Principles of Plant Physiology

Unite I

Plant - water relationships &

Transport, translocation of water and solutes

Water plays a crucial role in the life of plant

The Importance of Water in Plant Life.

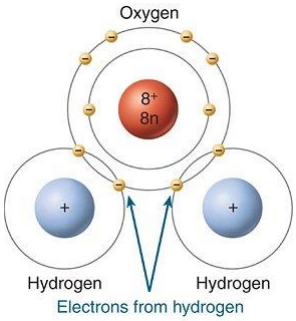
Facts !

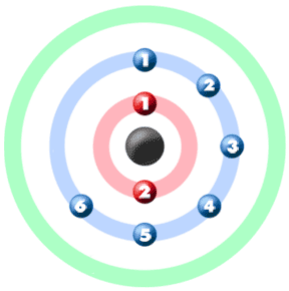
1. Water is the most abundant and **best solvent** known.
2. Helps in movement of molecules within the cell.
3. Influences structure of proteins, nucleic acids, polysaccharides *etc*.
4. Forms environment in which most biochemical reactions of the cell occur.
5. Directly participates in chemical reactions.
6. Builds up hydrostatic pressures - turgor pressure - within the cell due to cell wall.

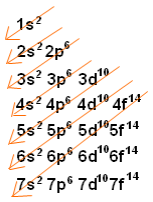
❖ Turgor pressure is important for cell enlargement, gas exchange, transport processes, rigidity and stability of non-lignified plant tissue.

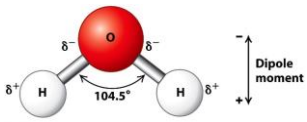
Properties of Water

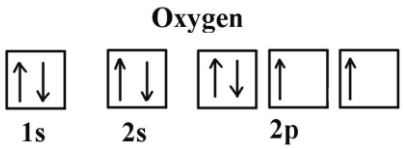
1. Water is a Polar Molecule











Water is a Polar Molecule !

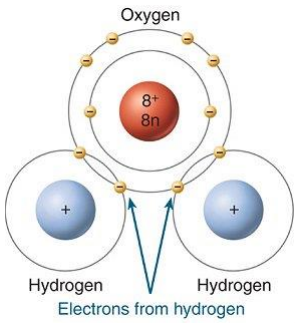
Why water molecule is polar?

In the covalent bond between oxygen and hydrogen, although the electrons are shared between O_2 and H , the sharing is not equal.

*** Why is not equal?**

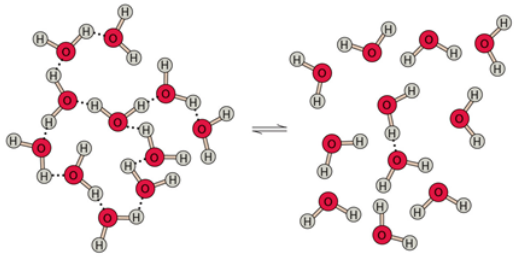
 # Oxygen (O_2) has a **stronger pull on electrons** than the **Hydrogen** (H). Therefore , the electrons **spend more time near the oxygen**, making the oxygen part of atom **slightly negative**.

Since the **electrons are not near the hydrogens** as much, the part of the molecule (H) is **slightly positive**.



The Polarity of Water Molecules Gives Rise to Hydrogen Bonds

(A) Correlated configuration (B) Random configuration



Hydrogen bonding between water molecules results in local aggregations of water molecules.

Because of continuous thermal agitation of water molecules, these aggregations are short-lived.

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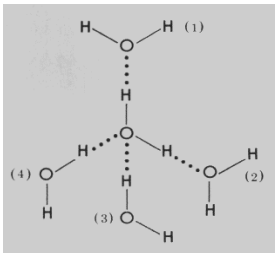

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2. Water is an Excellent Polar Solvent

❖The **polarity** of the water molecule gives it the ability to dissolve polar molecules as well as less-polar molecules.

