

Unit-1  
Plant Physiology  
Lecture 1A

# PLANT WATER RELATION

IMBIBITION, DIFFUSION, OSMOSIS AND PERMEABILITY

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# Declaration

**The source of Data/Text used in the preparation of power point presentation were Google, E-Books, Books and Journals. It is used for teaching purpose only.**

# WATER IS ESSENTIAL FOR ALL LIVING ORGANISMS

## Functions of water:

1. is a major component of cells.
2. is a solvent for the uptake and transport of materials.
3. is a good medium for biochemical reactions.
4. is a reactant in many biochemical reactions (i.e., photosynthesis).
5. provides structural support via turgor pressure (i.e., leaves).
6. is the medium for the transfer of plant gametes (sperms swim to eggs).
7. in water, some aquatic plants shed pollen underwater.

# Plant water relationship

## Imbibition

- Imbibition is the absorption of water by hydrophilic colloids. Examples of plant material which exhibit imbibition are dry seeds before germination.
- Different types of organic substances have different imbibing capacities.
- Proteins have a very high imbibing capacity, starch less and cellulose least.
- That is why proteinaceous pea seeds swell more on imbibition than starchy wheat

# Plant water relationship

## Imbibition

- Certain substances if placed in a particular liquid absorb it and swell up.
- For example, when piece of dry wood or dry seeds are placed in water they absorb the water quickly and swell up considerably so that their volume is increased.
- These substances are called as **imbibants** and the phenomenon as **imbibition** these exists certain force of attraction in between the **imbibant** and the imbibed substances.
- In plants this is because of the presence of a large number of hydrophilic colloids both in living as well as dead cells in the form of proteins, carbohydrates, such as starch, cellulose, pectic substances etc, which have strong attraction towards water.

## Imbibition

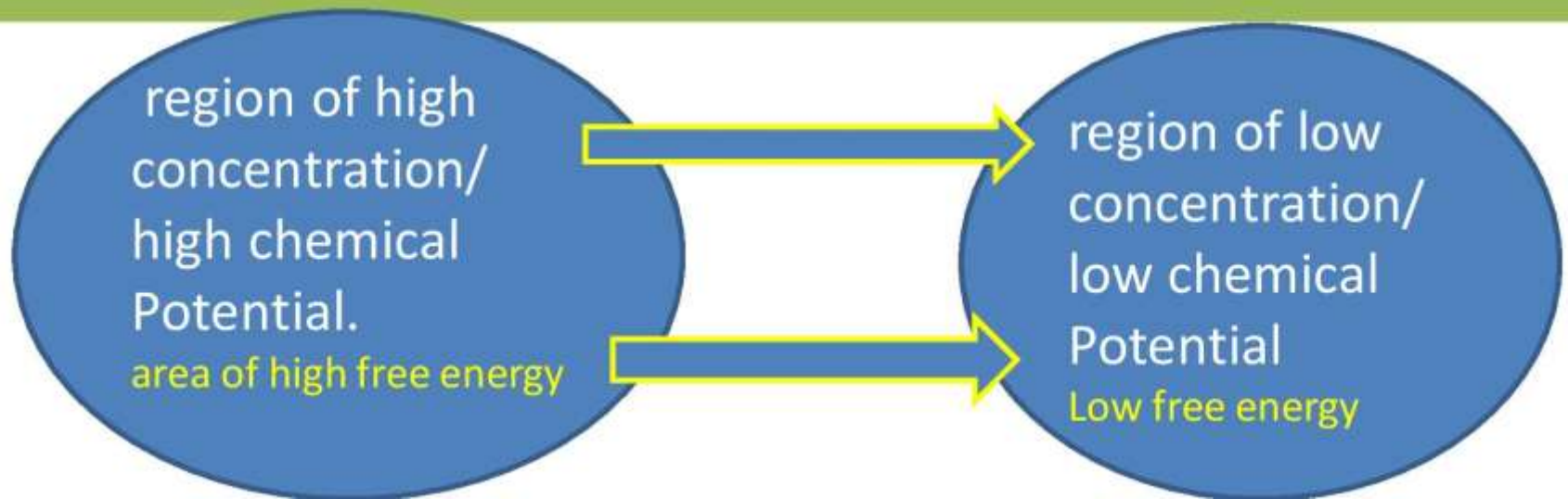
### Role of Imbibition plants life:-

- 1.The first step in the absorption of water by the roots of higher plants is the imbibition of water by the cell walls of the root hairs.
  - 2.Imbibition of water is very essential for dry seeds before they start germination.
- As a result of imbibition a pressure is developed which is called as **imbibition pressure**. The magnitude of this pressure is tremendous if the imbibant is confined (i.e., closed) and allowed to imbibe so much so that a rock can be splited.

# Plant water relationship

## Diffusion

- The net random movement of individual molecules from area of high concentration to an area of low concentration.
- Another way of stating this is that the molecules move from an area of high free energy (higher concentration) to an area of low free energy (lower concentration). The net movement stops when a dynamic equilibrium is achieved.



# Diffusion Pressure

❖ The potential ability of a substance to move from a region of high concentration to a region of low concentration when the temperature and atmospheric pressure is constant, is known as diffusion pressure.

❖ For example, the diffusion pressure of air inside a balloon is higher than the diffusion pressure of the air outside. Consequently, if the balloon bursts, the air inside the balloon spreads throughout the surrounding air due to its higher diffusion pressure.



# Factors influencing the rate of diffusion

### 1. Concentration Gradient

- Solutes move from an area of high concentration to one of lower concentration.

The rate of diffusion is directly proportional to the concentration gradient.

