Cell membrane structure and transport across cell membrane

objectives

At the end of this session, the students should be able to:

- **Describe the fluid mosaic model of membrane structure and function.**
- **Define permeability and list factors influencing permeability.**
- **Identify and describ transport processes: Primary active transport, secondary active transport, facilitates diffusion. simple diffusion,osmosis.**

Cell Membrane

- **It covers the cell.**
- **It is a fluid and not solid.**
- **Plasma membrane .**

Composition

Protein

Phospholipids

Cholesterol

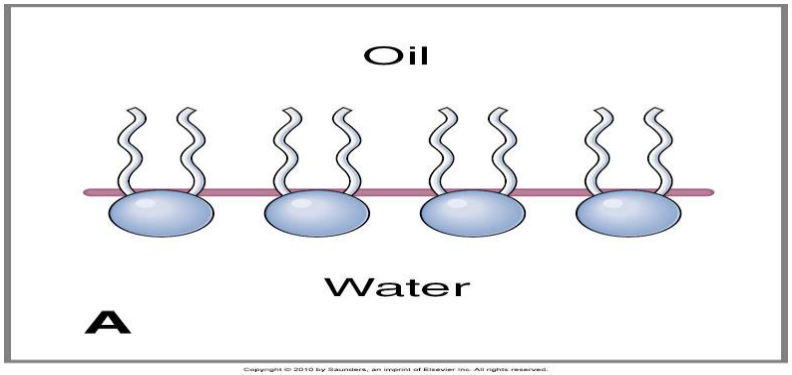
Glycolipid

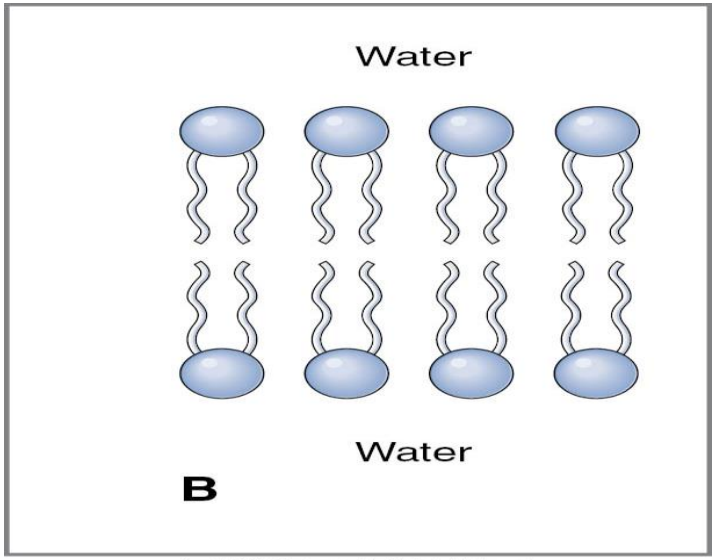
} **lipid**

Carbohydrates

The Cell Membrane Phospholipids Consist Of :

1. **Glycerol head (hydrophilic).**
2. **Two fatty acid "tails" (hydrophobic).**





- **Heads (hydrophilic) facing ICF and ECF and tails (hydrophobic) face each other in the interior of the bilayer.**

- **Amphipathic.**

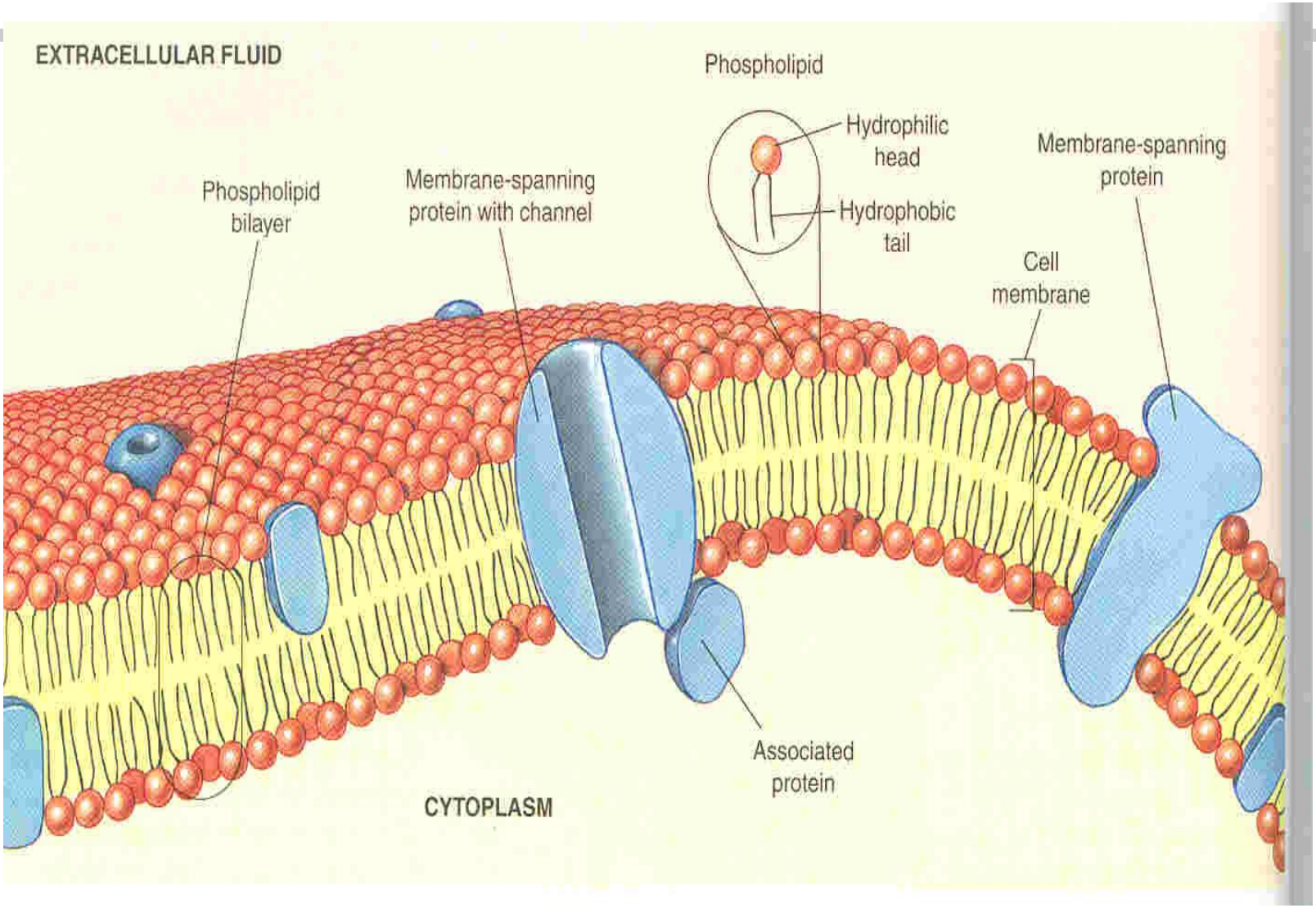
The Cell Membrane Proteins.

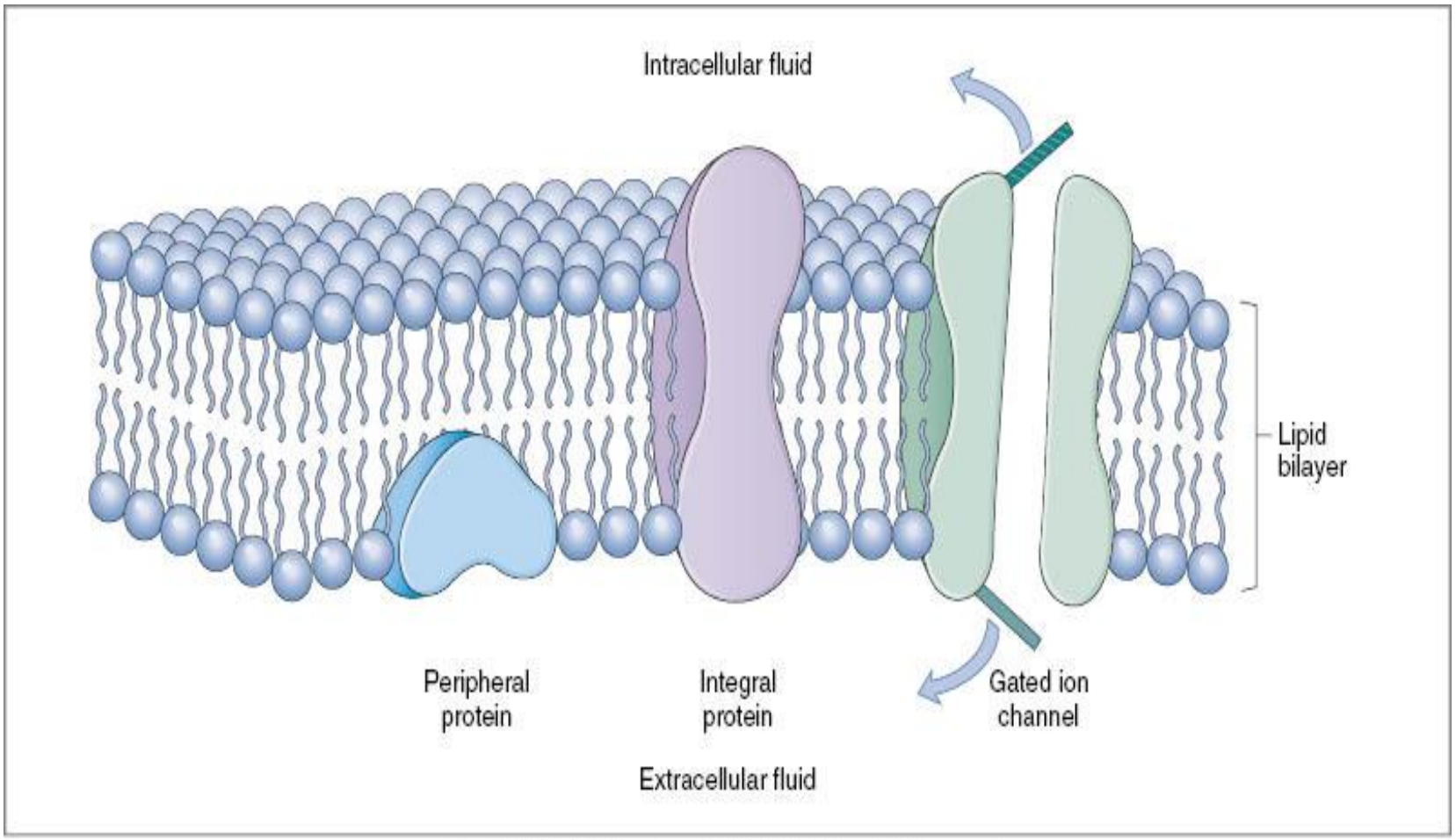
1. **Integral proteins span the membrane .**
   Proteins provide structural channels or pores.

