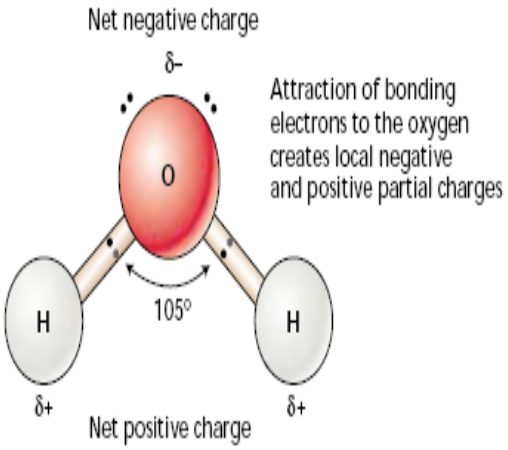
02. Role and significance of water

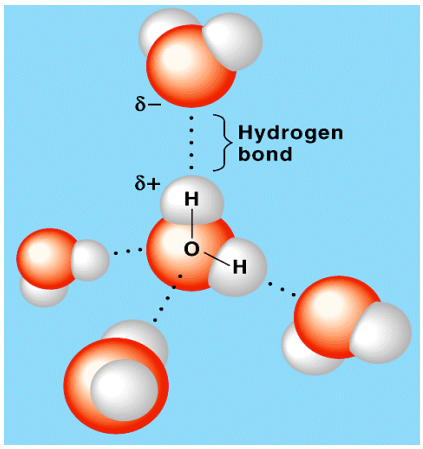
Water is said to be the liquid of life. Because, life is originated in organs, environmental and in the course of evolution it became fully dependent upon water in a number of ways. Water is one of the most plentiful chemicals available in the earth and the chemical formula is H_20. It is a tiny V-shaped molecule contains three atoms do not stay together as the hydrogen atoms are constantly exchanging between water molecules

The water molecule consists of an oxygen atom covalently bonded to two hydrogen atoms. The two O—H bondsform an angle of 105° (Figure). Because the oxygen atom is more **electronegative** than hydrogen, it tends to attract the electrons of the covalent bond. This attraction results in a partial negative charge at the oxygen end of the molecule and a partial positive charge at each hydrogen.

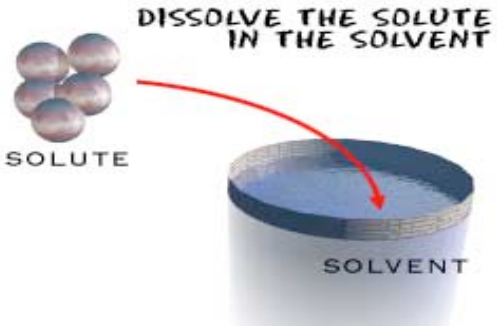
Water has special properties that enable it to act as a solvent and to be readily transported through the body of the plant. These properties derive primarily from the polar structure of the water molecule.

- The Polarity of water molecules gives rise to hydrogen bonds
- The Polarity of water makes an excellent solvent
- The Thermal properties of water result from hydrogen bonding
- The Cohesive and adhesive properties of water are due to hydrogen bonding





- Solute: type of molecule dissolved in another type of substance; that substance is called a...
- Solvent: substance that dissolves the solute



Importance of water to plants

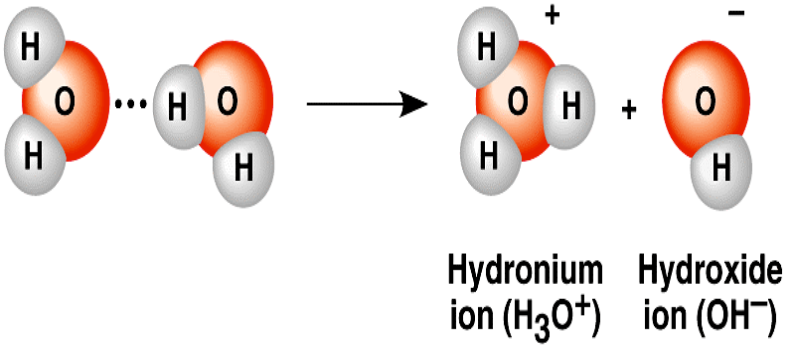
- Water typically constitutes 80 to 95% of the mass of growing plant tissues.
- Water is the main constituent of protoplasm comprising up to about 90-95 per cent of its total weight. In the absence of water, protoplasm becomes inactive and is even killed.
- Different organic constituents of plants such as carbohydrates proteins, nucleic acid and enzymes etc. Lose their physical and chemical properties in the absence of water.
- Water participates directly in many metabolic processes. Inter conversion of carbohydrates and organic acids depend upon hydrolysis and condensation reaction.
- Water increases the rate of respiration. Seeds respire fast in the presence of water.
- Water is the source of hydrogen atom for the reduction of CO_2 in the reaction of photosynthesis.

