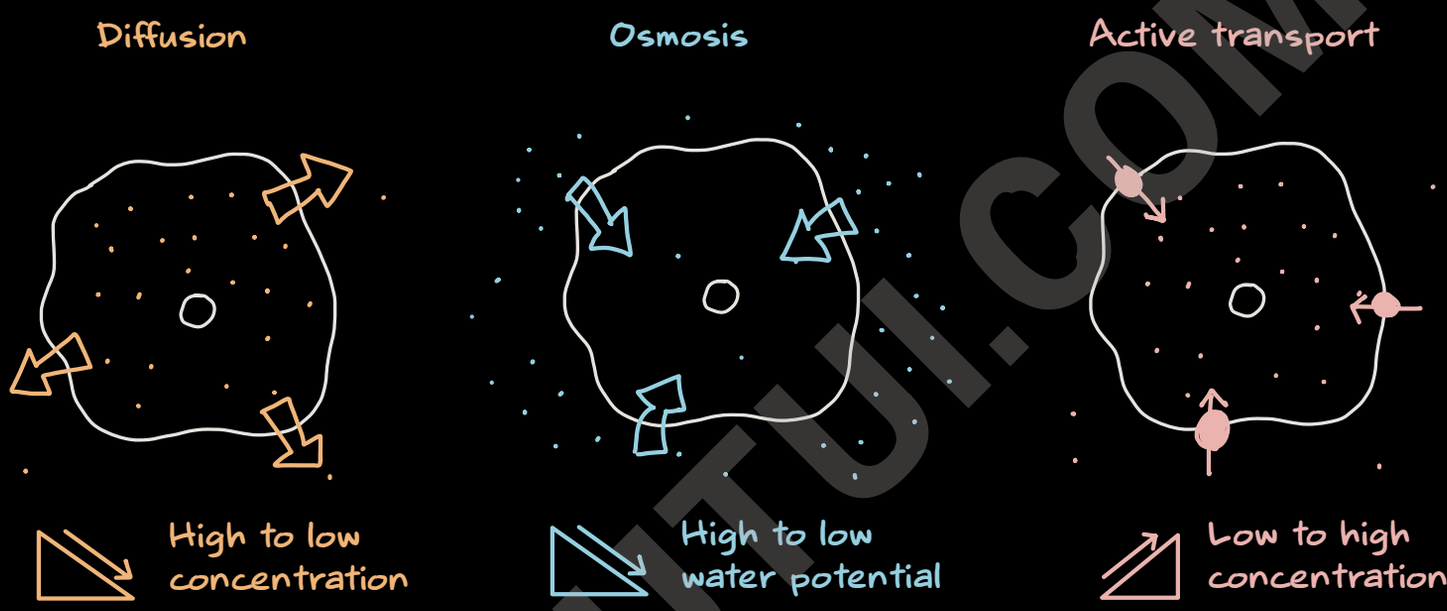
Movement in and out of cells

- ☑ Diffusion: definition, importance, and the factors affecting diffusion rate
- ☑ Osmosis: definition, its effects on living cells, investigations, and importance
- ☑ Active transport: definition and importance

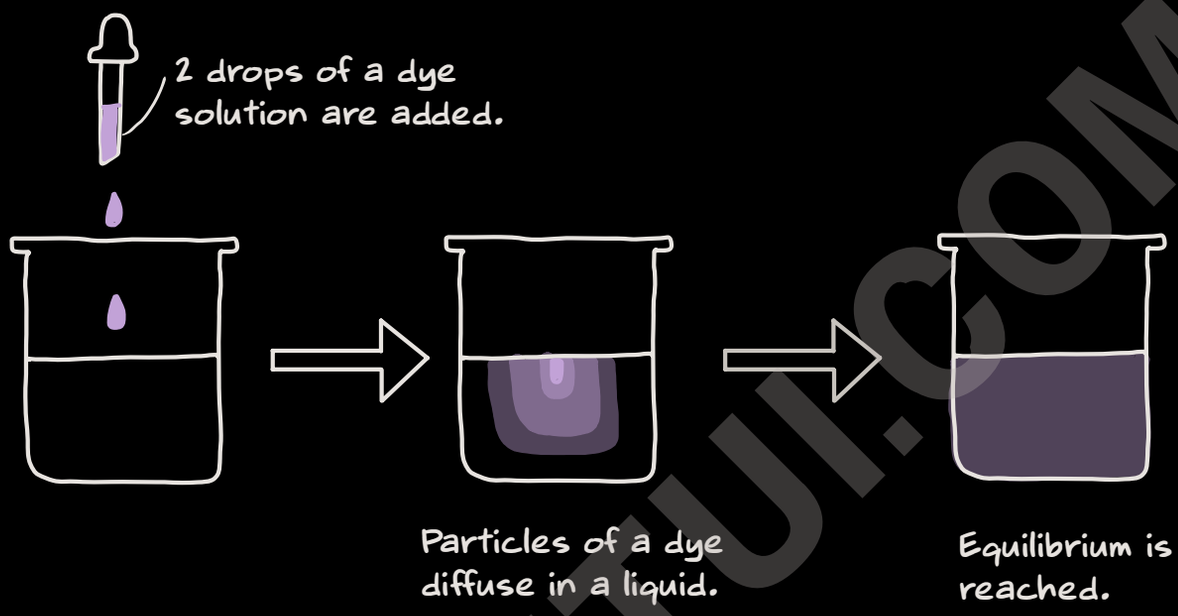
Overview of how substances move across cell membrane



