

Passive Transport

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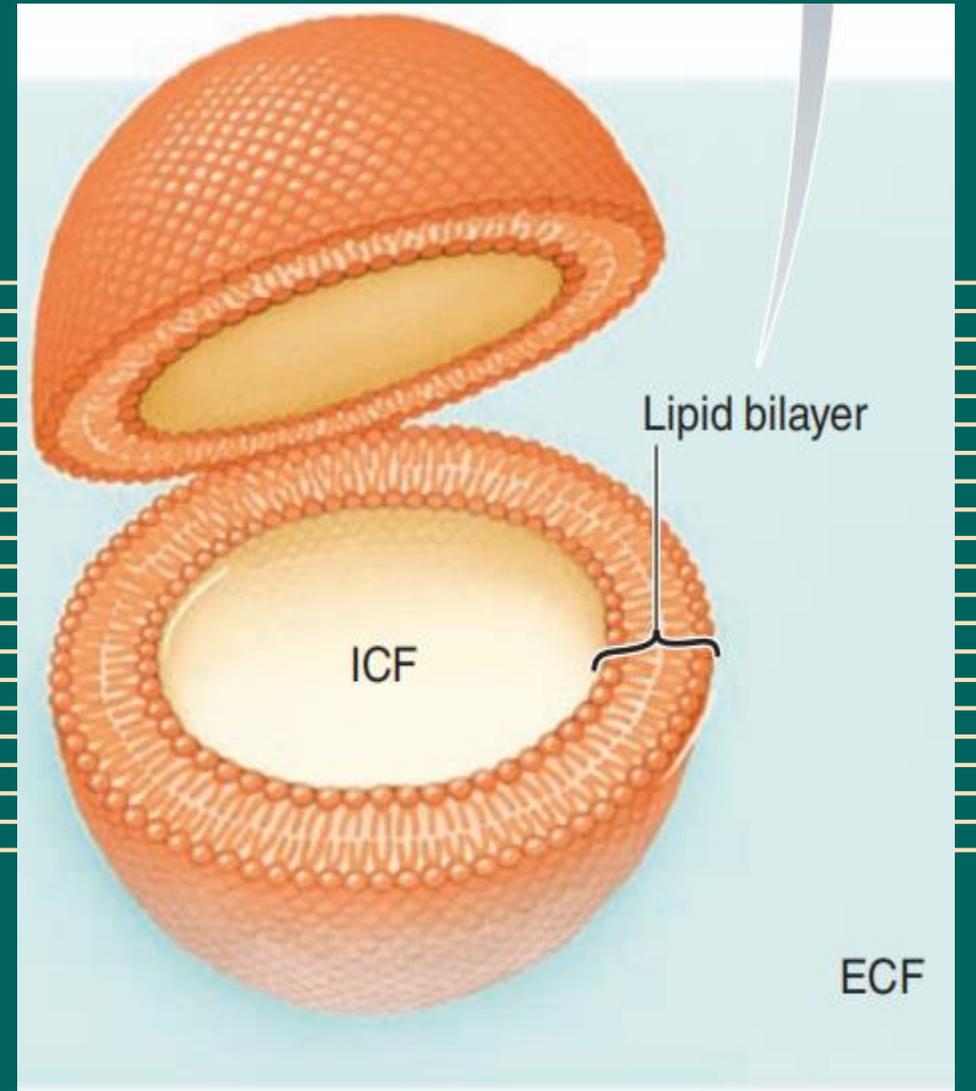
Contents

- Membrane Structure and Functions
- Basic Principles of Membrane Permeability
- Diffusion and Osmosis

Membrane Structure and Functions

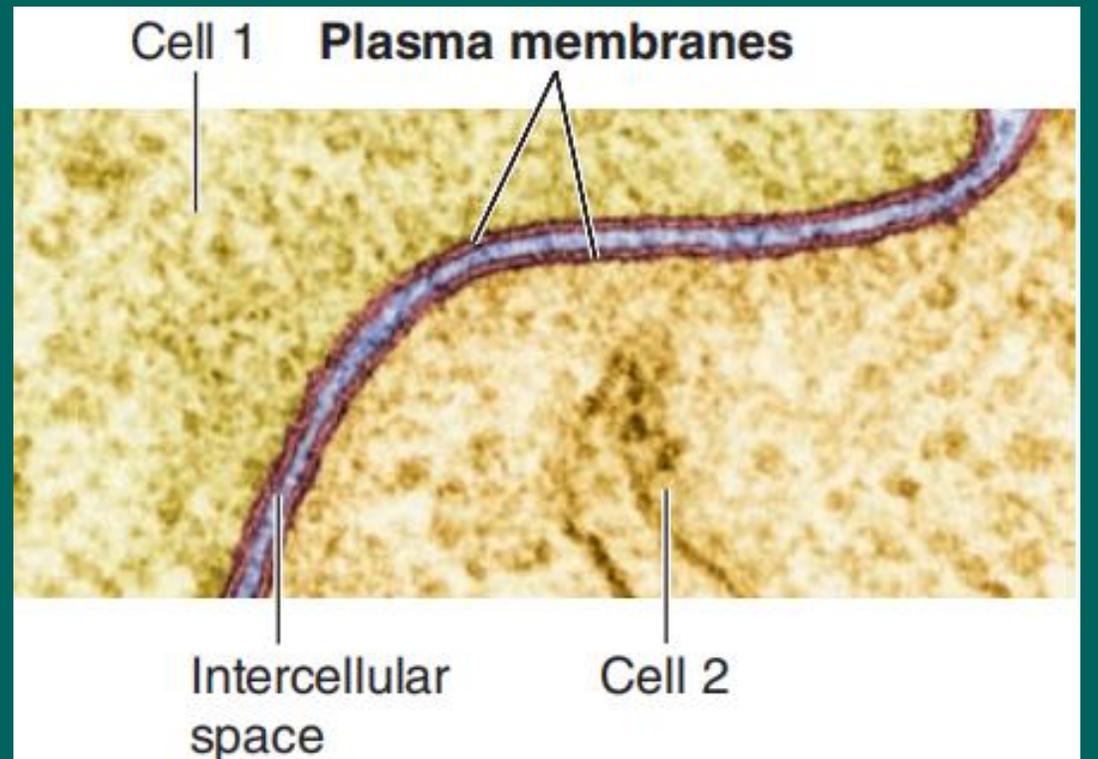
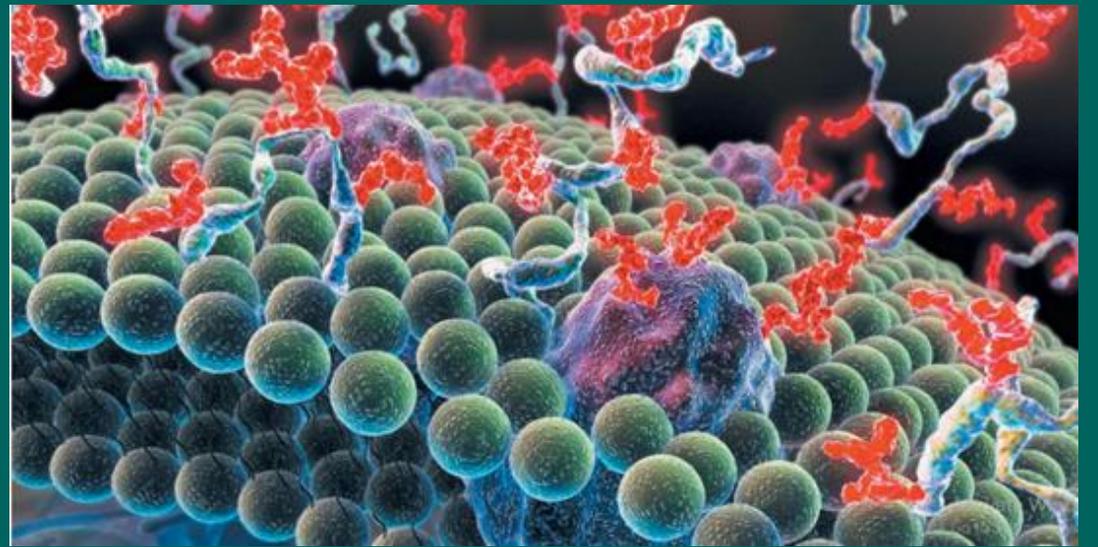
The plasma membrane

- ✓ It is a **thin outer boundary** that encloses all intracellular contents.
- ✓ It maintains a **distinct intracellular composition** despite the very different extracellular fluid (ECF).
- ✓ Functions as a **selectively permeable membrane**:
 - Controls entry of nutrients.
 - Regulates exit of wastes and secretory products.



