

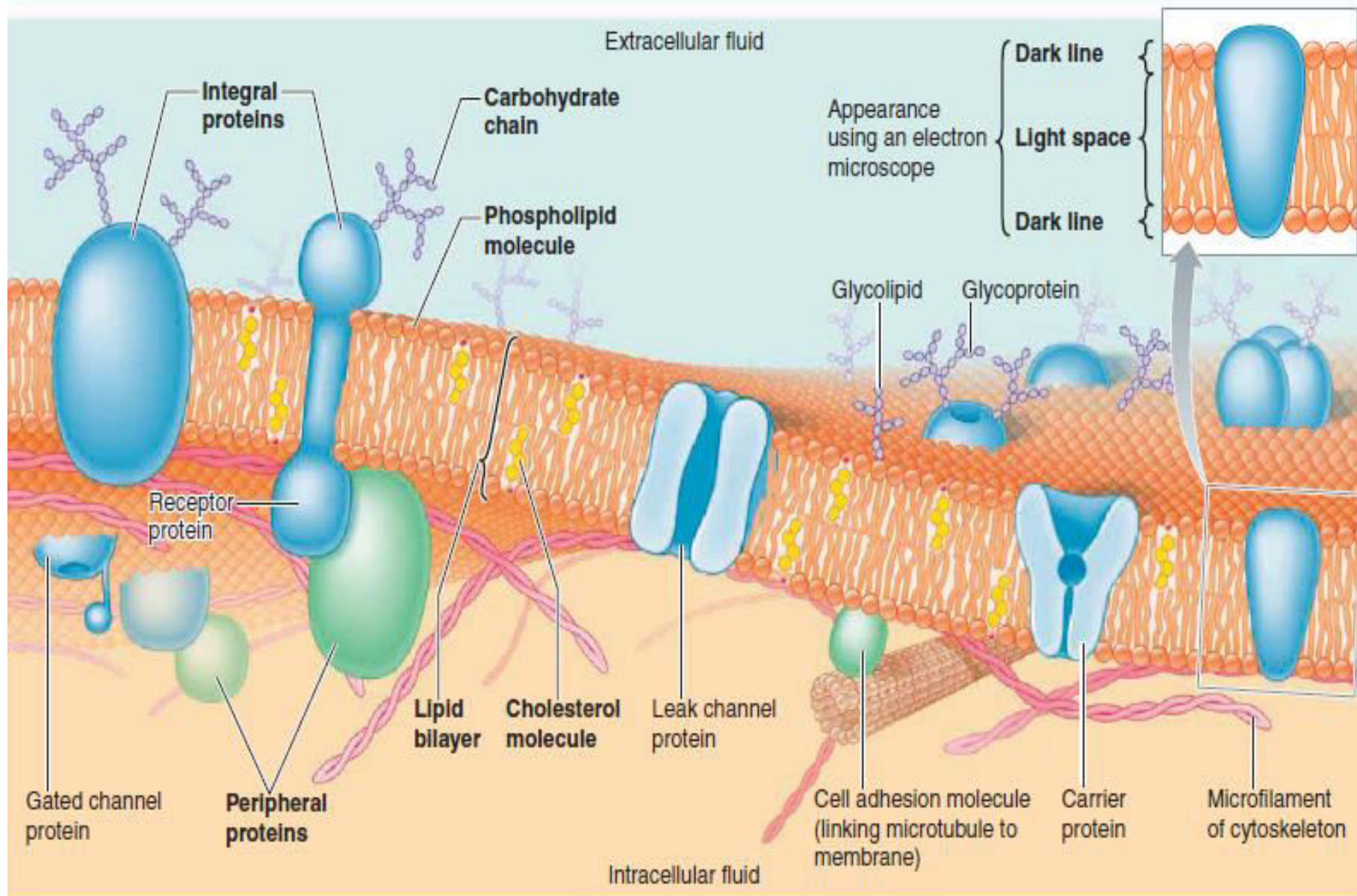
TRANSPORT ACROSS CELL

MEMBRANE-1

(Guyton, 12th Ed. (chapter 4): pg 45-56)

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● **FIGURE 3-3 Fluid mosaic model of plasma membrane structure.** The plasma membrane is composed of a lipid bilayer embedded with proteins. Integral proteins are

QUESTIONS

**What holds all the cells together and
why is it important??**

Extracellular Matrix

- The extracellular matrix (ECM) is an intricate meshwork of fibrous proteins embedded in a watery, gel-like substance composed of complex CHO. The ECM serves as the biological “glue”. The watery gel provides a pathway for the diffusion of nutrients, wastes and other water-soluble traffic between the blood and the tissue cells.
- It is usually called **interstitial fluid**. Interwoven within the gel are three major types of protein fibers: collagen, elastin and fibronectin.
- **Functions of the ECM:**
 1. Composition of the ECM varies according to the different tissues.
 2. Scaffolding for cellular attachment among cells.
 3. Plays a role in growth and differentiation.
 4. Cells can only survive in the ECM.

CELL-TO-CELL ADHESIONS:

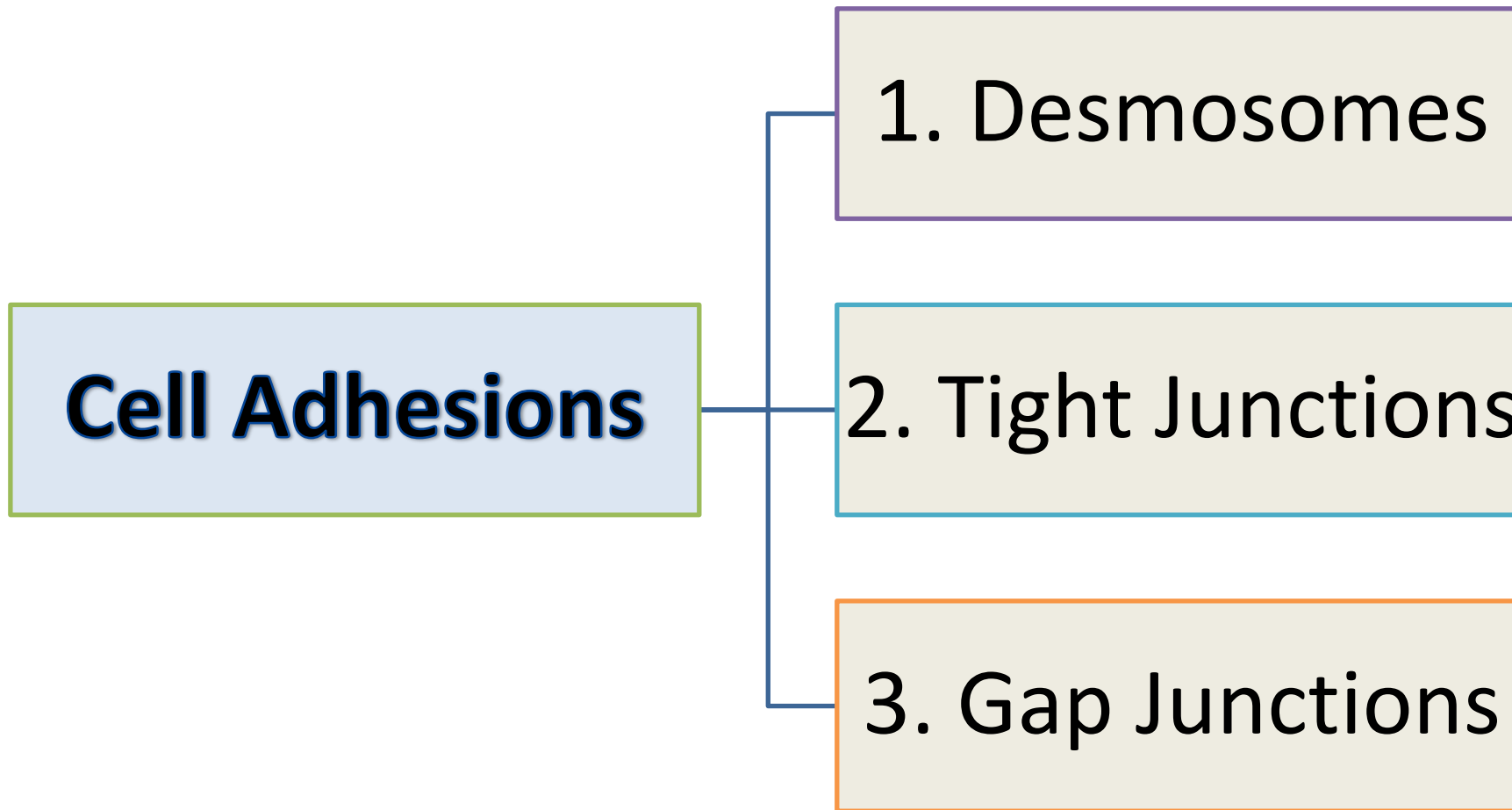
(SHERWOOD, CHAPTER 3 (PAGE 76-79))

What are cell adhesions and Why do we need Cell-Cell Adhesions?

- What is cell adhesion and Why do we need Cell-Cell Adhesions?

Cell adhesion is the binding of a cell to the surface of another cell using cell-cell adhesions (as we will study) or to the ECM, using cell adhesion molecules (CAMs) as integrins, selectins (CAMs work as 'Velcro').

