PHYSIOLOGY

النادي الطبي

Lec: 5

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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.

Types of active transport

- Secondary active transport
- Primary active transport

Primary active transport

يزيد من انجذاب ال Na^+ لدخول الخلية

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.

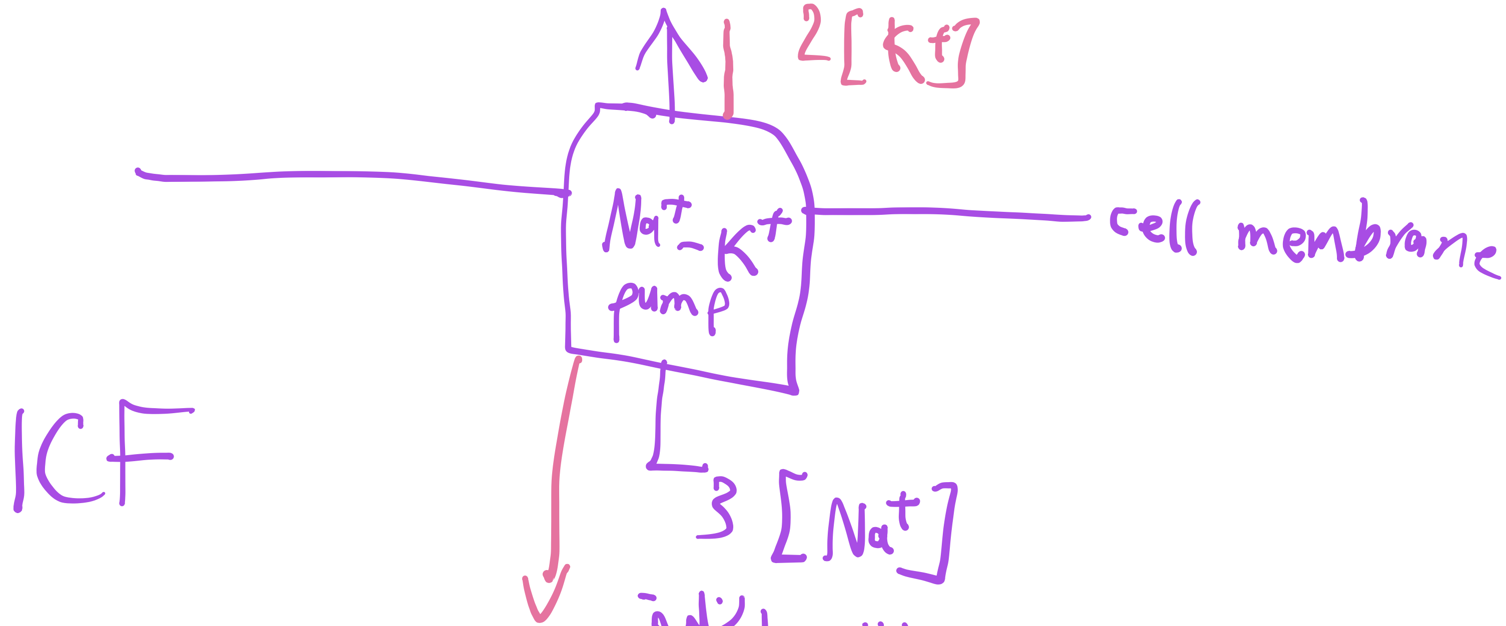
يشل حركة ال pump — مثبطات ال pump — $[Na^+]$↑ intracellular

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.

يتم طرد ال H^+ ← سبب حموضة البول

A.



(رح تزيد سالبية الخلية بطرد الـ Na^+ خارج الخلية)

* داخل الخلية دائمًا سالب حتى بعدم وجود الـ Na^+-K^+ pump

الـ Na^+-K^+ pump و الـ pharmacology ← عائلة الـ digitalis وهو عبارة عن دواء

← يستخدم في علاج فشل القلب (لقدام رح اوضح المقصود)

