3. Movement into and out of a cell.

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BIOLOGY

3.1 Describe the role of water as a solvent in organisms with reference to digestion, excretion and transport.

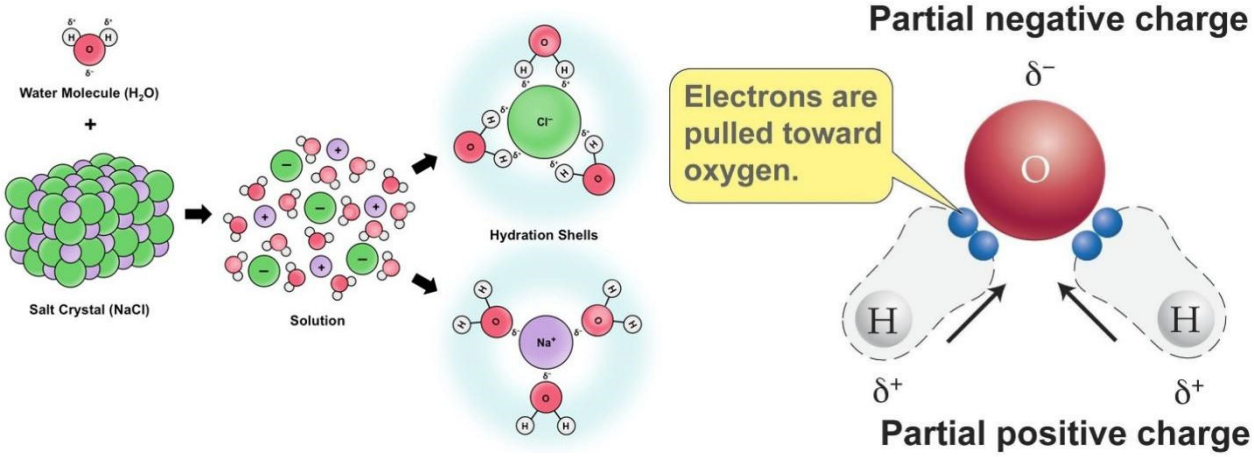
Water as a solvent

Water is a universal solvent and this is due to its polar properties.

This makes water extremely useful.

Polarity of water

- A water molecule forms when two hydrogen atoms form single polar covalent bonds with one oxygen atom.
- Oxygen is more electronegative than hydrogen so the region around oxygen has a partial negative charge.
- The region near the hydrogen atoms has a partial positive charge.
- The polarity in water molecule is due to the uneven distribution of electrons between oxygen and hydrogen atoms.
- This polarity enables the water molecule to form hydrogen bond which gives it its solvent properties.



Role of water in digestion

The process of digestion requires a lot of enzymes and these enzymes work in an aquatic environment. Water activates these enzymes. Water is also used in the hydrolysis of starch and proteins.

Role of water in excretion

Toxic substances such as urea and substances in excess of requirements such as salts are dissolved in water which makes them easy to remove from the body in urine. Urine contains 97% water which removes urea out of the body.

Role of water in transport

Water acts as a solvent for substances such as glucose, amino acids and salts, and it transport the substances to the whole organism. In case of animals this transport is carried through blood and in plants through vascular bundles. Water is also an important part of cytoplasm (90% of cytosol), tissue fluid and plasma.

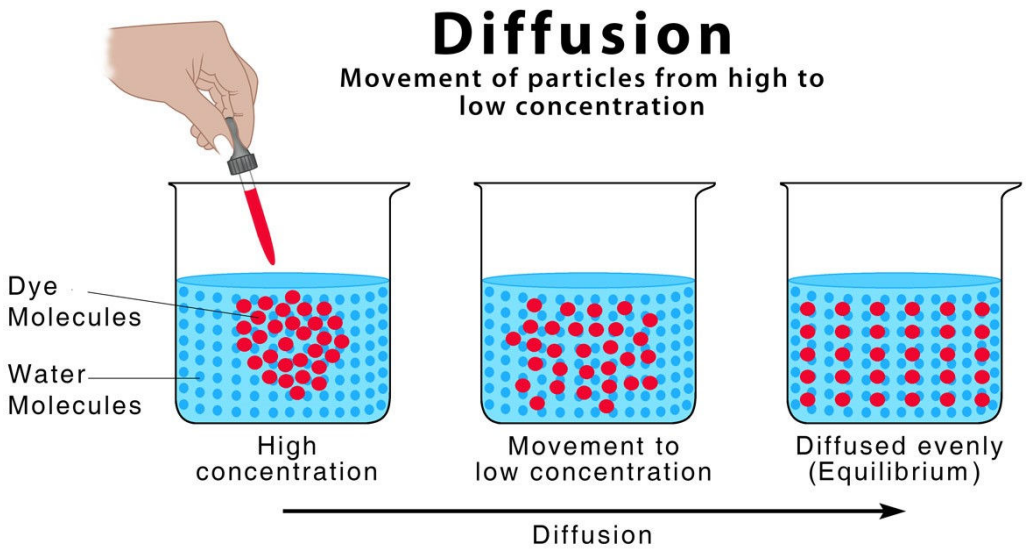
Understand that the energy for diffusion and osmosis comes from the kinetic energy of random movement of molecules and ions.