❖Water dissolves the widest range of chemical solutes. This makes water a medium for chemical transport and exchange.

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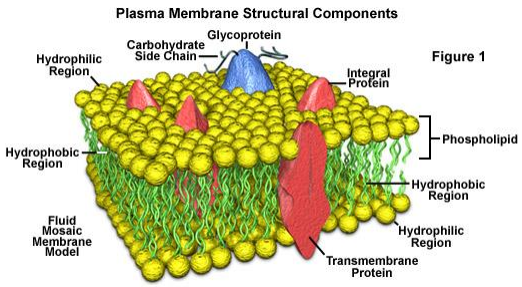
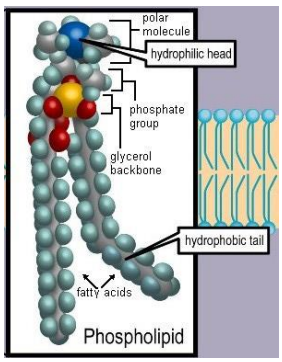
• In Plants :- examples

A- Water dissolves soil minerals and carries them up the plant in the transpiration stream in the xylem.

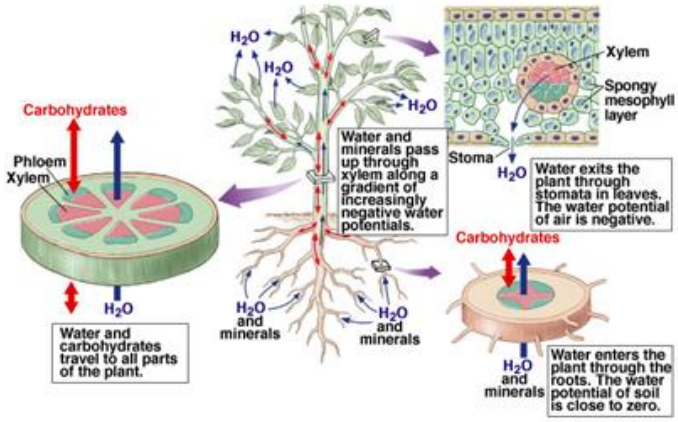
B- Photosynthesis produces carbohydrates which are dissolved in water and carried from the leaf to the rest of the plant in the translocation stream in the phloem.

C- Solubility in water causes phospholipids to orient themselves into membrane bilayers, and causes amino acid R-groups to twist in space to bring about protein conformation.





Water Movement Through A Plant



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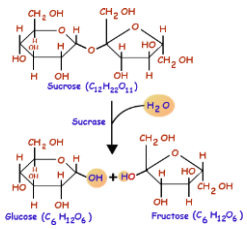
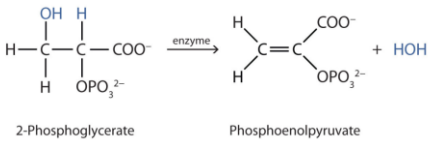
3. Water is Reactive

Water serves as a medium for chemical reactions, and also react chemically with solutes.

A. hydrolysis reaction **B. dehydration reaction**





- Water is a reactant in photosynthesis (CO_2 + $\underline{H_2O}$ + light → O_2 + CH_2O) and a product of respiration (CH_2O + O_2 → CO_2 + $\underline{H_2O}$ + energy).

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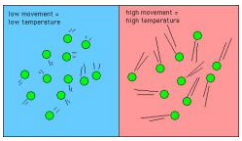
4. Water has high specific heat

- The polarity of water and the resulting hydrogen bonding among water molecules means that it takes much heat (one calorie) to raise the temperature of 1 ml of water just 1°C.

- The hydrogen bonding has to be given a lot of energy to get them to vibrate and generate the temperature change. This property of water is called "**specific heat**".



- any matter has a temperature associated with it. The temperature of matter is a direct measure of the motion of the molecules: The greater the motion the higher the temperature.