- The greater the difference in concentration between two areas, the greater the rate of diffusion.
- if the gradient is zero, there will be no net diffusion.

## Factors influencing the rate of diffusion

### ii. Molecular Speed

- atoms and molecules are always in motion at temperatures above absolute zero
- Molecular speed is directly proportional to temperature

### iii. Temperature

- increases the rate of molecular movement
- therefore, increases the rate of diffusion

### iv. Pressure

increases speed of molecules  
increase the rate of diffusion

### v. Size of molecules or ions

- Generally, the larger the molecule or ion, the slower

# PHYSICO-CHEMICAL PROPERTIES OF WATER

## Osmosis

If two solutions of different concentration are separated by a semi-permeable membrane then the solvent will tend to diffuse across the membrane from the less concentrated to the more concentrated solution. This process is called osmosis.

□ Osmosis may also be defined as the movement of solvent *from high concentration (water) to low concentration across a semipermeable membrane.*

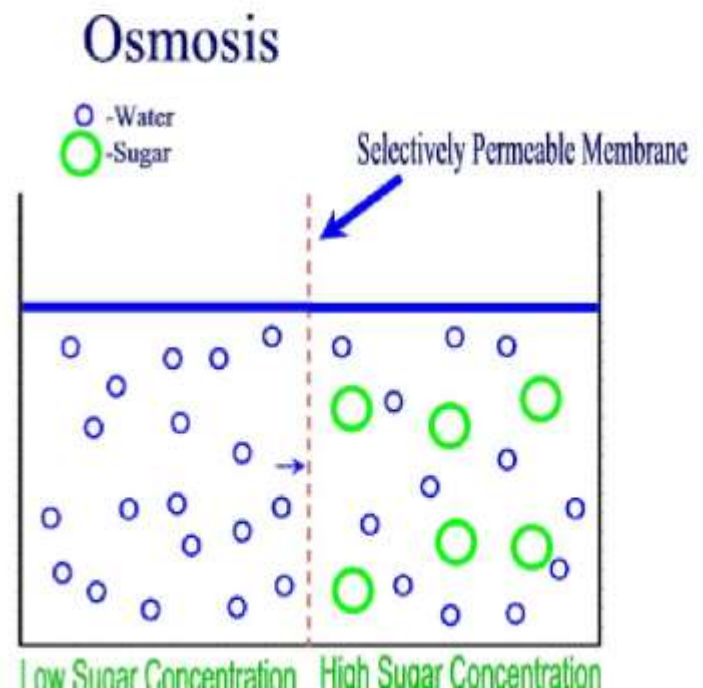
□ Osmosis to occur :

– two solutions of the same solvent.

– separated with selectively permeable membrane

– pressure and concentration

Difference in concentration between solutions on either side of semi permeable membrane called concentration gradient



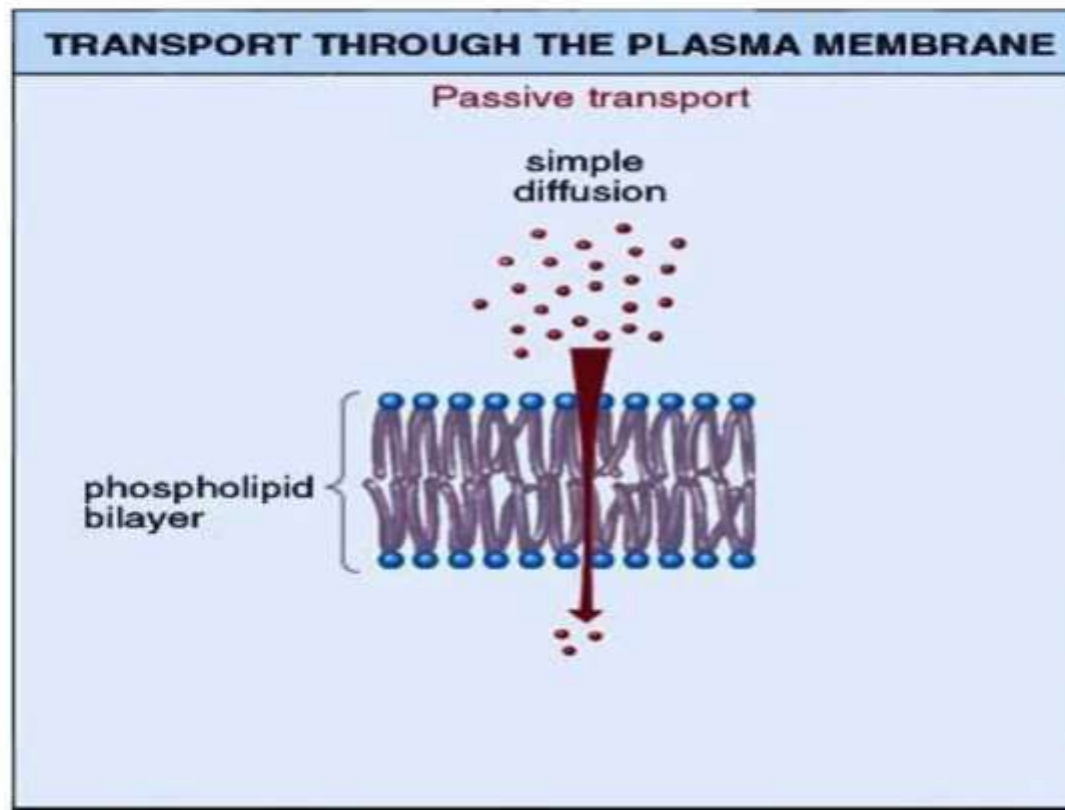
## Osmosis – A Special kind of Diffusion

Diffusion of water across a selectively permeable membrane (a barrier that allows some substances to pass but not others).