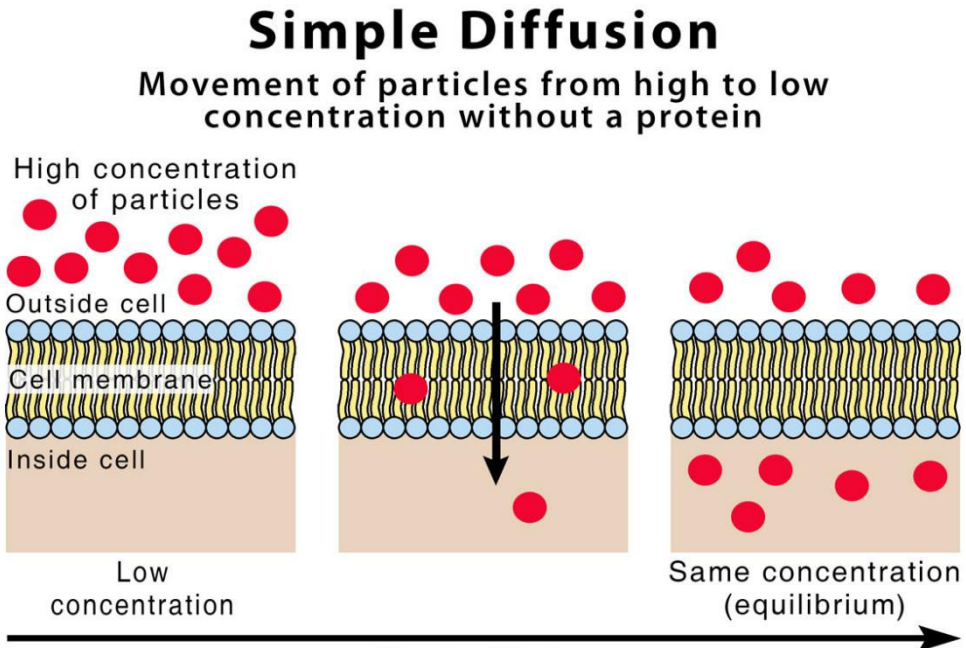
Diffusion

Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration.

The liquid and gas molecules are moving about all the time as a result of this movement, the molecules spread themselves out evenly to fill all the available space.

All particles move randomly. The energy for diffusion comes from the kinetic energy of this random movement of molecules and ions.



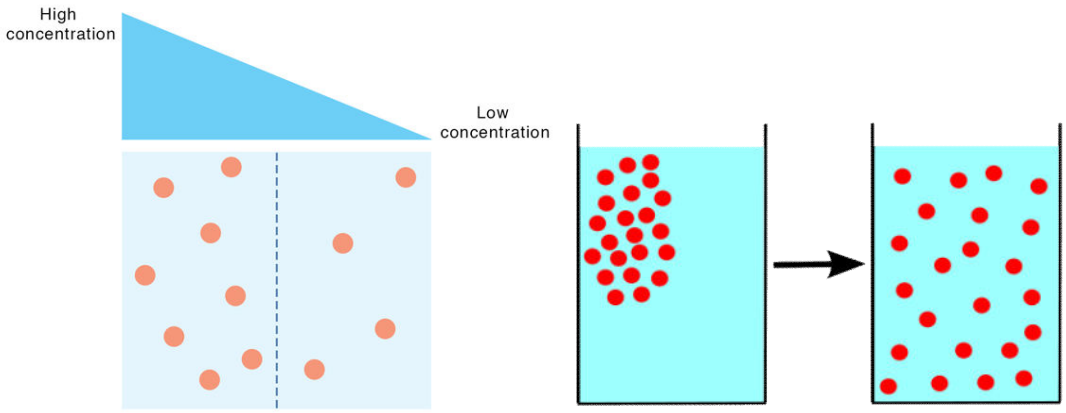


Understand diffusion as the net movement of molecules or ions from a region of their higher concentration to origin of their lower concentration (i.e. down a concentration gradient) as a result of their random movement.

Investigate the factors that influence diffusion, limited to: surface area, temperature, concentration gradient and distance.

Diffusion

- Movement of liquid or gas molecules.
- From high to low concentration (down the concentration gradient).
- No energy required.
- It may or may not be through a partially permeable membrane.
- The rate of diffusion increases as concentration gradient increases and vice versa.