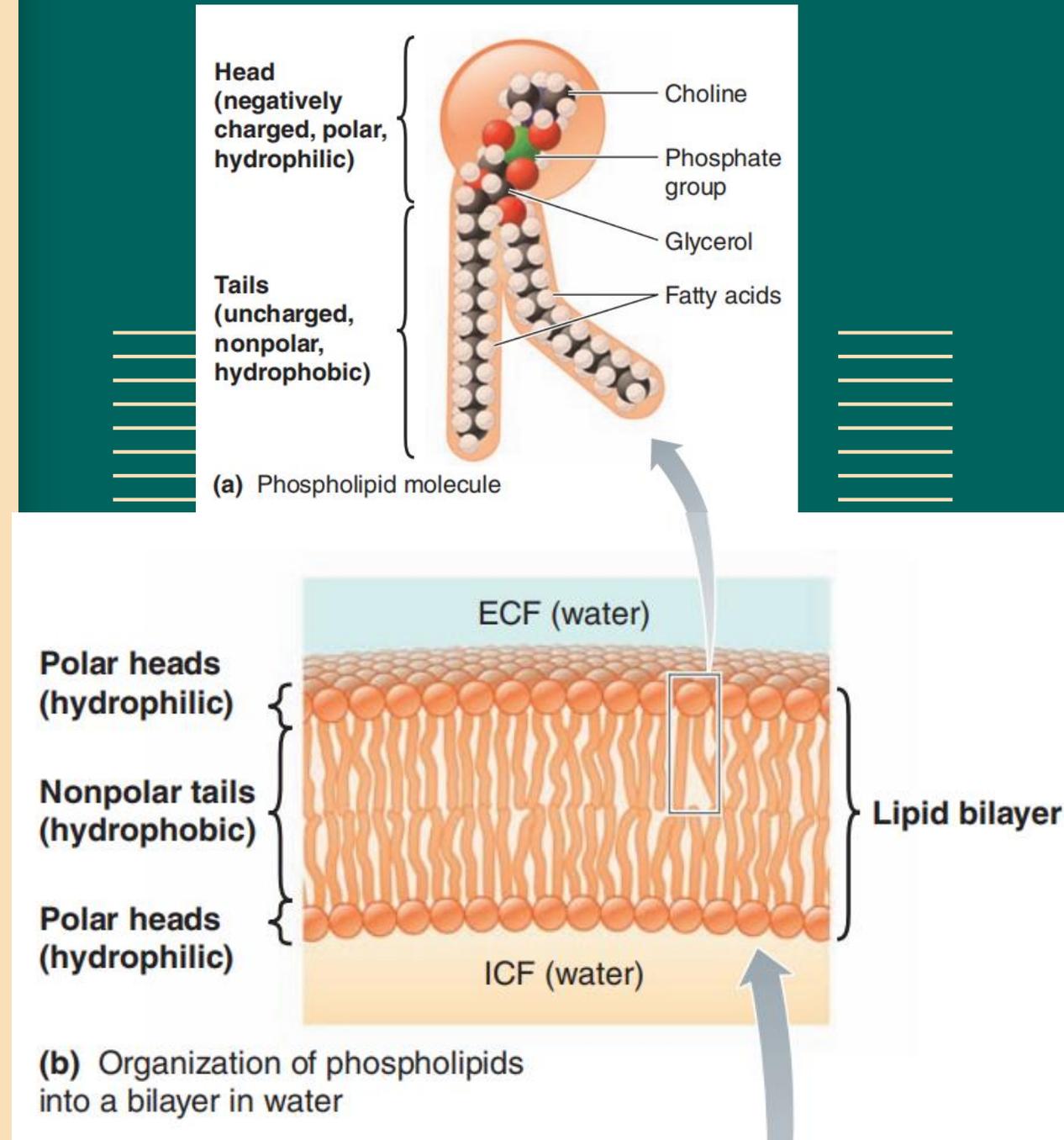
The plasma membrane

- ✓ The plasma membrane follows the fluid mosaic model:
 - Fluid lipid bilayer.
 - Proteins embedded within it.
- ✓ Main components:
 - Phospholipids (most abundant)
 - Cholesterol
 - Proteins
 - Small amounts of carbohydrates



The plasma membrane

- ✓ Lipid bilayer composed mainly of **phospholipids**:
 - Hydrophilic (polar) heads
 - Hydrophobic (nonpolar) fatty acid tails
- ✓ Self-assemble into a bilayer in aqueous environments.
- ✓ Outer surface faces ECF
- ✓ Inner surface faces ICF
- ✓ **Forms the primary diffusion barrier.**



