Water relation in plants

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Properties of water:

- Water is a liquid at physiological temperatures (i.e., between 0-100 C).
- Water has a high heat of vaporization
- Water has a high specific heat .
- Water has a high heat of fusion.
- Water has a high surface tension.
- Water is a universal solvent.
- Water has high tensile strength and incompressibility.
- Water is transparent to light.
- Water is chemically inert.

Importance of water to plants

Abundantly used - Herbaceous plants 80 – 90 %; woody plants 50 %

Constituent of protoplasm - 90-95 per cent

Cell turgidity -Frame work - Structural cell enlargement & growth

Metabolic processes - photosynthesis, transpiration, respiration
Transpiration – Helps cooling leaf temperature

Gas exchange - Helps stomatal opening

Carrier - for nutrients & metabolites

Medium- for biochemical reaction

Solvent - for nutrients & assimilates; gases, minerals & other solutes

Reactant - many biochemical reactions (photosynthesis & Hydrolysis)

End product - respiration

Bulk (Mass) Flow

- Bulk movement of solutions in response to a pressure or energy gradient. E.g. water in a hose or drinking straw, river flow, rain.

- Rate of flow is very sensitive to radius

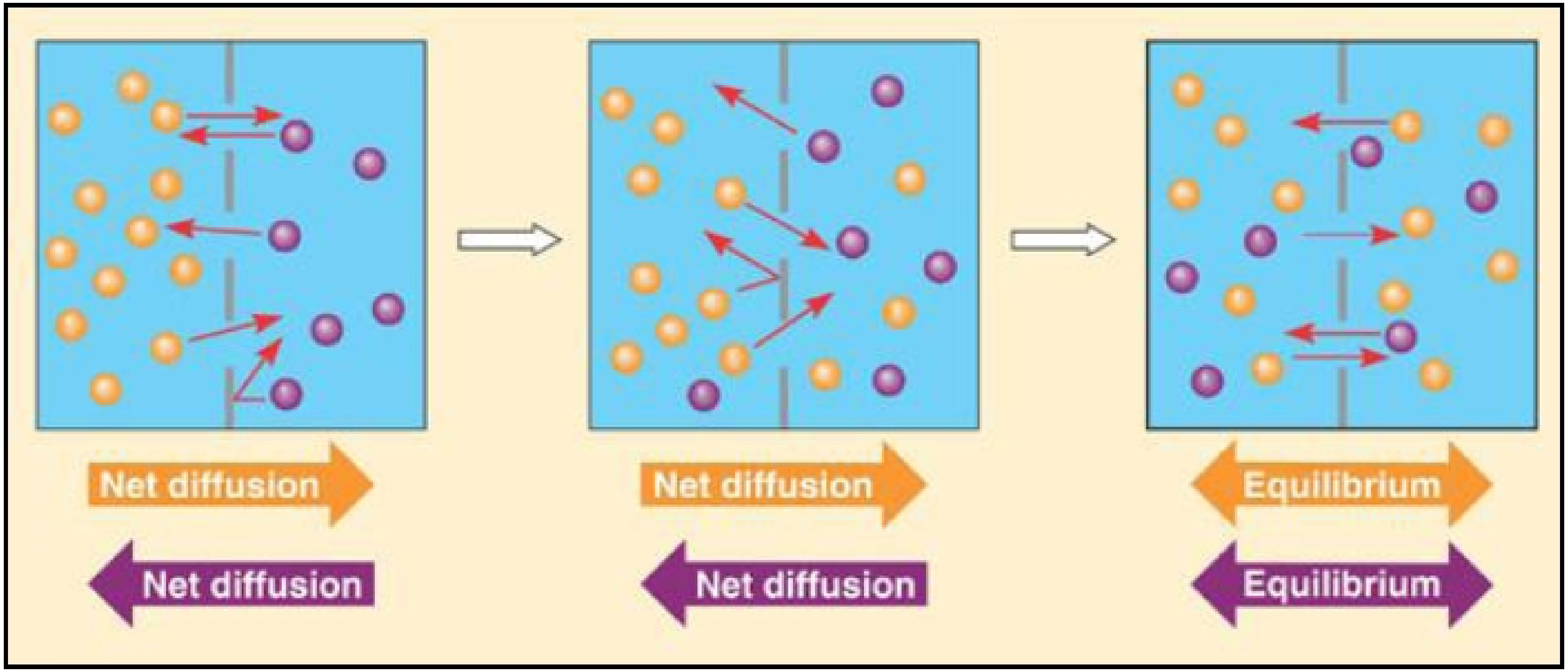
Diffusion, Osmosis and Imbibition

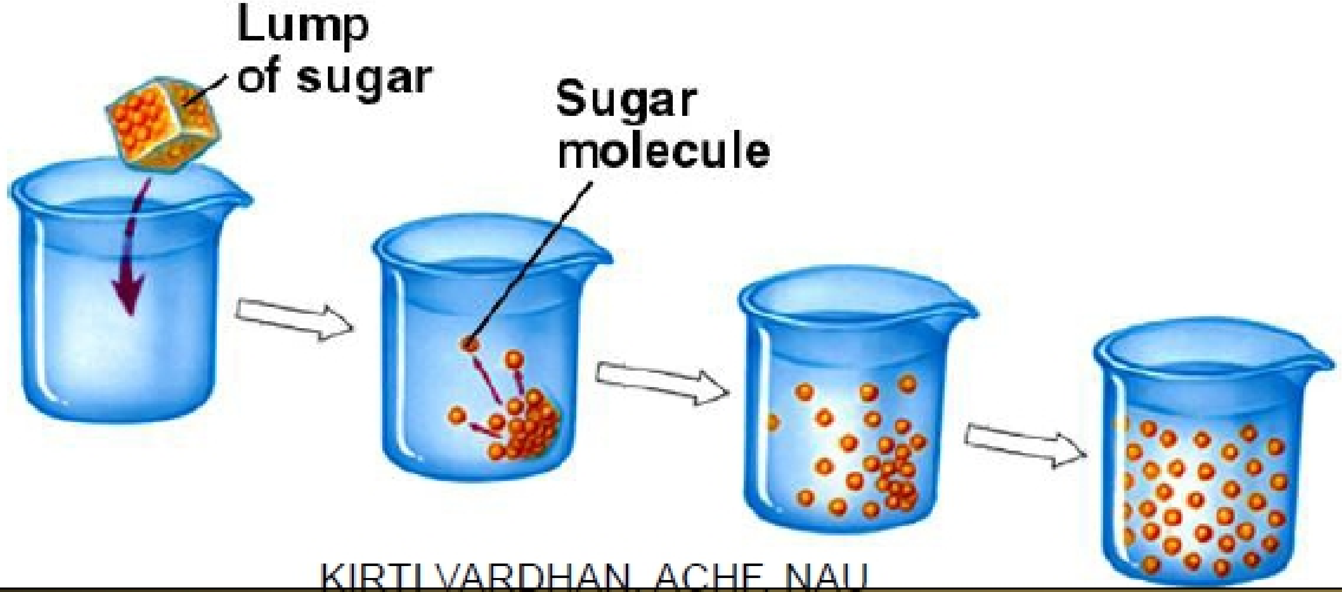
Diffusion

- The process by which molecules intermingle as a result of their own kinetic energy.

- Results in progressive movement of substances (e.g. gases, solutes, liquids) from regions of high concentration to regions of low concentration

Diffusion: molecules moving randomly





Diffusion rates depend on?

- Temperature
- Size of molecule
- Density of the medium
- Concentration gradient

Diffusion Pressure:

The potential ability of matter to diffuse from its higher concentration to lower concentration

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What is a semipermeable membrane?

- A barrier impermeable to large solute molecules but permeable to small solute and solvent molecules. Selects on basis of size.