Diffusion

Diffusion = A net movement of particles in a liquid or gas from a region of high to low concentration (down a concentration gradient) due to random motion until equilibrium is reached

Diffusion and the state of equilibrium

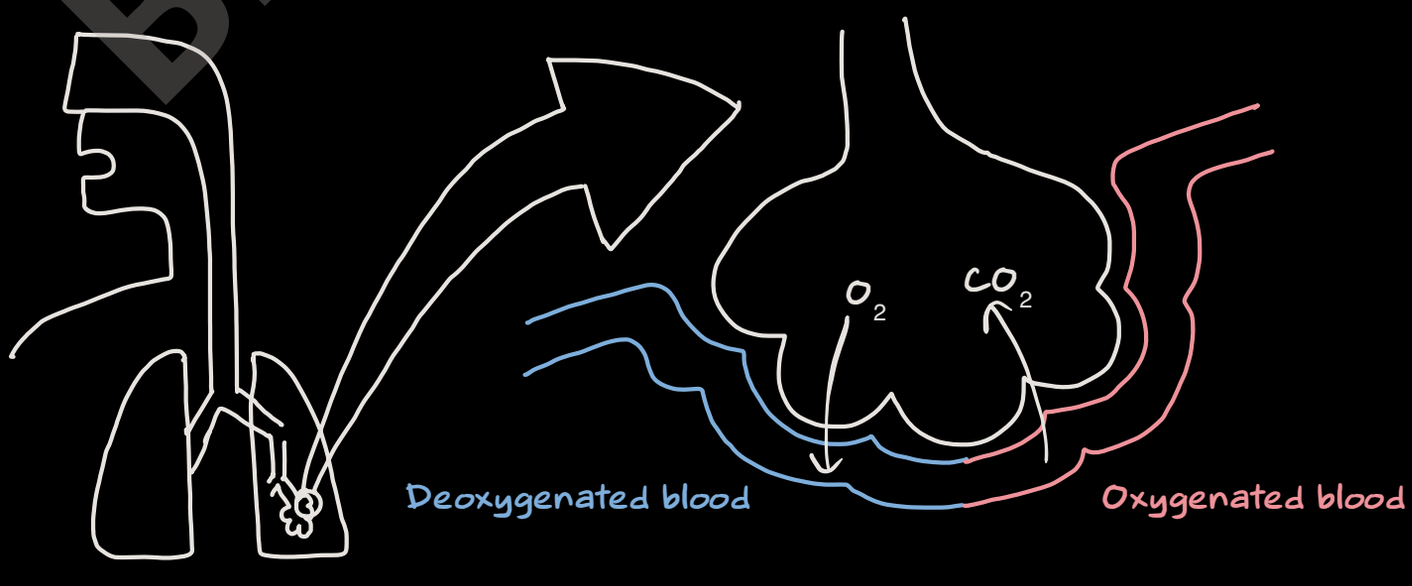


Equilibrium = a state when particles are distributed evenly with equal space between them

- In the state of equilibrium, the particles still move randomly, but the net movement is zero due to the absence of a concentration gradient.