The cell membrane is such a barrier.

Small molecules pass through – ex: water

Large molecules can't pass through – ex: proteins and complex carbohydrates

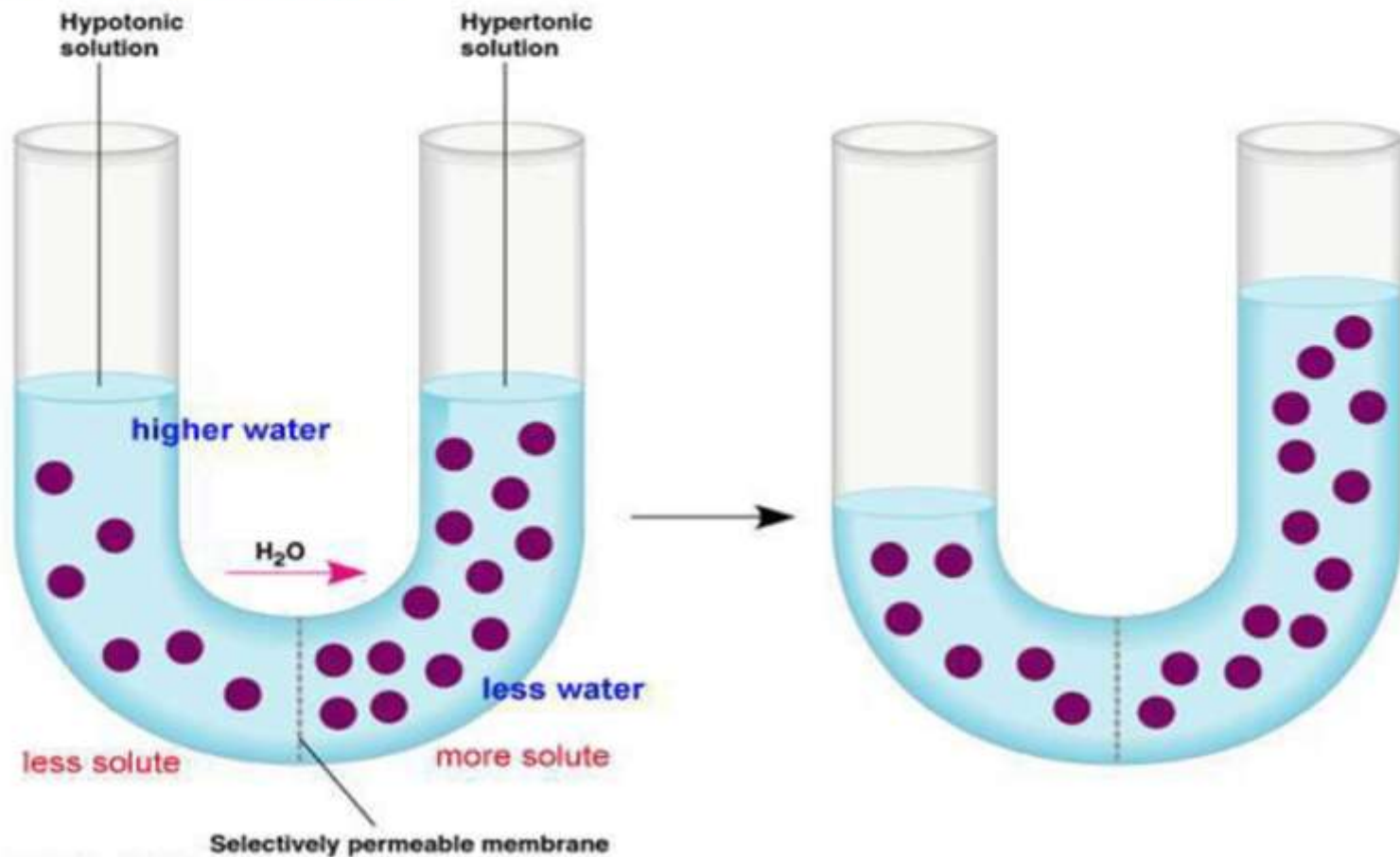


## **HYPOTONIC, HYPERTONIC & ISOTONIC SOLUTION**

- **The direction of movement of substances across the plasma membrane in the cell depends on the concentration of the solution around it.**
- **There are 3 types of solution;**
  - **hypotonic solution,**
  - **hypertonic solution**
  - **isotonic solution.**