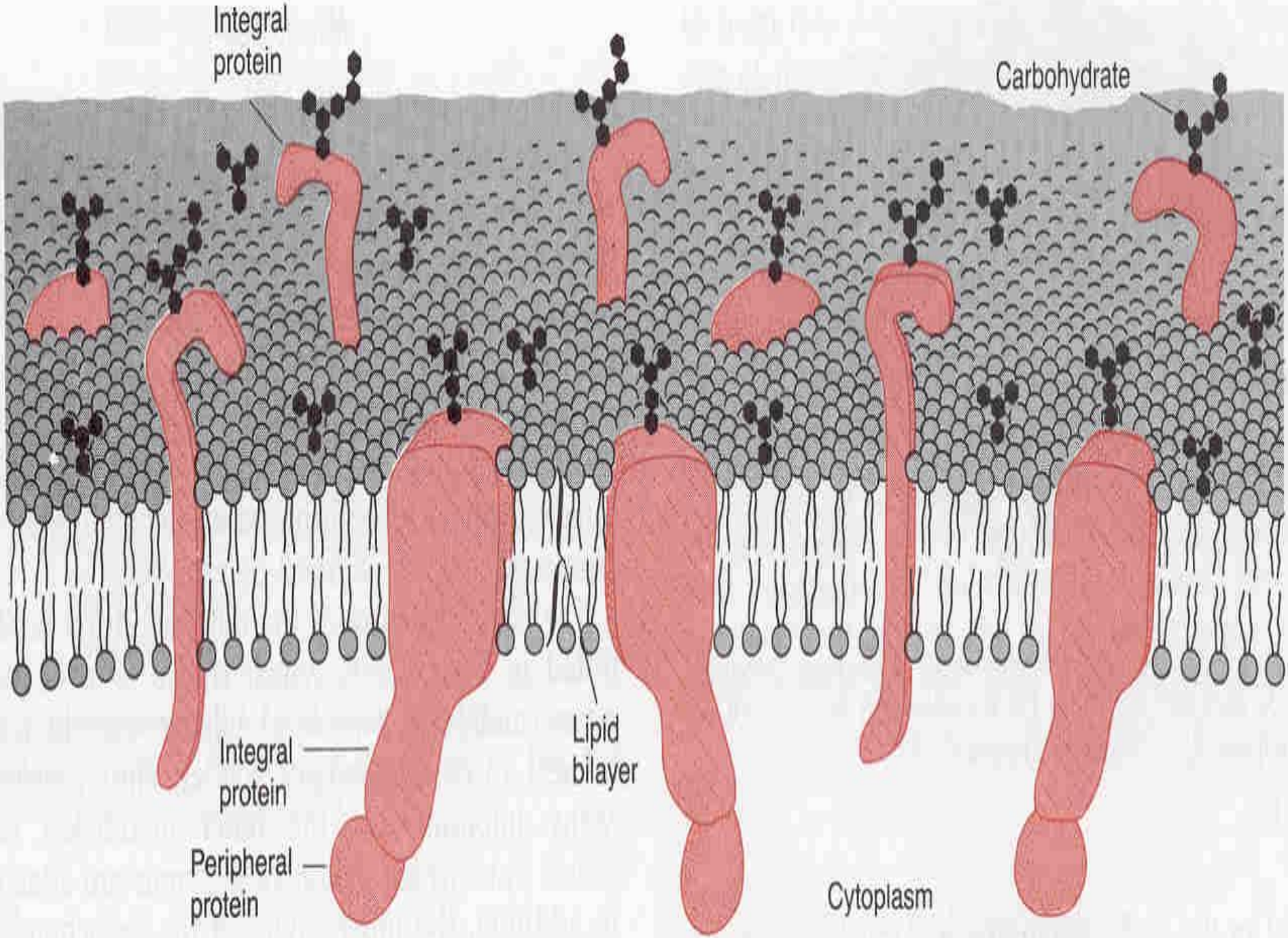
2. **Peripheral proteins (carrier proteins)**

   -Present in one side.

   - Hormone receptors ..

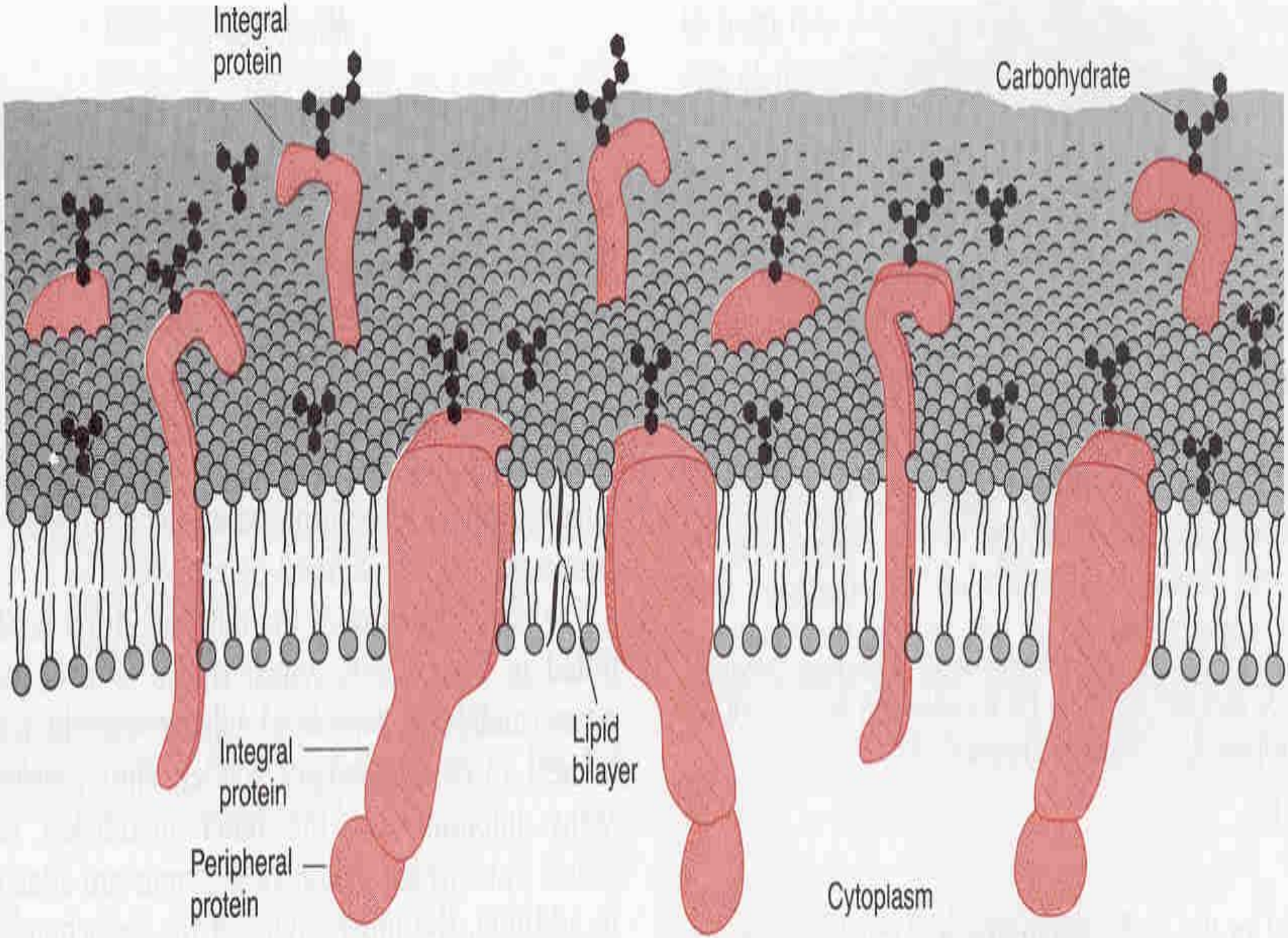

EXTRACELLULAR FLUID
Phospholipid
Hydrophilic head
Hydrophobic tail
Membrane-spanning protein
Phospholipid bilayer
Membrane-spanning protein with channel
Cell membrane
Associated protein
CYTOPLASM




Integral protein
Carbohydrate
Integral protein
Lipid bilayer
Peripheral protein
Cytoplasm

The Cell Membrane Carbohydrates:

- ***Glycoproteins** (most of it).*
- ***Glycolipids***
- ***Proteoglycans** (mainly carbohydrate substance bound together by protein)*
- *‘’glyco” part is in the surface forming.*
- ***Glycocalyx.**(loose coat of carbohydrates.*


Integral protein
Carbohydrate
Integral protein
Lipid bilayer
Peripheral protein
Cytoplasm

Function Of Carbohydrates:

- **Attaches cell to each others.**
- **Act as receptors substances. (help ligend to recognize its receptor).**
- **Some enter in to immune reactions.**

Transport Through The Cell Membrane

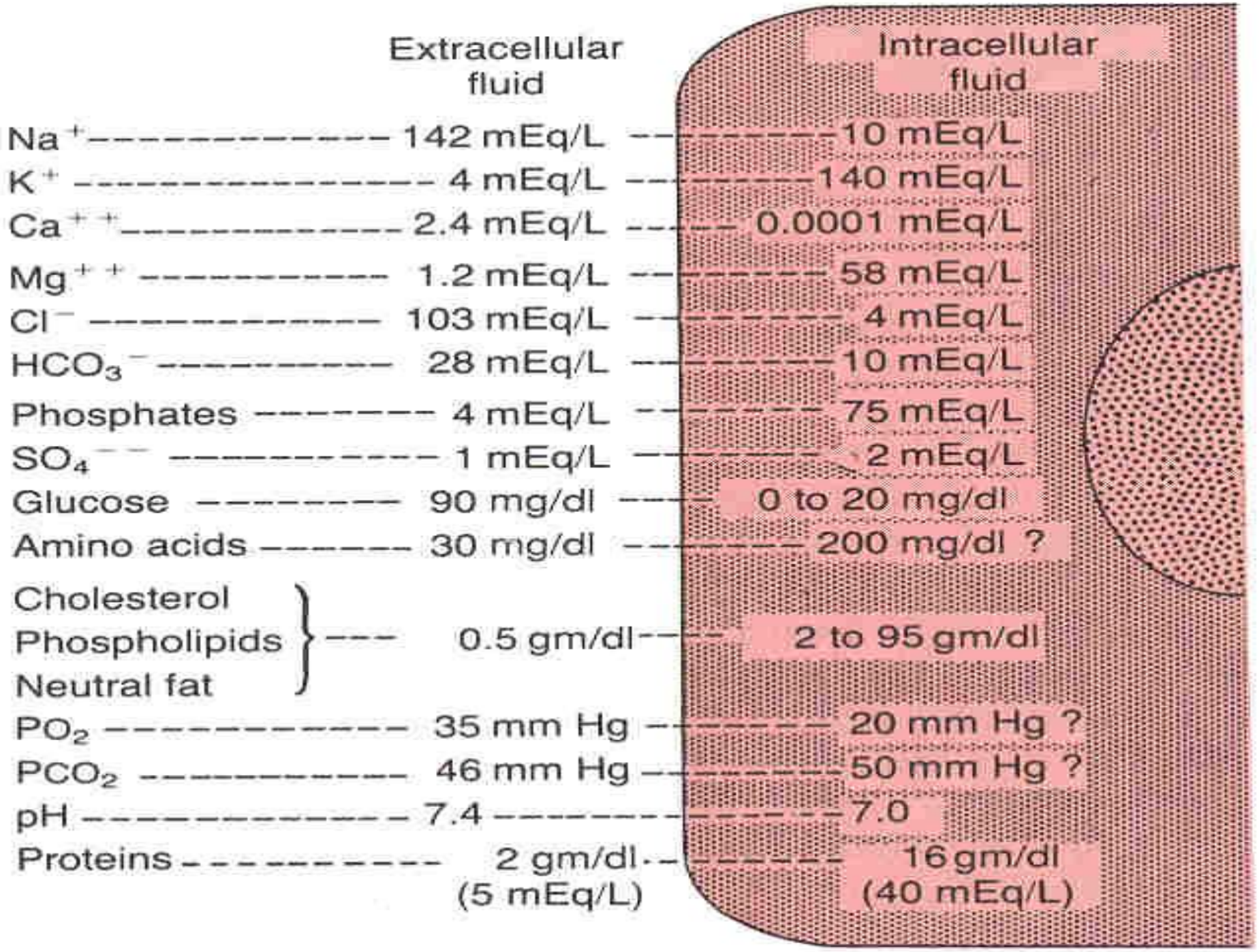
- **Cell membrane is selectively permeable.**

- **Through the proteins.**

water –soluble substances e.g. ions, glucose .