Types of Cell Adhesions:



1. DESMOSOMES

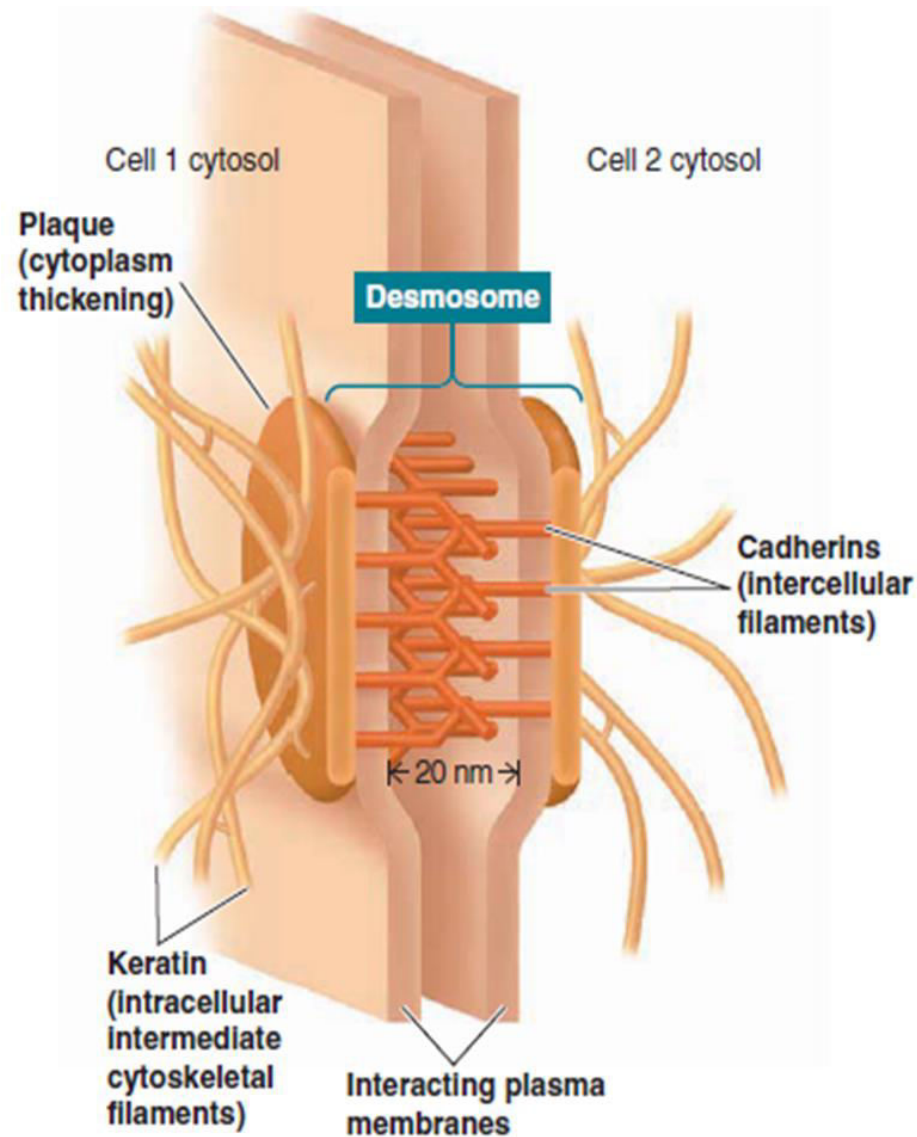
DESMOSOME

S

- **Definition:**

It is a circular, dense body that forms at the site of attachment/ adhesion between 2 adjacent cells, consisting of a dense plate in each cell separated by a thin layer of extracellular material.

- These are also called ***macula adherens***.
- Act like 'spot rivets'.
- Anchor together two closely adjacent but ***nontouching*** cells.

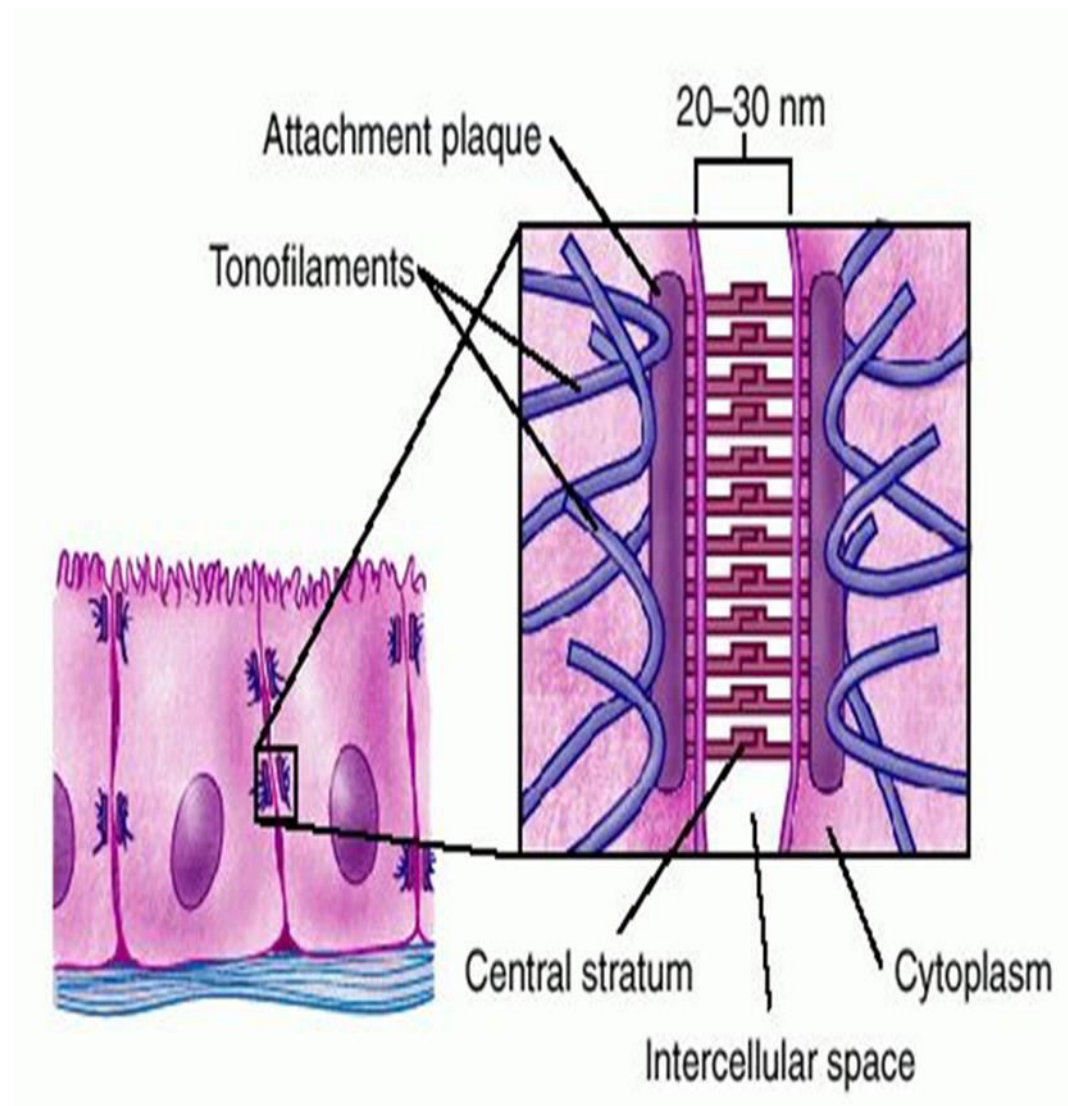


● **FIGURE 3-4 Desmosome.** Desmosomes are adhering junctions

STRUCTURE OF A DESMOSOME:

A desmosome has **2 components**:

1. A pair of dense, button-like cytoplasmic thickenings known as **plaque** located on the inner surface of each of the two adjacent cells.
2. Strong **glycoprotein filaments** that extend across the space between the two cells and attach to the plaque on both sides.



FUNCTIONS OF DESMOSOMES

1. Abundant in tissues subjected to considerable stretching e.g. skin, heart and uterus. In these tissues, the cells are joined together by desmosomes that extend from one cell to the next, then to the next and so on.
2. A continuous network of strong fibers extend throughout the tissue, both through the cells and between the cells: ***they are like a continuous line of people holding hands.***
3. Provides tensile strength.
4. Reduces the chances of tissue being torn when stretched.

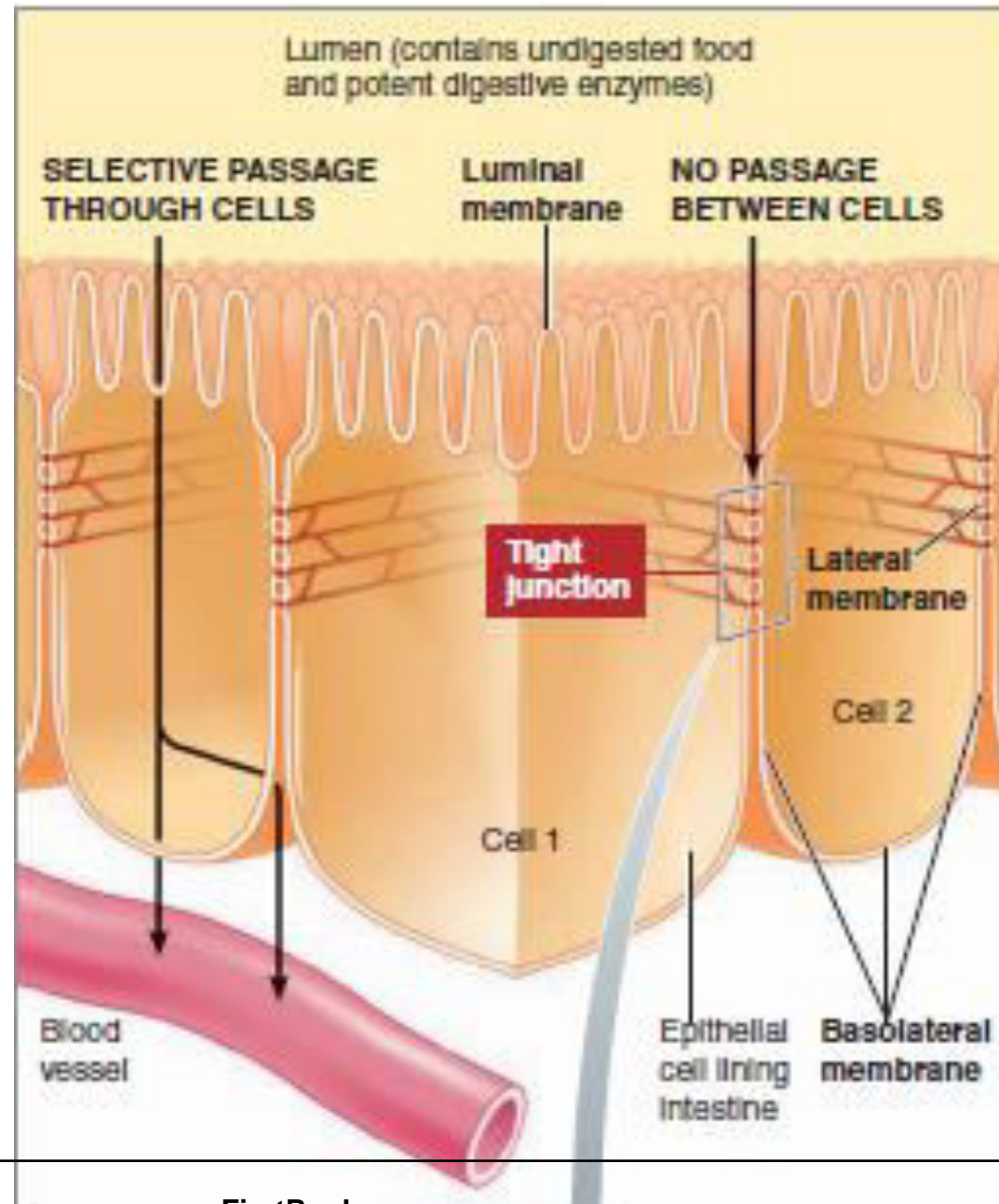
2. TIGHT JUNCTIONS

TIGHT JUNCTIONS:

Definition:

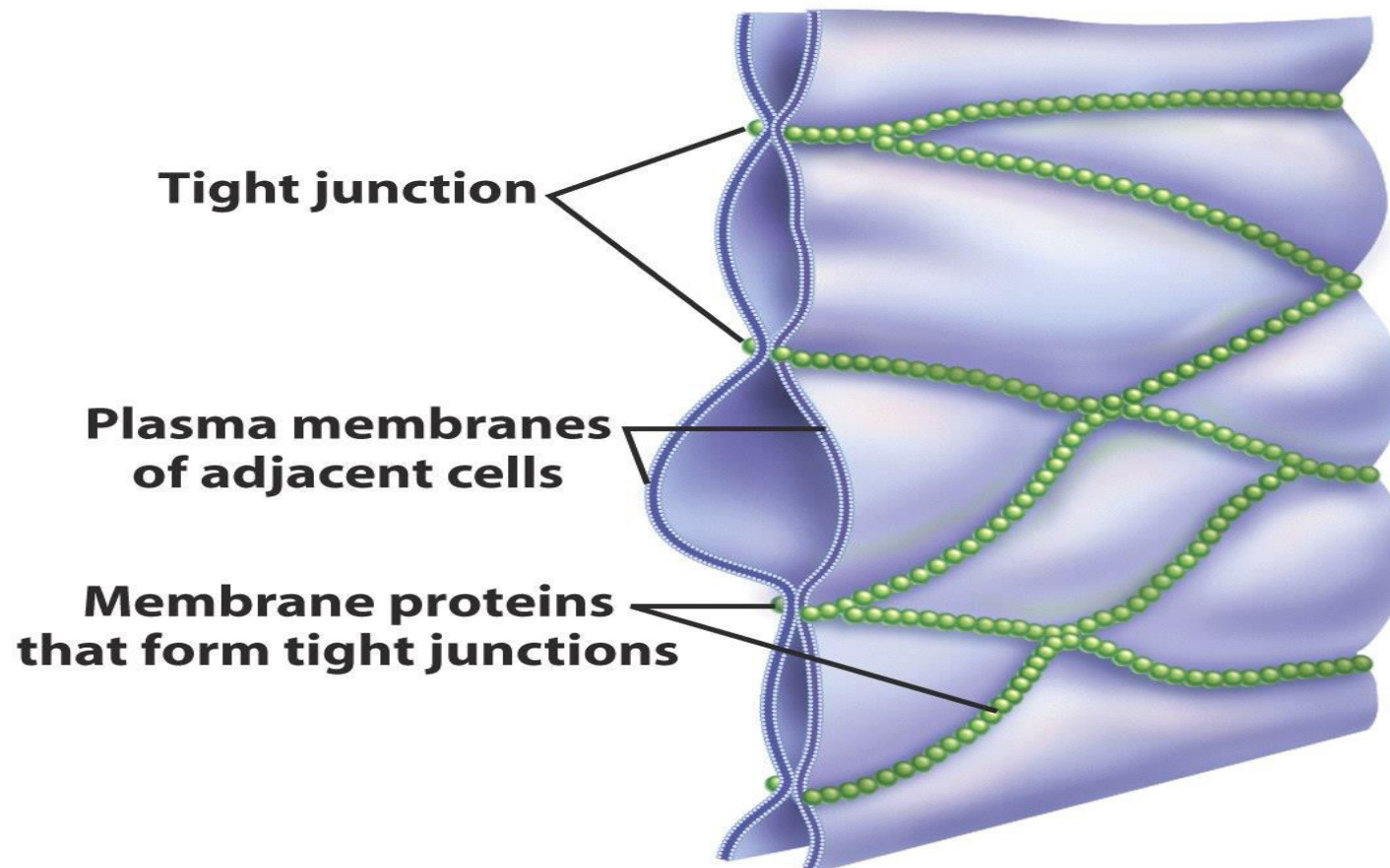
It is an intercellular junction, where adjacent cells firmly bind with each other at points of contact to seal off the passageway between the two cells.

- The tight junctions are impermeable.
- Passage across the epithelial barrier, must take place through the cells, not between the cells: the traffic across the cell is regulated by means of the carriers and channels present.
- Tight junctions thus prevent undesirable leaks within epithelial cells.



TIGHT JUNCTIONS

Three-dimensional view of tight junctions



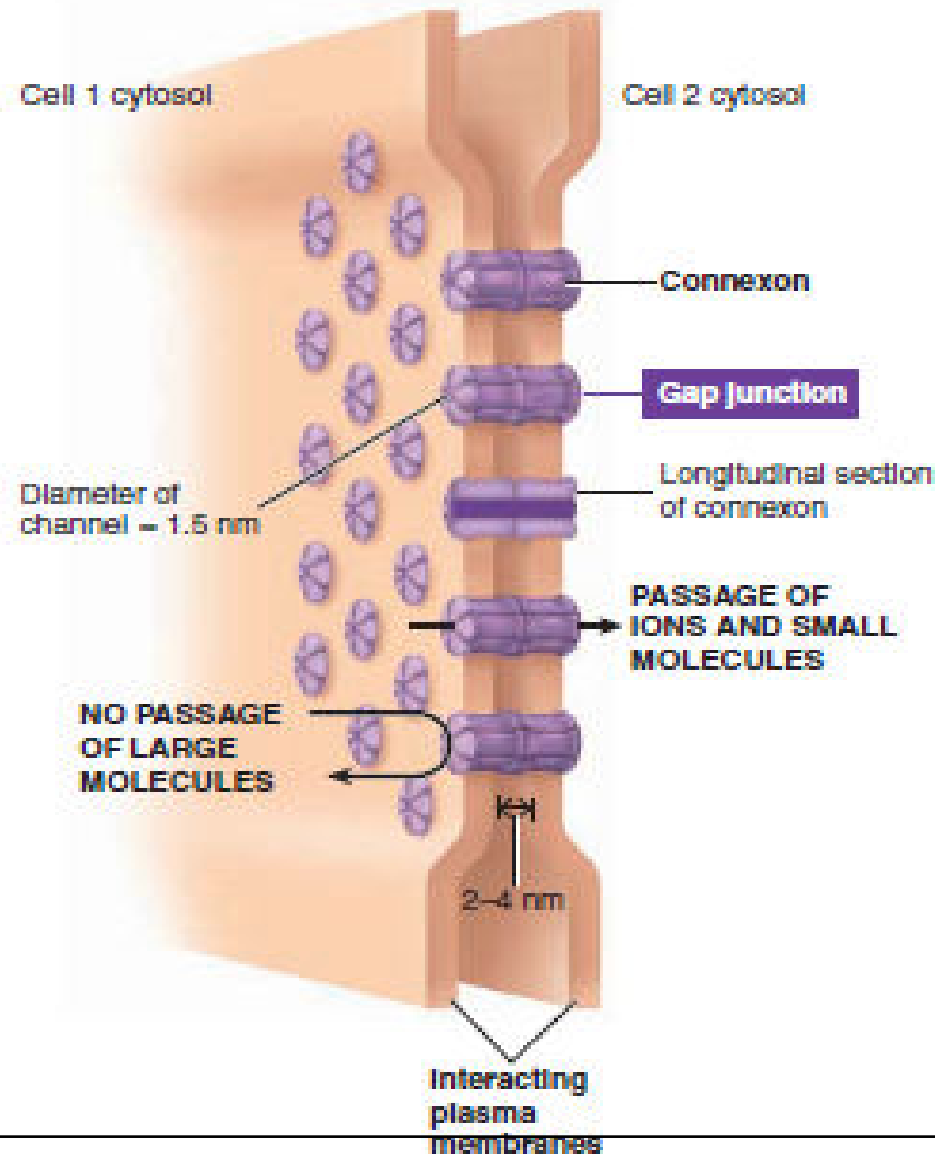
3. GAP JUNCTIONS

GAP JUNCTIONS:

Definition:

Gap junctions are communicating junctions. It is a gap which exists between adjacent cells, which are linked by small, connecting tunnels formed by connexons.

- Abundant in cardiac muscle and smooth muscle where they transmit electrical activity.
- In non-muscle tissues they permit small nutrient molecules e.g. glucose, aa,.
- Serve as roads for transfer of small signaling molecules from one cell to next.



GAP JUNCTIONS

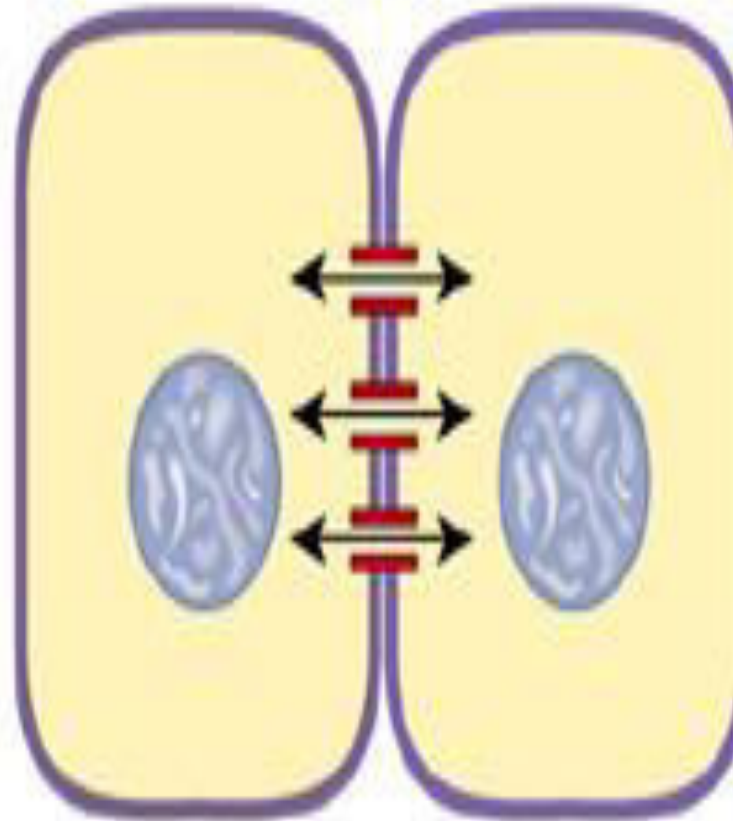
It has a small diameter that allows water and water-soluble particles to pass between the connected cells but does not allow large molecules like intracellular proteins.