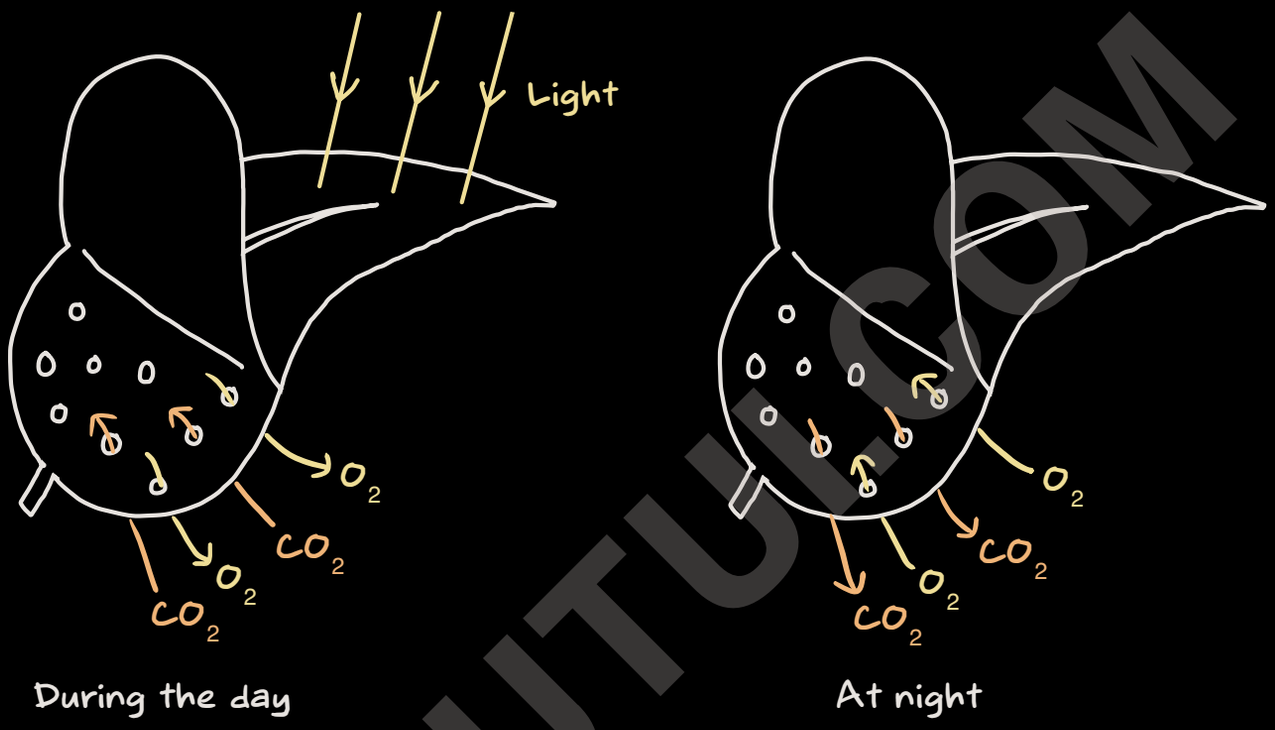
Importance of diffusion in living organisms

1. Diffusion facilitates gas exchange across the alveolus wall.



The exchange of gases across the alveolus wall occurs through diffusion, with oxygen moving from the alveolus into the blood (where oxygen concentration is lower) and carbon dioxide moving from the blood into the alveolus (where carbon dioxide concentration is higher).

2. Diffusion allows for gas exchange through stomata.

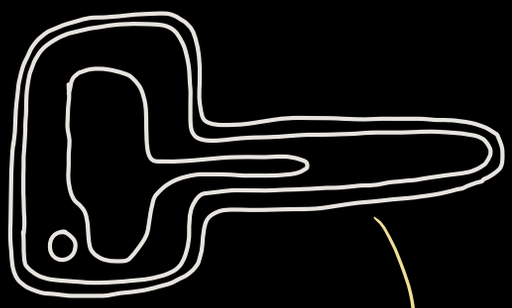


- During the day, the low concentration of carbon dioxide in the leaves due to its use in photosynthesis (occurring with the presence of light) leads to the diffusion of carbon dioxide into the leaves through the stomata, down a concentration gradient.
- At night, with no photosynthesis and only respiration taking place, the concentration of carbon dioxide in the leaves becomes higher than in the atmosphere due to it being a product of respiration. This results in the diffusion of carbon dioxide out of the leaves when there is no light.

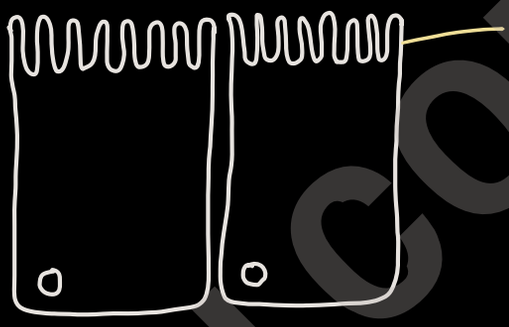
Factors affecting diffusion rate

1. Surface area

- The larger the surface area, the faster the diffusion rate due to the increase in the number of paths for particles to pass through the membrane.
- Some specialised cells have specialised structures, such as root hairs and microvilli, that increase surface area to enhance the cells' absorption capabilities.