- **Directly through the bilayer.**

Fat – soluble substance (O2, CO2, OH..


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
HCO3− 28 mEq/L 10 mEq/L
Phosphates 4 mEq/L 75 mEq/L
SO4−− 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 gm/dl
2 to 95 gm/dl
PO2 35 mm Hg 20 mm Hg ?
PCO2 46 mm Hg 50 mm Hg ?
pH 7.4 7.0
Proteins 2 gm/dl (5 mEq/L) 16 gm/dl (40 mEq/L)

Types Of Membrane Transport

- **1- Diffusion**
- a)- Simple diffusion.
- b)- Facilitated diffusion.
- **2- Active transport.**
- a)- Primary active transport.
- b)- Secondary active transport.
- **3- Osmosis.**

Diffusion

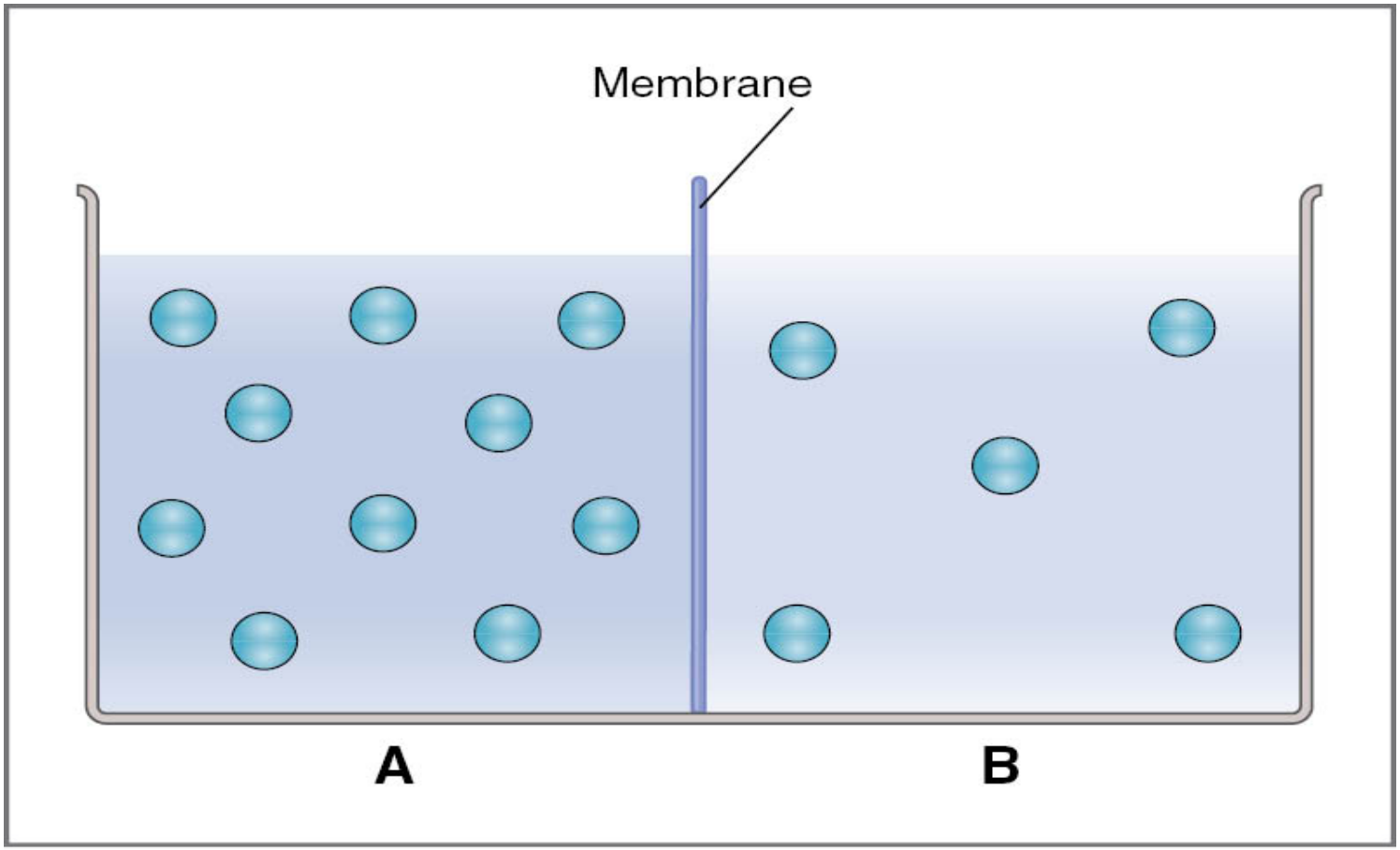
- Random movement of substance either through the membrane directly or in combination with carrier protein down an electrochemical gradient.

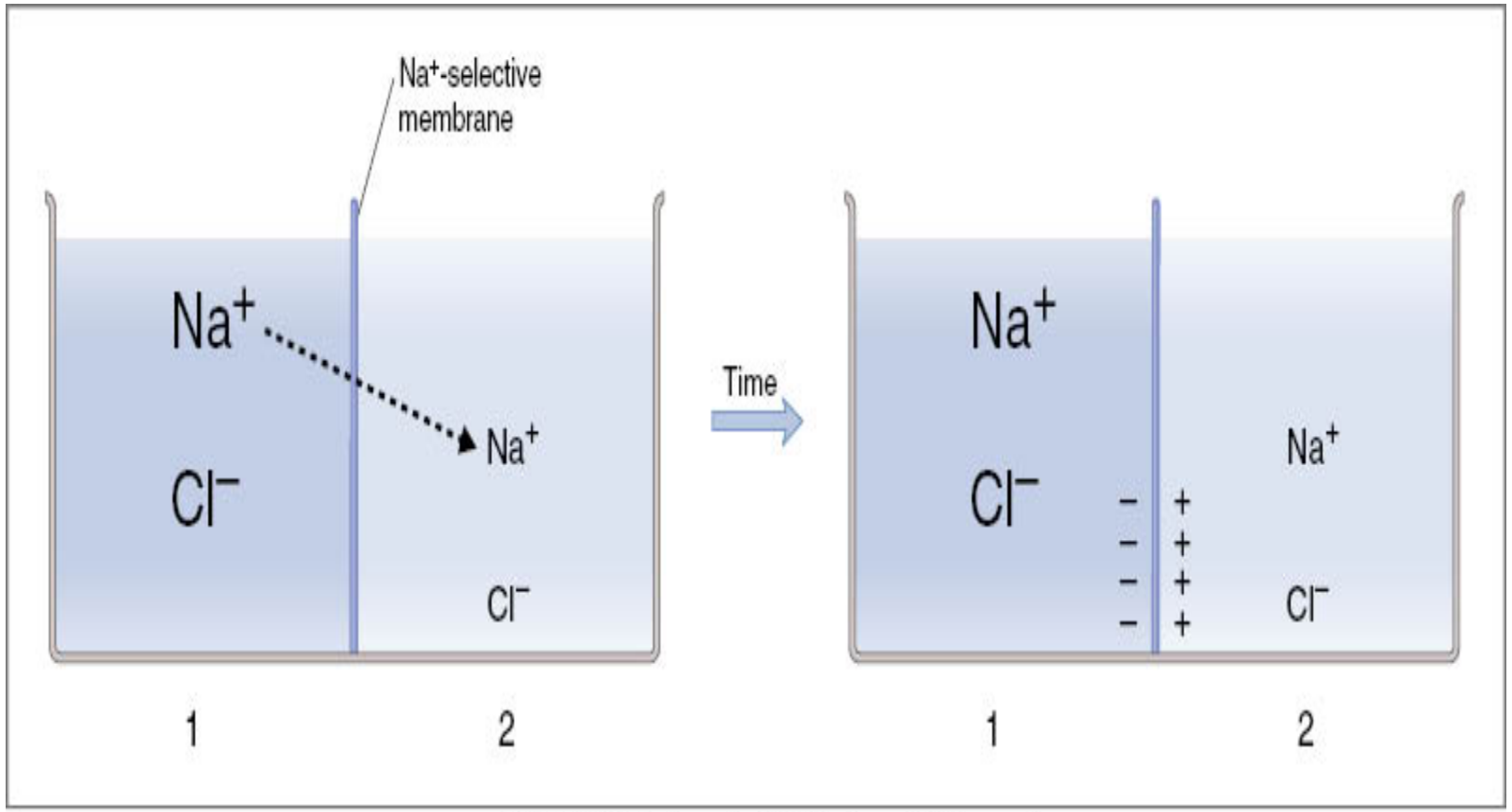
1- Simple diffusion.