- The hydrogen bonding has to be given a lot of energy to get them to vibrate and generate the temperature change. This property of water is called "**specific heat**".

Specific Heats of Some Common Substances

Substance	Specific Heat [cal/(g · °C)]
Water (liquid)	1.00
Water (solid)	0.50
Water (gas)	0.47
Ethyl alcohol	0.54
Wood	0.42
Aluminum	0.21
Glass	0.12
Iron	0.11
Copper	0.09
Silver	0.06
Gold	0.03

What does it means?!

It means:-

A. Water can absorb much heat from the various chemical reactions occurs in cells without temperature change (Rise).

B. It helps maintain an even plant body temperature.

5. Water has a high latent heat of vaporization

(The input energy required to change the state from liquid to vapor at constant temperature).

Water has the highest latent heat of vaporization 2,260 kJ/kg, which is equal to 40.8 kJ/mol

This means:-

When water goes from liquid to gas it takes a lot of energy

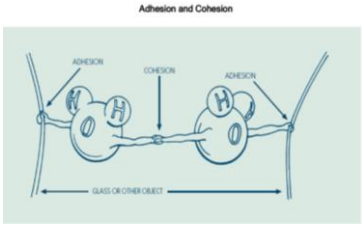
Evaporative cooling

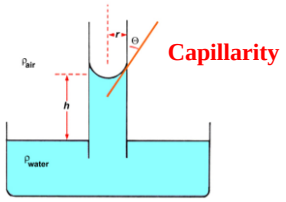
6. Water demonstrates adhesion and cohesion

The partial polarity of the water molecule makes it attractive to polar and less-polar surfaces.

A. Adhesion ⟶ Water adheres to and climbs up materials like glass.

B. Cohesion ⟶ Water molecules attract each an other.

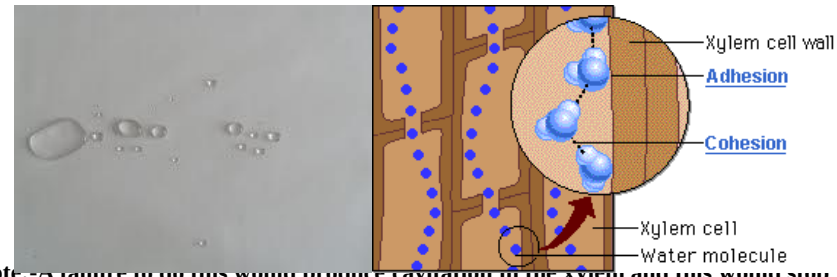




7. Water has high tensile strength

❖The cohesive property of water keeps the column of water in the xylem unbroken all the way up to the top of a tree.

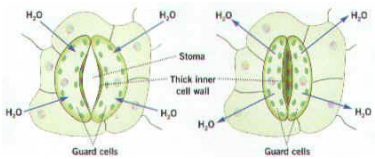
❖This property play a major role in the continues transportation of water from roots to lives.



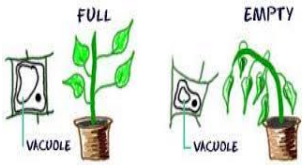
- **Note: A failure to do this would produce cavitation in the xylem and this would stop all flow of water up the tree in that column of xylem elements.**

8. Water is non-compressible

❖Opening and closing of stomata.



❖Rigidity and support for herbaceous plant.



9. Water is commonly available

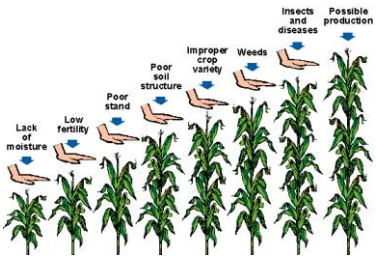
Water cycle, rainfall and ground water are linked through the transpiration and evaporation from plants

Vacuole water provides up to 90% of the volume of a cell. Perhaps 5% more is found in the water of the cytosol

plants is an excellent "diet food

10. Water can be limiting to growth

❖A drought is common in late summer and can reduce the yield of crop plants quite significantly.