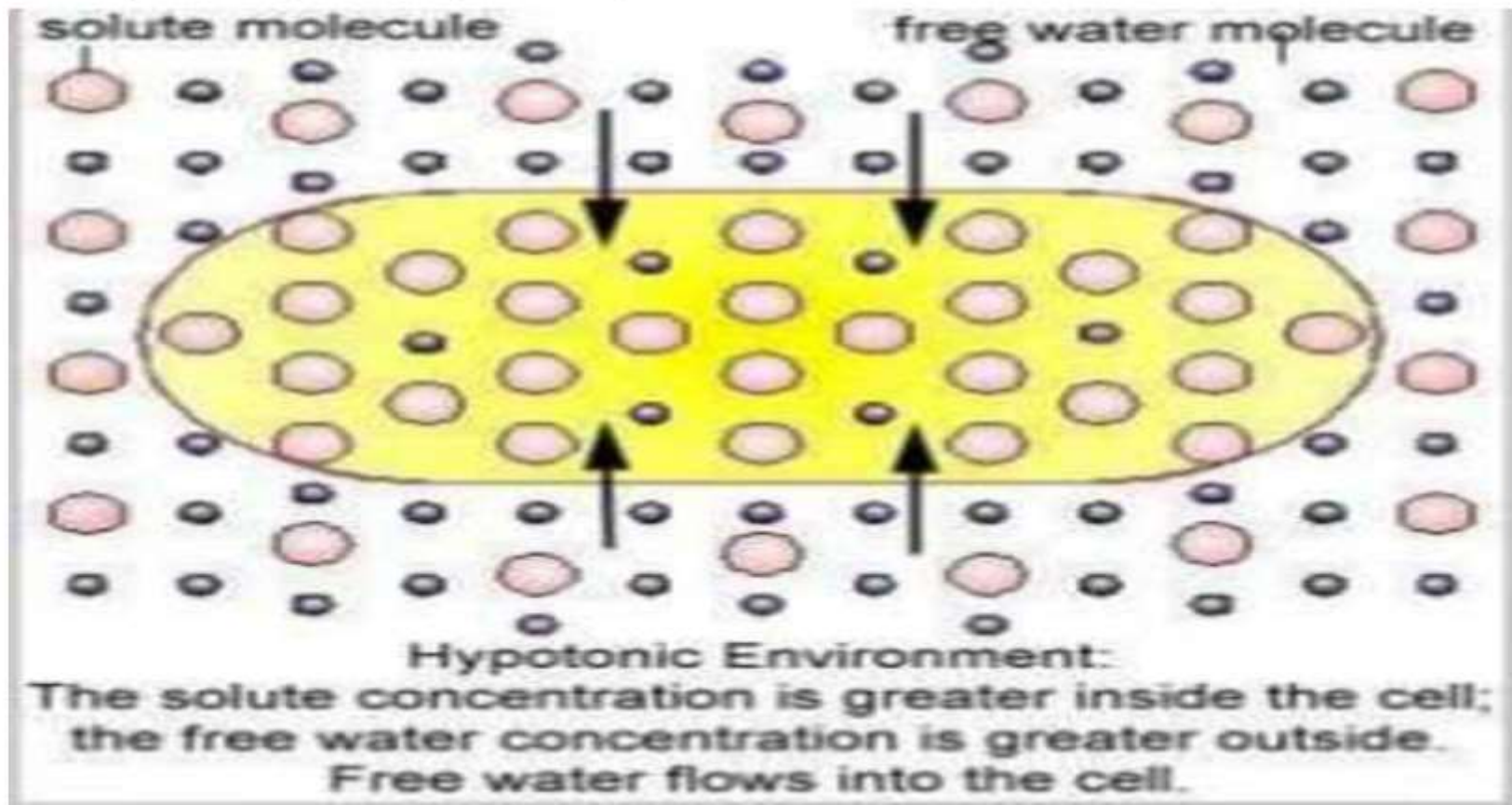
## Hypotonic solution –

The solution on one side of a membrane where the solute concentration is less than on the other side. **Hypotonic Solutions contain a low concentration of solute relative to another solution.**



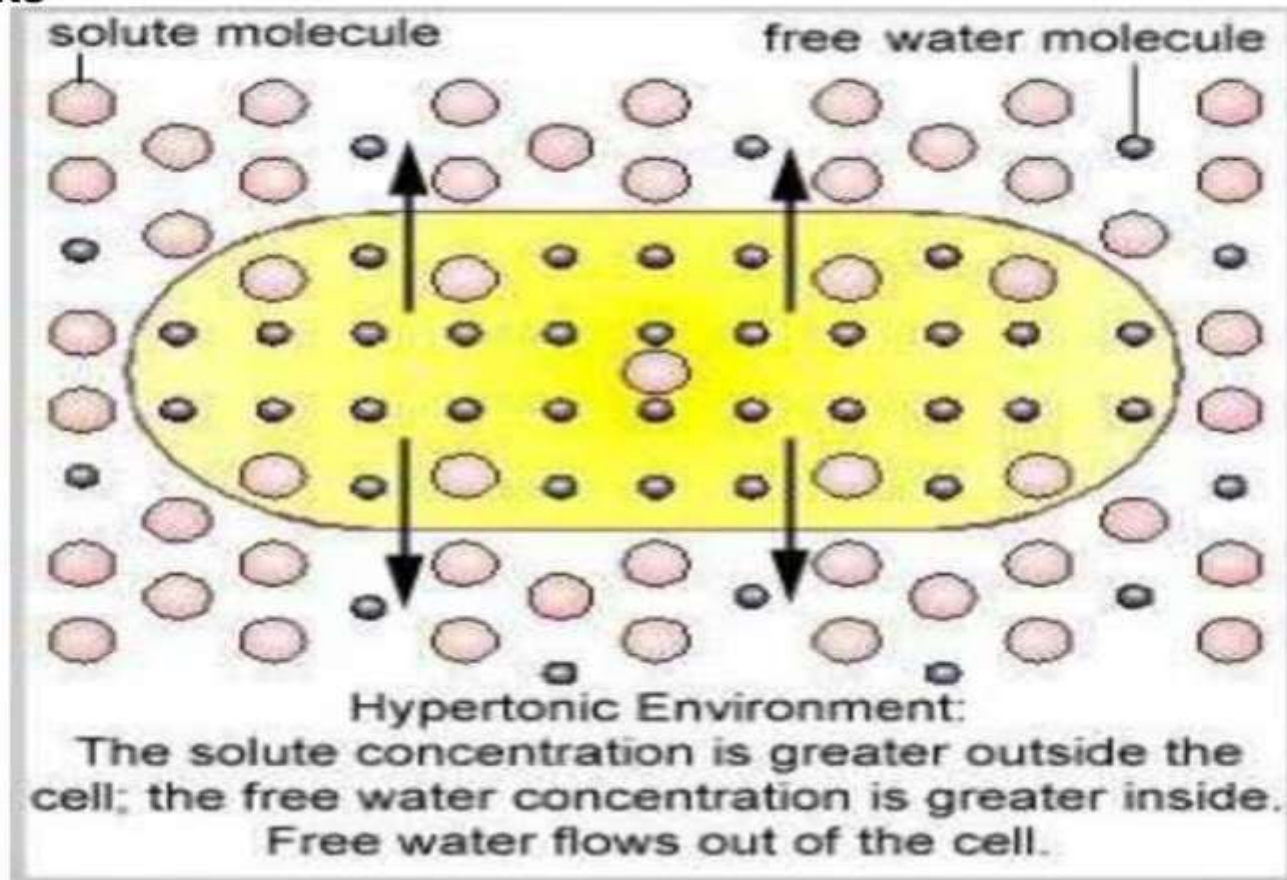
## HYPOTONIC SOLUTION :