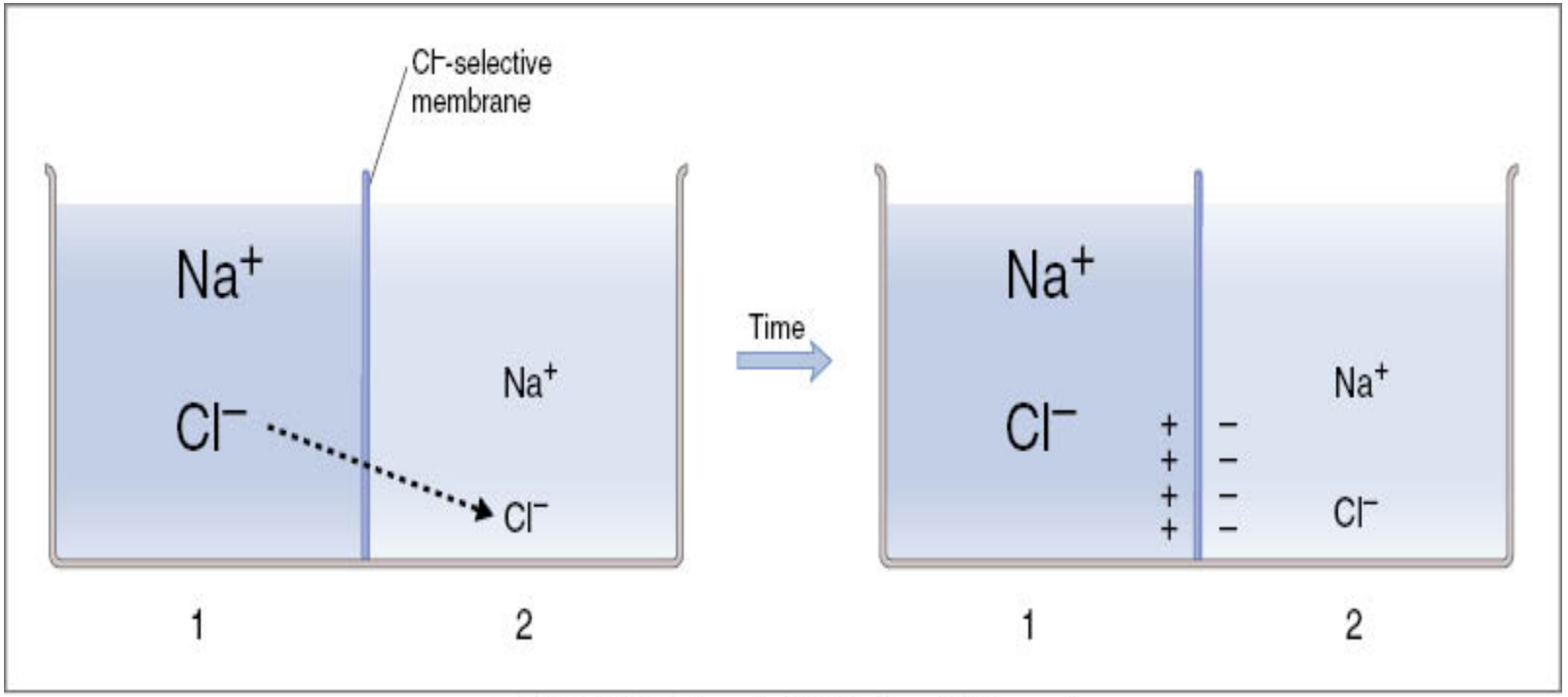
2- Facilitated diffusion.

Simple Diffusion

- Non carrier mediated transport down an electrochemical gradient.
- Diffusion of nonelectrolytes (uncharged) from high concentration to low concentration.
- Diffusion of electrolytes (charged) depend on both chemical as will as electrical potential difference.







Rate Of Simple Diffusion Depend On:

1- Amount of substance available.

2- The number of opening in the cell membrane for the substance.

selective gating system

3- Chemical concentration difference.

net diffusion= P x A (Co-Ci)

4- Electrical potential difference.

5- Molecular size of the substance.

6- Lipid solubility.

7- Temperature.

Facilitated Diffusion

- **Carrier mediated transport down an electrochemical gradient.**

Features Of Carrier Mediated Transport

1- Saturation:

↑ concentration ⟶ ↑ binding of protein

If all protein is occupied we achieve full saturation.

2- Stereopecificity:

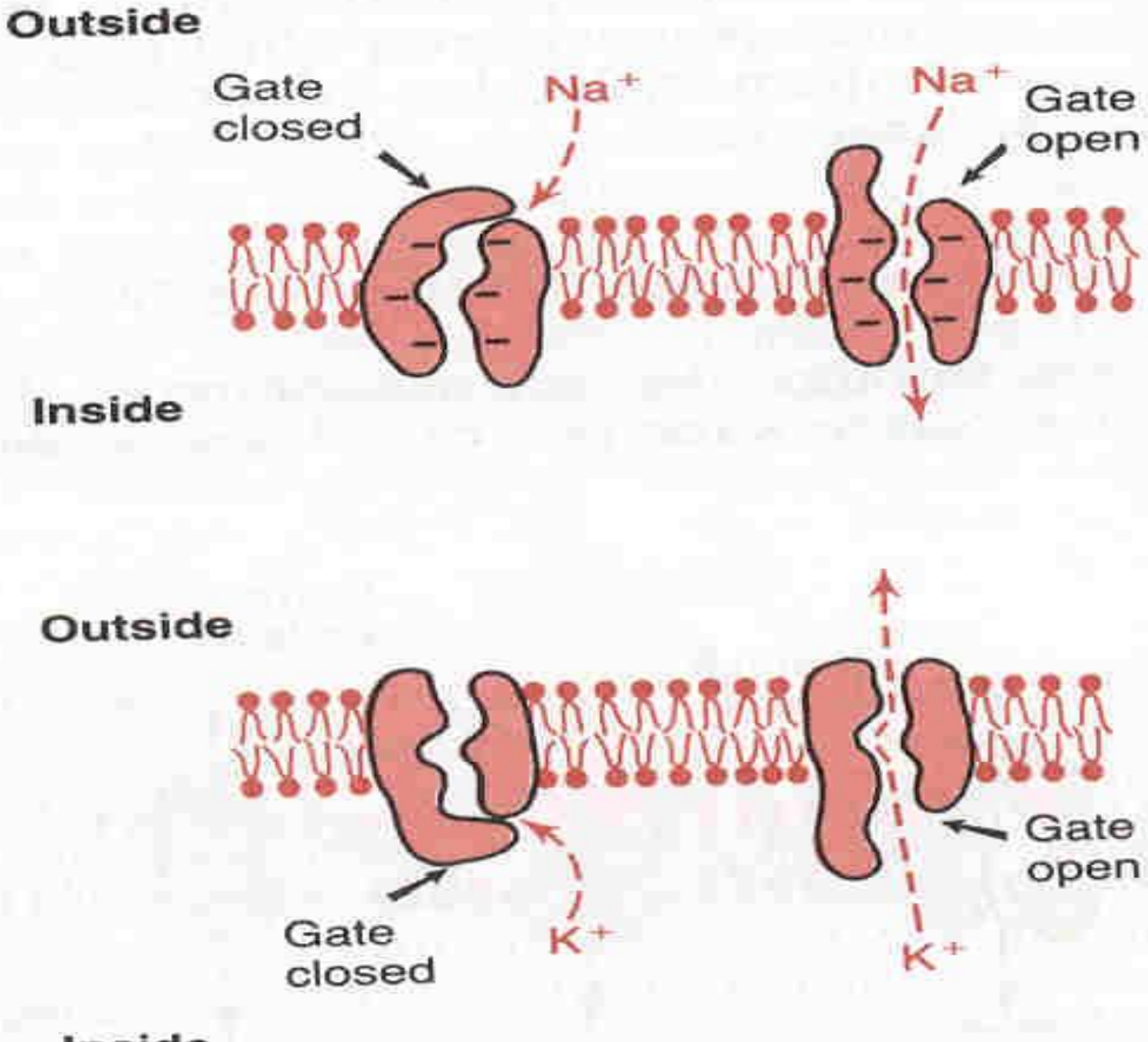
The binding site recognize a specific substance