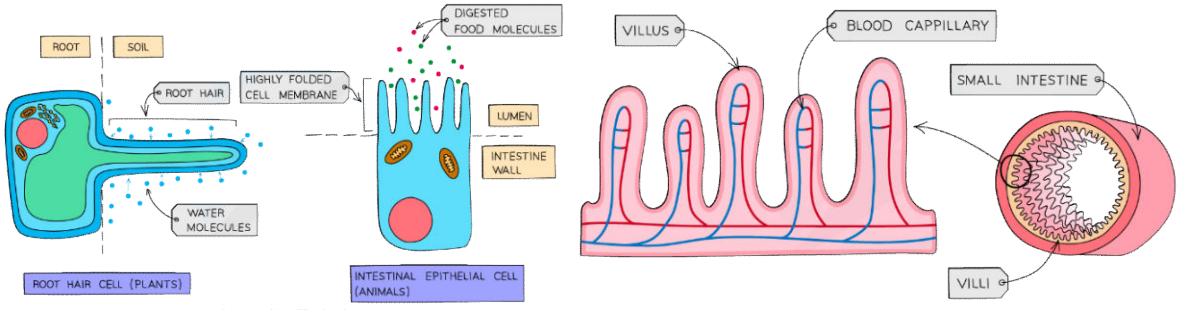


The rate of diffusion is influenced in the following manner

- Diffusion ∝ Surface Area.
- Diffusion ∝ Temperature.
- Diffusion ∝ Concentration Gradient.
- Diffusion $\propto \frac{1}{distance}$.

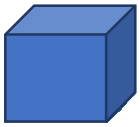
Investigating the effect of Surface area on diffusion.

Increase in the surface area to volume ratio increases the rate of diffusion.

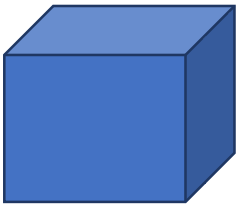


Calculate the surface area to volume ratio of each cube and investigate that which cube has more diffusion rate.

1cm×1cm×1cm



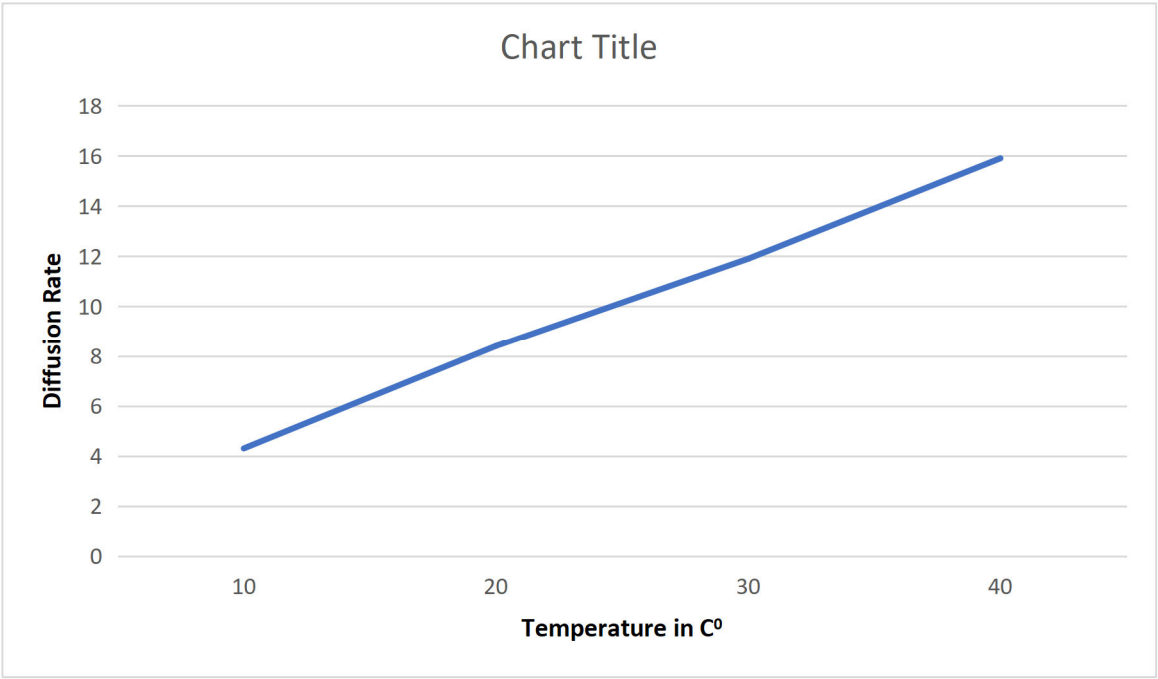
1.5cm×1.5cm×1.5cm



2cm×2cm×2cm

Investigating the effect of Temperature on diffusion.

- High temperature increases the kinetic energy of the molecules.
- This results in faster movement of molecules.
- The faster movement increases the collision between molecules and therefore an increase in diffusion rate.



Investigating the effect of concentration gradient on diffusion.

- The greater the difference in concentration, greater is the diffusion rate.
- This is because high concentration will involve more movement of molecules, hence increasing the rate.