- A solution that contains a *LOWER* concentration of solute molecules (*HIGHER* concentration of water molecules) than the other solution (cell).
- Cell expands (or may burst)



## HYPERTONIC SOLUTION :

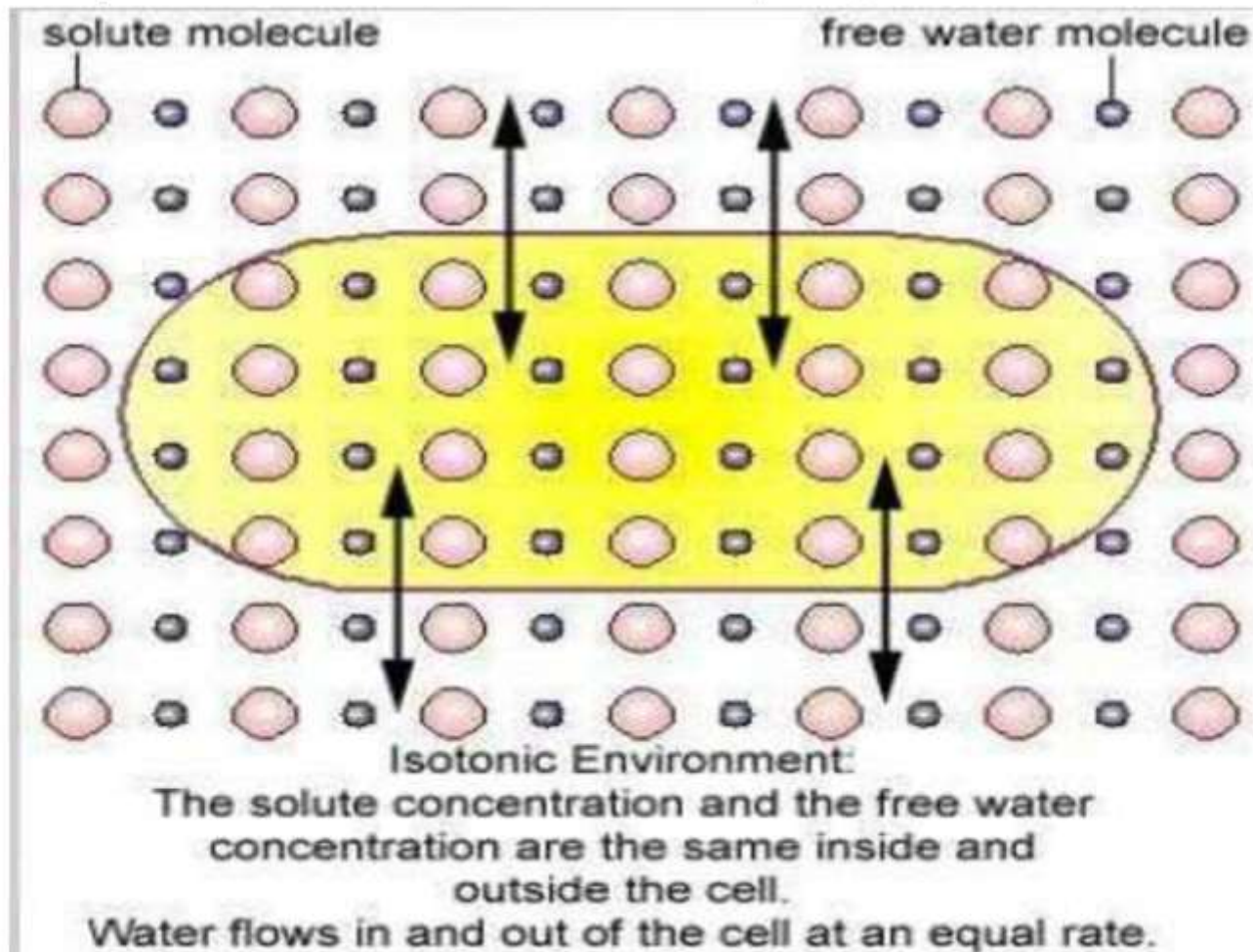
- A solution that contains a *HIGHER concentration of solute molecules* (*LOWER concentration of water molecules*) than the other solution (cell).
- Cell shrinks





## ISOTONIC SOLUTION :

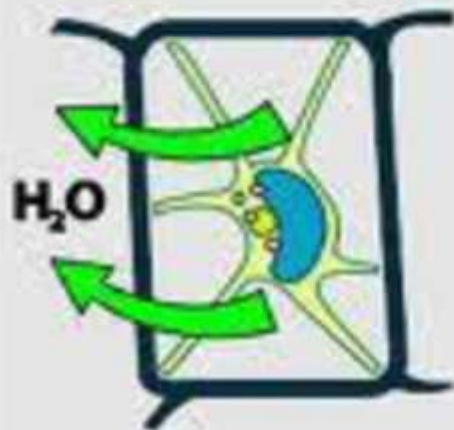
A solution has the *SAME solute concentration (EQUAL water concentration)* than the other solution (cell).