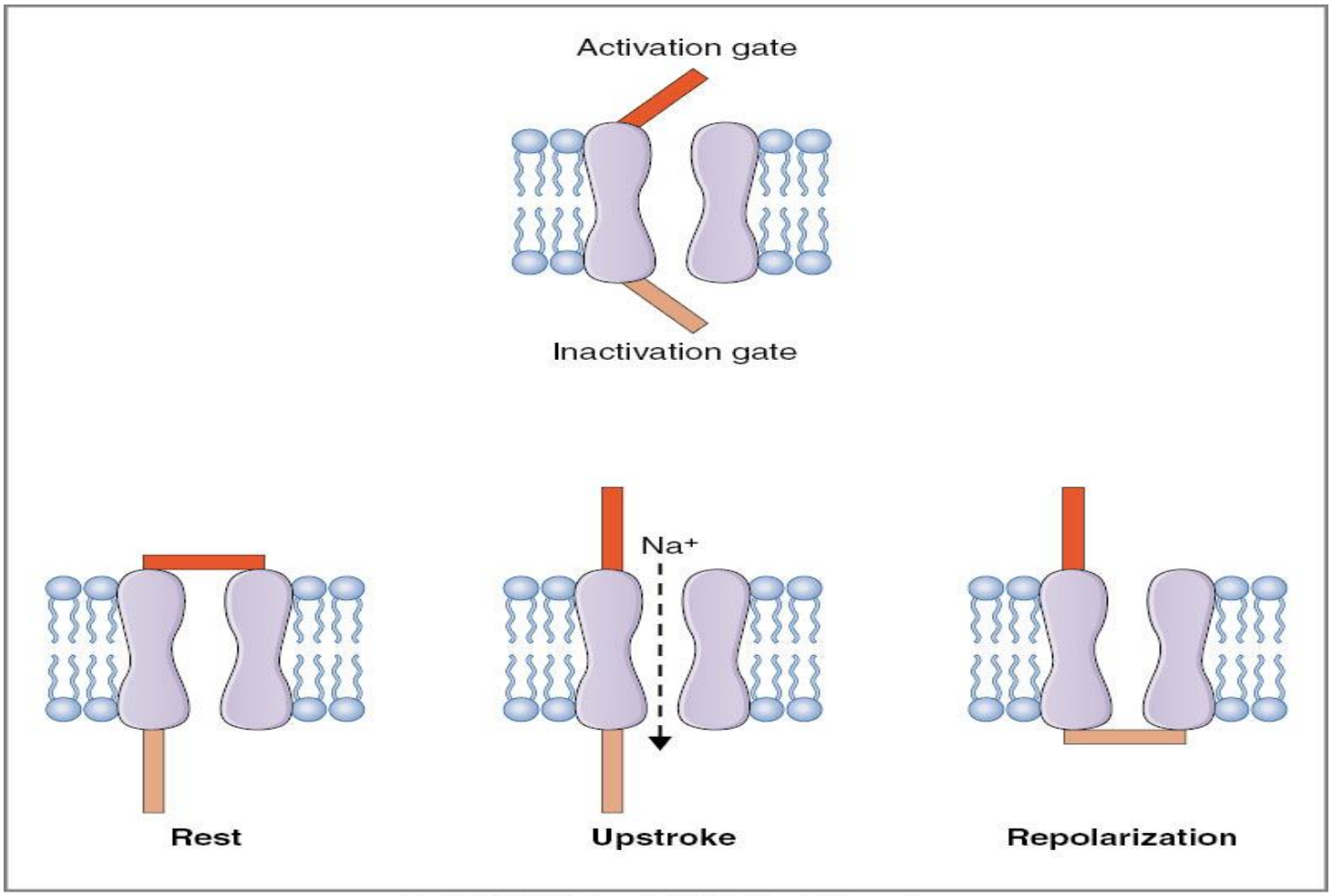
D-glucose but not L-glucose

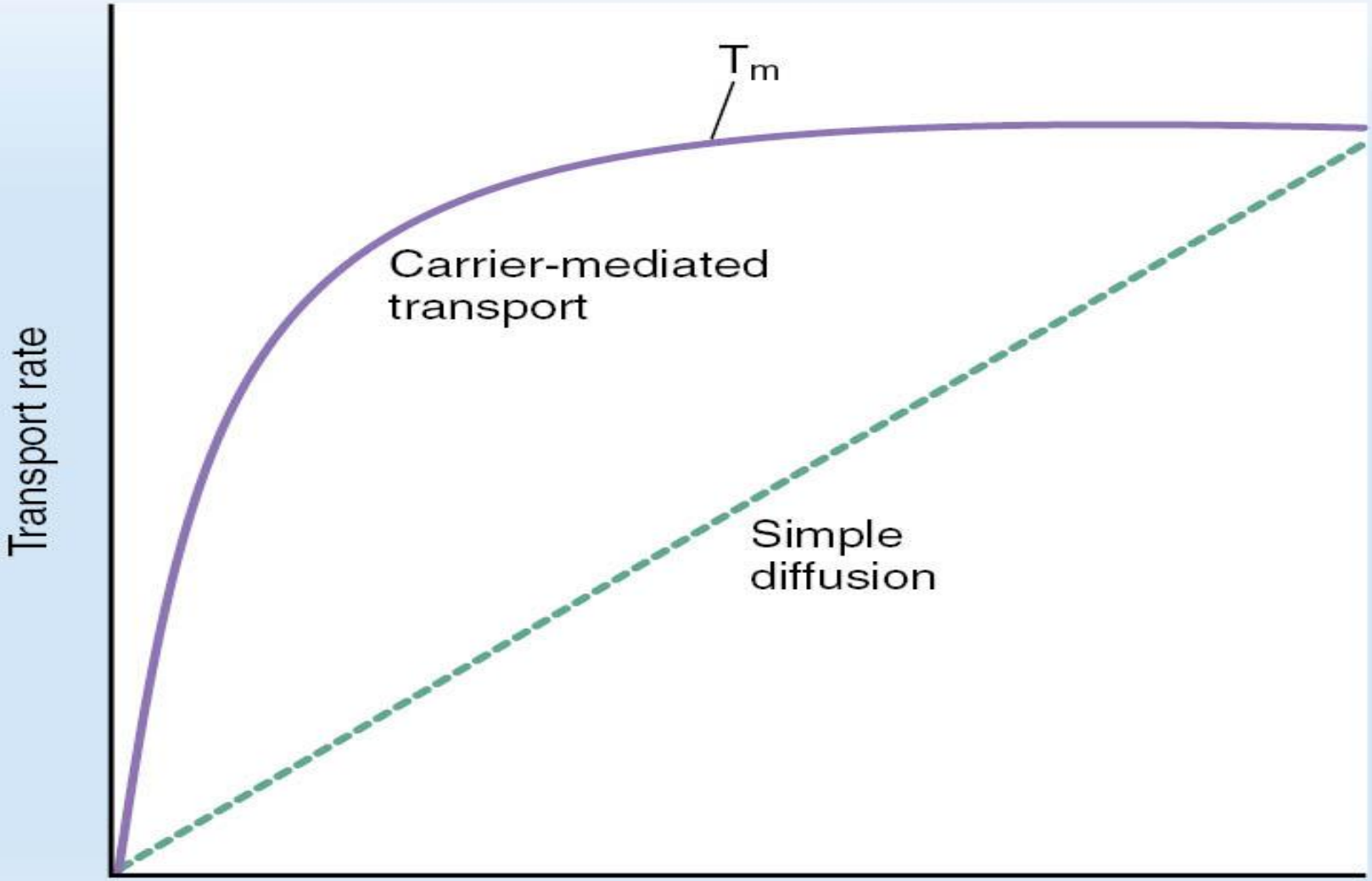
3- Competition:

Chemically similar substance can compete for the same binding site.

Substance → binding site → substance protein complex ⟶ conformational changes release of substance


Outside
Gate closed
Na+
Na+
Gate open
Inside
Outside
Gate closed
K+
K+
Gate open
Inside





- Glucose, most of amino acids.

Active Transport:

- **Transport (uphill) → against electrochemical gradient.**
- **Required energy → direct.**
  indirect.

- **Required carrier – protein.**

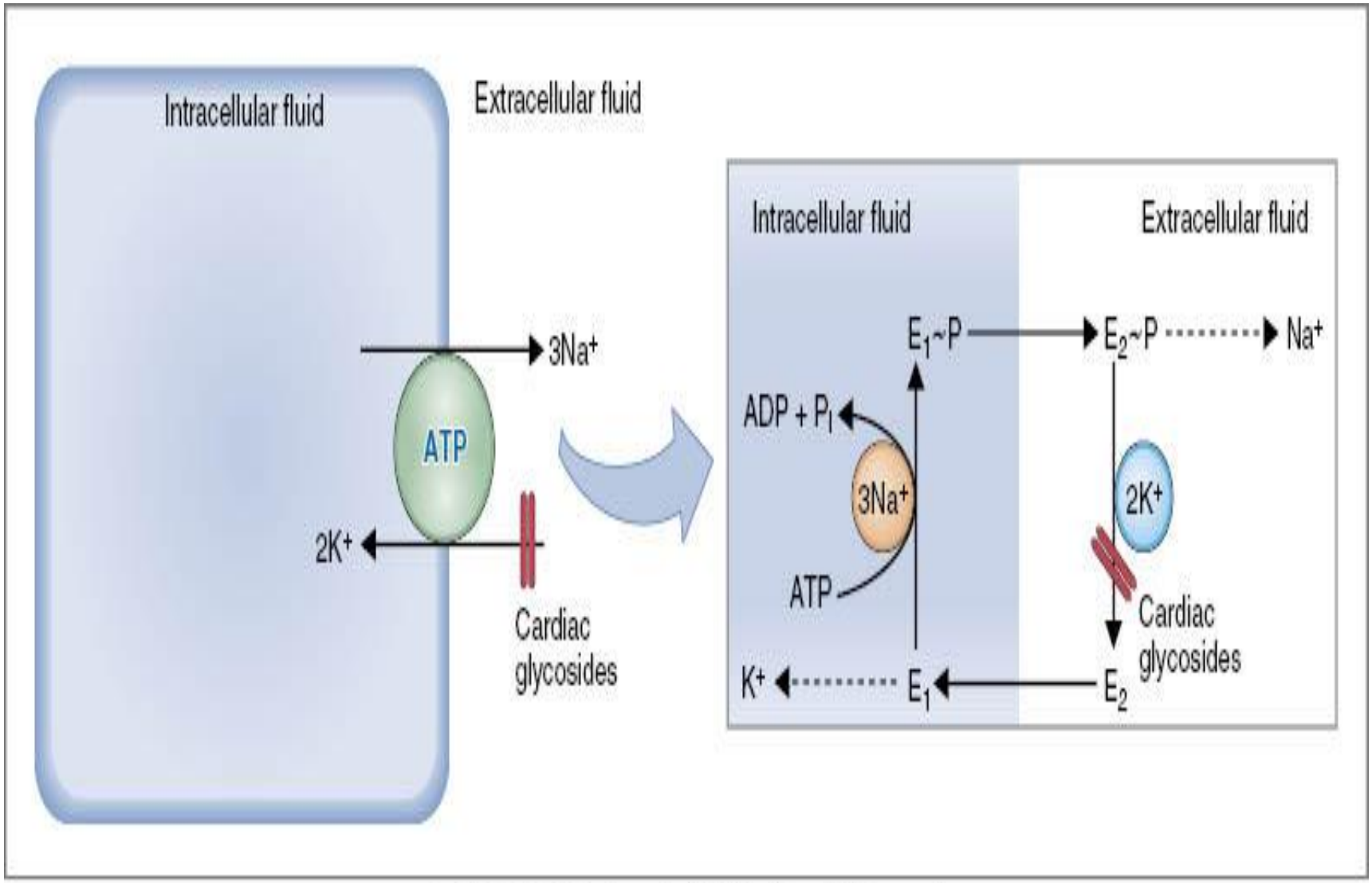
1- Primary Active Transport:

-Energy is supplied directly from ATP.

ATP ⟶ ADP +P+ energy.

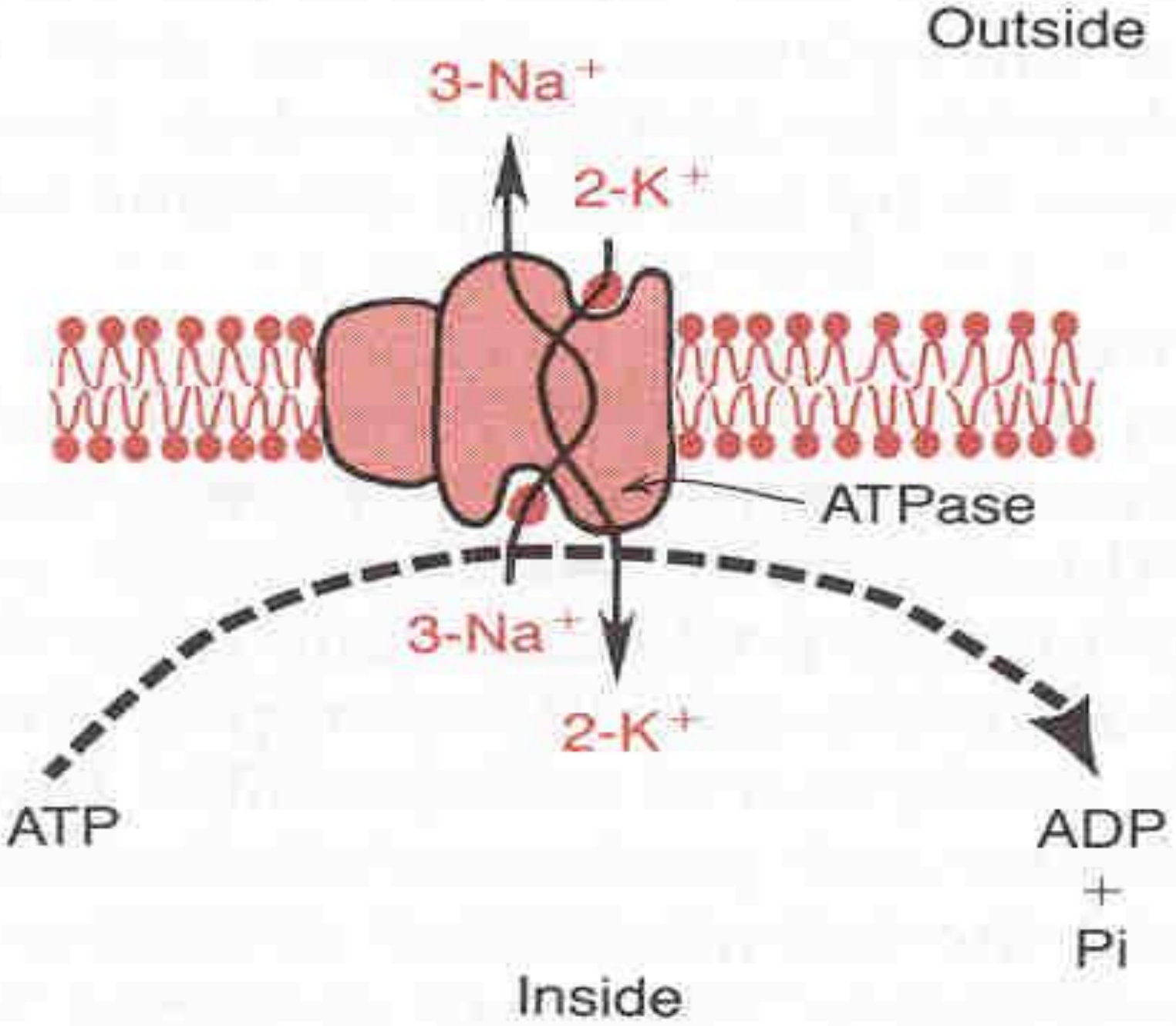
A. - **Sodium-Potassium pump (Na-K pump).**

- its present in all cell membranes.
- Na in ⟶ out.
- K out ⟶ in.