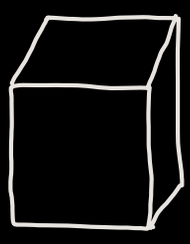


The root hair increase the surface area for more water and mineral absorption.

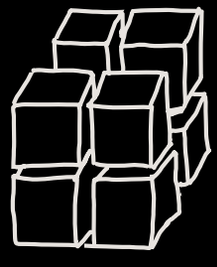


Microvilli of intestinal epithelial cells increase the cells' surface area for faster absorption of nutrients.

- Practical investigation: the effect of surface area on the diffusion rate
  - Method:
    - 1. Cut the agar jelly containing a universal indicator into different sizes: one cube with a side length of 1 cm and a group of 8 cubes with a side length of 0.5 cm.

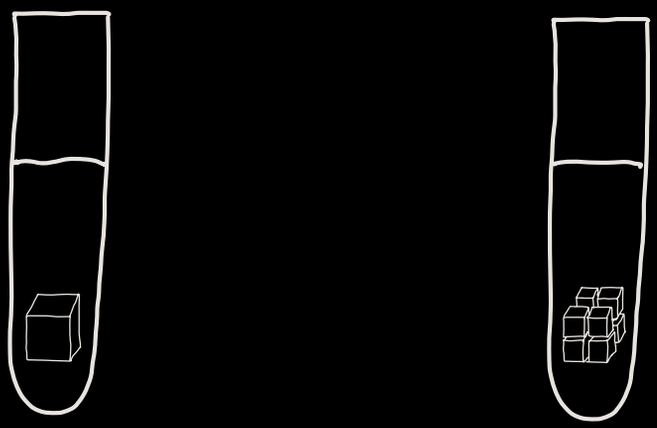


A large agar jelly cube



8 pieces of smaller agar jelly cubes

- 2. Place a large cube and a group of small cubes into test tubes with the same volume and concentration of hydrochloric acid.



- 3. Measure the time taken for the agar jelly cubes in each test tube to turn completely orange.

- Result and explanation:
  - The small cubes in the test tube turn orange faster because they have a larger surface area for the hydrochloric acid to reach, which means the acid can react with the universal indicator more quickly to change its colour to orange.

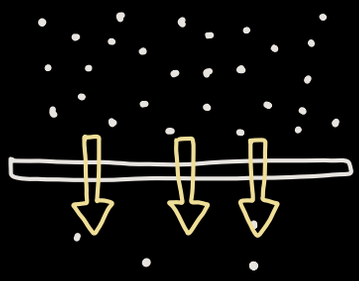
2. Temperature

- Diffusion rate increases at a higher temperature because the particles have more kinetic energy, which results in a faster random motion.

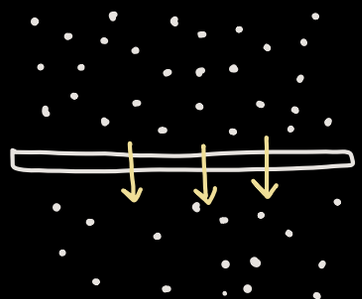
3. Concentration gradient

- The diffusion rate increases in a steeper concentration gradient because there is a higher difference in concentration between two points.
- When there is a greater difference in concentration, more molecules move more quickly from high to low concentration, increasing the diffusion rate.

Effect of a concentration gradient on diffusion



Fast diffusion



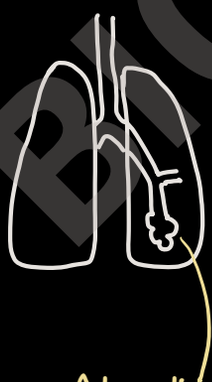
Slow diffusion

4. Diffusion distance

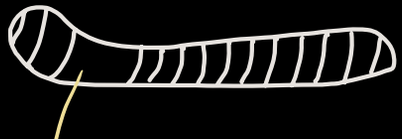
- Diffusion rate increases in a short distance because it takes less time for molecules to travel between the two points.