These molecules can be exchanged between cells without ever entering the ECF.

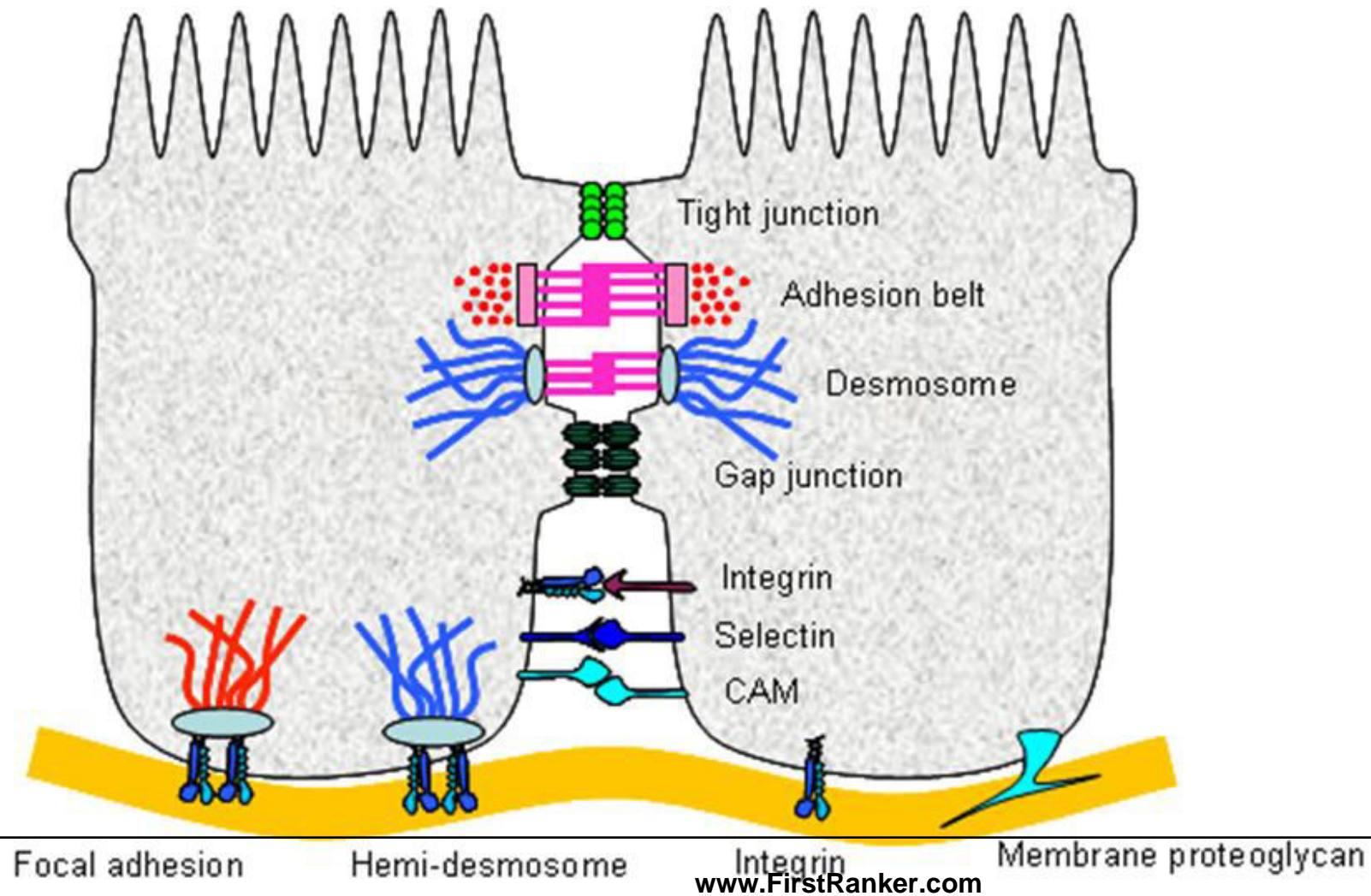
They do not seal membranes together, but permit small molecules to shuttle from one cell to another and link their interiors.

They allow electrical and metabolic signals to pass from one cell to another.

(a) Gap junctions form direct cytoplasmic connections between adjacent cells.



Cell-Cell Adhesions

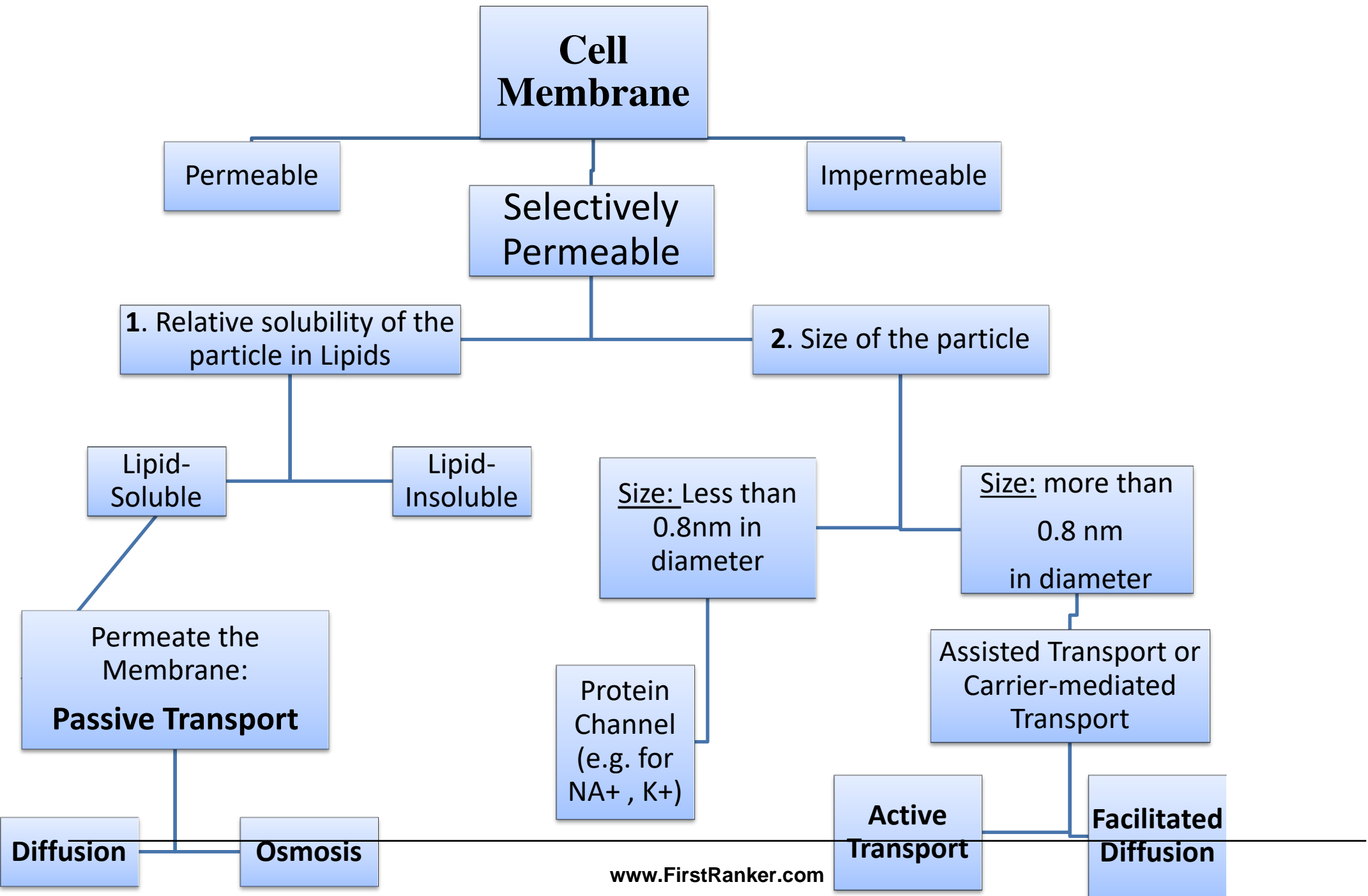


DIFFERENT TYPES OF TRANSPORT ACROSS THE CELL MEMBRANE:

Permeability of a membrane

Anything that passes between a cell and the surrounding ECF must be able to pass through the plasma membrane.

- If a substance can pass thru the membrane, the membrane is said to be **permeable** to that substance;
- if a substance cannot pass, the membrane is **impermeable** to it.
- The plasma membrane is **selectively permeable** in that it permits some substances to pass through while excluding others.