← يعمل عن طريق تثبيط الـ Na^+-K^+ pump

B. Ca^{+2} pump

ال Ca^{+2} مسؤول عن انقباض العضلات

تركيز ال Ca^{+2} في الخلية يكاد ان يكون معدوم

(زيرو تركيز) ولا يكاد يكون صفر

، ، ، ، ، ، في ال SR عالي

يحاول ال Ca^{+2} ان يدخل الخلايا لكن

يتم طرده ونتيجة لذلك يحدث انقباض

للعضلات

Secondary active transport

- Metabolic energy is not provided directly, but indirectly from the ***Na^+ gradient*** that is maintained across cell membranes (potential energy).
- Two or more solutes are coupled to the carrier protein; one of the solutes (Na^+) is transported ***downhill*** and provides the energy for the uphill transport of the other solute(s). Thus, inhibition of Na^+-K^+ pump eventually inhibits secondary active transport.
- If Na^+ ions pull other substances along with them while diffusing to the interior (solutes move in the same direction), the phenomenon is called ***co-transport***. **Glucose** and many **amino acids** are transported by this mechanism (such as in intestinal epithelial cells and in the renal proximal tubules of the kidney).

ال Na^+ يمتلك طاقة كامنة ويدخل مع التركيز عن طريق بروتين
و المادة المرافقة لل Na^+ تدخل عكس تركيزها

هذا يسمى cotransport

مبدأ عمل ال digitalis ⟵ يحدث secondary active transport

فيدخل ال Na^+ لداخل الخلية ويخرج ال Ca^{+2} (عكس تركيزه)
ومع مرور الوقت تقل كفاءة هذه العملية فيزيد تركيز ال Ca^{+2}
داخل الخلية (بسبب قلة خروجه من الخلية) مما يزيد من انقباض عضلة القلب ← يؤدي إلى فشل في القلب

↑ Ca^{+2} in cytoplasm ↑ انقباضات العضلة

Secondary active transport (cont.)

عملية تبادل (اشي بدخل و اشي بطلع)

- Other form of secondary active transport is the ***counter-transport*** or **exchange** phenomenon. Here Na^+ ions diffuse in replacement for intracellular substances that must be transported to the outside.

- Two counter-transport mechanisms are especially important; they are:

ال Na^+ بيدخل هون و بيطلع ال Ca^{+2}

هجوم ضعيف إخراج قليل

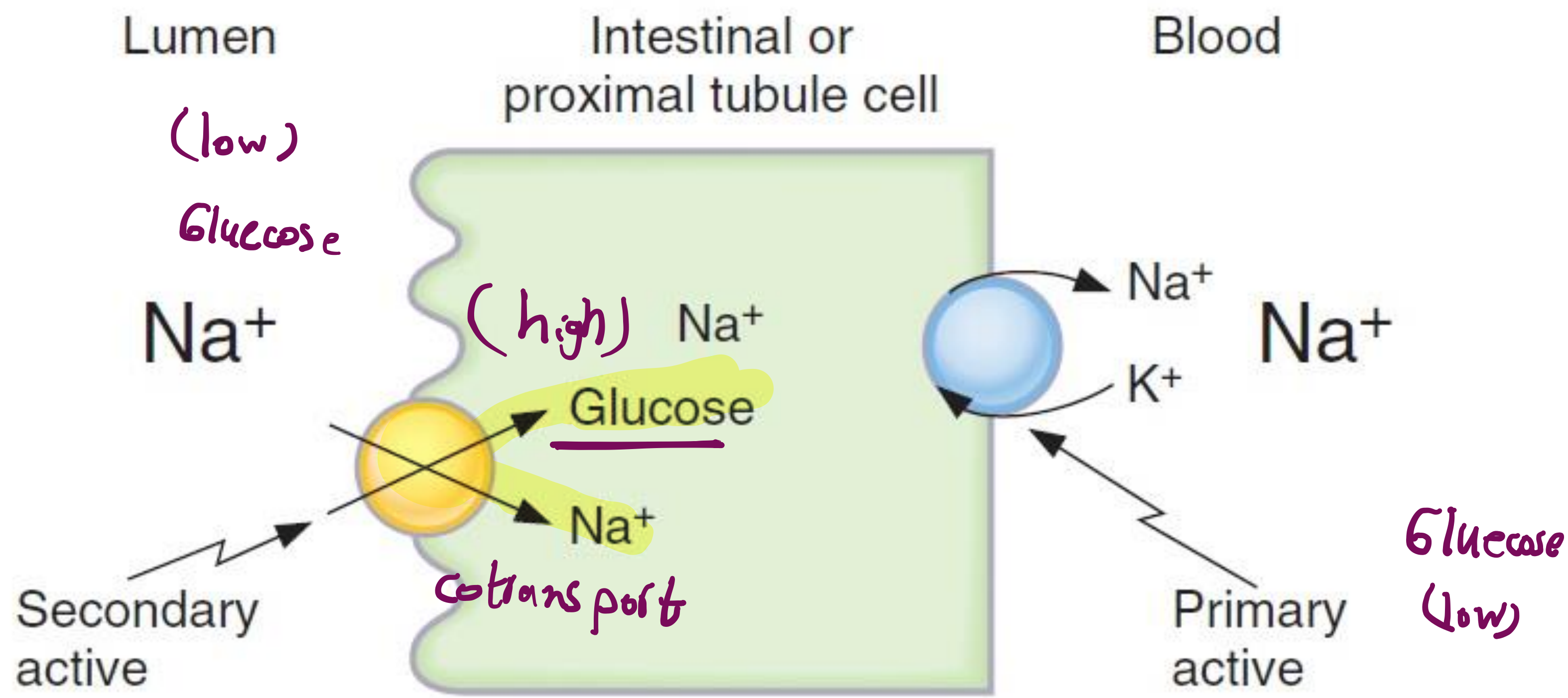
* The **Na^+-Ca^{2+} exchanger** (responsible for the removal of calcium from the cytoplasm of myocardial cells)