## Osmosis: Its Type

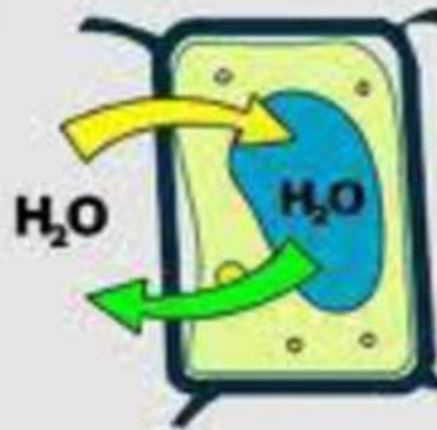
- Cytoplasm is a solution of water and solids (solutes dissolved in the water).
- Water moves into and out of cells because of the different concentrations of the solutes.
- Different kinds of cells react differently depending on the solution they are in.
- Below are examples of cells in different types of solutions

Hypertonic



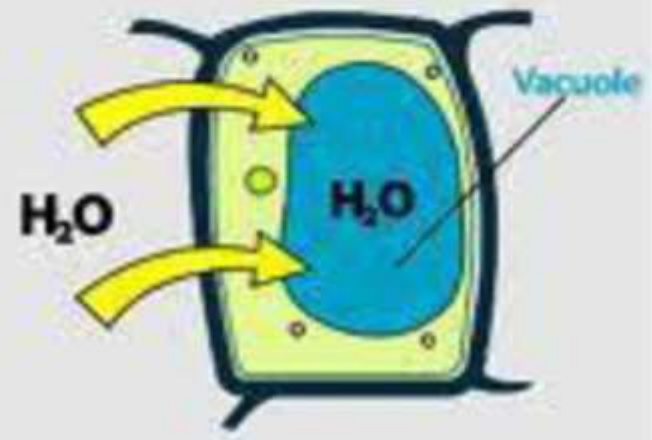
Plasmolyzed

Isotonic



Flaccid

Hypotonic



Turgid

## Osmosis: Its Type

- If the solution is hypotonic water will move into the cell from the solution. This process is called **Endosmosis**.
- Due to endomosis the cell becomes fully turgid.
  - If the solution is hypertonic, water will move away from cell . This process is called **exosmosis**.

Due to exosmosis cell causes plasmolysis ( the cell membrane pulls away from the cell wall. The cell wall stays intact. )

If the solution is isotonic, no osmosis the cell is not plasmolysed, but it is not fully turgid either.

# PHYSICO- CHEMICAL PROPERTY OF WATER

## Importance of Osmosis

- Absorption of water from the soil by the root hair cell.
- Opening and closing of stomata.
- Distribution of water from cell to cell.
- Growth of cells.
- Seed germination.
- Cell division.
- Giving firmness to the cell.
- Controlling the rate of transportation .

# Difference among Diffusion, Osmosis and Imbibition

## Diffusion

1. It refers to the movement of molecules ions of solids, liquids or gases from the region of higher to lower concentration.
2. It occurs in all states of matter. ie; solids, liquids or gas.
3. It's not a reversible process.
4. No need of semi-permeable membrane.
5. It takes place solid, liquids and gases.

## Osmosis

1. It refers to the absorption of water by general surface.
2. It happens only in the liquid state.
3. It's not a reversible process.
4. It requires semi-permeable membrane.
5. It takes place only for the solvent part of the solution