Properties of the gas exchange surface for increased diffusion of gases

1. Thin - for a short diffusion distance
2. Large surface area
3. Good blood supply to maintain a concentration gradient of gases
4. Good air ventilation to maintain a concentration gradient of gases



Alveoli



Moist surface of an earthworm

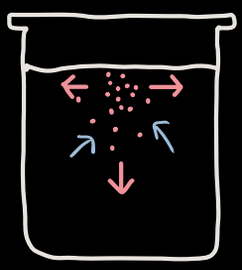
Moist skin of a frog

Osmosis

Osmosis = a net movement of water molecules down a water potential gradient through a partially permeable membrane

Osmosis vs. Diffusion of water

Diffusion of water



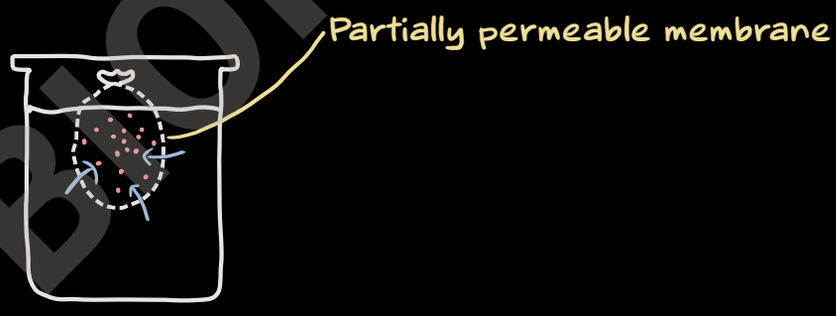
= sugar molecules in water

→ = The net movement of sugar molecules

← = The net movement of water molecules

When sugar is added to water, it diffuses from a region of higher concentration to a lower concentration. Meanwhile, water molecules move in the opposite direction, from an area of lower concentration (high water potential) to a region of higher concentration. This diagram only shows the diffusion of sugar and water, and does not depict osmosis, as it does not include a partially permeable membrane.