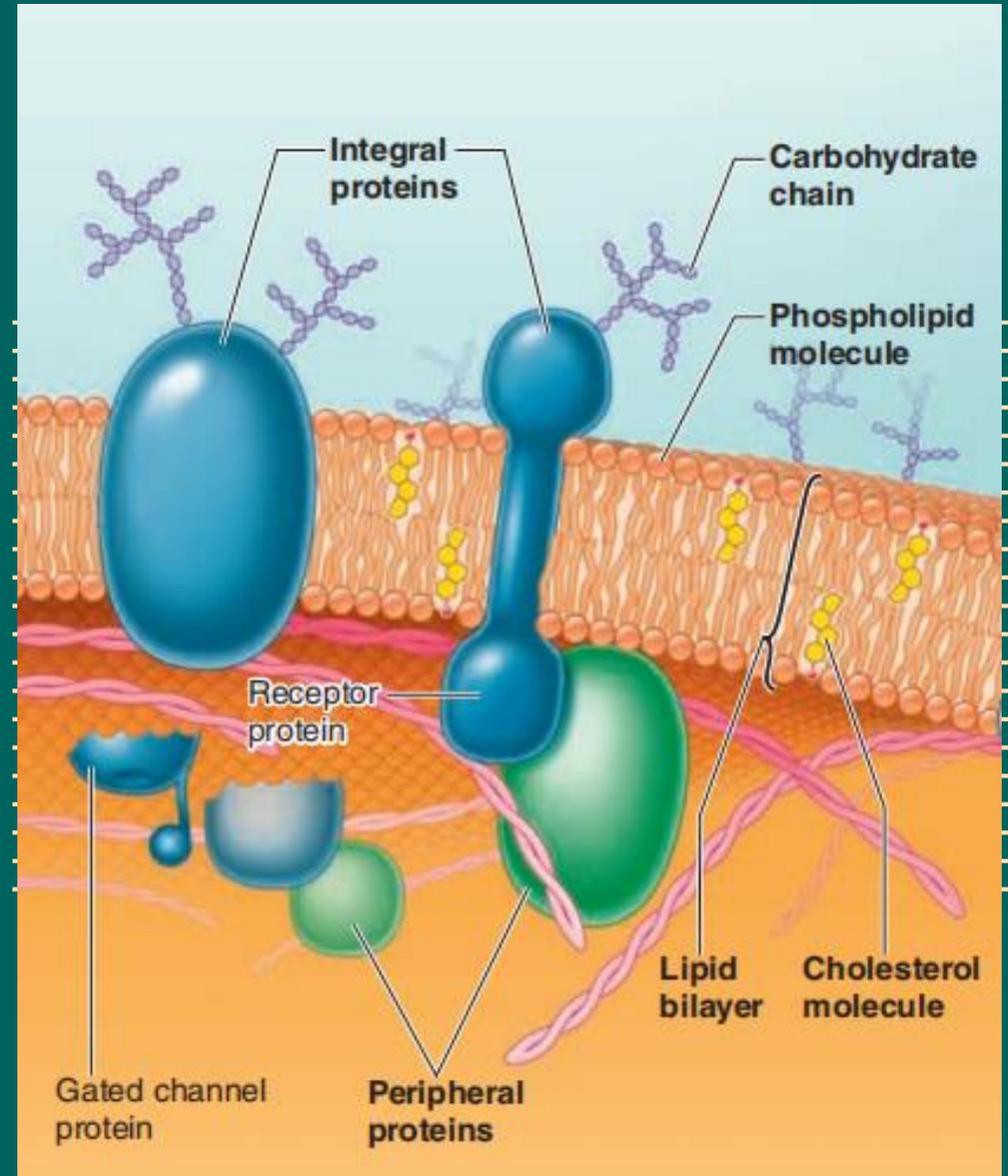
The plasma membrane

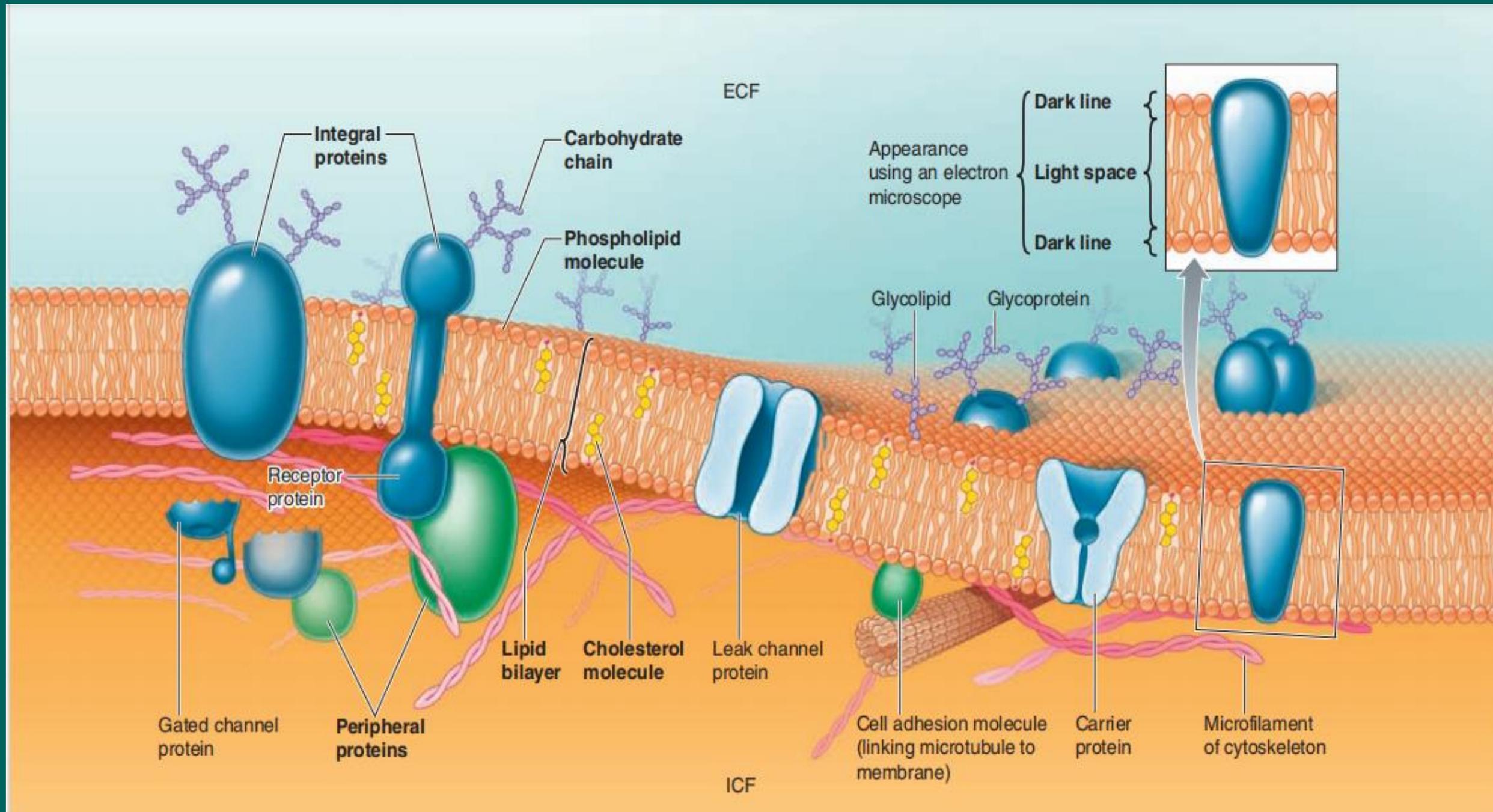
✓ Membrane Proteins

✓ Two major types:

1. Integral (transmembrane) proteins
2. Peripheral proteins

- Proteins: Account for ~50% of membrane mass.
- Perform most **specialized** membrane functions.
- Float within lipid bilayer → “**mosaic**” pattern.





The plasma membrane

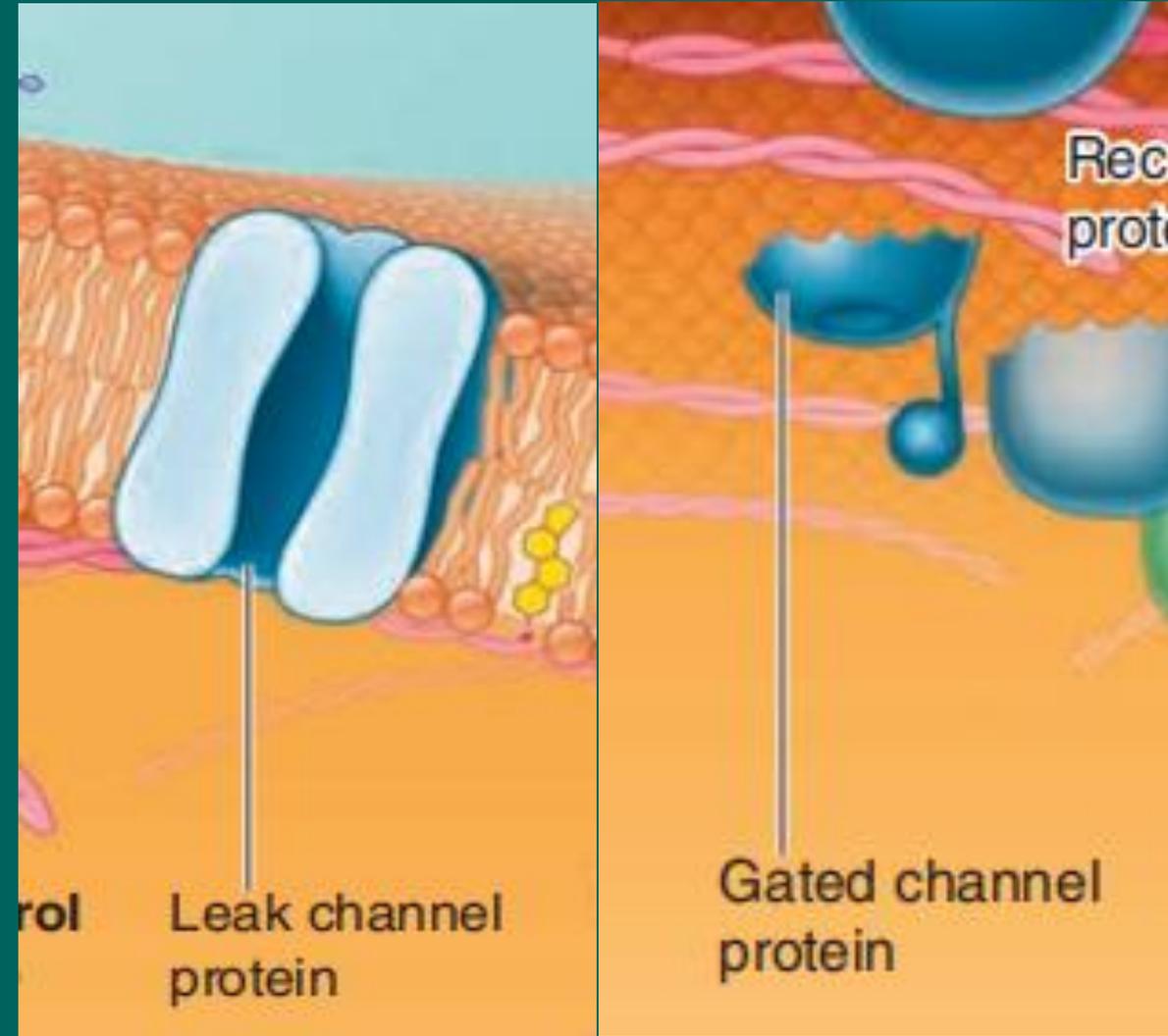
✓ Membrane **proteins** perform most of the **specific and functional activities of the plasma membrane.**

1. Channel Proteins:

- ✓ Form water-filled pores through the lipid bilayer
- ✓ Allow passage of small ions (≤ 0.8 nm)
- ✓ Given channels are **highly selective**:
- ✓ Na^+ channels \rightarrow sodium only
- ✓ K^+ channels \rightarrow potassium only

□ **Two types:**

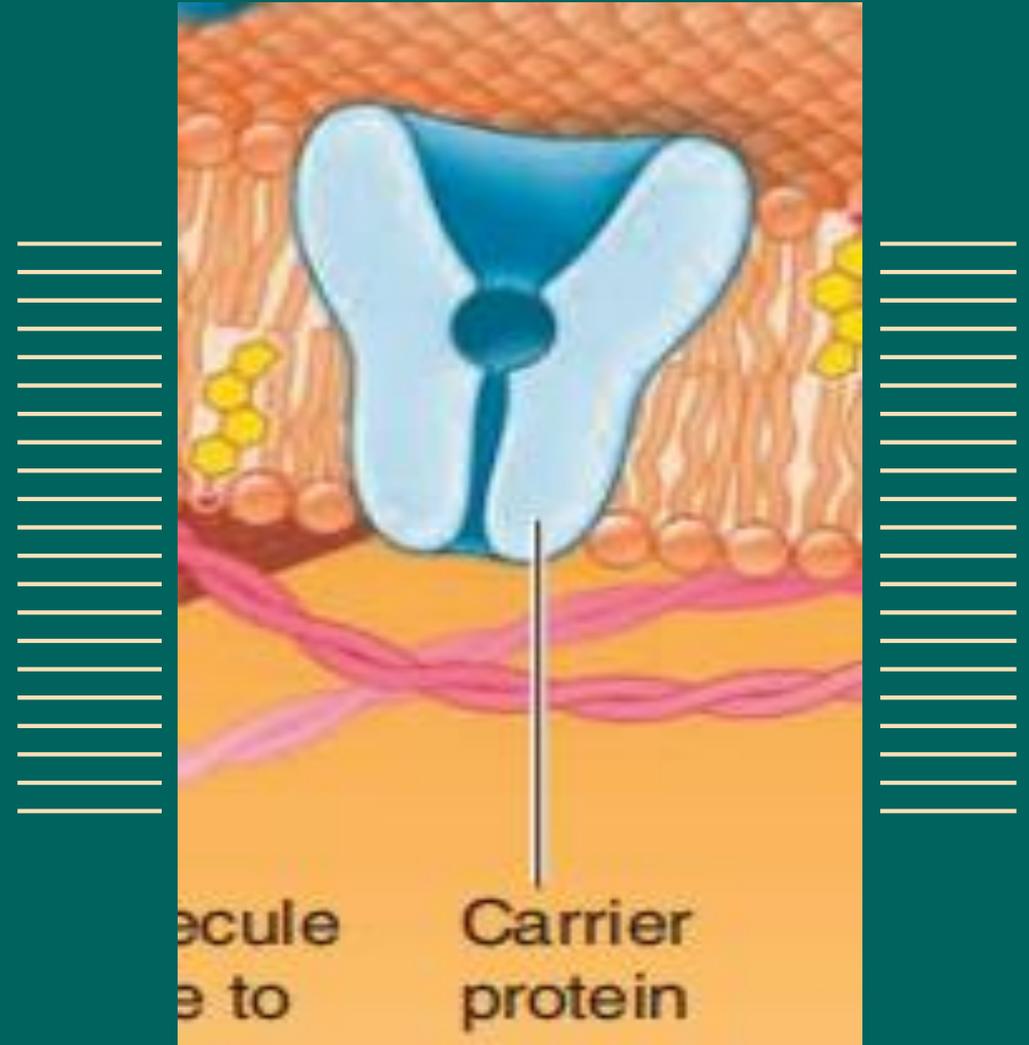
1. Leak channels (always open)
2. Gated channels (open/close via stimuli)



The plasma membrane

2. Carrier (Transport) Proteins

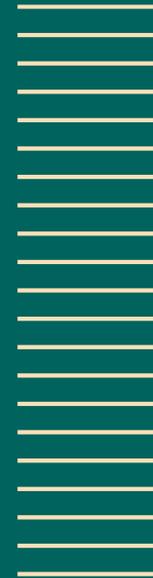
- ✓ Transport **specific molecules** across membrane.
- ✓ Highly selective (lock-and-key specificity).
- ✓ **Cell-type dependent**
- ✓ Example:
 - ✓ **Thyroid cells** have iodine carriers
 - ✓ Other cells do not



Basic Principles of Membrane Permeability

Basic Principles of Membrane Permeability

- ✓ Substances must cross the membrane to move between ICF and ECF.
- ✓ A membrane is:
 1. Permeable → substance can cross.
 2. Impermeable → substance cannot cross.
- ✓ The plasma membrane is **selectively permeable**.