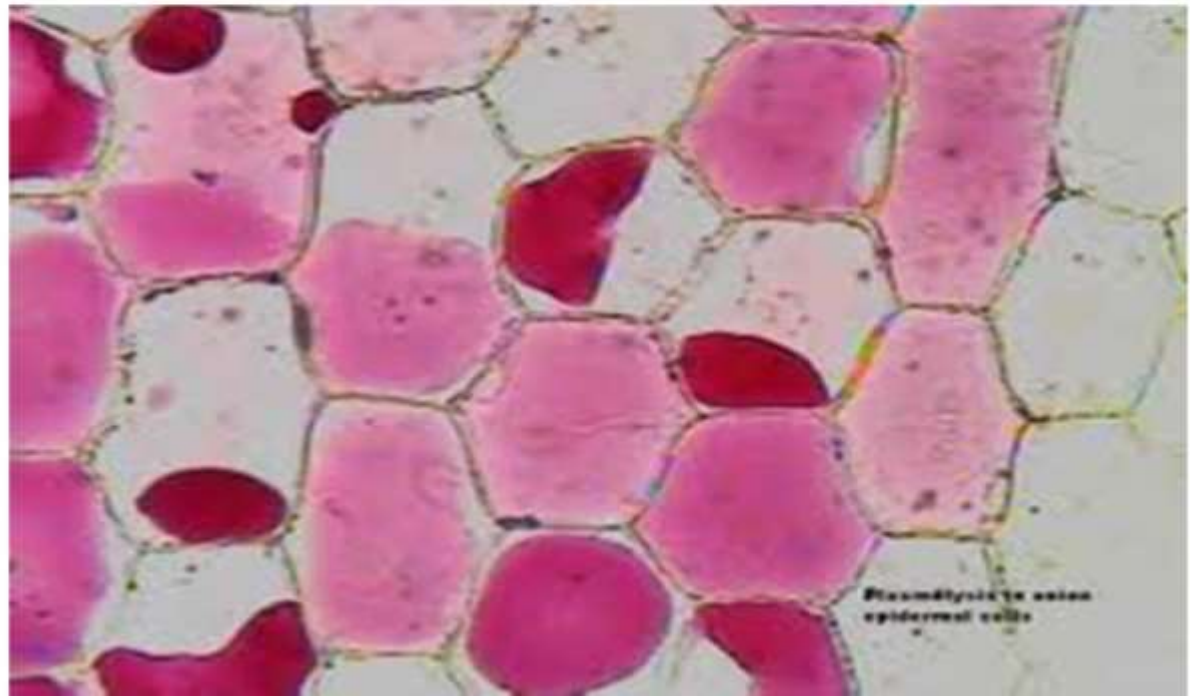
## Imbibition

1. It is the movement of only water or solvent from higher concentration area to lower concentration area.
2. It happens in the liquid state.
3. It's a reversible process.
4. An absorbent is involved but there is no membrane.
5. It takes place both living and dead cells.

# PHYSICO- CHEMICAL PROPERTY OF WATER

## Plasmolysis :

- In normal condition the protoplasm is tightly pressed against the cell wall.
- If this plant cell or tissue is placed in a hypertonic solution water comes out from the cell sap into the outer solution due to exosmosis and the protoplasm begins to contract from the cell wall.
- This is called as primary plasmolysis.



# PHYSICO- CHEMICAL PROPERTY OF WATER

## Plasmolysis :

- If the outer hypertonic solution is very much concentrated in comparison to the cell sap the process of exosmosis and contraction or shrinkage of protoplasm continues and ultimately the protoplasm separates from the cell wall and assumes a spherical form, this phenomenon is called as plasmolysis and the tissue is said to be plasmolysed

# PHYSICO- CHEMICAL PROPERTY OF WATER

## Deplasmolysis :

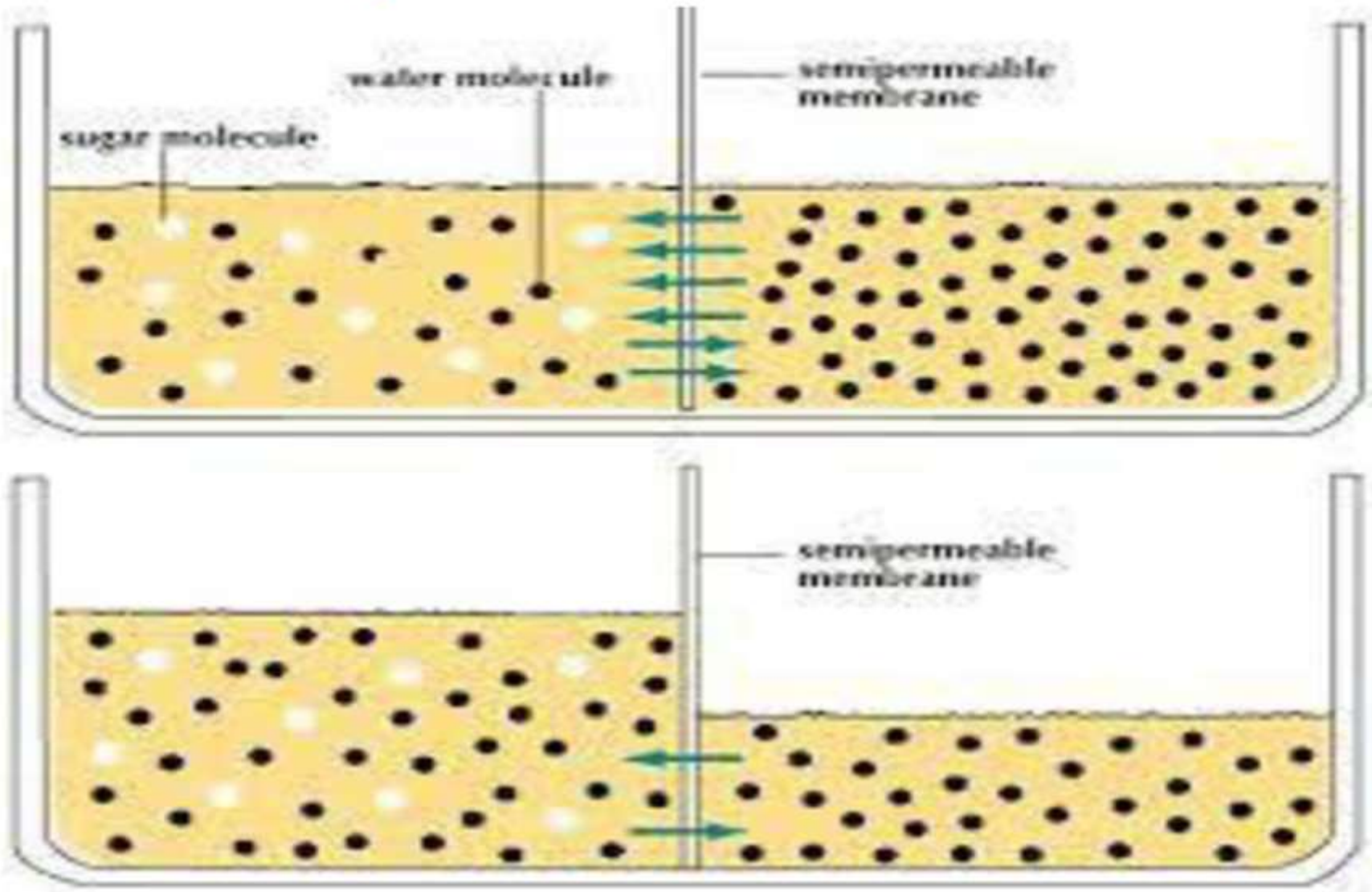
- If a plasmolysed cell or tissue is placed in water the process of endosmosis takes place.
- Water enters into the cell sap the cell becomes turgid and the protoplasm again assumes its normal shape and position. This phenomenon is called as **deplasmolysis**.