Investigating the effect of distance on diffusion.

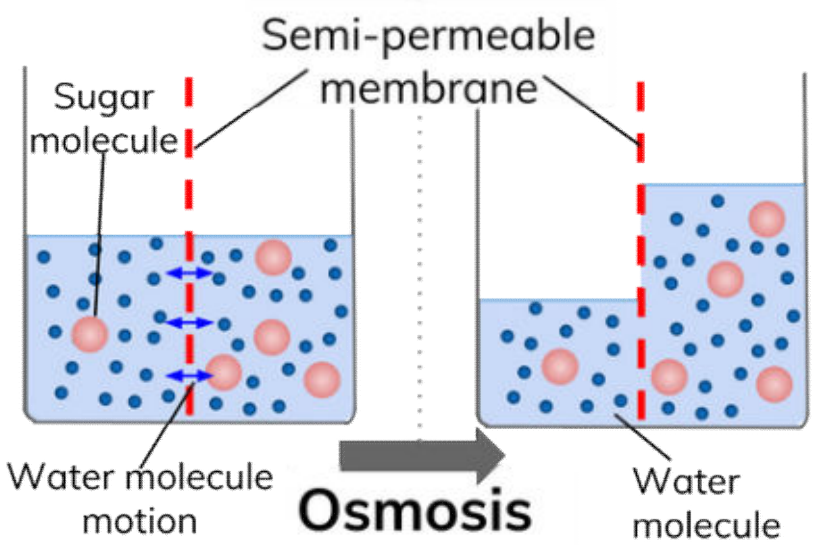
- Smaller the distance, the molecules have to travel less.
- Hence, higher the diffusion rate.

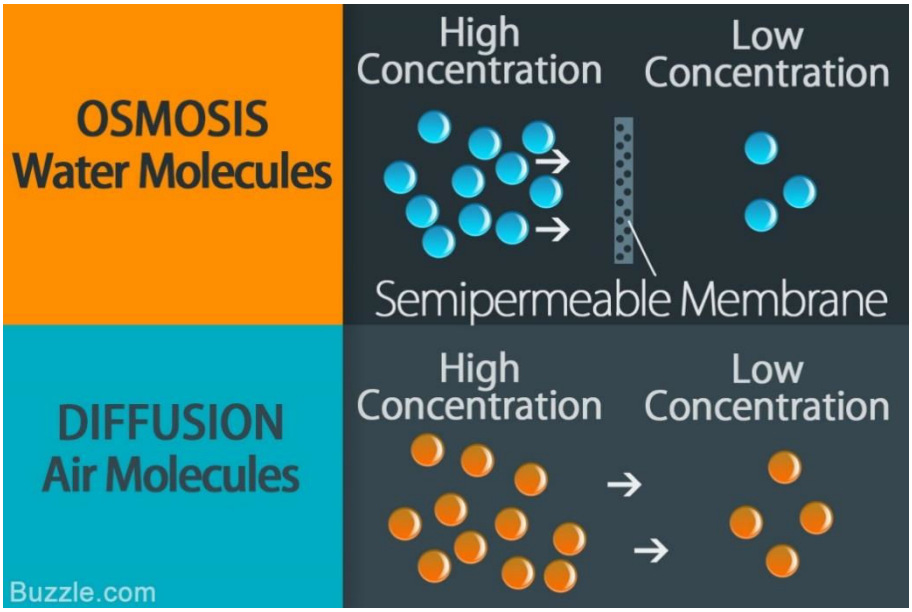
Understand osmosis as the net movement of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane.

Osmosis

Osmosis is the movement of water molecules from a solution with a higher concentration of water to a solution with a lower concentration of water through cell's partially permeable membrane.

- Movement is through a partially permeable membrane.
- Net movement of water molecules.
- Energy independent process.
- Movement is of water molecules.
- Direction of movement is from higher water potential to lower water potential.





Understand that plants are supported by the pressure of water inside the cells pressing outwards on the cell wall.

Describe the effects of osmosis on plant and animal tissues and explain the importance of water potential gradient and osmosis in the uptake and loss of water.

- Plant cells have vacuoles which can store large amount of water content.
- If a plant cell is surrounded by water or solution more dilute than its contents water will pass into the cell through the plasma membrane.
- These water molecules pass into the vacuoles by osmosis. The Vacuole will expand and swell.
- This swelling puts pressure on the cell membrane.
- The cell membrane presses against the inelastic cell wall.
- The wall pushes back on its contents resulting in a firm plant cell.
- The pressure keeps the plant cell firm and upright and is called as the turgor pressure.