CONCENTRATION EXAMPLES

- High solute concentration: lots of sugar dissolved in a relatively small amount of water
- Low solute concentration: little sugar dissolved in a relatively high amount of water

- Water acts as a solvent and acts as a carrier for many substance. If forms the medium in which several reactions take place.
- Water present in the vacuoles helps in maintaining the turgidity of the cells which is a must for proper activities of life and to maintain this from and structure.
- Water helps in translocation of solutes
- In tropical plants, water plays a very important role of thermal regulation against high temperature.
- The elongation phase of cell growth depends on absorption of water.

"Dissociation" of water



Properties of water

1. Solvent for electrolyte & non electrolyte
2. High specific heat
3. High latent heat of vaporization (540 cal g-1)
4. Cohesive and Adhesive Properties
5. High surface tension
6. High Tensile Strength
7. Stabilizes temperature
8. Transparent to visible radiation
9. Low viscosity

CONCENTRATION

- Concentration refers to how much of some substance is present, compared to another substance.
- For instance, a high solute concentration has a relatively high amount of solute and low amount of solvent.

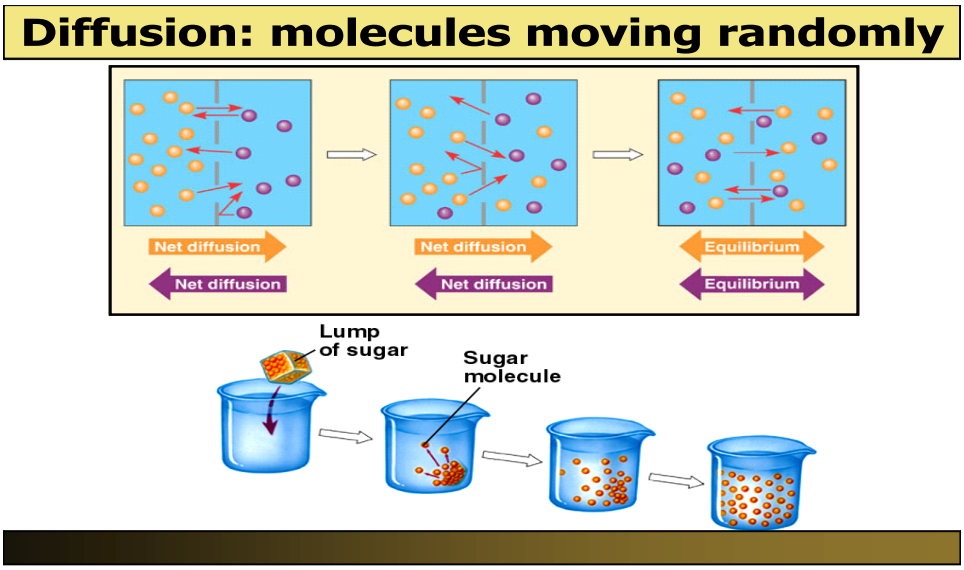
HOW IT HELPS IN PLANTS?

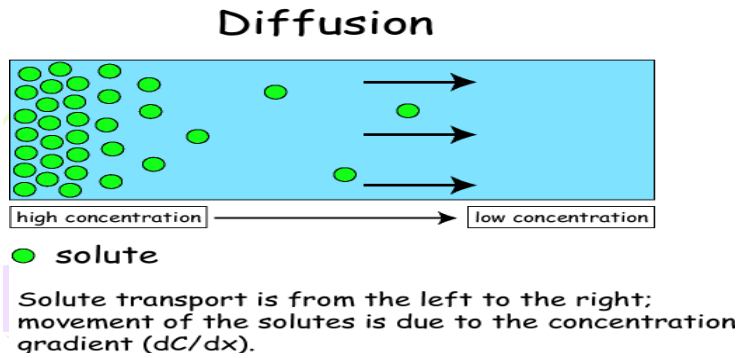
WATER PLAYS A CRUCIAL ROLE in the life of the plant. For every gram of organic matter made by the plant, approximately 500 g of water is absorbed by the roots, transported through the plant body and lost to the atmosphere. Even slight imbalances in this flow of water can cause water deficits and severe malfunctioning of many cellular processes. Thus, every plant must delicately balance its uptake and loss of water.