Characteristic Of The Pump:

1. Carrier protein is formed from α and β subunits.
2. Binding site for Na inside the cell.
3. Binding site for K outside the cell.
4. It has ATPase activity.
5. 3 Na out.
6. 2 K in.


Outside
3-Na+
2-K+
ATPase
3-Na+
2-K+
ATP
ADP
+
Pi
Inside

Function:

1. Maintaining Na and K concentration difference .
2. It’s the basis of nerve signal transmition .
3. Maintaining –Ve potential inside the cell.

- digitals

B. - **Primary active transport of calcium (Ca $^{2+}$ ATPase).**

- sarcoplasmic reticulum (SR).
- mitochondria.
- in some cell membranes.

Function:

Maintaining a low Ca^{2+} concentration inside the cell.

- **C. - Primary active transport of hydrogen lons H+-K ATPase.**

  - stomach.
  - kidneys.
  - pump to the lumen.
  - H+-K ATPase inhibitors (treat ulcer disease). (omeprazol)

2) Secondary Active Transport:

- **Co- transport and countertransport:**

  is transport of one or more solutes against an electrochemical gradient ,coupled to the transport of another solute down an electrochemical gradient .

- "downhill" solute is Na.
- Energy is supplied indirectly form primary transport.

- **Co transport:**

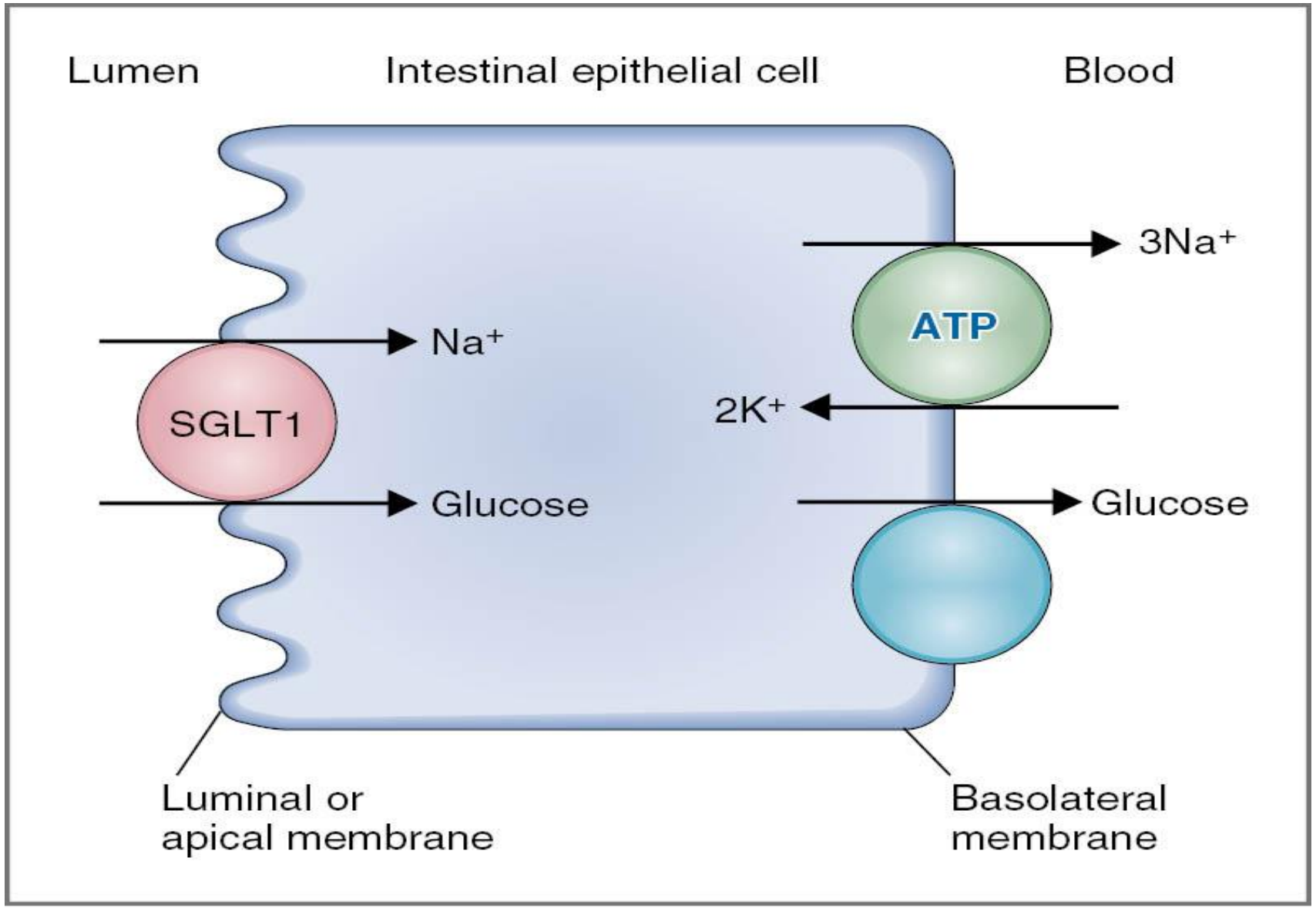
  - All solutes move in the same direction

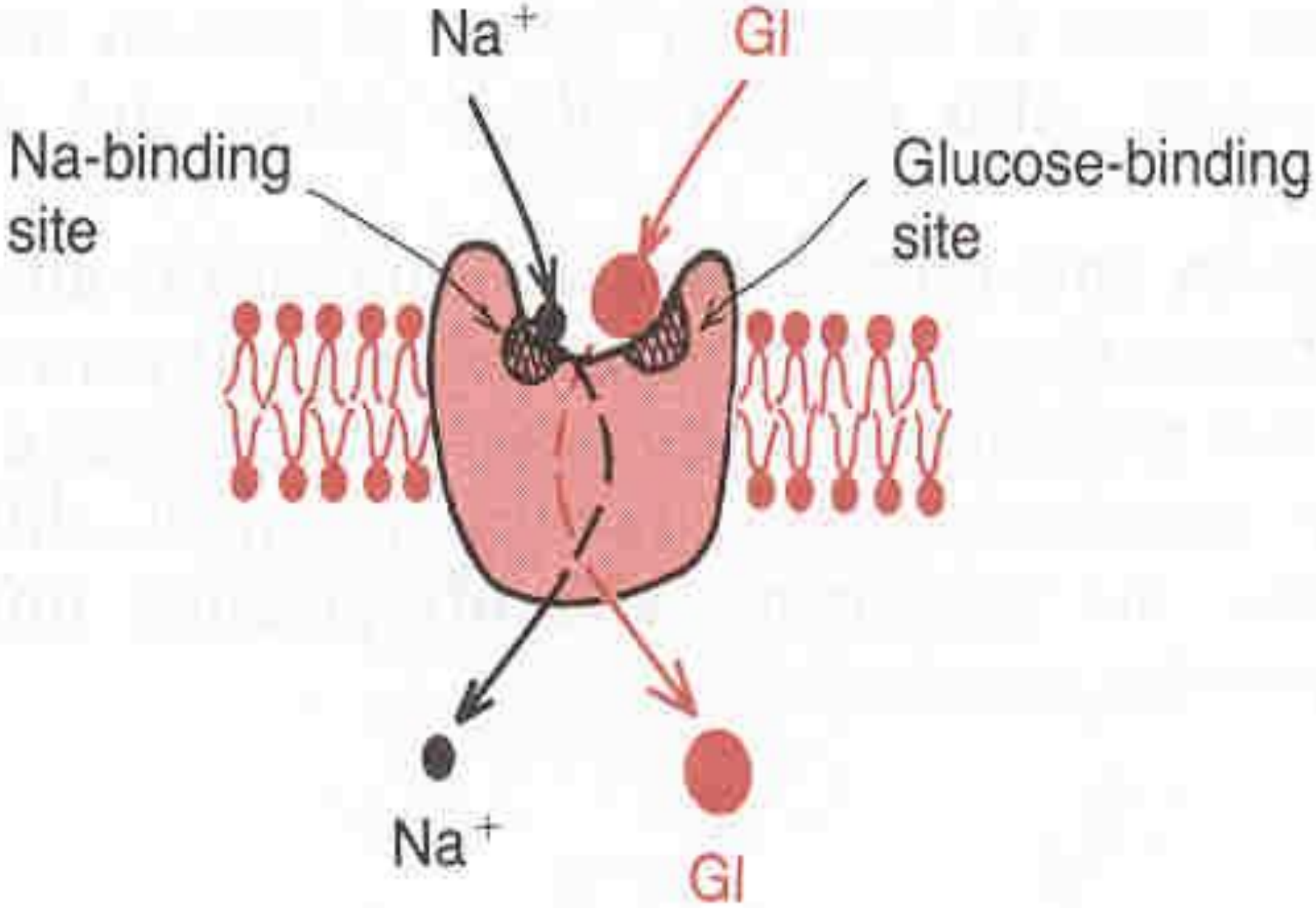
    " inside cell".

  - e.g. - Na - glucose Co transport.

    - Na – amino acid Co transport.

    - in the intestinal tract kidney.