* The **Na^+-H^+ counter-transport**. This latter mechanism is responsible for the removal of H^+ ions produced by cellular metabolism to the ECF. The same mechanism is also responsible for the reabsorption of bicarbonate ions in the proximal tubule of the kidney.

الجزء مقابل التجويف المعوي

secondary active transport <—

يخرج الغلوكوز للدم عن طريق ال facilitated diffusion

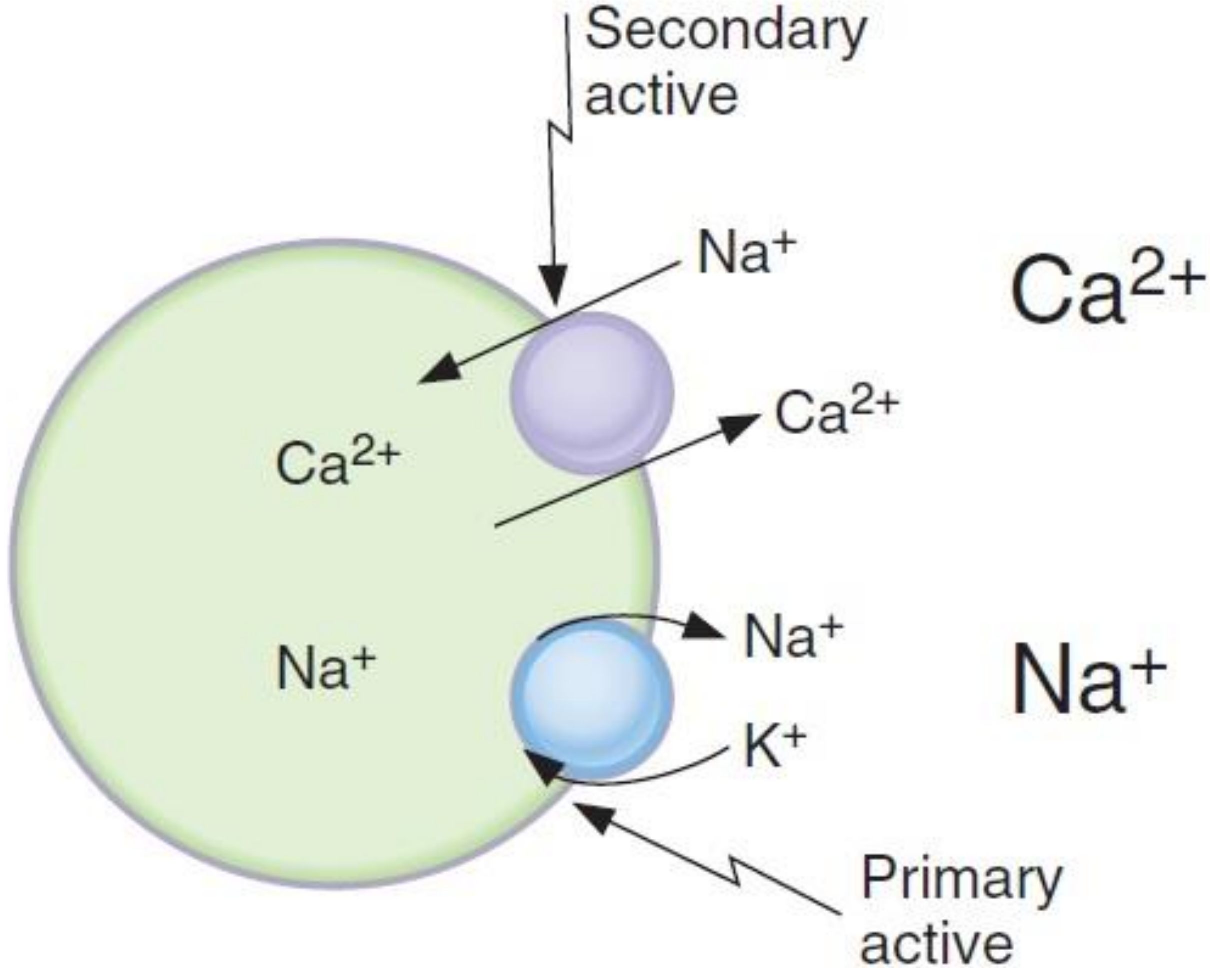


Na^+–glucose cotransport (symport) in intestinal or proximal tubule epithelial cell

Na^+ دخل مع التركيز

Glucose دخل عكس تركيزه (من الأقل للأعلى)

اكثر transport way



Na^{+}–Ca^{2+} countertransport (antiport)

Vesicular transport (active)

This mechanism is applied for the transport of large polar molecules or even multimolecular materials that must ***leave*** or ***enter*** the cell- such as during secretion of protein hormones by endocrine cells, or during ingestion of invading bacteria by white blood cells.

Vesicular transport requires energy expenditure by the cell, so it is an active method of membrane transport. Energy is needed to accomplish ***vesicle formation*** and ***vesicle movement*** within the cell.

Vesicular transport includes **endocytosis** and **exocytosis**.

A. In **endocytosis** the material to be transported first binds to a receptor, and then the receptor-substance complex is surrounded by the plasma membrane substance forming endocytic vesicle to be ingested by endocytosis. Endocytosis is of three types;