Why?

❖Because plants need water for photosynthesis, for evaporative cooling, and *etc*.

Note:-In a warm, dry, sunny day a plant can lose 100% of its water content in an hour!

Membranes

Permeability is different among membranes, and could be classified into two types.

1. Impermeable membranes:- Do not allow any particles to pass through them, like glass and polyester.

2. Semi permeable membranes:- Membranes may allow some substances to pass, but not the others according to the size of molecules, like cellophane and the biological membranes. They are selective for molecules that pass through them. Also called partial, selective or differential permeable membrane.

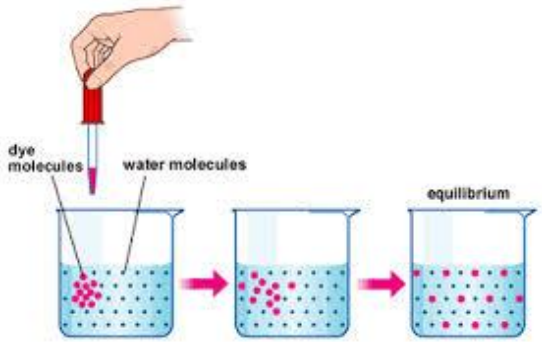
Water Transport Processes

There are two major ways to move molecules:-

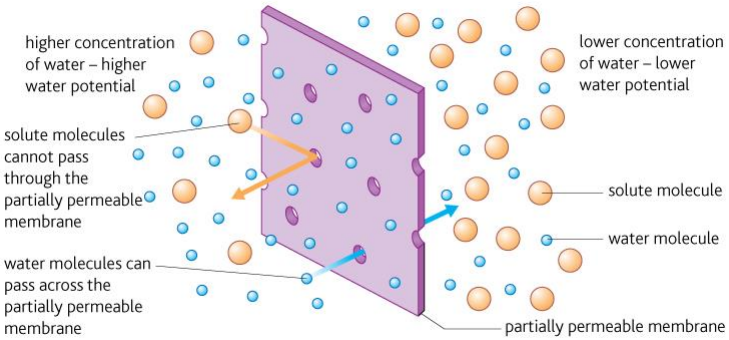
1. **Bulk (Mass) Flow:-** Mass movement of molecules in response to a pressure gradient. The molecules move from hi → low pressure, following a pressure gradient.

Water Transport Processes

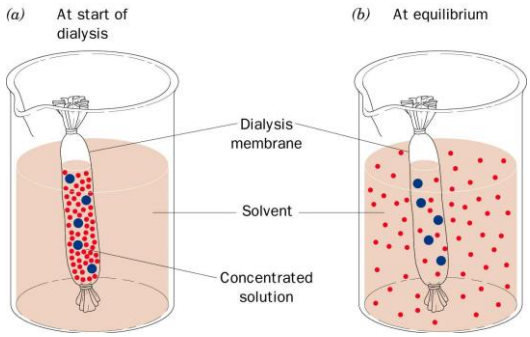
2. **Diffusion:-** Net, random movement of individual molecules from one area to another. The molecules move from [hi] → [low], following a concentration gradient.



2. a. Osmosis:- Is a specialized case of diffusion; it represents the diffusion of a solvent (typically water) across a membrane.



2. b. Dialysis:- Another specialized case of diffusion; it is the diffusion of solute across a semi-permeable membrane, like sugar



If water (solvent) moves out of the cell into the surroundings it moves **osmotically**.

If the sugar (solute) moves into the surroundings, it is an example of **dialysis**.

Factors influencing the rate of diffusion

A. Concentration Gradient.

B. Molecular Speed.

B. 1. Directly proportional to temperature; and

B. 2. Indirectly related to molecular weight (heavier particles move more slowly than lighter, smaller ones).

C. Temperature.

D. Pressure.

E. Solute effects on the chemical potential of the solvent.