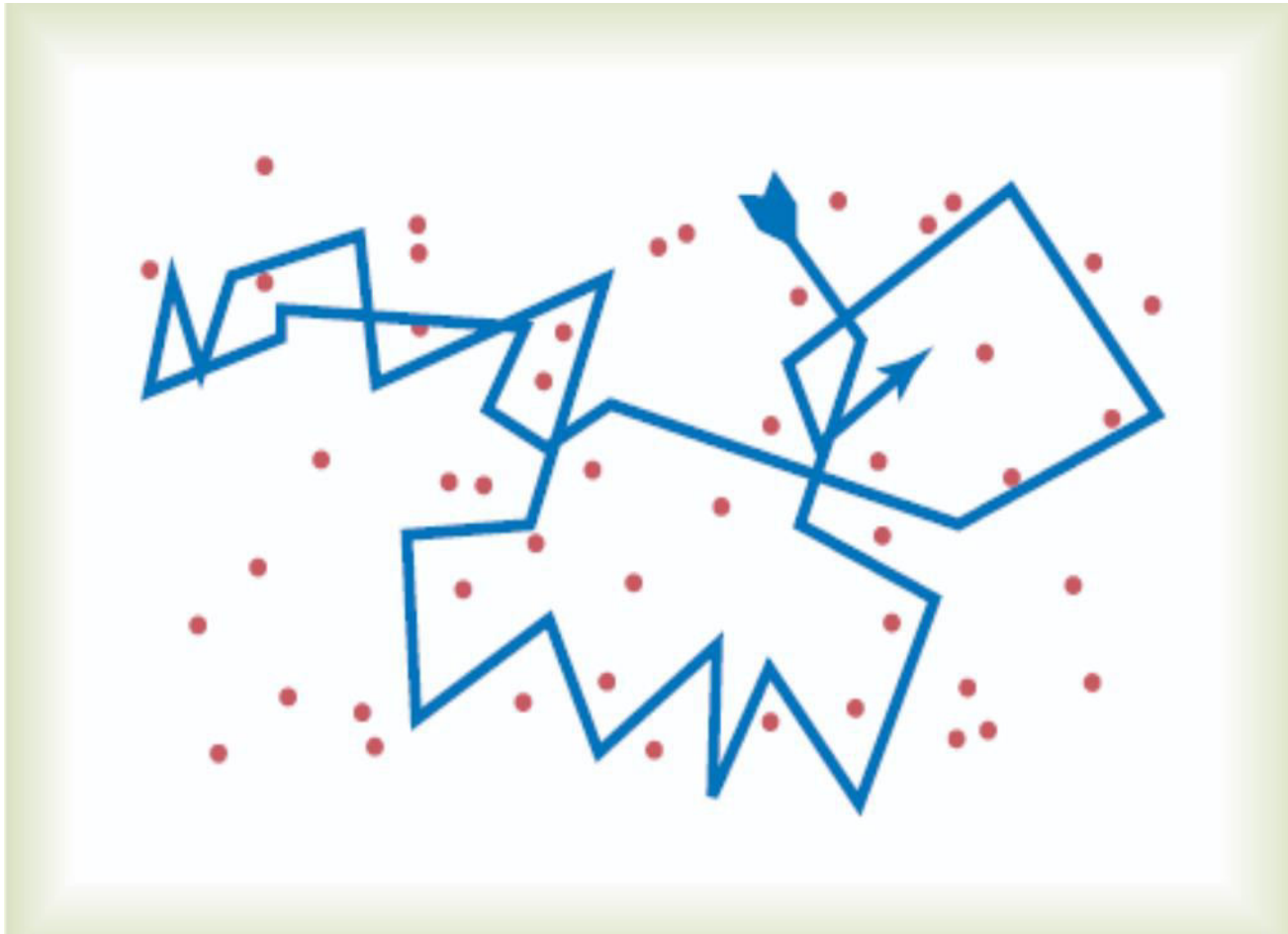
KEY WORDS

- **Solvent**: (relatively large amount of a substance which is the dissolving medium; in the body is water).
- **Solute**: (relatively small amount of a substance which is the dissolved substance and it dissolves in the solvent).
- **Solution**: is a homogenous mixture of a solute in a solvent.
- **Concentration**: of a solvent is the amount of solute dissolved in a specific amount of solution.
- **Concentration gradient**: difference in the concentration of a solute on two sides of a permeable membrane.
- **Equilibrium**: exact balance between 2 opposing forces.
- **Dynamic**: continuous motion or movement.

DIFFUSION

- What happens when you spray a can of an air freshener in the front of the classroom.... After some time can the people at the back or the other end of the room smell it...?

Diffusion of a Liquid Molecule



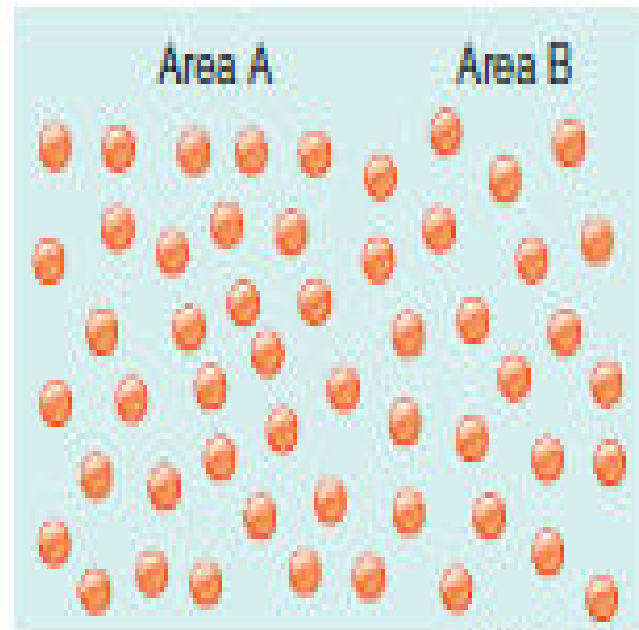


→ Diffusion from area A
to area B

← Diffusion from area B
to area A

→ Net diffusion

(a) Diffusion



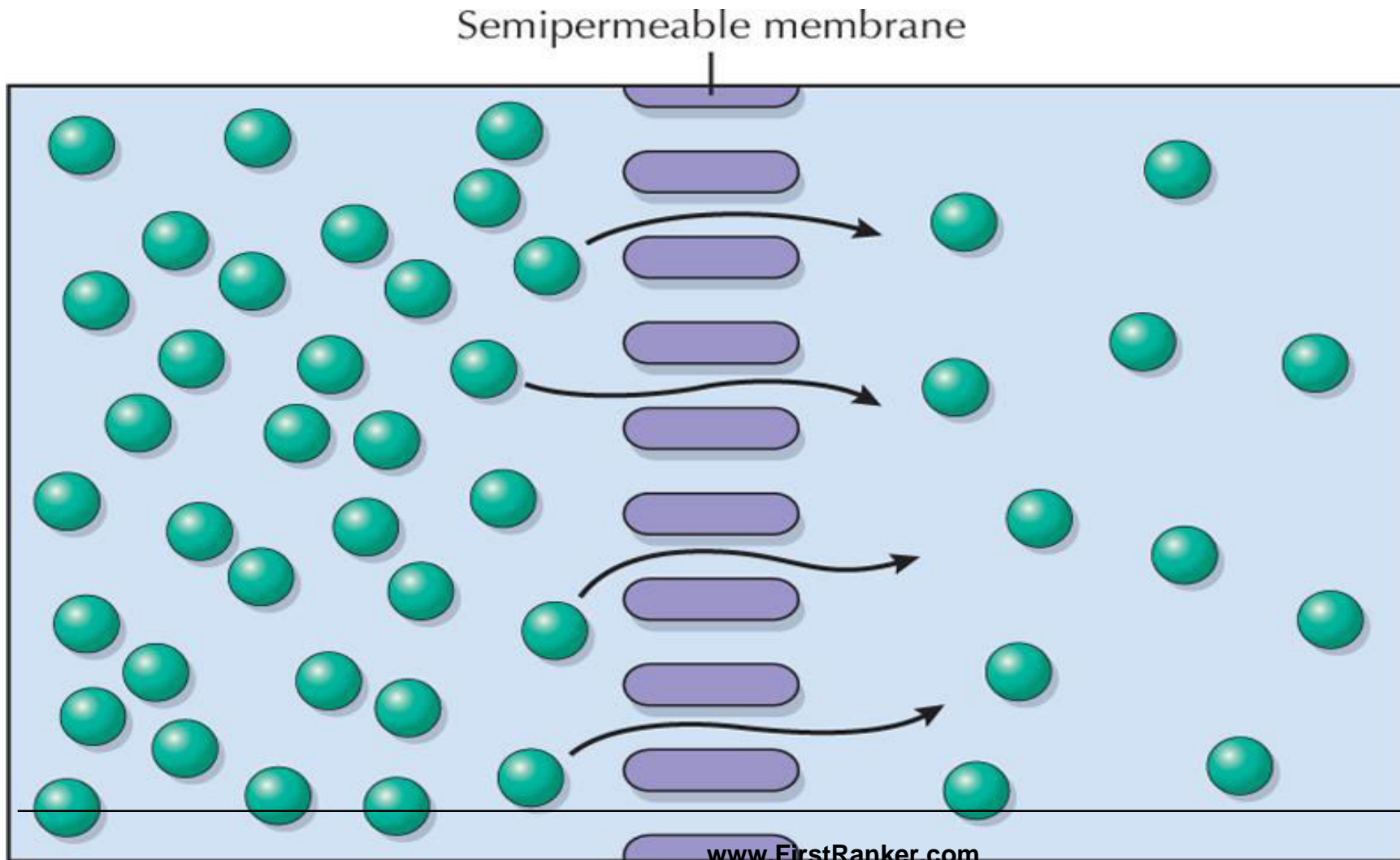
→ Diffusion from area A
to area B

← Diffusion from area B
to area A

No net diffusion

(b) Dynamic equilibrium

DIFFUSION & a semi-permeable membrane:



Definition:

Diffusion is the passive movement of molecules from an area of higher concentration of the molecule to an area of lower concentration of the molecule.

(diffusere means “to spread out”)

Particles that can permeate the membrane diffuse passively down their concentration gradient.

e.g. In our body, O₂ is transferred across the lung membrane by diffusion....

Diffusion

Diffusion is:

1. Passive.
2. Requires a concentration gradient.
3. Occurs until a dynamic equilibrium is reached.
4. Rapid over short distance, slow over long distance.
5. Increased at increased temperature.
6. Inversely related to molecular size, as molecular size increases the resistance.
7. Can occur in an open system or across a membrane.

Factors affecting rate of Diffusion

1. Concentration Gradient: the rate of diffusion is directly proportional to the concentration difference across the cell membrane. Thus, when the gradient is zero, there will be no diffusion. Diffusion will only occur as long as a concentration gradient exists. (Net diffusion $\propto c_o - c_i$)

2. Temperature: Rate of Diffusion is directly proportional to Temperature. As the temperature increases, so does rate of diffusion.

3. Pressure Difference: increases the rate of diffusion.

4. Molecular Weight: Rate of Diffusion is inversely proportional to the molecular weight of the substance. (heavier molecules move more slowly than smaller, lighter ones)

5. Distance Travelled: Rate of diffusion is inversely proportional to distance traveled.

6. Lipid Solubility: Rate of diffusion is directly proportional to the lipid solubility of the substance.

7. Surface Membrane: Rate of Diffusion is directly proportional to the surface area of the membrane.

8. Membrane Electrical Potential: Rate of diffusion is directly proportional to the membrane electrical potential across the membrane.