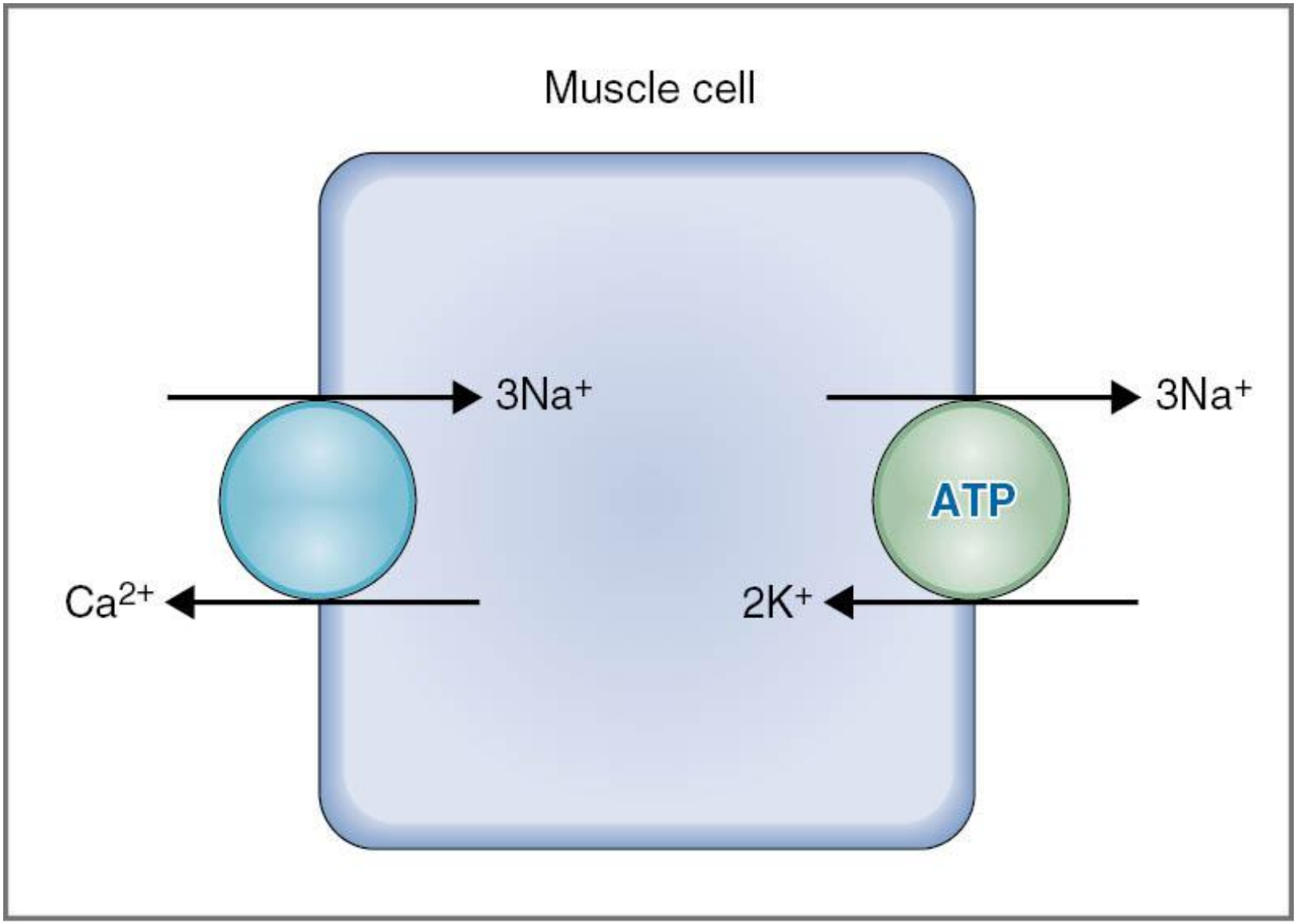

Na+
Gl
Na-binding site
Glucose-binding site
Na+
Gl

- **Countertransport:**
- Na is moving to the interior causing other substance to move out.

- Ca^{2+} - Na^{+} exchange.

  (present in many cell membranes)

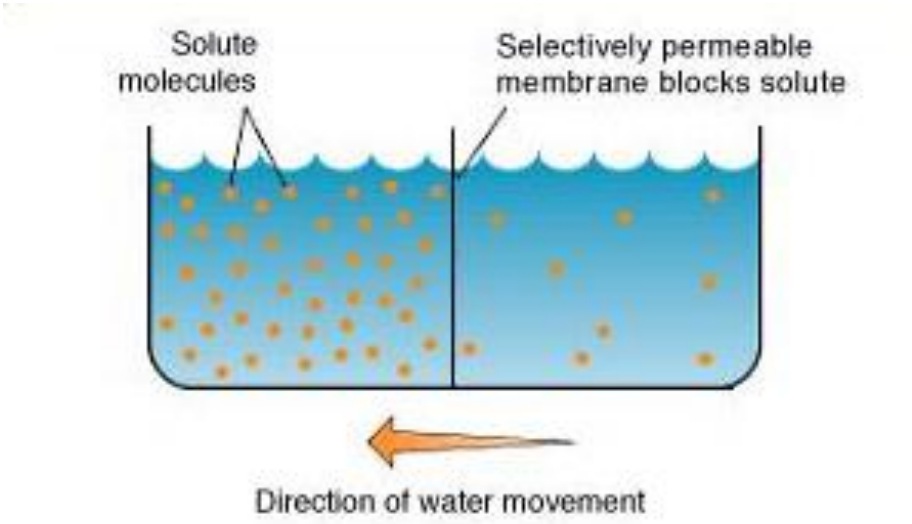
- Na –H^{+} exchange in the kidney.

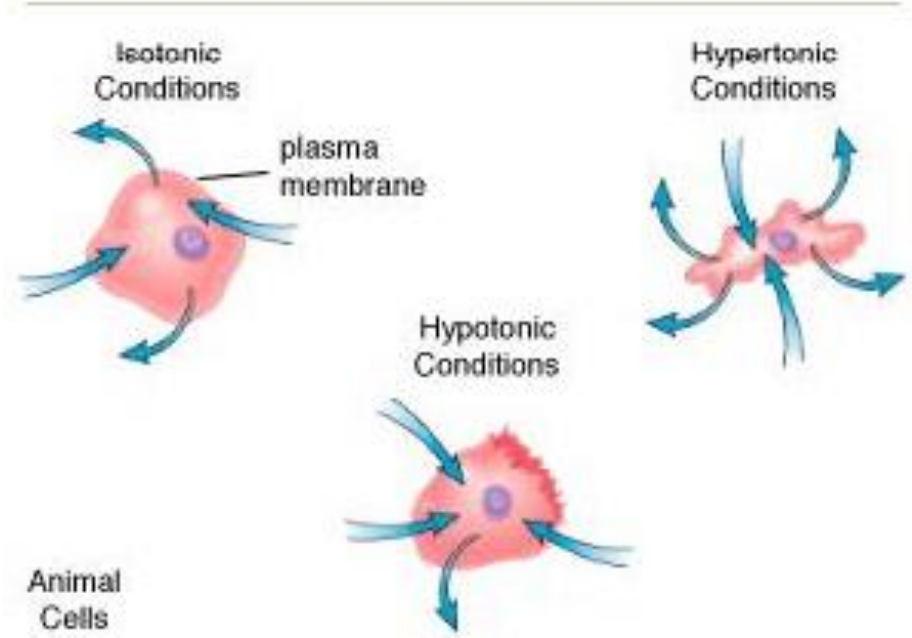


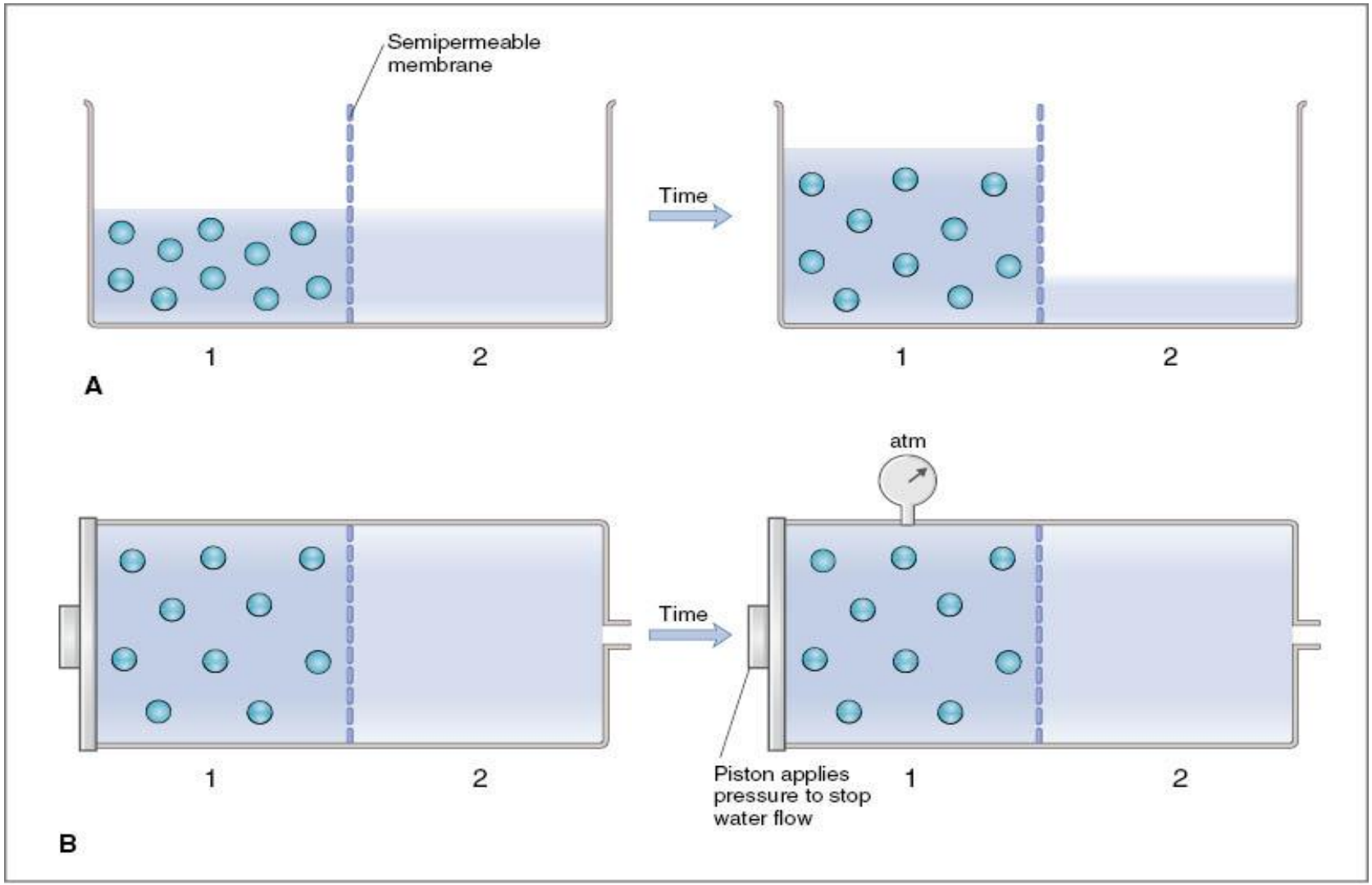
osmosis

- **net diffusion of water from a region of high water concentration to region of low water concentration.**