REMEMBER!

- Solutes can be many different kinds of molecules (sugars, gases, nutrients, proteins, and lipids)
- Solvents can vary as well (solids, liquids, or gases), but are usually H_2O

Diffusion, osmosis and imbibitions





The movement of materials in and out of the cells in plants taken place in a solution or gaseous form. Although the exert process of this is not very clear, three physical process are usually involved in it. They are diffusion, osmosis and imbibition.

The movement of particles or molecules from a region of higher concentrations to a region of lower concentration is called as diffusion. The rate of diffusion of gases is faster than liquids or solutes. The diffusion particles have a certain pressure called as the diffusion pressure which is directly proportional to the number as concentration of the diffusing particles. These forms the diffusion takes place always from a region of higher diffusion pressure to a region of lower diffusion pressure (i.e) along a diffusion pressure gradient. The rate of diffusion increases if,

i) Diffusion pressure gradient is steeper

ii) Temperature is increased

iii) Density of the differing particles is lesser

iv) Medium through which diffusion occurs is less concentrated.

Diffusion of more than one substance at the same time and place may be at different rates and in different direction, but is independent of each other. A very common example of this is the gaseous exchange in plants.

Beside osmotic diffusion the above mentioned simple diffusion also plays a very important role in the life of the plants.

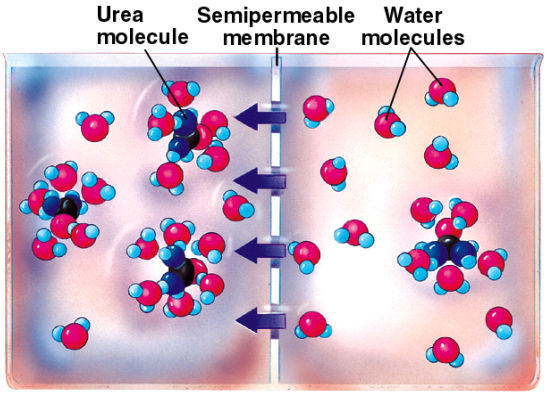
- It is an essential step in the exchange of gases during respiration and photosynthesis
- During passive salt uptake, the ions are absorbed by diffusion
- It is important in stomatal transpiration as the last step in the pollen, where diffusion of water vapour from the interrelation space into the outer atmosphere occurs through open stomata.

Osmosis

The diffusion of solvent molecules into the solution through a semi permeable membrane is called as osmosis (some times called as *Osmotic diffusion*). In case there are two solutions of different concentration separated by the semi permeable membrane, the diffusion of solvent will take place from the less concentrated suitable into the more concentrated solution till both the solutions attain equal concentration.