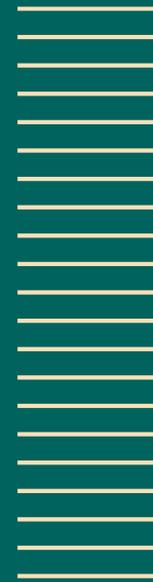


Determinants of Unassisted Membrane Permeability

- ✓ Two main factors determine if a substance can cross without assistance:

A. Lipid Solubility

- ✓ Highly lipid-soluble substances diffuse easily through the lipid bilayer.
- ✓ Examples: O_2 , CO_2 , Fatty acids
- ✓ Ions and polar molecules have low lipid solubility → cannot cross directly.



Determinants of Unassisted Membrane Permeability

✓ Two main factors determine if a substance can cross without assistance:

A. Lipid Solubility

B. Particle Size

✓ Small water-soluble molecules (< 0.8 nm) may pass through specific protein channels.

✓ Larger molecules (e.g., glucose, proteins) require assisted transport.



Types of Transport Forces

1. Passive Transport:

- ✓ **No** ATP required.
- ✓ Movement driven by:
 - ✓ **diffusion down a concentration gradient**
 - or
 - ✓ **movement along an electrical gradient.**

2. Active Transport:

- ✓ Requires **ATP**.
- ✓ Moves substances **against their gradient.**



Types of Transport Forces

□ Solutions:

1. Solvent
2. Solutes

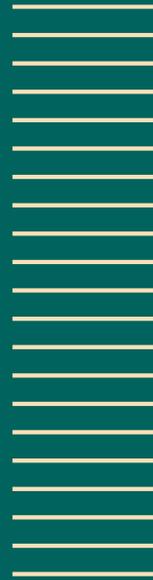
□ Concentration:



Diffusion

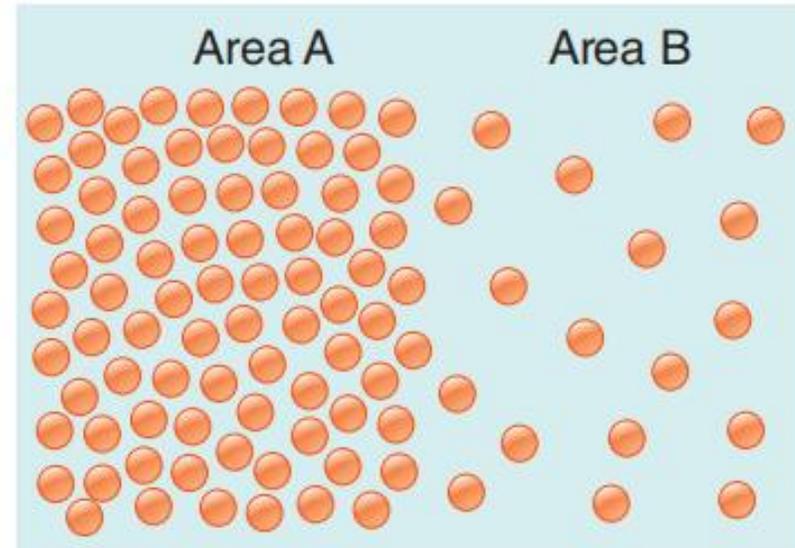
Diffusion

- ✓ **Diffusion: Movement of particles due to random molecular motion.**
 - ✓ **diffusion for short (diffusere means “to spread out”).**
1. Simple diffusion
 2. Facilitated diffusion



Simple diffusion

- ✓ The concentration of the solute in a solution differs between area A and area B.
- ✓ Such a difference in concentration between two adjacent areas is called a **concentration gradient (or chemical gradient)**.
- ✓ **Net movement** of molecules by diffusion is from the area of **higher concentration** to the area of **lower concentration**.

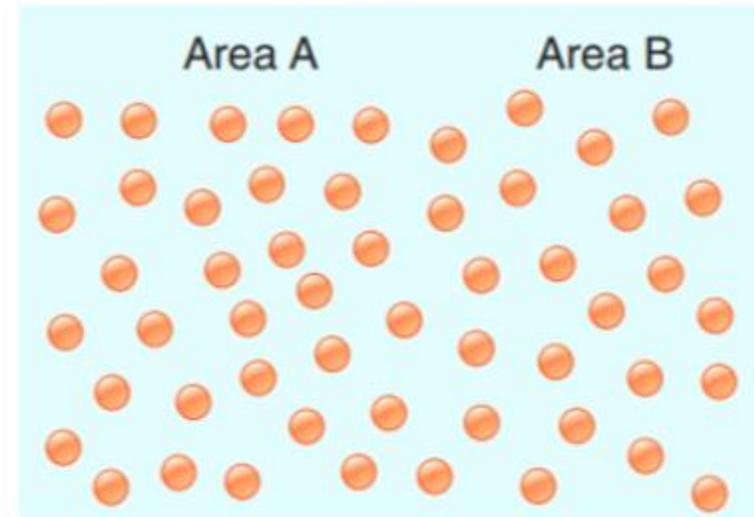
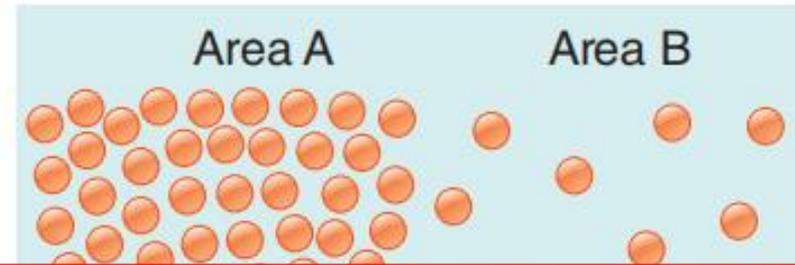


→ Diffusion from area A to area B
← Diffusion from area B to area A
→ Net diffusion

(a) Diffusion

Simple diffusion

- ✓ The **term net diffusion** refers to the difference between two opposing movements.
- ✓ **Dynamic equilibrium** (dynamic in reference to the continuous movement, equilibrium in reference to the **exact balance** between opposing forces).
- ✓ No net diffusion, but molecules continue moving.



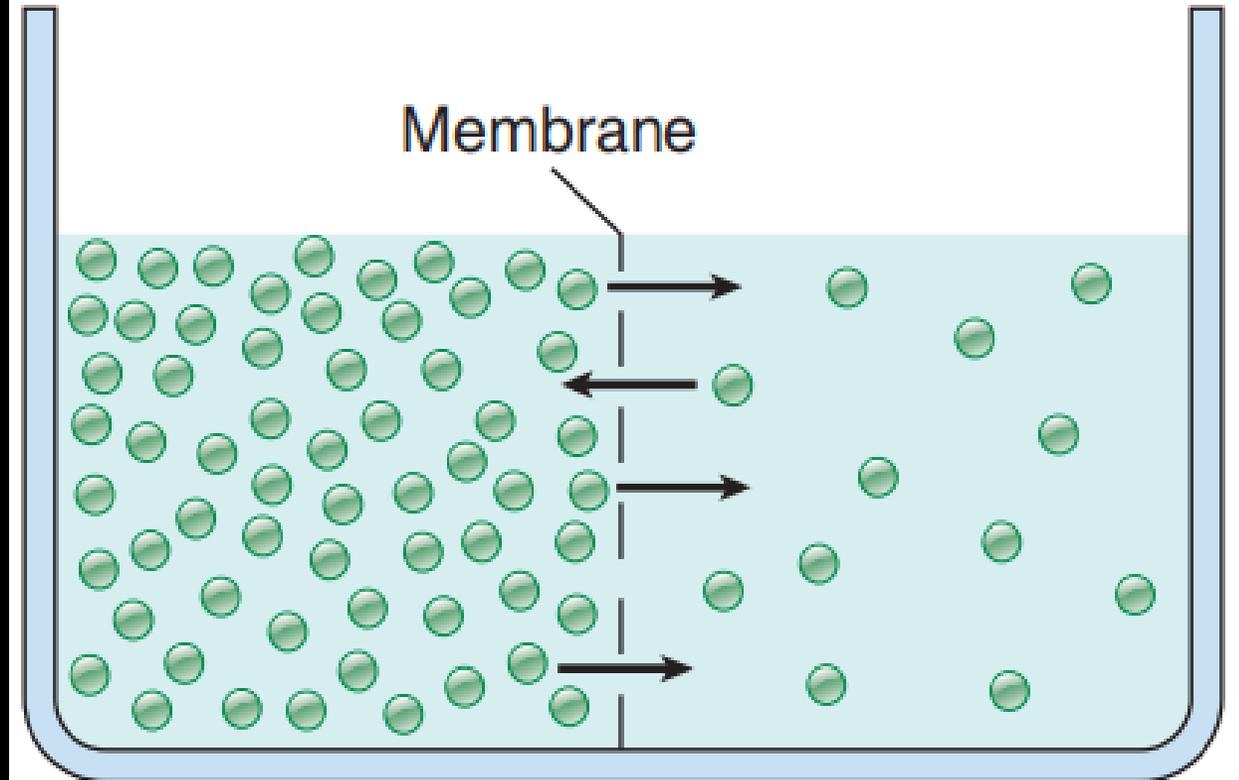
→ Diffusion from area A to area B
← Diffusion from area B to area A
No net diffusion

(b) Dynamic equilibrium

Simple diffusion

- ✓ What happens if a plasma membrane separates different concentrations of a substance?
- ✓ **Example:**
 - O_2 diffuses from lungs \rightarrow blood.