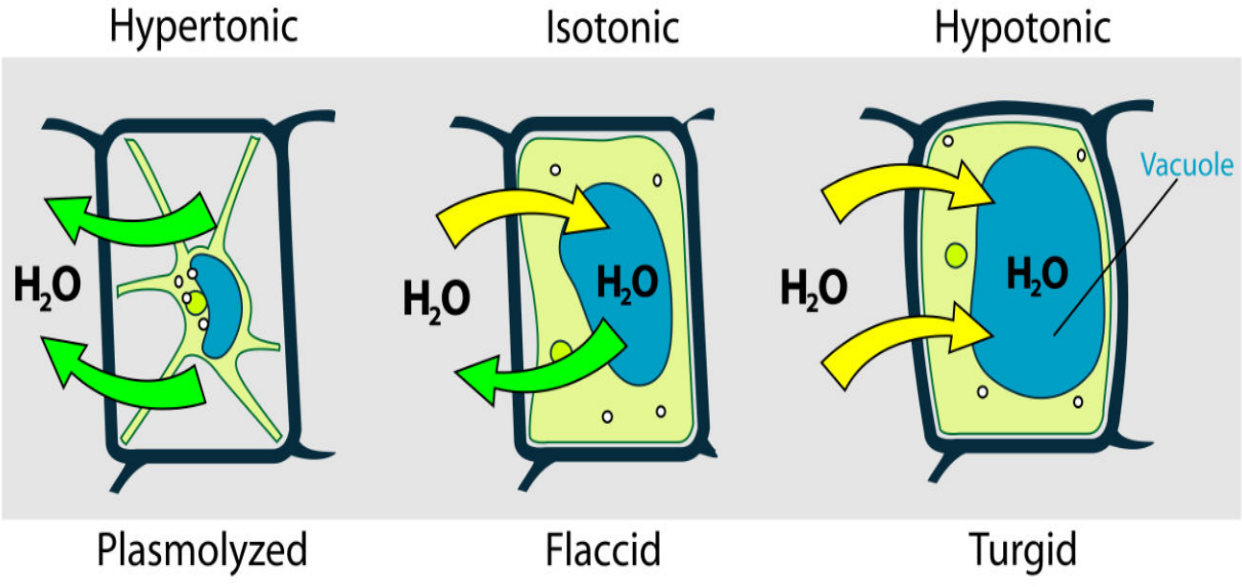
The importance of water potential and osmosis in plants.

A plant cell with the vacuole pushing out on the cell wall is turgid. Plant cells that are turgid are full of water and contain a high turgor pressure. This keeps them firm and upright. The leaves are held out straight. If the vacuoles lose water, the cells lose their turgor pressure and become flaccid.

Plant roots are surrounded by soil water which has a higher potential than that of plant roots. So, when the water potential of the cell sap is lower than the water potential of the soil water, the water will enter the cells by osmosis. The water moves across the root from cell to cell by osmosis until it reaches the xylem. Once they enter the xylem, they are transported away from the roots by transpiration stream. This supplies the plant with the water it needs.

When fertilizer is used on the soil, it's amount should be checked. Too much fertilizer will dissolve in the soil water and lower the water potential of the soil. Which in turn increases the water potential of root cells. Water moves from higher potential to lower potential thus leaving the root cells. Crops can then no longer grow on the land because they will die through water loss by osmosis.

This can be studied experimentally by making a slide of plant epidermis and keeping and observing them in different concentrations.



The importance of water potential and osmosis in Animals.

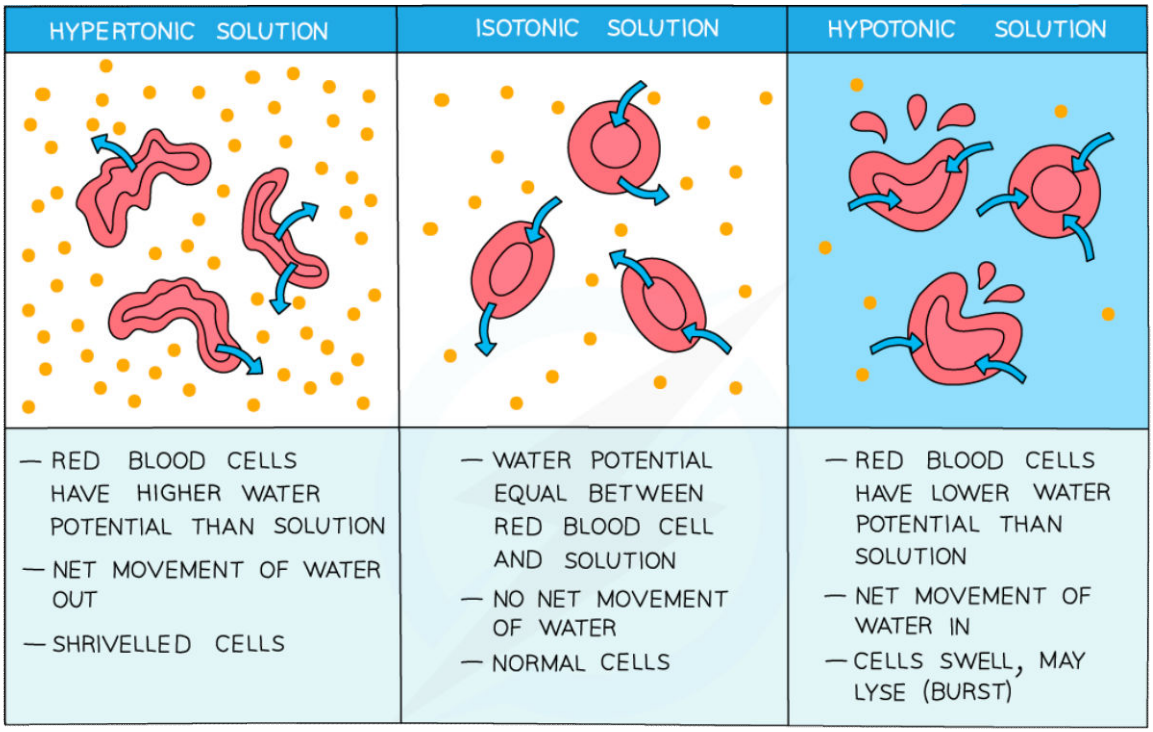
Animal cells also lose and gain water as a result of osmosis. As animal cells do not have a supporting cell wall, the results on cell are more severe.