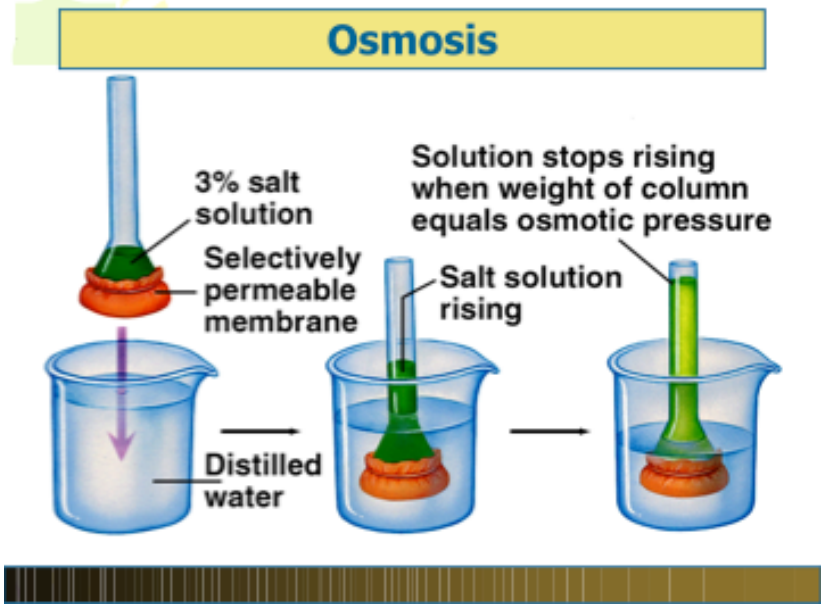
What happens in osmosis

- **Osmosis is the diffusion of water across selectively permeable membranes.**

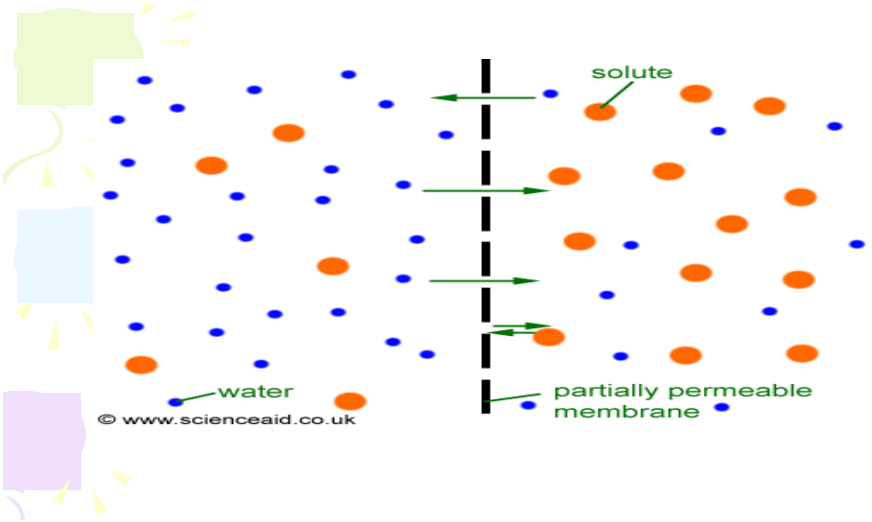


Osmotic pressure

As a result of the separation of solution from its solvent (or) the two solutions by the semi permeable membrane, a pressure is developed in solution to the pressure by dissolved solutes in it. This is called as osmotic pressure (O.P). OP is measured in-terms of atmospheres and is directly proportional to the concentration of dissolved solutes in the solution. More concentration solution has higher O.P. O.P of a solution is always higher than its pure solvent.



During osmosis, the movement of solvent molecules taken place form the solution whose osmotic pressure is lower (i.e less concentration as hypotonic) into the solution whose osmotic pressure is higher (i.e, more concentrated as hypertonic). Osmotic diffusion of solvent molecules will not take place if the two solutions separated by the semipermeable membrane are of equal concentration having equal *Osmotic pressures* (i.e., they are isotonic). In plant cells, plasma membrane and tonoplant act as selectively permeable or differentially permeable membrane.



End-osmosis

Of a living plant cell is placed in water or hypotonic solution whose O.P is lower than cell sap, water in-terms into the cell sap by osmosis and the process is called end osmosis. As a result of entry of water with the cell sap, a pressure is developed which press the protoplasm against the cell wall and become turgid. This pressure is called a turgor pressure.

Consequence of the turgor pressure is the wall pressure which is exerted by the elastic cell wall against the expanding protoplasm. At a given time, turgor pressure (T.P) equals the wall pressure (W.P).

T.P = W.P

Exosmosis

If on the other hand, the plant cell is placed in hypertonic solution (whose O.P is higher than cell sap) the water cover out the cell sap into the outer solution and the cell becomes flaccid. This process is known as exosmosis. Cell (or) tissue will remain as such in isotonic solution.