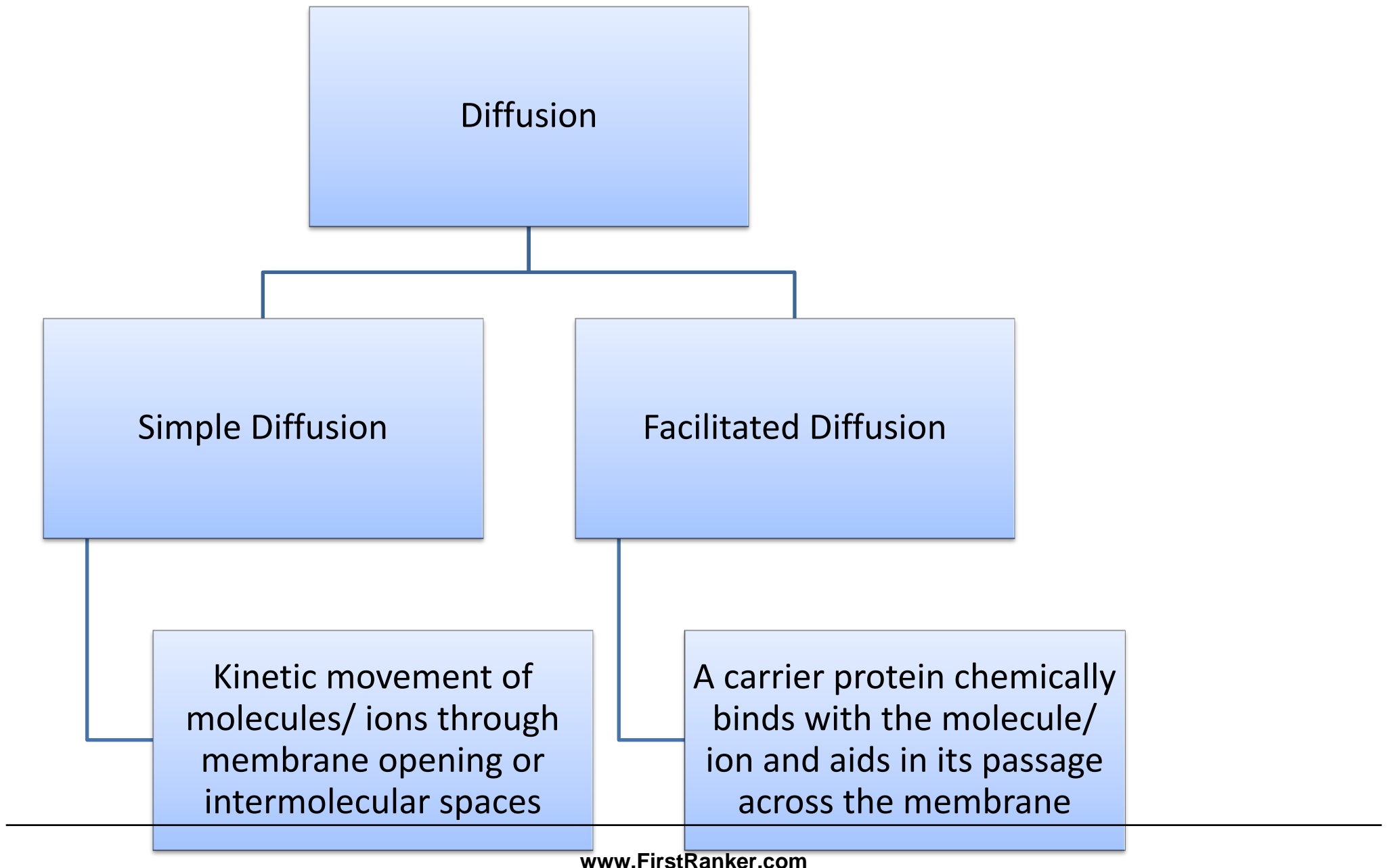
Fick's Law of Diffusion:

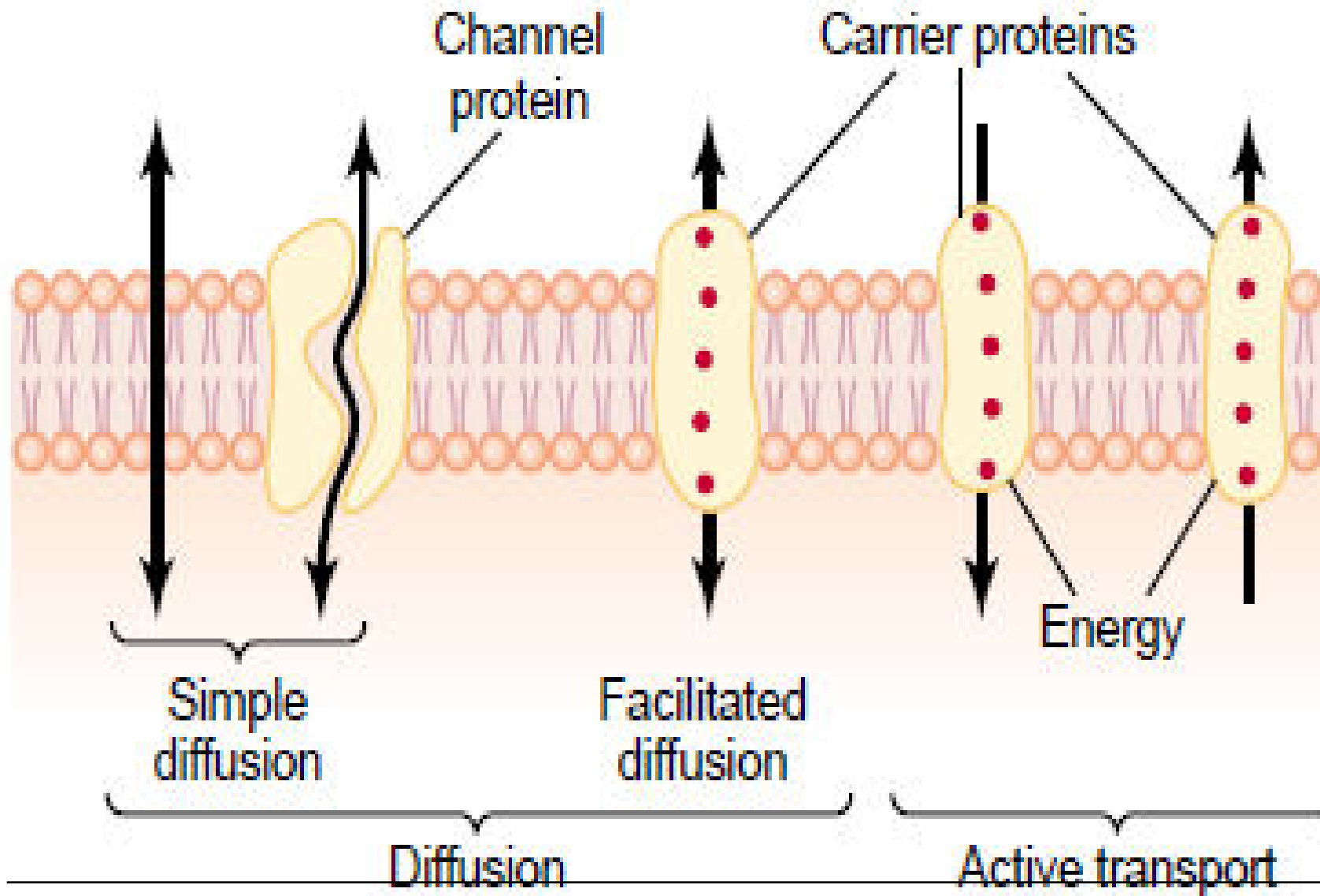
$$\text{Rate of Diffusion (Q)} = \frac{\Delta \text{ conc. Surface Area. Lipid Solubility}}{MW. \Delta X}$$

Where $\Delta \text{ conc.}$ = concentration gradient

ΔX = distance travelled (thickness of the membrane)

MW = Molecular weight





Simple Diffusion thru gated channels

- Protein channels are present all the way from the ECF to the ICF, thus substances can move by simple diffusion directly along these channels from one side of the membrane to the other. These channels are distinguished by 2 important features:
 1. Selective permeability of the channel
 2. Presence of gates

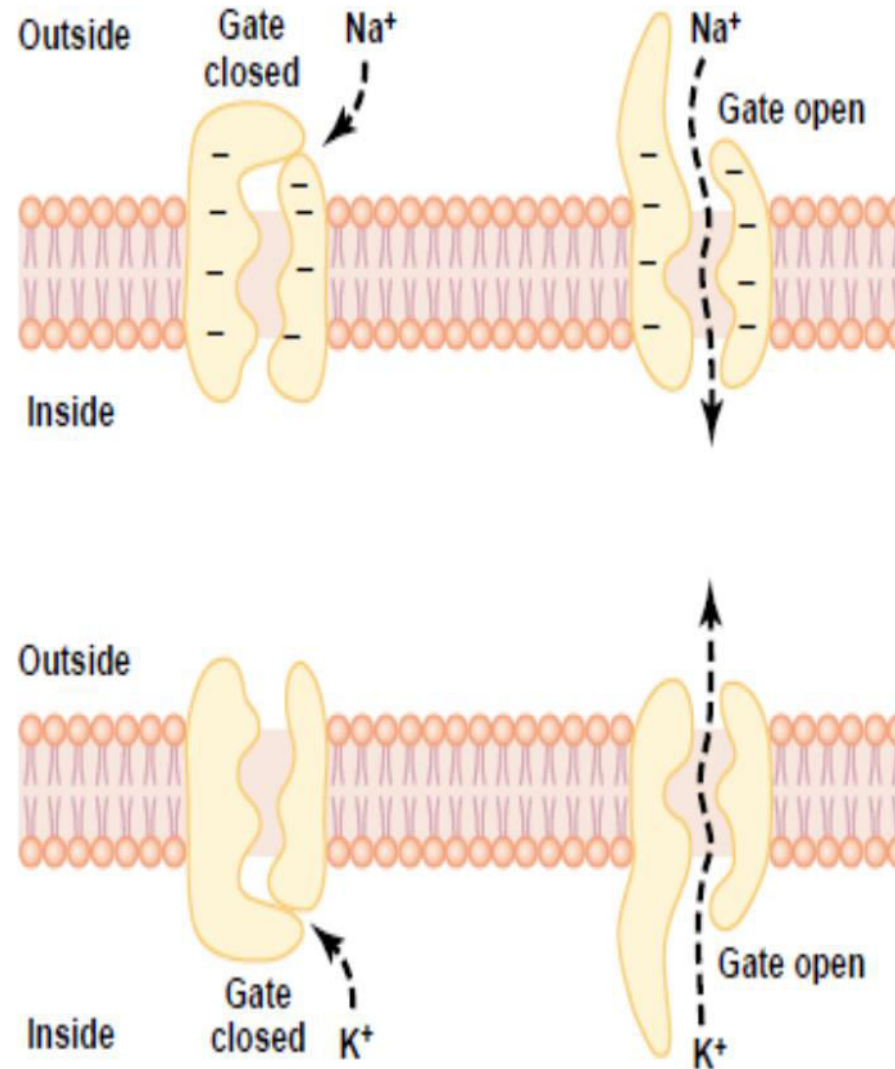
Gated channels in Simple Diffusion:

Sodium Channels:

- 0.3 by 0.5 nm in diameter
- Negatively charged on the inside
- Because of the negative charges they pull the positively charged sodium ion inside, away from the water molecule.