To prevent the net flow of water into or out of the cell it is essential that the fluid which bathes the cells, like blood plasma or tissue fluid has the same water potential as the cell contents. If blood plasma has a higher water potential than the cells water will move into the cells by osmosis causing them to swell up and burst.

Single cell animals like amoeba live in freshwater and they face this problem. Amoeba have contractile vacuoles which regulate the water flow and regularly releases it through the cell membrane keeping the water content of the cell under control and avoids bursting of the cell. Surgeons while performing a surgery use normal saline to rinse a wound instead of water because it will enter the cells and cause them to burst.

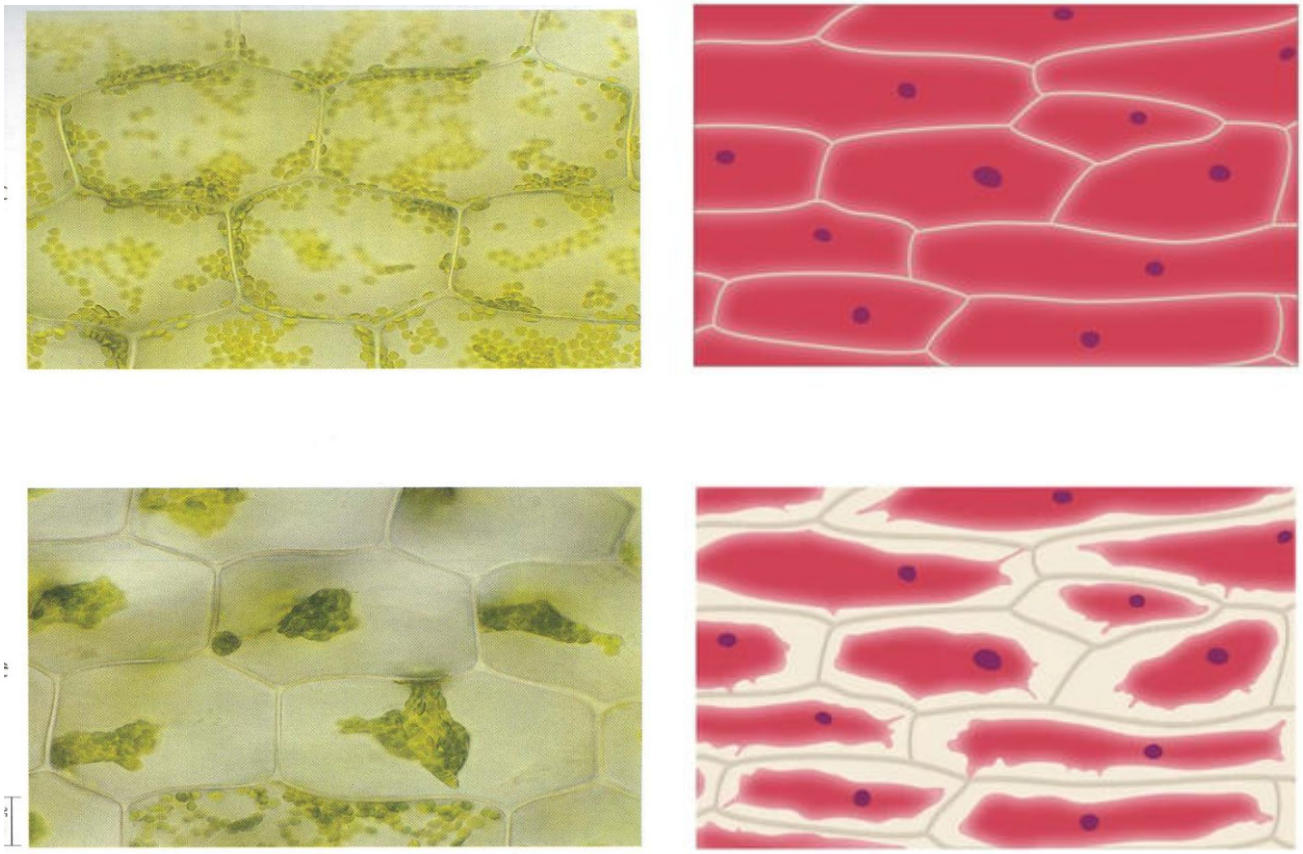
In a hot sunny day, body sweats and becomes dehydrated. This loss of water from the blood results in plasma becoming more concentrated. Water is then drawn out of the red blood cells by osmosis and the cells become plasmolysed. This reduces the surface area and the effectiveness of RBCs to carry oxygen.