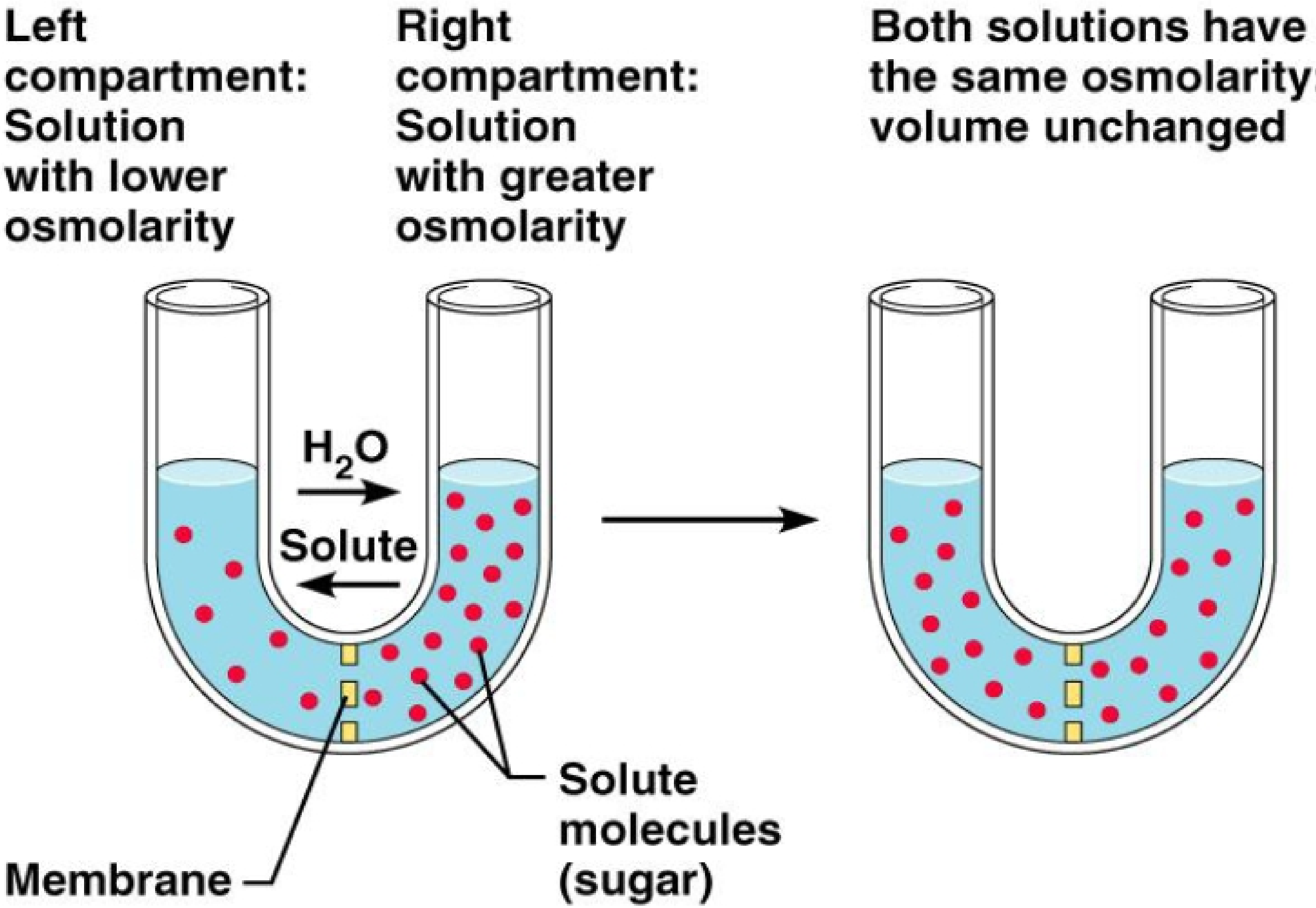
- E.g: Plasma membrane

Differentially (or Selectively) Permeable Membranes

- Characteristic of biological membranes
- Water passes readily, solutes slowly or not at all
- Depends on size, chemical & charge properties
- Depends on interaction with specific membrane components e.g. channels, carriers.

Osmosis

- Net movement of water across a membrane from a region of higher potential (e.g. more dilute solution) to a region of lower potential (e.g. more concentrated solution)



(a) Membrane permeable to both solute molecules and water

How Will Water Move Across Semi-Permeable Membrane?