If a substance can permeate the membrane:

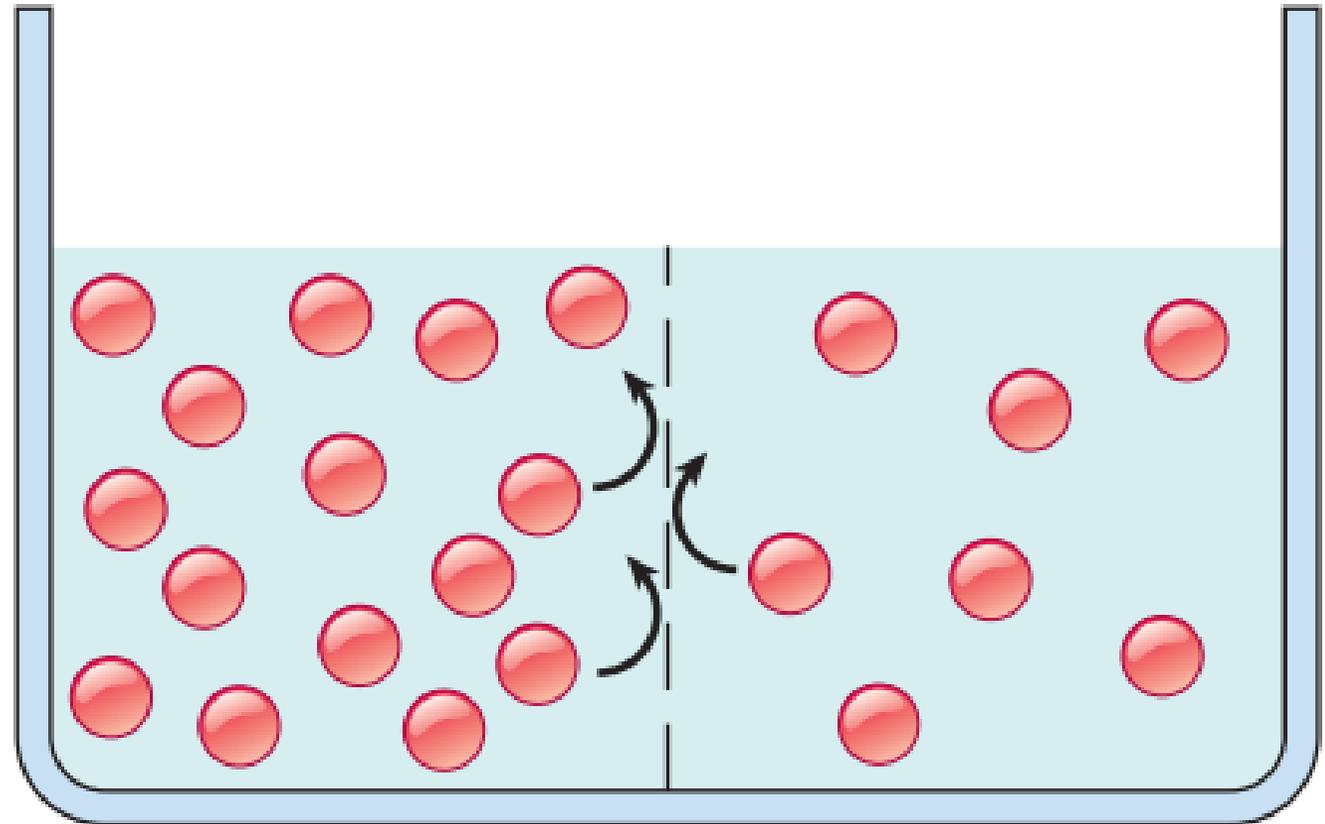


(a) Diffusion occurs

Simple diffusion

- ✓ What happens if a plasma membrane separates different concentrations of a substance?
- ✓ **Example:**
 - Intracellular proteins cannot diffuse out of cells.

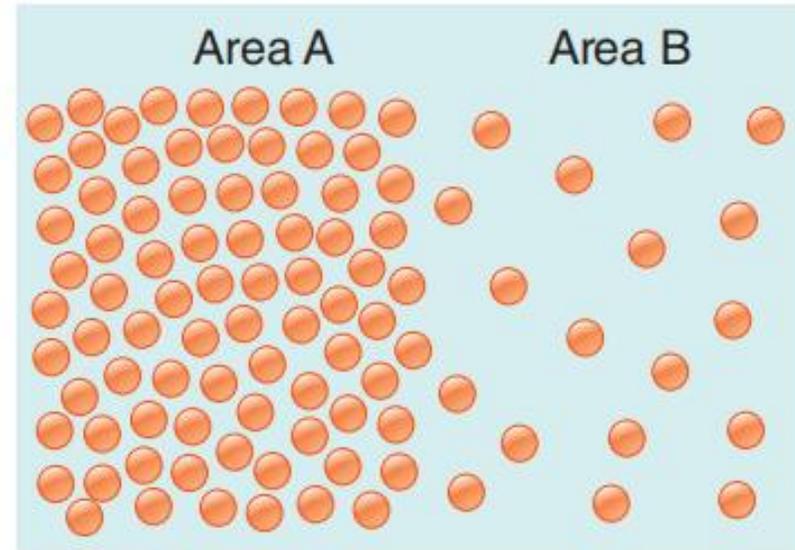
If the membrane is impermeable to a substance:



(b) No diffusion occurs

Simple diffusion

- ✓ **No energy is required** for this movement, so it is a **passive** means of membrane transport.



→ Diffusion from area A to area B
← Diffusion from area B to area A
→ Net diffusion

(a) Diffusion

Simple diffusion

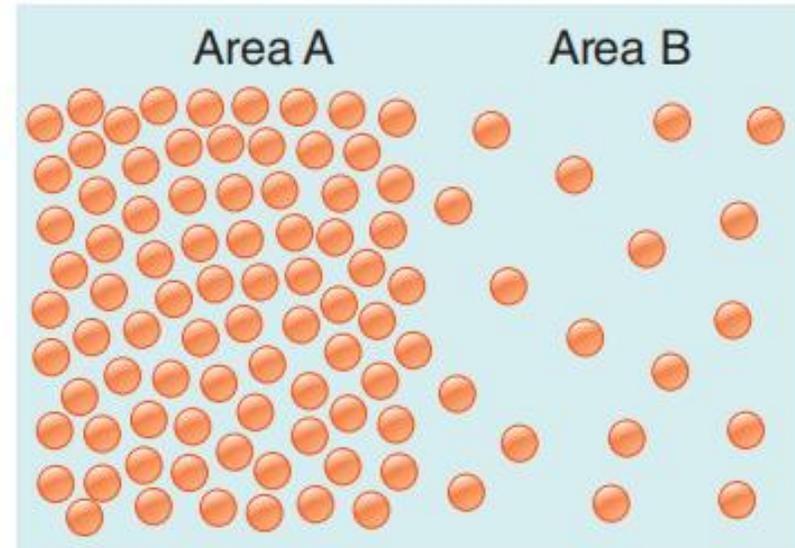
✓ Fick's Law of Diffusion (Determinants of Diffusion Rate):

□ Rate of diffusion increases with:

- ↑ Concentration gradient
- ↑ Membrane surface area
- ↑ Lipid solubility

□ Rate of diffusion decreases with:

- ↑ Molecular weight (MW)
- ↑ Membrane thickness



→ Diffusion from area A to area B

← Diffusion from area B to area A

→ Net diffusion

(a) Diffusion

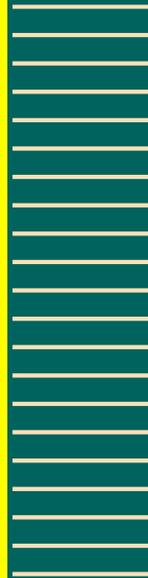
Simple diffusion

- ❖ Electrical Gradient and Ion Movement
- ❖ Ions are influenced by:
 - ❖ **Concentration (chemical) gradient**
 - ❖ **Electrical gradient**
- ❖ Electrical gradient = difference in charge between two areas.
- ❖ Cations (+) move toward negative areas.
- ❖ Anions (-) move toward positive areas.
- ❖ Movement along an electrical gradient is:
Passive
- ❖ Does not require ATP
- ❖ **Only** possible if the membrane is permeable to that ion.



Simple diffusion

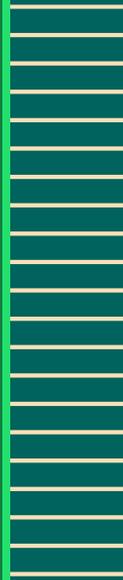
- ❖ Electrical Gradient and Ion Movement
- ❖ Both an electrical and a concentration (chemical) gradient may be acting on a **particular ion** at the **same time**.
- ❖ The net effect of simultaneous electrical and concentration gradients on this ion is called an **electrochemical gradient**.



