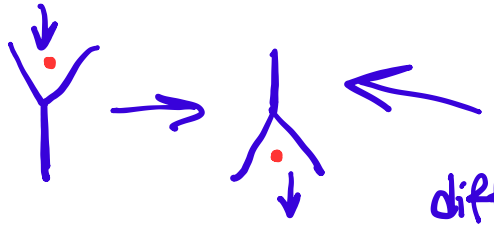
ال aquaporins مخصصة للماء فقط

في aquaporins تكون أقل انتقائية وتسمح بمرور ال urea

(في المحاضرات المتقدمة رح نحكي كيف ال urea فعليًا تنتقل عن

طريق ال carrier proteins)

shuttle



مبدأ الـ facilitated diffusion

Diffusion (cont.)

- Some lipid-insoluble molecules (such as urea) can use less selective water channels to pass.

بصير مع الـ gradient

- 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.

≥ 0.8 nm

- 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***.

شكل معين للجزيء

- **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.

حالات خاصة بصير في خداع للـ carrier بسبب تشابه الجزيئات

e.g Mg^{+2} و Ca^{+2}

كل amino acid إله carrier خاص فيه

نستنتج إنه الـ Tm هو 1000 جزيء

Diffusion (cont.)

1000 carrier binding sites

1000 بدخل فقط ← 1500 اجا جزيء

- **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***). → Velocity maximum (تسمية أخرى فقط)

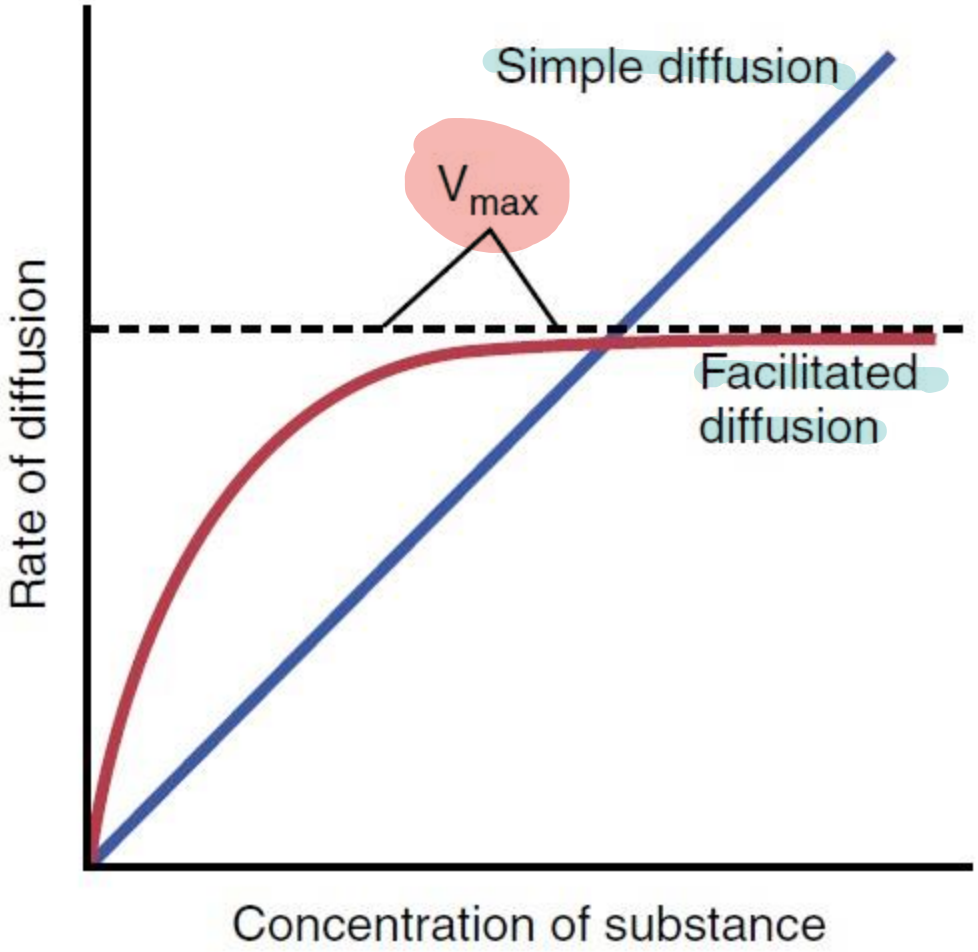
  This means that initially facilitated diffusion depends on the concentration gradient until all binding sites are filled (saturated); at this point, the rate of diffusion can no longer rise with increasing the concentration gradient.

بالرغم من إنه تركيز الجزيئات بزيد لكن بسبب انشغال جميع المواقع رح تثبت سرعة الانتشار

- **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.

← صون بصير حالات الخداع

السرعة تقل عندما يتنافس جزيئان متشابهان على نفس الناقل



عند حدوث ← saturation لـ

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}.

من التركيز الأقل للأعلى

يحتاج طاقة (ATP)

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***.

يعتمد على

Transport depends on carrier proteins in cell membrane.

Types of active transport

Secondary active transport

Primary active transport

يصنع طاقته بنفسه (يشتغل كأنزيم ATPase)
يكسر الـ ATP

Primary active transport

Uses the hydrolysis of ATP as source of energy. Ions transported by this mechanism are Na^+, K^+, Ca^{2+},H^+, Cl^-, and few other ions. Examples are;

A. **Na^+- K^+ pump** (Na^+- K^+ ATPase) is a clear example of this mechanism. Both Na^+ and K^+ are transported against their electrochemical gradients. Each cycle of the pump uses 1 molecule of ATP to remove 3 Na^+ ions from the ICF and transport 2 K^+ ions into the ICF. The Na^+-K^+ pump controls ***cell volume*** and creates ***electrical potential*** across the cell membrane as it pumps.

   This pump is inhibited by **digitalis**, a drug used in the treatment of heart failure. Also this pump stops functioning if no Na^+, K^+, or ATP is available.

B. **Ca^{2+} pump** on the sarcoplasmic reticulum (SR) of muscle cells, which maintains the intracellular ionic Ca^{2+} concentration below 0.1 µmol/L.

C. **H^+-K^+ ATPase or proton pump**. This pump is found in (1) the gastric glands of the stomach and in (2) the late distal tubules and cortical collecting ducts of the kidneys.

هيك بنكون خلصنا الجزء الاول من المحاضرة
الرابعة والخامسة لإنهم جايين مع بعض

هذا الدكتور ميو

الدكتور ميو يسمع كلام دكتور
وليد ويفتهم وما يبصم