Solution A has a glucose concentration of 100 mM
Solution B has a fructose concentration of 100 mM

Solution A has a glucose concentration of 100 mM
Solution B has a fructose concentration of 75 mM

Solution A has a glucose concentration of 100 mM
Solution B has a NaCl concentration of 100 mM

Solution Types Relative to Cell

Hypertonic Solution: Solute concentration of solution higher than cell

More dissolved particles outside of cell than inside of cell

Hyper = more (think hyperactive); Tonic = dissolved particles

Water moves out of cell into solution

Cell shrinks

Hypotonic Solution: Solute concentration of solution lower than cell

Less dissolved particles outside of cell than inside of cell

Hypo = less, under (think hypodermic, hypothermia); Tonic = dissolved particles

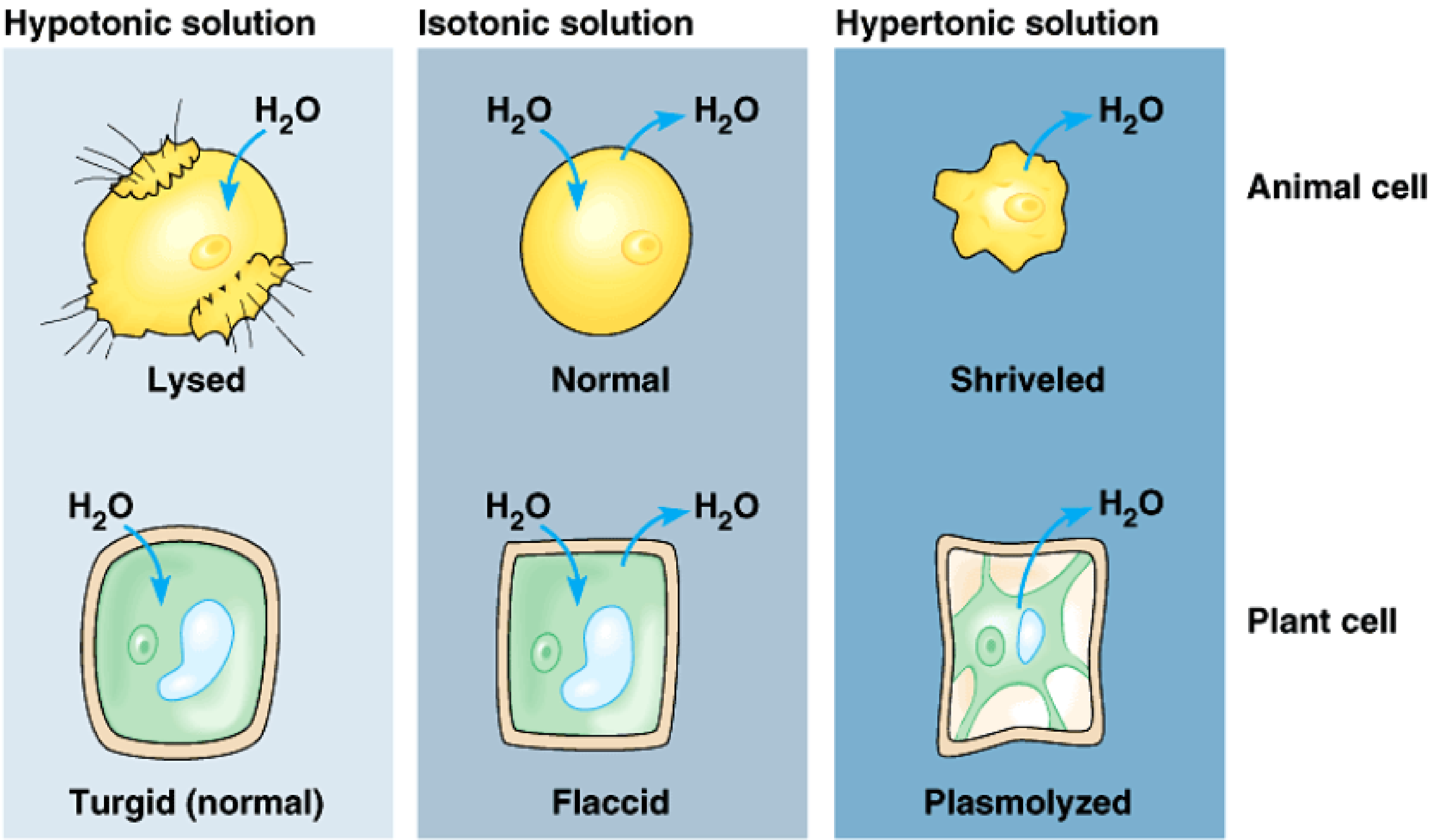
Water moves into cell from solution

Cell expands (and may burst)