This can be studied experimentally by making a slide of red blood cells or cheek cells and keeping and observing them in different concentrations.



Investigate and explain the effects on plant tissues of immersing them in solutions of different concentrations, using the terms turgid, turgor pressure, plasmolysis and flaccid.

- Make a slide of plant epidermis as studied in chapter 1.
- Observe it under microscope.
- Now place 2-3 drops of 40% salt solution on the side of the slide and draw the solution under the coverslip.
- Study the cells and record your observation.



Observation

The cells appear to shrink and pull the cytoplasm, leaving clear spaces. The cells are plasmolysed and are dead.

Investigate osmosis using materials such as dialysis tubing.

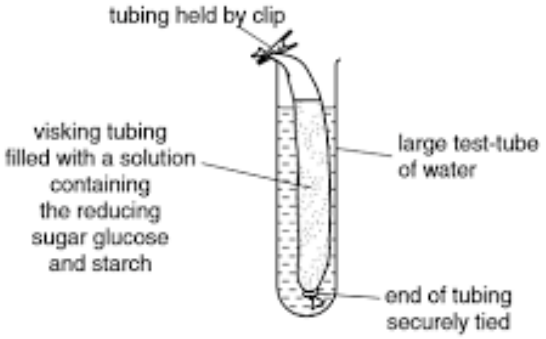
Dialysis tubing (sometimes referred to as visking tubing) is a non-living partially permeable membrane made from cellulose.

To investigate osmosis using dialysis tubing we will need following equipment.

- Dialysis tubing.
- Two beakers.
- Water.
- Sugar solution with a known concentration.

Here are the steps to conduct the experiment.

Take 20cm length of dialysis tubing and tie off one end.



- Fill it with $3cm^3$ of strong sugar solution using a plastic syringe and add small amount of coloured dye.
- Tie off the other end of the tubing.
- Fill two beakers with water.
- Place the bag of solution into one of the beakers, making sure it is completely submerged.
- Leave the setup for a few hours, allowing time for osmosis to occur.
- After a few hours, remove the bag of solution from the beaker and observe any changes in the size of the bag.
- Compare the size of the bag to the original size to determine if water moved in or out of the bag.
- Repeat the experiment with solutions of different concentrations to observe the effect of concentration on osmosis.

Result.

The tubing will become firm, distended because of the diffusion of water inside the tubing.

3.2 Active transport

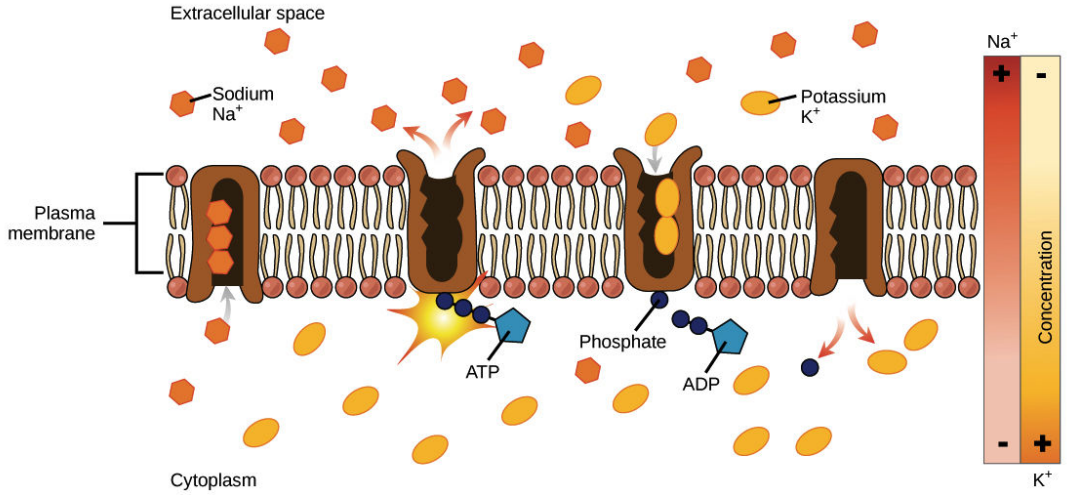
Understand active transport as the movement of molecules or ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration (i.e. against a concentration gradient), using energy released during respiration.