Osmosis

Osmosis

- ❖ Osmosis = net diffusion of water down its own concentration gradient.
- ❖ Water moves: From high water concentration to low water concentration (i.e., toward higher solute concentration).
- ❖ Occurs across a selectively permeable membrane.



Osmosis

❖ Water Permeability:

• Water crosses membranes by:

1. Direct diffusion (slow)

2. **Aquaporins** (rapid, specialized water channels)

❖ Different cells vary in aquaporin density → variable water permeability.



Osmosis

- ❖ Relationship Between Solute & Water Concentration:
- ❖ Adding solute:
 - ❖ ↓ Water concentration
 - ❖ ↑ Solute concentration
- ❖ Water always diffuses toward:
 - Area of higher nonpenetrating solute concentration.

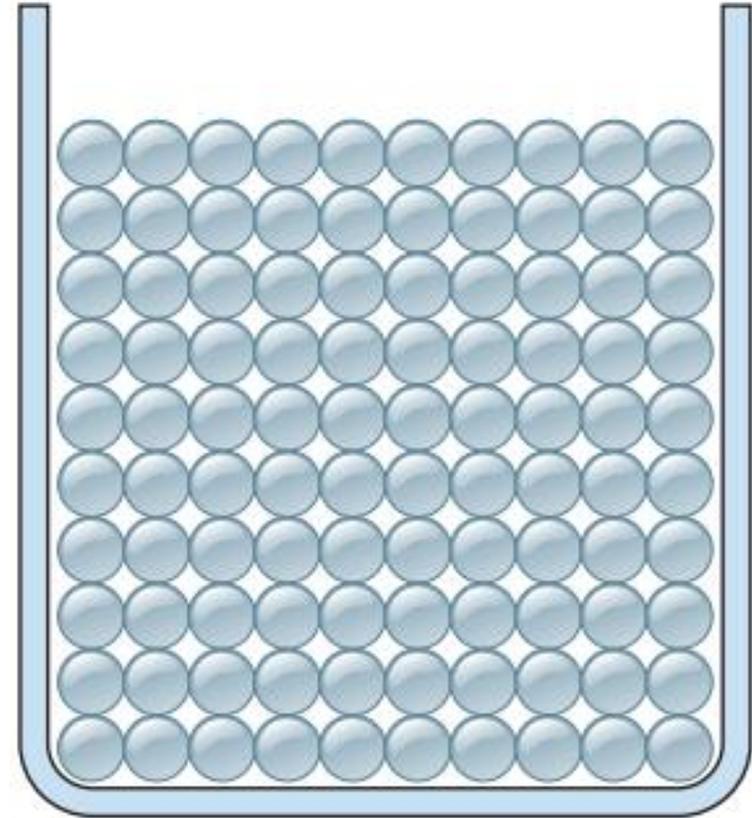
KEY



= Water molecule



= Solute molecule



100% water concentration
0% solute concentration

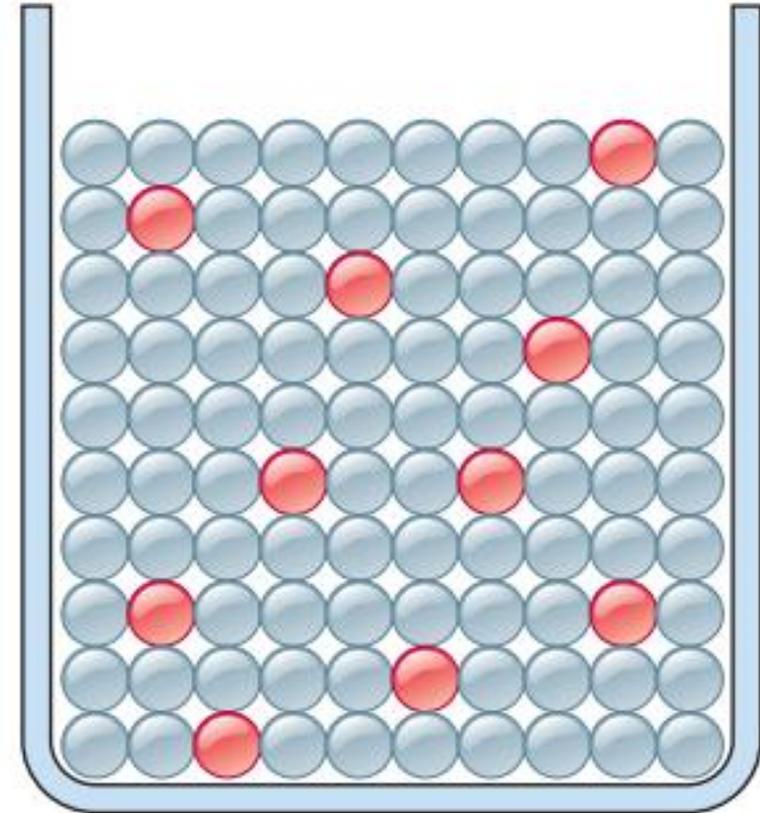
(a) Pure water

Osmosis

- ❖ Relationship Between Solute & Water Concentration:
- ❖ Adding solute:
- ❖ ↓ Water concentration
- ❖ ↑ Solute concentration