1. Phagocytosis (cell eating), for bacteria, dead tissue, and bits of material. Few specialized cells (such as WBC) are capable of phagocytosis. A lysosome fused with the membrane of the internalized vesicle releases its hydrolytic enzymes into the vesicle, breaking down the engulfed material into reusable raw ingredients.

e.g lipid anchored proteins on the cell membrane acts as a receptor for the vesicle

خلايا الدم البيضاء

e.g كسر بروتين لحتى يصير احماض امينية

Vesicular transport (cont.)

2. Receptor-mediated endocytosis. is a highly selective process that enables cells to import specific large molecules that it needs from its environment. **Iron**, **cholesterol**, **vitamin B12**, and the **hormone insulin** are important examples.
3. Pinocytosis (cell drinking), the ingested substances are in solution and cannot be seen under the microscope. Pinocytosis provides a way to retrieve extra plasma membrane that has been added to the cell surface during exocytosis.

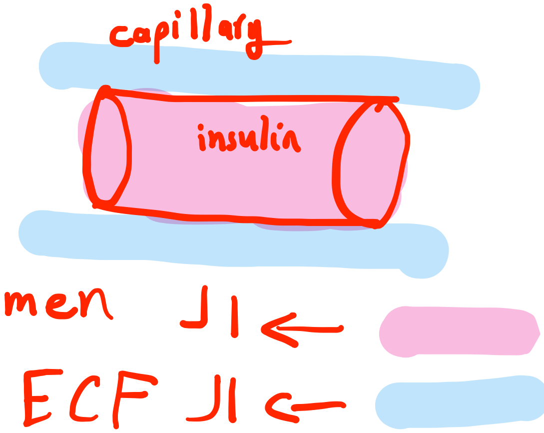
B. In **exocytosis**, intracellular material is trapped within vesicles, the vesicles fuse with the cell membrane and release the content to the ECF. ***Hormones***, ***digestive enzymes***, and ***synaptic transmitters*** are examples of materials transported by such mechanism.

Exocytosis enables the cell to add specific components to the membrane, such as selected carriers, channels, or receptors, depending on the cell's needs. Exocytosis is a process that requires Ca^{2+} and energy.

Notes: Exocytosis-endocytosis coupling maintains the surface area of the cell at its normal size.

Flu viruses and HIV, the virus that causes AIDS, gain entry to cells via receptor-mediated endocytosis.