Isotonic Solution: Solute concentration of solution equal to that of cell

No net water movement

Osmotic effects on cells



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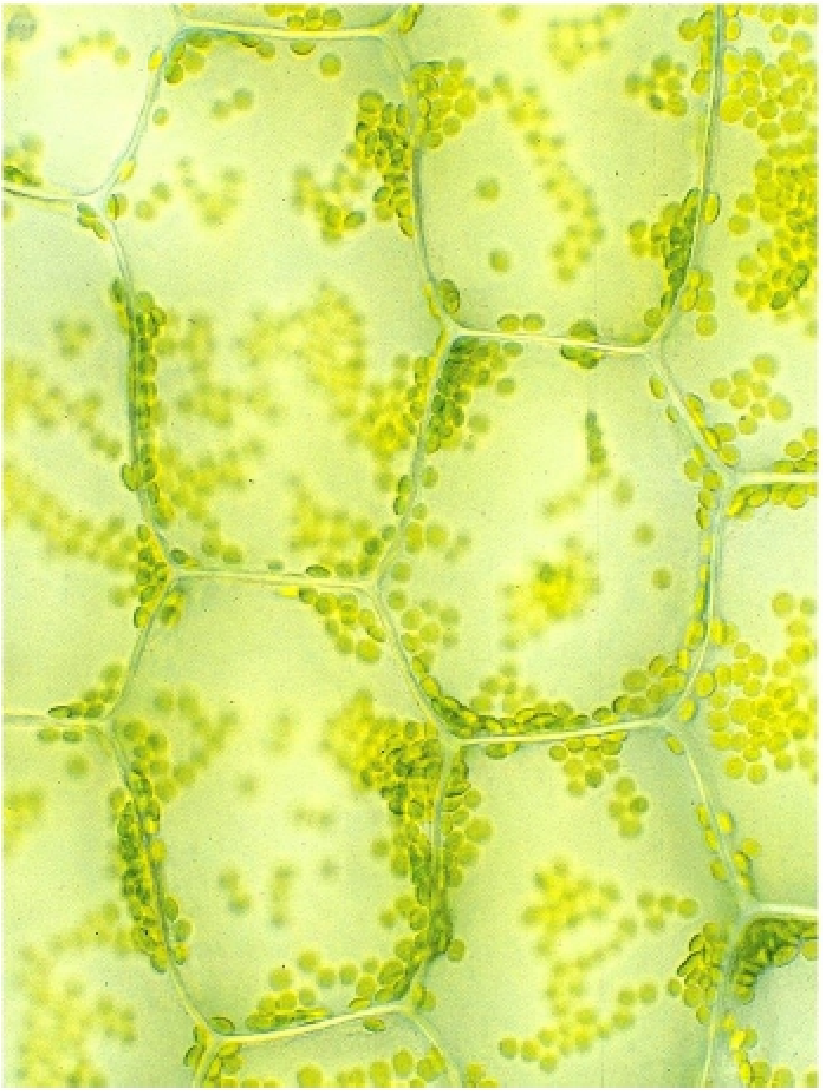
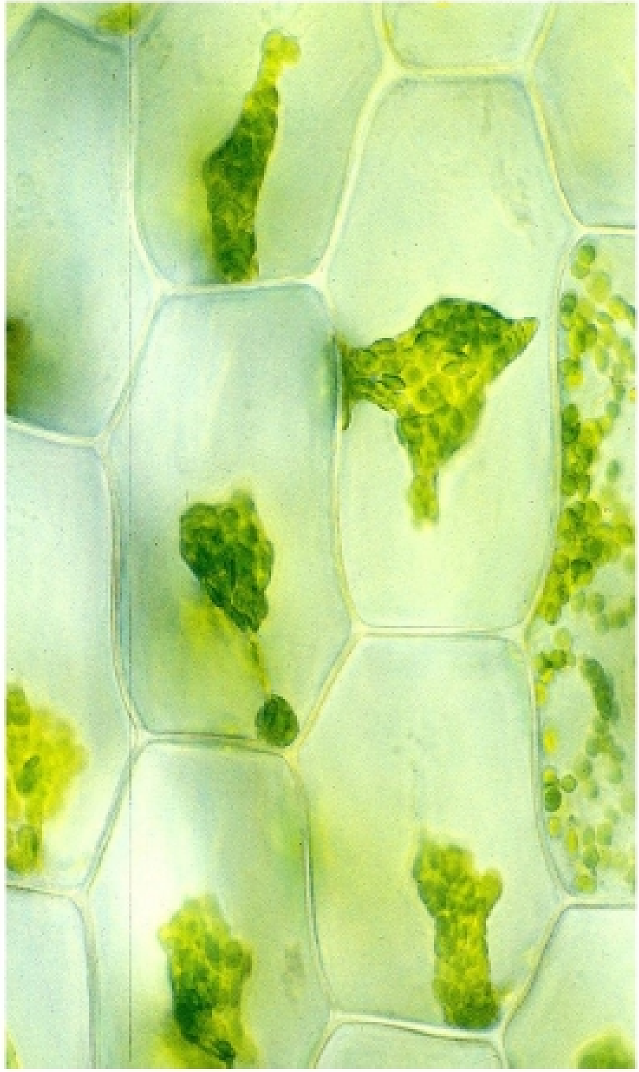
Hypotonic