Potassium channel:

- 0.3 by 0.3 nm in diameter
- No negative charge on the inside
- Pull the hydrated K ion inside. As no negative charge on the inside of the channel, no attractive forces for the Na ion... also, Na ions hydrated form is far too big....



THINK!

How does water get through the
HYDROPHOBIC Plasma membrane?

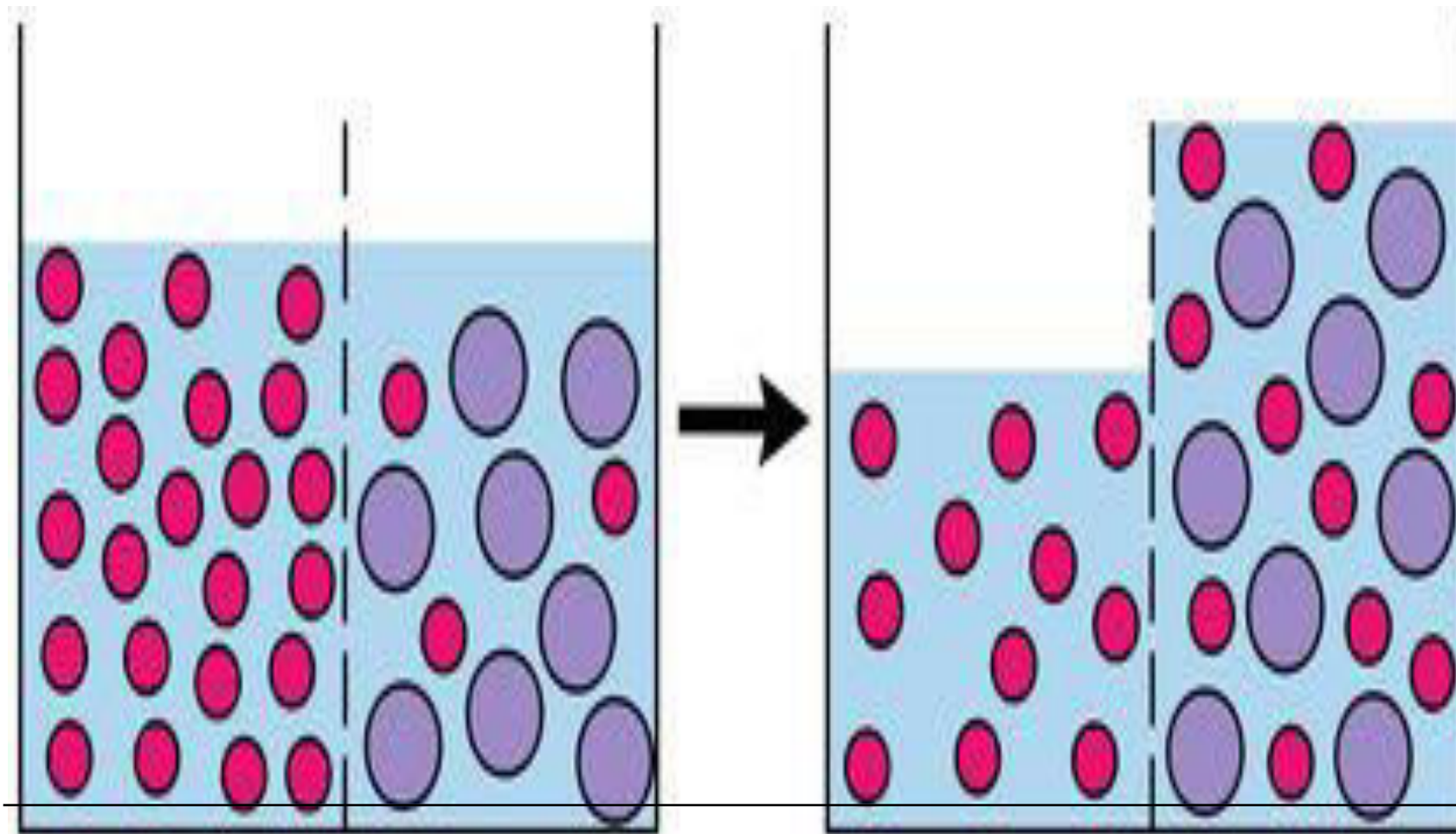
How does water get through the HYDROPHOBIC Plasma membrane?

Answer: Even though water is polar and so highly insoluble in the membrane lipids, it readily passes through the cell membrane thru 2 ways:

1. Water molecules are small enough to move through the monetary spaces created between the phospholipid molecules' tails as they sway and move within the lipid bilayer.
2. In many cells, membrane proteins form **aquaporins**, which are channels specific for the passage of water. About a billion water molecules can pass in single file through an aquaporin channel in one second.

OSMOSIS:

OSMOSIS



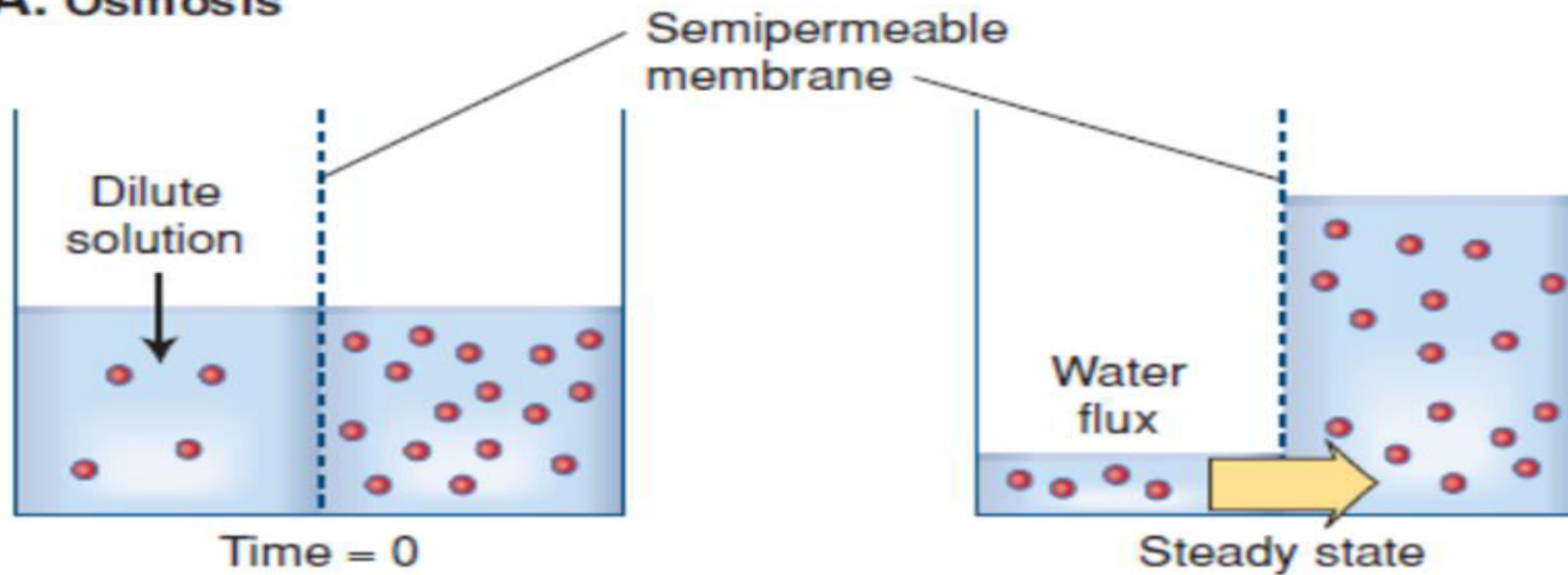
OSMOSIS

Definition:

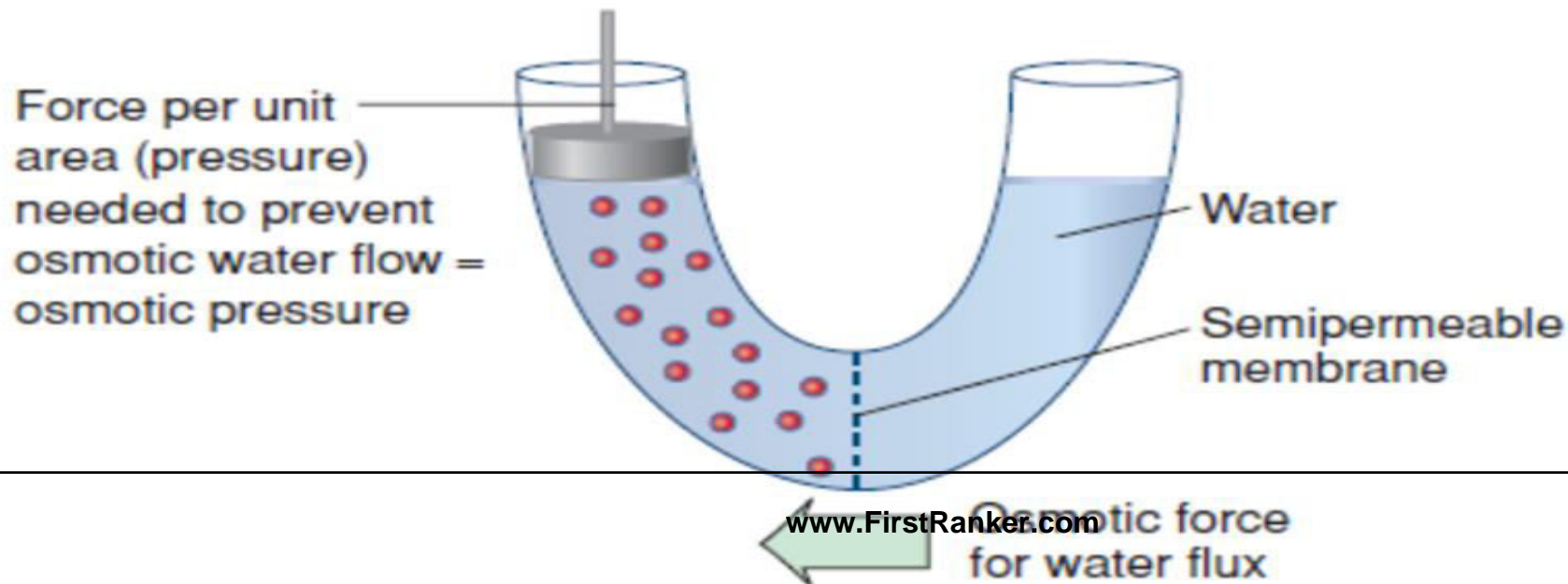
The diffusion of water down its concentration gradient (that is, an area of higher water concentration to an area of lower water concentration) thru a semi-permeable membrane is called ***Osmosis***.