2



capillary consists of one layer of cells

* بما إنه في طبقة خلايا وحدة رح ينتقل الانسولين عن طريق
ال endocytosis من جهة الدم
و exocytosis من جهة ال ECF
تخرج جزيئات الانسولين وتذهب لمستقبلاتها في الخلايا

* موكل endocytosis يصير فيها التهام ممكن تكون عملية نقل فقط

endocytosis ⟶ يقطع جزء من السطح

exocytosis ⟵ يضيف للسطح مساحة

* في بعض الامراض تخترق الخلية فيرتبط ال virus بال receptor ويدخل الخلية عن طريق ال vesicles ⟵ مثال HIV or AIDS

إذا كانت الايونات تنتقل
الماء لا ينتقل

شرط ال osmosis
ان يكون هناك انتقال للماء فقط

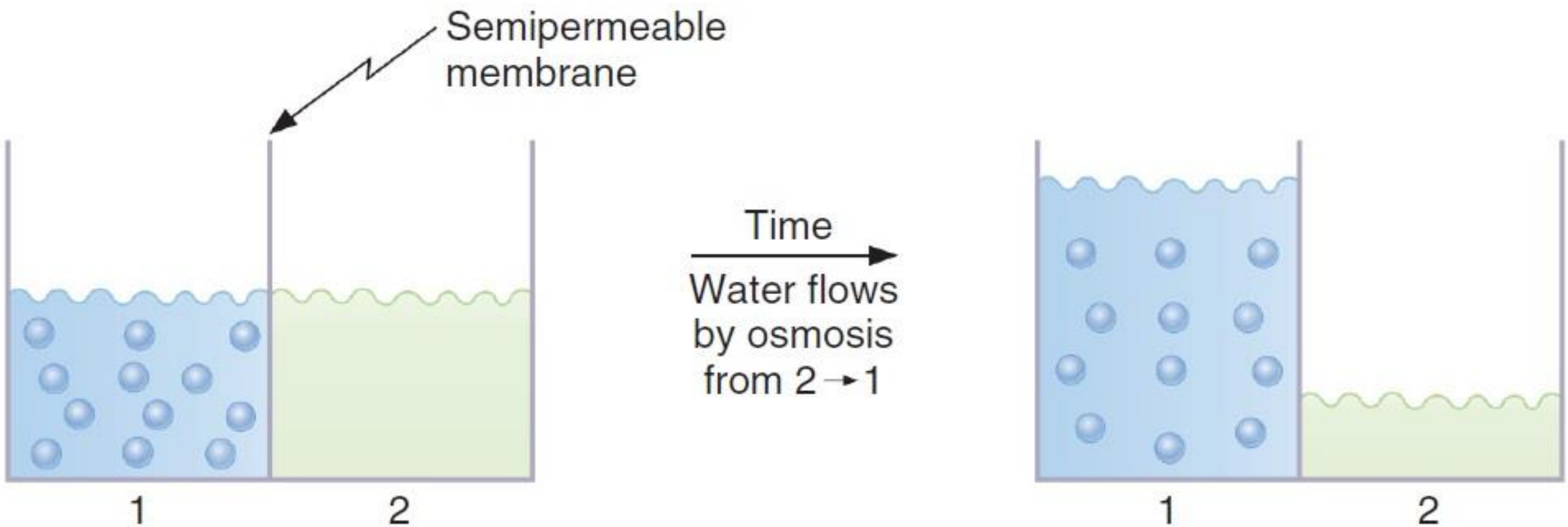
Osmosis

- It is the net ***passive*** flow of water across a selectively permeable membrane down an osmotic pressure gradient.

الأعلى للأقل
مع

- The driving force for movement of water is the same as for any other diffusing molecule, i.e. from a region of high water concentration to one that has a lower water concentration.
- It is important to recognize, however, that adding a solute to pure water in effect decreases the water concentration.
- In general, adding one molecule of a solute displaces one molecule of water.
- Therefore, water flows from pure water to salty solution (i.e. ***water moves by osmosis to the area of higher solute concentration***).

الماء يلحق الملح بشرط الملح ما يقدر يعبر ال membrane



$CaCl_2$

NaCl

Na^+ Cl^-

القوة عبارة عن كسر الروابط بين الجزيئات

قوة انتقال الماء ← osmolarity

لا تعتمد على عدد الجزيئات

يعتمد على عدد الاجزاء

Osmosis of H_2O across a semipermeable membrane solute concentration ↑ osmotic pressure ↑ flow of water ↑

Osmosis (cont.)