Hypertonic



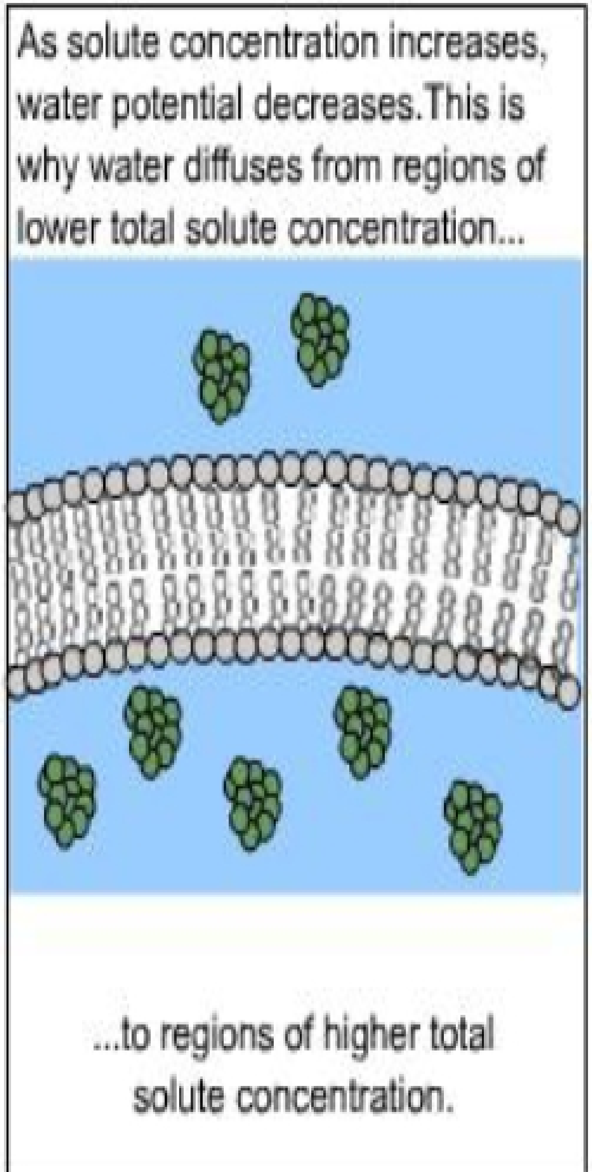
Water Potential

- A measure of the relative energy available for reaction or movement
- movement is always from a region of higher potential to a region of lower potential
- potential of pure water is defined as zero at ambient temp. & pressure
- water potential (Ψ_W) is measured in megapascals (MPa).
  1 MPa = 10 bars