KEY

● = Water molecule ● = Solute molecule

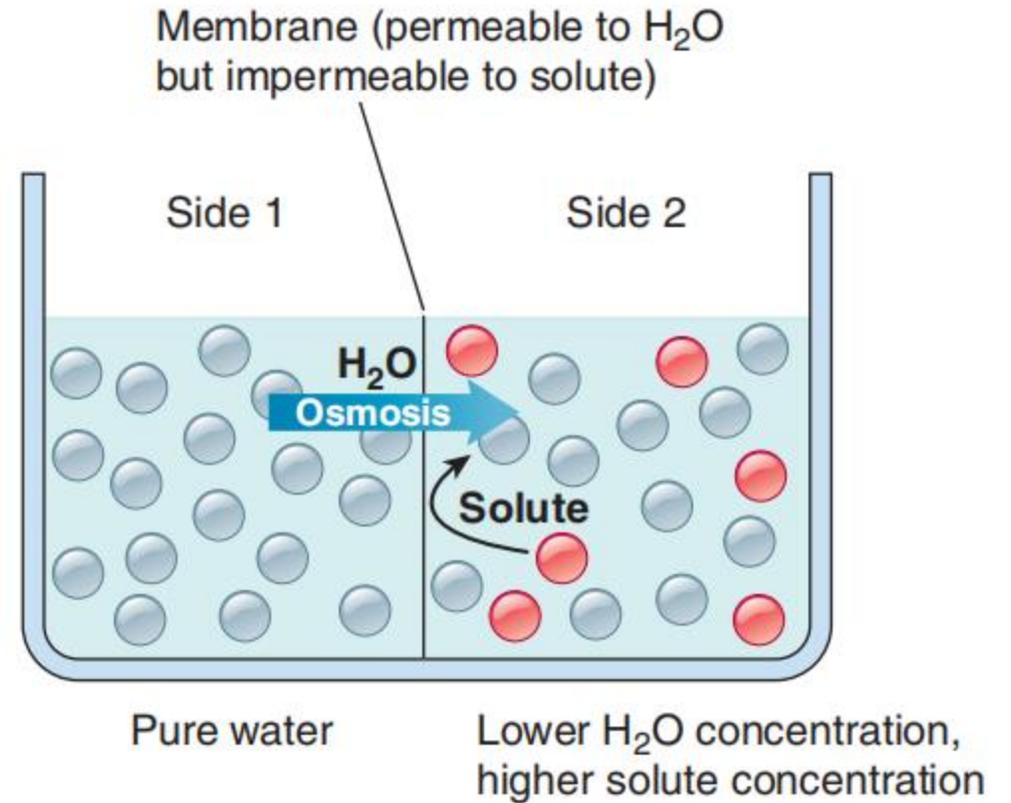


90% water concentration
10% solute concentration

(b) Solution

Osmosis

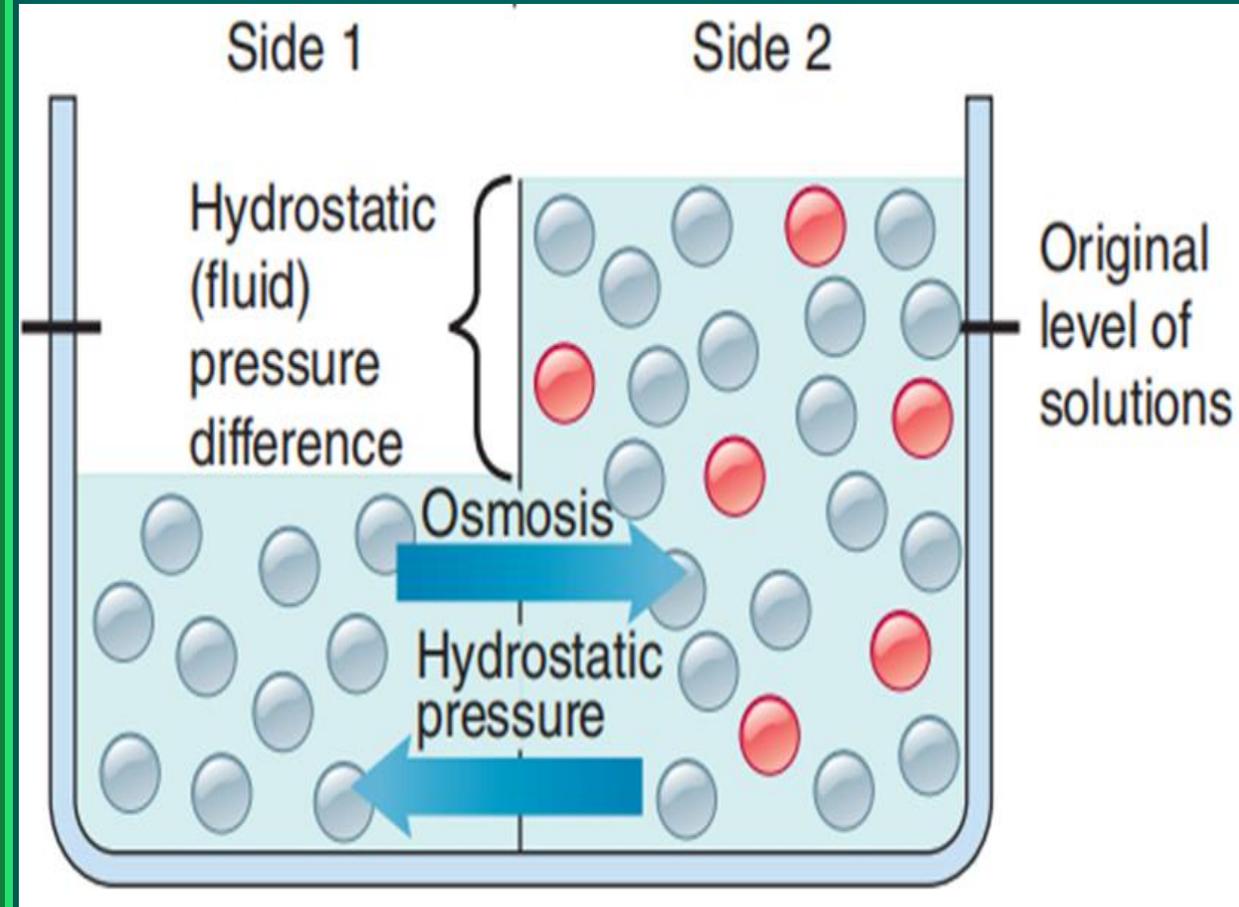
- ❖ This net diffusion of water down its concentration gradient through a selectively permeable membrane is known as **osmosis**.
- Because solutions are always referred to in terms of concentration of solute, water moves by osmosis to the area of **higher solute concentration**.



H₂O moves from side 1 to side 2
down its concentration gradient = osmosis

Osmosis

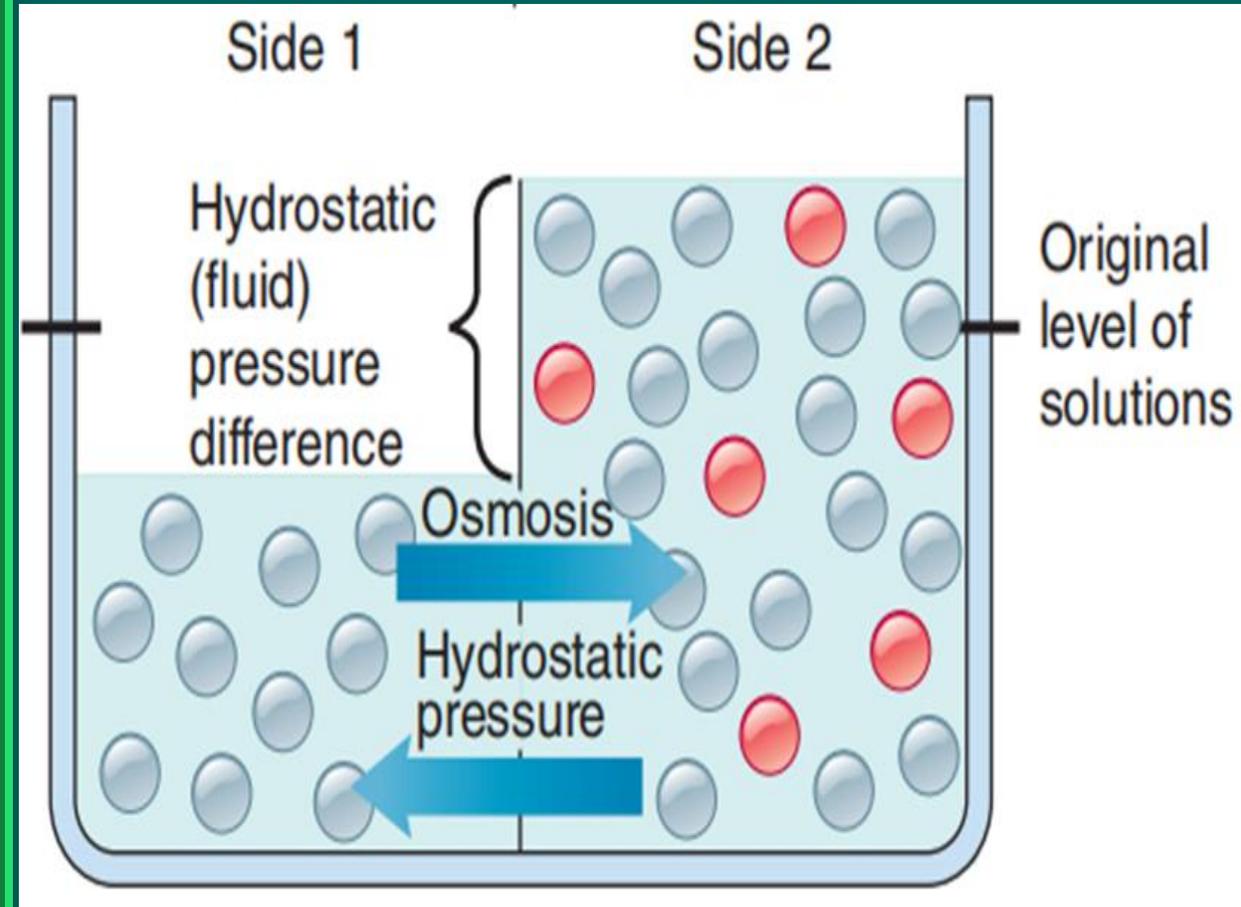
- ❖ **Osmotic Pressure:**
- ❖ Osmotic pressure = “pulling force” drawing water into a solution.
- ❖ **(The osmotic pressure of a solution (a “pulling” pressure) is a measure of the tendency for osmotic flow of water into that solution because of its relative concentration of nonpenetrating solutes and water).**
- ❖ **Opposed by hydrostatic pressure = “pushing force”.**



Osmosis

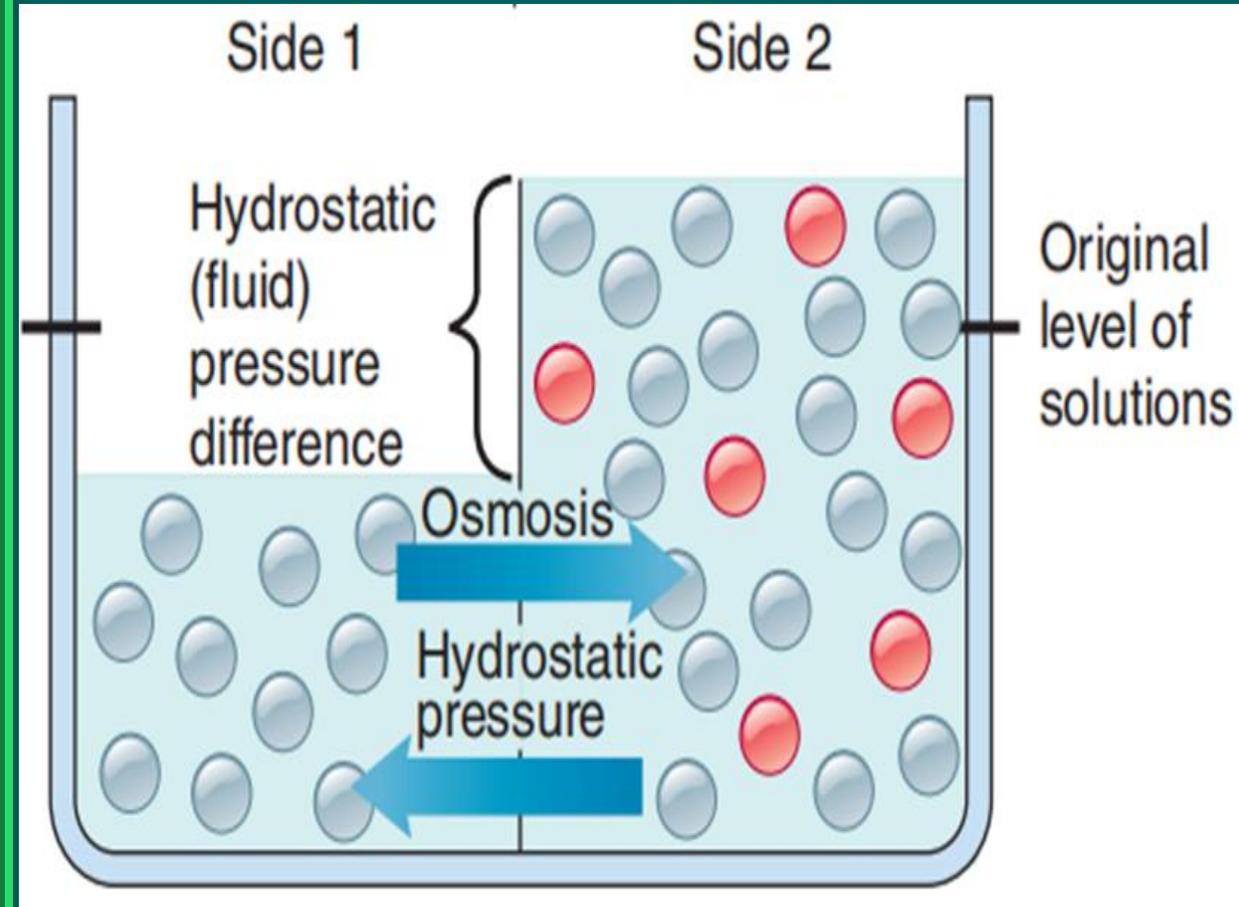
- ❖ Osmosis **stops** when:
- ❖ Hydrostatic pressure = Osmotic pressure
- ❖ Dynamic equilibrium is reached