- **Osmotic pressure (π)** of a solution is a measure of the tendency for water to move ***into that solution***. It is equal to the hydrostatic pressure needed to stop osmosis.

  It is determined by the number of particles in a solution per unit volume of fluid (i.e. molar concentration). The osmotic pressure increases when the solute concentration increases.

- The higher the osmotic pressure of a solution, the greater the water flow ***into it***.

- The **Osmole** of a substance = 1 gram molecular weight of undissociated solute of that substance.

  Osmolarity = concentration X number of dissociable particles

  mOsm/L = mmol/L X number of particles/mole

- The **Osmolality** = the number of osmoles per kilogram of water. The normal osmolality of the extracellular and intracellular fluids is about 300 milliosmoles per a kilogram of water.

  The average osmotic pressure of the body fluids is about 5500 mmHg, since one milliosmole per liter is equivalent to 19.3 mmHg osmotic pressure.

- The **Osmolarity** = the number of osmoles per liter of solution ≈ osmolality for dilute solution, such as those in the body.

كل ال particle
osmotic pressure

الضغط المائي ← الضغط على الماء
بسبب قوة الجاذبية

الضغط الاسموزي = الضغط المائي اللازم
لتوقف ال osmosis

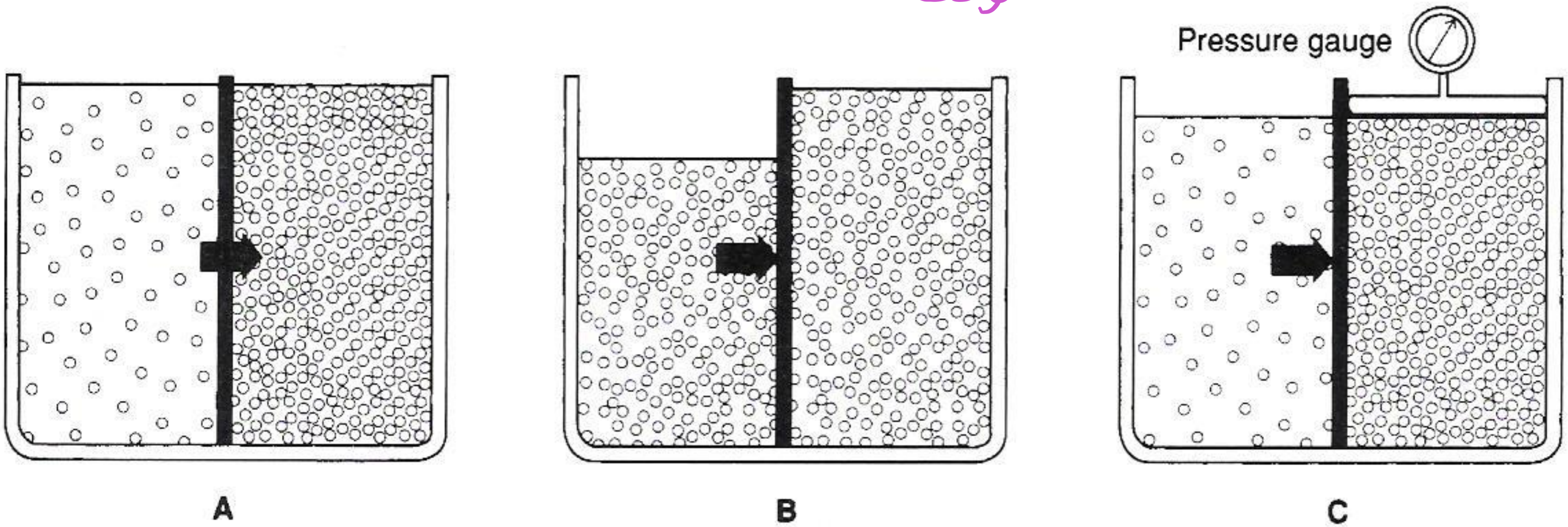


FIGURE . When a selectively permeable membrane separates two solutions of different osmolalities (*A*), water flows from the solution with the lower osmotic pressure (concentration) to the solution with the higher osmotic pressure (concentration). (*B*) Water flows into the chamber until the pressure (i.e., hydrostatic and osmotic) difference between the two chambers is zero. (*C*) The application of pressure to the chamber that contains the higher solute concentration prevents the flow of water. The amount of pressure that must be applied to prevent the flow of water is a measure of the osmotic pressure between the two chambers.