# PHYSICO-CHEMICAL PROPERTY OF WATER

## Permeability



# PHYSICO- CHEMICAL PROPERTY OF WATER

## Permeability

- It is the ability of a membrane to permit transport through it.
- In living cells, permeability refers to the passage of water and solutes through the plasma-membranes (cytomembranes).
- However, it should be noticed that the passage of dissolved solutes across membranes is independent of the passage of water and the passage of water and the entrance of solutes both proceed towards their own equilibrium and is controlled by the demand of each individual cell.

# PHYSICO- CHEMICAL PROPERTY OF WATER

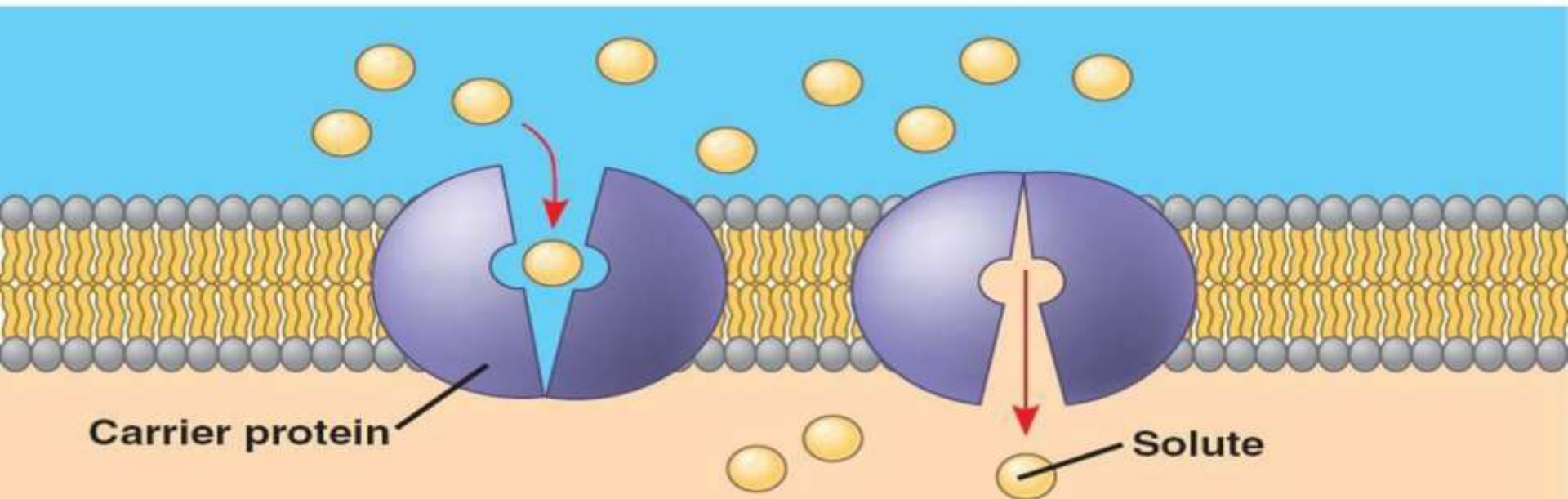
## Permeability

- The structure and composition of plasma membrane play an essential role in determining and controlling the rate by which the permeating substance can pass through the membrane.
- The plasma membrane is essentially a lipid bilayer modified by proteins i.e. is a mosaic structure of lipo-proteins.

## Permeability

### Selective permeability

- It means that plasma membrane can permit for specific ion to permeate across it at very high rate and another to permeate at very low rate at equal concentration of both ions in the medium.
- Due to this selectivity in ion absorption, some ions may be absorbed and accumulated inside the cell at concentration much greater than that in the external medium which means that these ions are absorbed against their concentration gradient, i.e. from the side of low to the side of high concentration.



## Permeability

### Selective permeability

- On the other hand, some other ions may present at relatively high con. in the medium and permeated at very low rate and the cells maintain very low con. of these ions inside the cell.
- For example, in the marine alga *Ulva lactuca*, it is found that the con. of  $K^+$  was 80 mM and that of  $Na^+$  10 mM inside the cell whereas their con. in the seawater are 10 and 500 mM respectively.
  - The absorption of same ions i.e.  $K^+$  against its con. gradient indicates that the absorption of such ions is an active process.
  - The **active absorption** of ions mediated by the carrier molecules derived its energy from the metabolic energy of the plant cell.
  - Thus selective permeability of the cellular membranes is dependent on the metabolic activities of living cells and it will be lost if the plant cell is treated with metabolic inhibitors or killed.

# Types of transport across the plasma membrane

Solute move across the plasma membrane by two main process:

- a) Passive transport- which does not require a cell to use energy.
- b) Active transport- which requires a cell to use energy to move molecules through its cell membrane.

## Passive Transport

- Passive transport is a means of moving biochemicals, and other atomic or molecular substances, across membranes.
- This process does not involve chemical energy.
- Passive transport is dependent on the permeability of the cell membrane, which, in turn, is dependent on the organization and characteristics of the membrane lipids and proteins.

Passive transport consists of:

- a) Osmosis is the special name given to simple diffusion of water molecules through a semipermeable membrane.
- b) Simple diffusion and
- c) Facilitated diffusion (aided by carrier protein or channel protein of the plasma protein).

**THANK YOU**