- ❖ Greater nonpenetrating solute concentration → Greater osmotic pressure



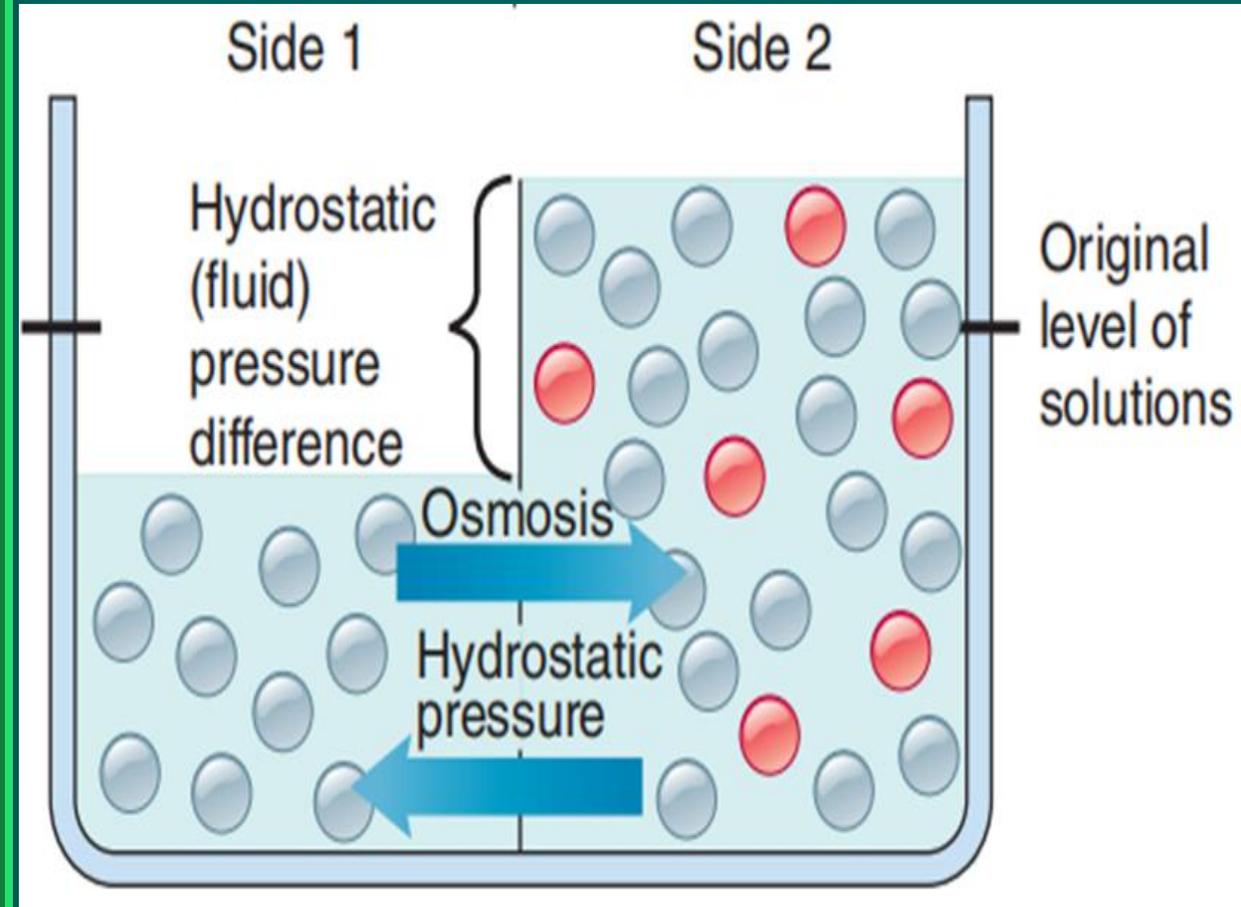
Osmosis

- ❖ Osmotic pressure is an **indirect measure of solute concentration**, expressed in units of pressure.
- ❖ A more direct means of expressing solute concentration is the **osmolarity** of a solution, which is a measure of its **total solute concentration given in terms of the number of particles (molecules or ions)**.
- ❖ Osmolarity is expressed in osmoles per liter (or **Osm/L**), the number of moles of solute particles in 1 liter of solution.



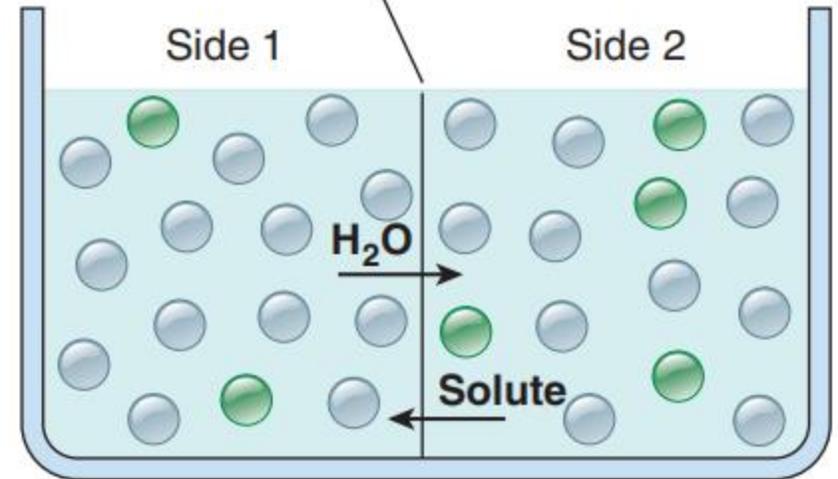
Osmosis

- ❖ Osmolarity : Depends on number of particles, not type.
- ❖ Normal body fluid osmolarity ≈ 300 mOsm/L.
- ❖ Osmolarity includes all solutes.



Movement of Water and Solute When a Membrane Separates Unequal Solutions of a Penetrating Solute

Membrane (permeable to both H₂O and solute)



Higher H₂O concentration,
lower solute concentration

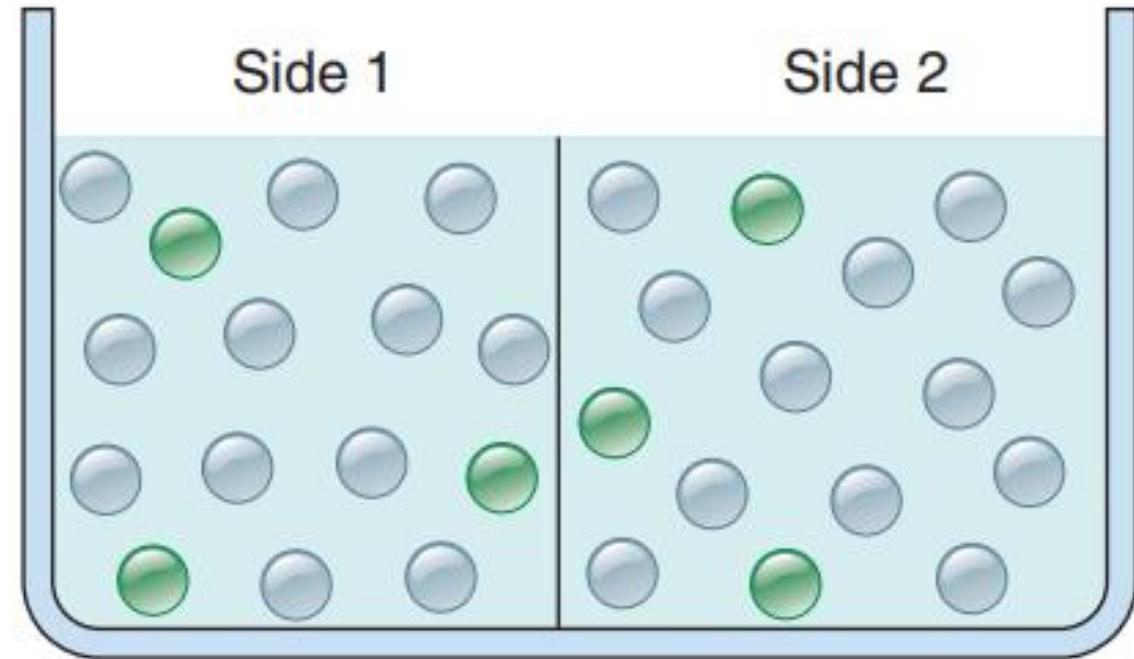
Lower H₂O concentration,
higher solute concentration

**H₂O moves from side 1 to side 2
down its concentration gradient**

**Solute moves from side 2 to side 1
down its concentration gradient**

Movement of Water and Solute When a Membrane Separates Unequal Solutions of a Penetrating Solute

- ❖ Solutes that can penetrate the plasma membrane do **not contribute** to osmotic differences between the ICF and the ECF and **do not affect** cell volume.
- ❖ Only nonpenetrating solutes affect tonicity and cell volume.



Thank You