The Component of Water Potential

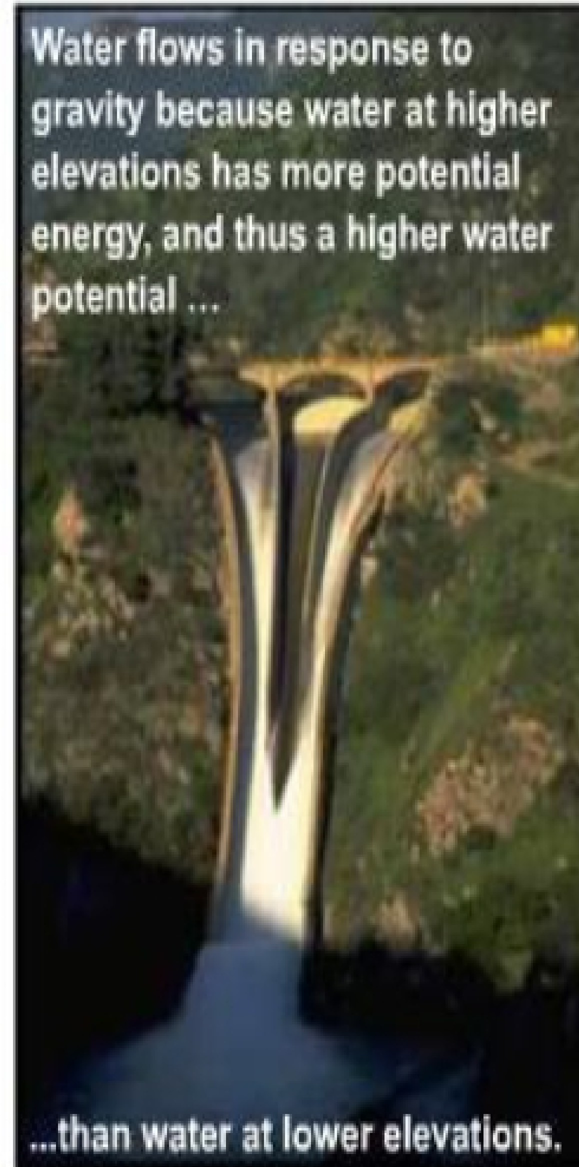
$$\Psi w = \Psi p + \Psi s + \Psi m + \Psi g$$

1) Solute concentration



2) Pressure

3) Gravity



Solute (or osmotic) potential (Ψs)

This is the contribution due to dissolved solutes. Solutes always decrease the free energy of water, thus there contribution is always negative.

Pressure (or Pressure Potential; Ψp)

Due to the pressure build up in cells thanks to the wall. It is usually positive, although may be negative (tension) as in the xylem. Pressure can be measured with an osmometer.

Matric potential

This is the contribution to water potential due to the force of attraction of water for colloidal, charged surfaces. It is negative because it reduces the ability of water to move. In large volumes of water it is very small and usually ignored. However, it can be very important in the soil, especially when referring to the root/soil interface.

Gravity (Ψg)

Contributions due to gravity which is usually ignored unless referring to the tops of tall trees.

Measuring Water Potential

1. Constant Volume Method

- $\Psi_P = 0$ MPa

- The Yw of the plant tissue can be assumed equal to the Ψw of the solution when there is no net water movement between the plant tissue and the solution

2. Chardakov's Method

Measure change in density of solution and determinate the water potential of tissue.

3. Pressure Bomb: A steel chamber that can be pressurized, usually with nitrogen. The sample is placed in the chamber with the petiole or surface exposed through a hole in the lid. The sample is pressurized and the pressure that is required to force water to appear on the cut surface is assumed to be equivalent to the water potential of the tissue.

Imbibition:

Adsorption of water molecule by hydrophilic colloids

Imbibition of water increase the volume of imbibant due to which pressure is created which is known as imbibitional pressure.

Different organic substances have different imbibing capacities.

Proteins > Starch > Cellulose

The Movement of water across a membrane is a combination of diffusion and bulk flow ?

Thank You