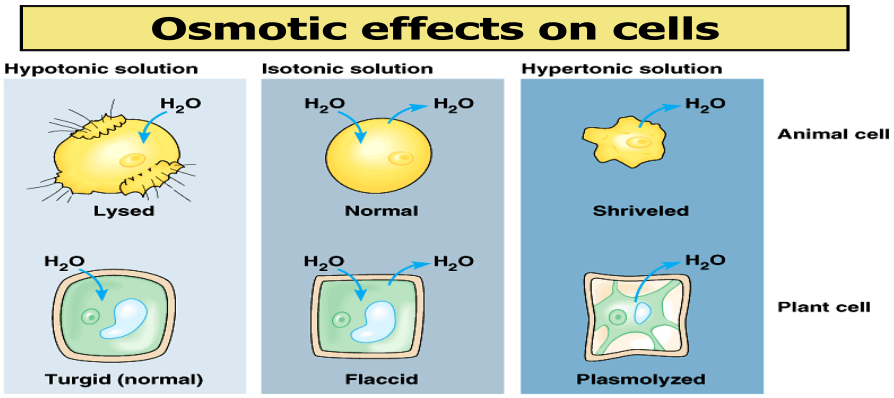
Significance of osmosis in plants

1. Large quantities of water are absorbed by roots from the soil by osmosis
2. Cell to cell movement of water and other substances dissolve is involves osmosis
3. Opening and closing of stomata depend upon the turgor pressure of guard cells
4. Due to osmosis, the turgidity of the cells and hence the shape or from of them organs is maintained.
5. The resistance of plants to drought and frost increases with increase in osmotic pressure to later cells
6. Turgidity of the cells of the young seedling allows them to come out of the soil.

hypotonic - solution whose osmotic pressure is lower (less concentration)

hypertonic - solution whose osmotic pressure is higher (more concentration)

isotonic - diffusion of solvent molecules will not take place



Imbibition

Certain substances if placed in a particular liquid absorb it and swell up. For example, when some pieces of grass or 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, certain force of attraction is existing between imbibants and the involved substance. In plants, the hydrophilic colloids *viz*., protein and carbohydrates such as starch, cellulose and pectic substance have strong altercation towards water.

Imbibition plays a very important role in the life of plants. 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. Dry seeds require water by imbibition for germination.

As a result of imbibition, a pressure is developed which is called as imbibition pressure or matric potential (ψ_m). It is analogous to the osmotic potential of a solution. With reference to pure water, the values of ψ_m are always negative. The water potential of an imbibant is equal to its matric potential plus any turgor or other pressure (pressure potential) which may be imposed upon the imbibant.

$$\psi_w = \psi_m + \psi_P$$

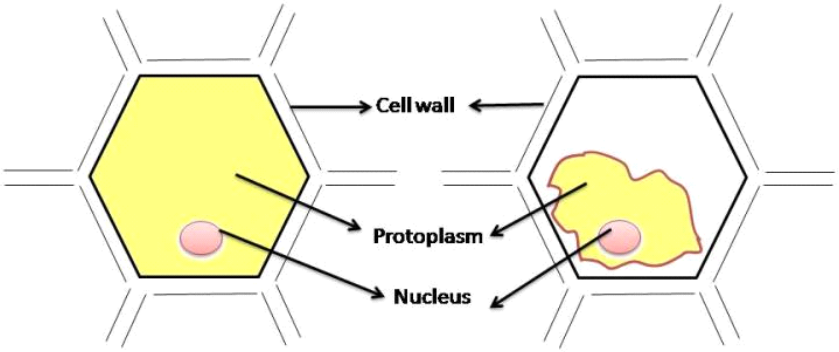
If the imbibant is unconfined to turgor or such pressure, the equation can be significant to

$$\psi_w = \psi_m$$

Plasmolysis

When a plant cell or tissue is placed in a hypertonic solution water cover out from the cell sap into the outer solution of exosmosis and the protoplasm begins to sprinkler or contract. The protoplasm separate from the cell wall and assures a spherical form and them phenomenon is called plasmolysis. Incipient plasmolysis is stage where protoplasm begins to contract from the cell wall. If a plasmolysed cell in tissue is placed in water, the process of endosmosis take place. Water enters into the cell sap, the cell becomes turgid and the protoplasm again assumes it normal shape and position. This phenomenon is called deplasmolysis.

Diagrammatic view of normal plant cell and plasmolysed plant cell



Normal plant cell **Plasmolysed plant cell**

Advantages of plasmolysis

1. It indicates the semi permeable nature of the plasma membrane.
2. It is used in determine the osmotic pressure of the cell sap.
3. Plasmolysis is used in salting of meat and fishes. Addition of concentrated sugar solution to jam and jellies check the growth of fungi and bacteria which become plasmolysed in concentrated solution.