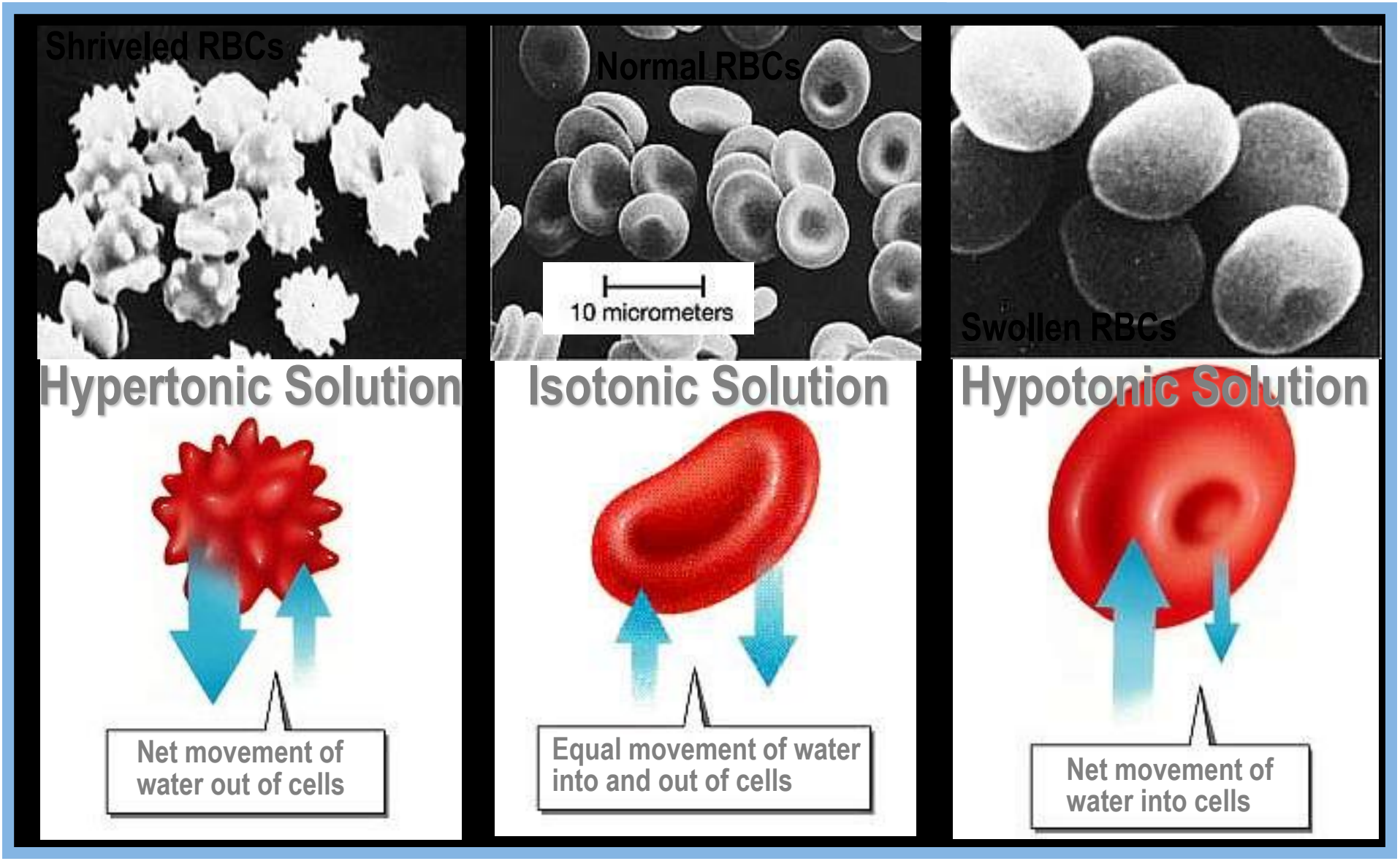
Osmosis

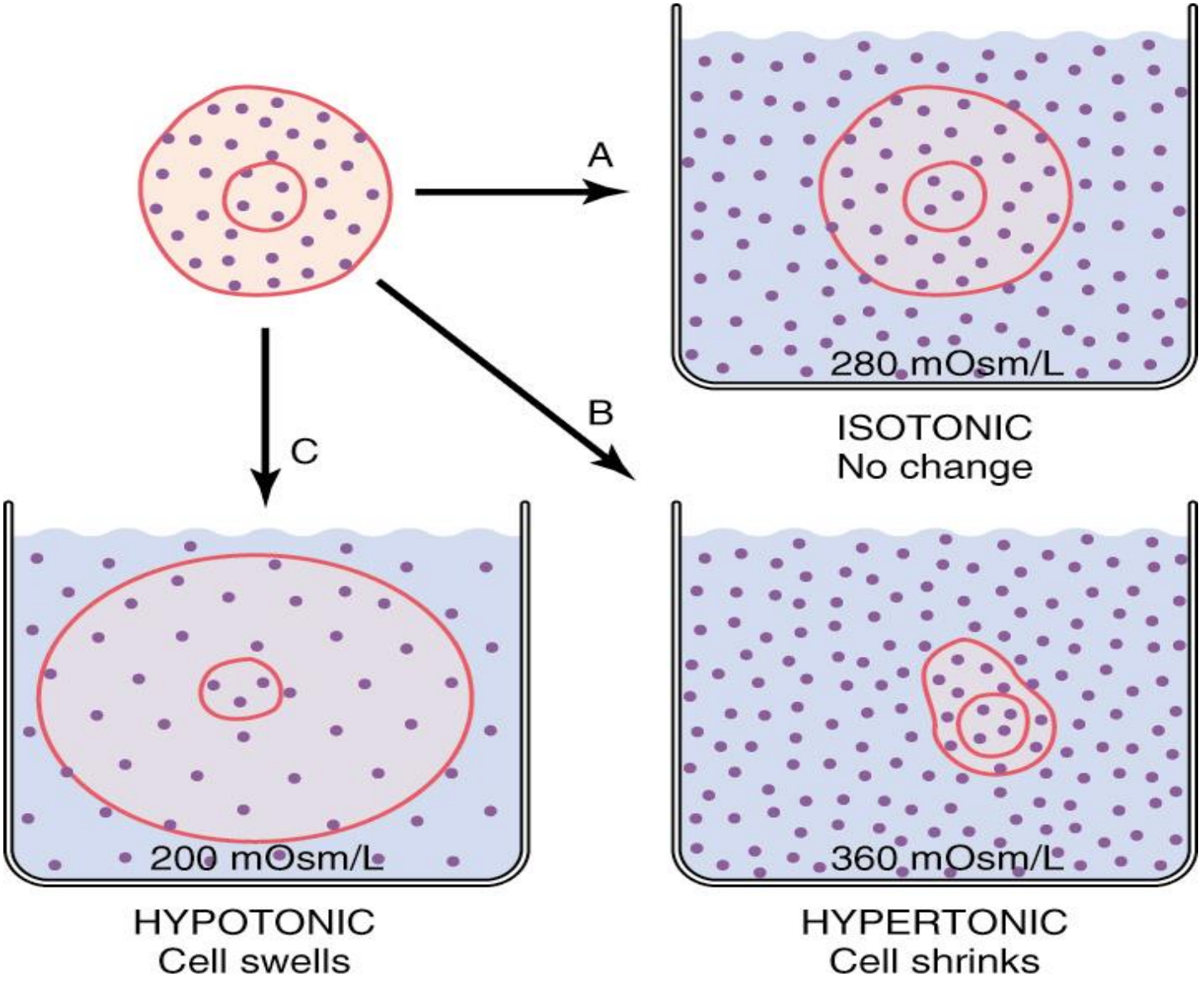

Solute molecules
Selectively permeable membrane blocks solute
Direction of water movement

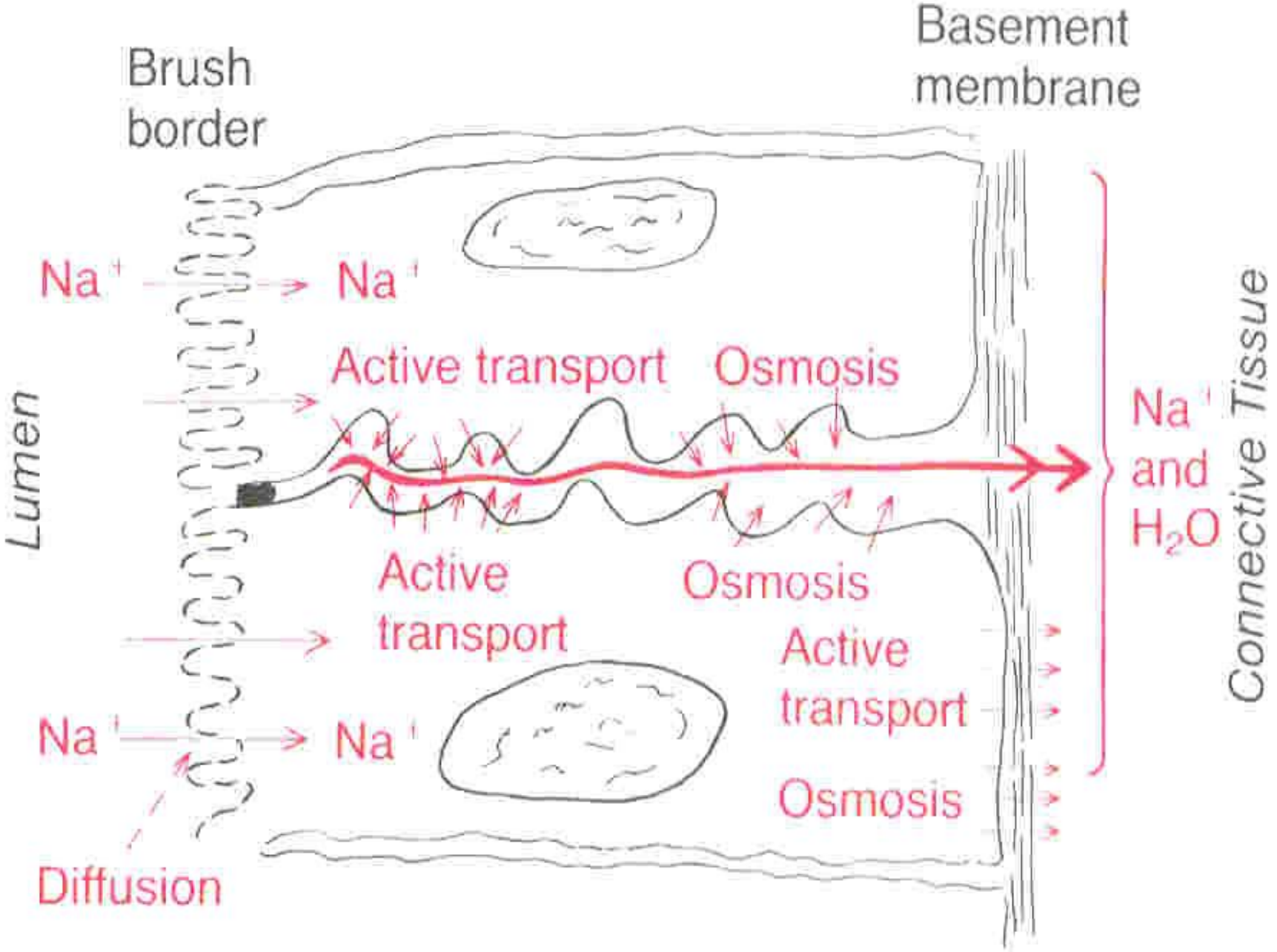

Isotonic Conditions
plasma membrane
Hypertonic Conditions
Hypotonic Conditions
Animal Cells



Osmosis


Shriveled RBCs
Normal RBCs
10 micrometers
Swollen RBCs
Hypertonic Solution
Net movement of water out of cells
Isotonic Solution
Equal movement of water into and out of cells
Hypotonic Solution
Net movement of water into cells


A
B
C
280 mOsm/L
ISOTONIC
No change
200 mOsm/L
HYPOTONIC
Cell swells
360 mOsm/L
HYPERTONIC
Cell shrinks


Brush border
Basement membrane
Lumen
Connective Tissue
Na+
Na+
Active transport
Osmosis
Na+ and H2O
Active transport
Osmosis
Active transport
Osmosis
Na+
Na+
Diffusion

Thank you