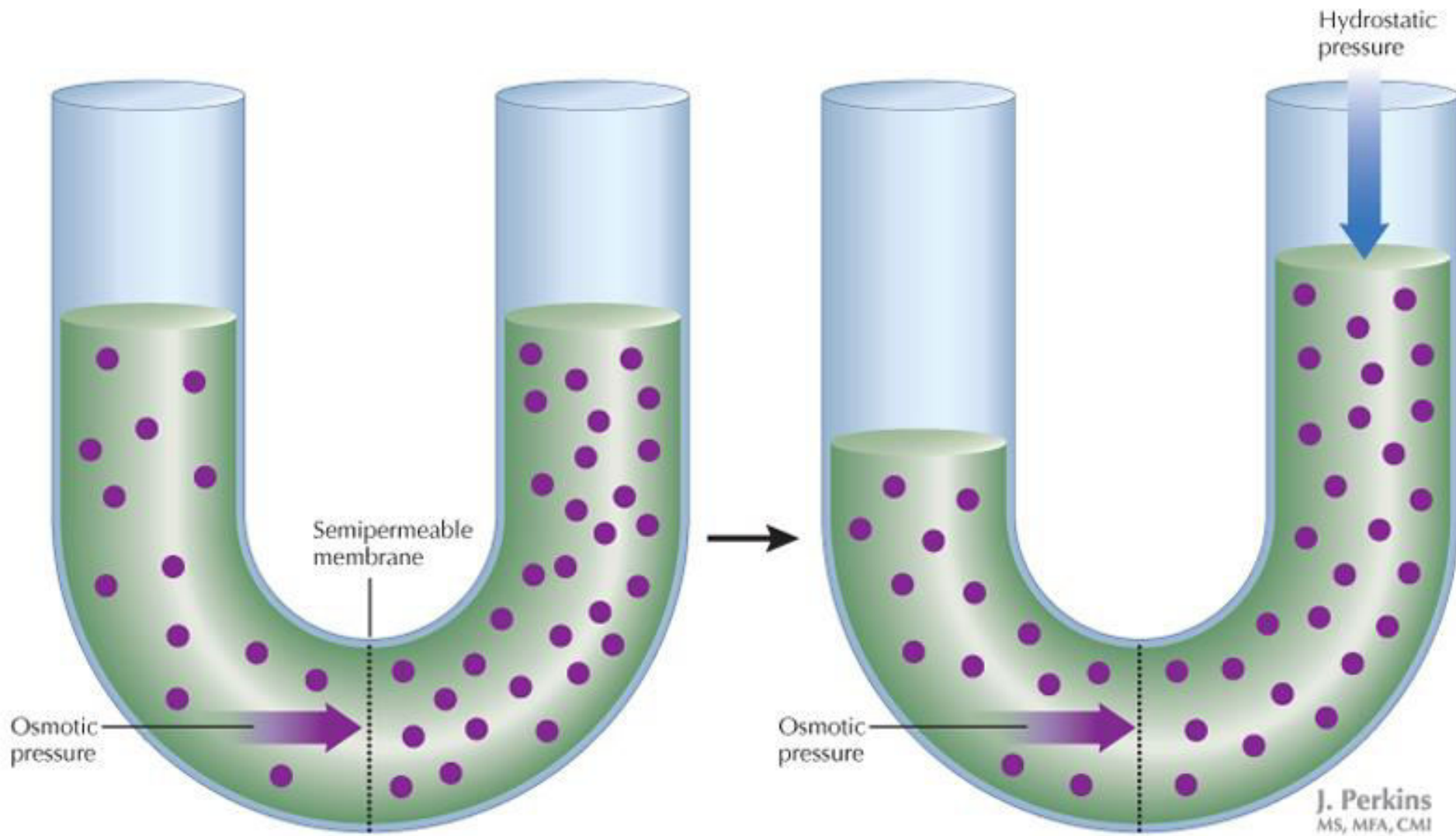
Concept: Because solutions are always referred to in terms of concentration of solute, *water moves by osmosis to the area of higher solute concentration*. Despite the impression that the solutes are “pulling,” or attracting, water, osmosis is nothing more than diffusion of water down its own concentration gradient across the membrane.

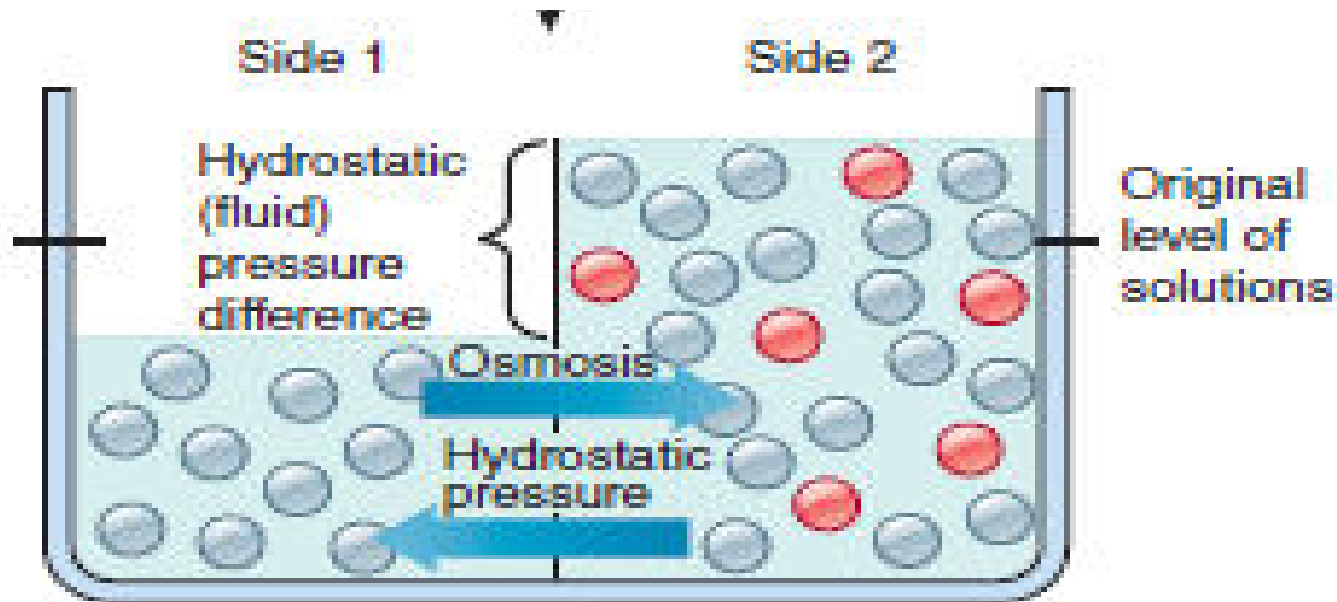
A. Osmosis



B. Concept of osmotic pressure







- Water concentrations not equal
- Solute concentrations not equal
- Tendency for water to diffuse by osmosis into side 2 is exactly balanced by opposing tendency for hydrostatic pressure difference to push water into side 1
- Osmosis ceases; dynamic equilibrium exists

KEY



= Water molecule



= Nonpenetrating solute

Osmotic pressure: is the pressure that is required to stop osmosis. It is the pressure necessary to prevent osmosis into a given solution when the solution is separated from the pure solvent by a semipermeable membrane. The greater the solute conc. of a solution, the greater its osmotic pressure.

(HYDROSTATIC PRESSURE = OSMOTIC PRESSURE)

An **osmole** is **one mole of dissolved particles** in a solution. E.g. glucose when dissolved in solution does not dissociate, so 1 mole of glucose is also 1 osmole of glucose. On the other hand, NaCl dissociates into 2 ions (Na and Cl) so is taken as 2 moles.

Osmolarity is the **number of osmoles of solute per liter** of solution. Simply put, osmolarity is a measure of total solute conc. given in terms of number of particles of the solute in 1 liter of solution. The osmolarity of body fluids is usually expressed in milliosmoles per liter (mOsm/L). (The normal osmolarity of body fluid is 300 mOsm.) It is usually employed in clinical settings.

Osmolality is the number of **milliosmoles of solute per kg** of solvent. It is usually calculated in laboratories using an osmometer.

Key Concept!

Understand: Between Osmosis and Diffusion, the difference is only in the terminology: we are describing water instead of solute. The principles are the same as those of diffusion of solute molecules thru a membrane.

REVIEW: Compare Diffusion and Osmosis.

CARRIER-MEDIATED TRANSPORT

What is a carrier protein?

- A carrier protein spans the thickness of the plasma membrane and change its conformation so that specific binding sites within the carrier are alternately exposed to the ECF and ICF.
- Carrier-mediated transport systems display 3 characteristics:
 1. **Specificity:** e.g. glucose cannot bind to amino acid carriers and vice versa.
 2. **Saturation:** A limited no. of carrier binding sites are available within a particular plasma membrane for a specific substance. Thus, there is a limit to the amount of substance a carrier can transport across the membrane in a given time. This is called Transport Maximum (T_m).
 3. **Competition:** Several different substances are competing for the same carrier site.

Facilitated Diffusion

Definition:

Facilitated diffusion is a mediated-transport that moves molecules from higher to lower concentration across a membrane by means of a transporter which is a carrier protein. That is, the carrier facilitates the diffusion of the substance to the other side.

Metabolic energy is **NOT** required for this process.

E.g: Glucose, amino acids

Changes in the conformation of the transporter move the binding site to the opposite side of the membrane, where the solute dissociates from the protein.