Active Transport.

- Active Transport is defined as a process that involves the movement of molecules from a region of lower concentration to a region of higher concentration against the gradient or with the use of external energy.
- Only takes place in living cells.
- Cellular respiration provides energy i.e ATP which is required for active transport.
- It occurs through carrier proteins in the cell membrane, which binds to specific molecules or ions and use energy to move them across the membrane.

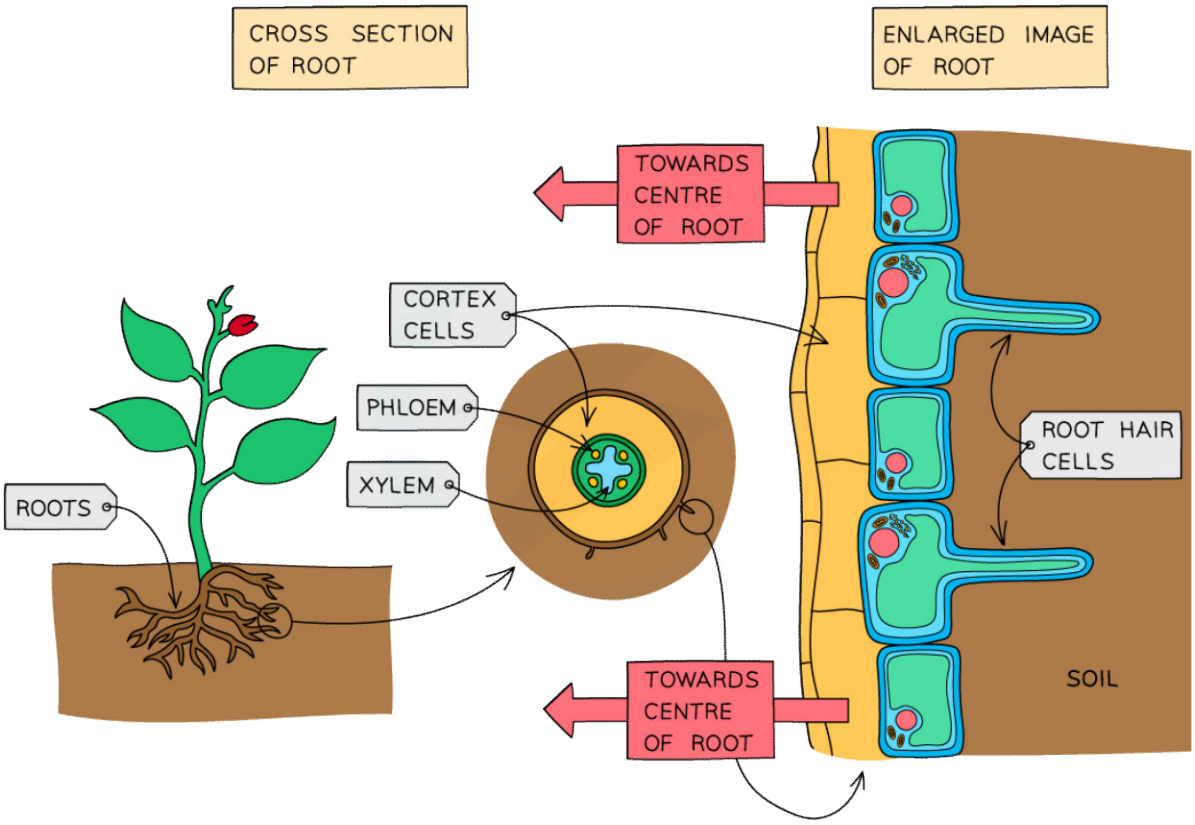
Examples.

- Reabsorption of sodium ions and glucose in kidney.
- Uptake of mineral ions from soil by root hairs.
- Uptake of glucose and amino acids from ileum by villi.
- Sodium Potassium pumps and proton pumps



Explain the importance of active transport in ion uptake by root hair cells.

- If diffusion was the only way a cell could take in substances it would have no control over what went in or out.
- Substances which the cell needed would diffuse out as soon as the concentration inside the cell increases above their concentration outside it.
- The cell membrane, however has a great deal of control over the substances which enter and leave the cell.
- Root hair cells are specialized cells found in the roots of plants, which are responsible for the uptake of water and nutrients from the soil.
- Active transport is necessary for the uptake of ions such as potassium, calcium, and magnesium, which are present in the soil at a much lower concentration than inside the cell.
- Root hair cells use carrier proteins in their cell membranes for active transportation.
- Plants need to absorb mineral salts from the soil, but these salts are in very dilute solution. Active transport enables the cells of plant roots to take up salts from this dilute solution against concentration gradient. Active transport allows efficient absorption of ions, maintenance of ion gradient inside cell and selective ion uptake.



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