Osmosis

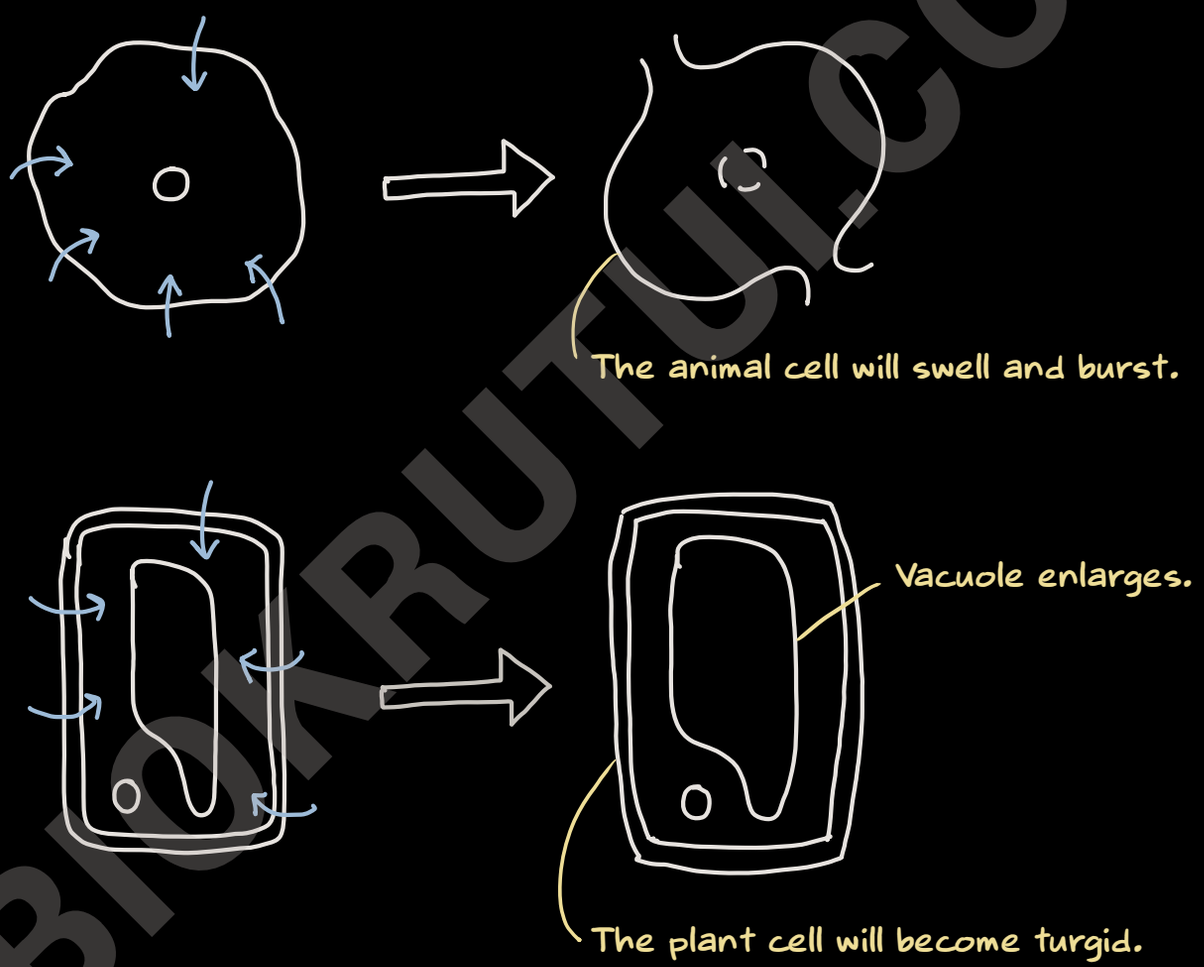


The sugar solution is contained within a sac made of a partially permeable membrane. The membrane allows for greater permeability of water molecules. As a result, water diffuses into the sac along a gradient of decreasing water potential, as the water potential inside the sac is lower than outside. This diagram represents osmosis due to the presence of a partially permeable membrane, which allows for the diffusion of water across it.

Effects of osmosis on living cells

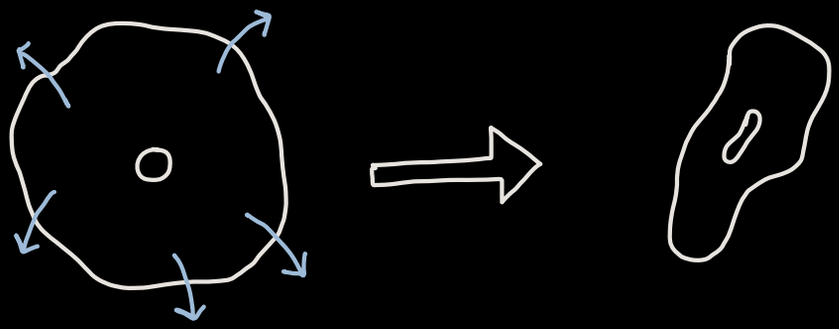
- Osmosis causes cells to change shape when placed in a solution with different water potential.
- When living cells are placed in distilled water, which has a higher water potential, water will diffuse into the cells by osmosis.
    - Animal cells will swell and burst.
    - Plant cells will become turgid due to the rigid cell wall, which prevents them from bursting. Turgor pressure will also increase and press against the cell wall

The appearance of cells in distilled water

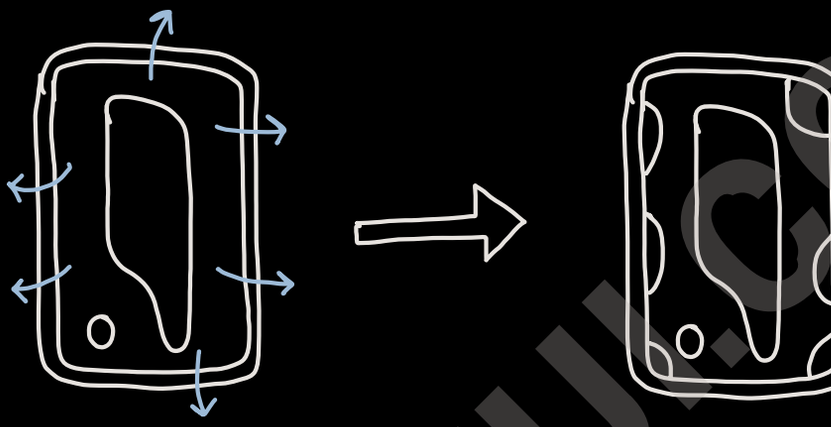


- When living cells are placed in a concentrated salt or sugar solution, the water potential of the solution is lower than that of the cytoplasm within the cells. As a result, water moves out of the cells through osmosis, passing through the partially permeable membrane.
    - Animal cells will shrink or become crenate.
    - Plant cells will lose turgor pressure and become flaccid, leading to plasmolysis, which is when the cell membrane separates from the cell wall.

The appearance of cells in a concentrated solution



The animal cell will shrink.



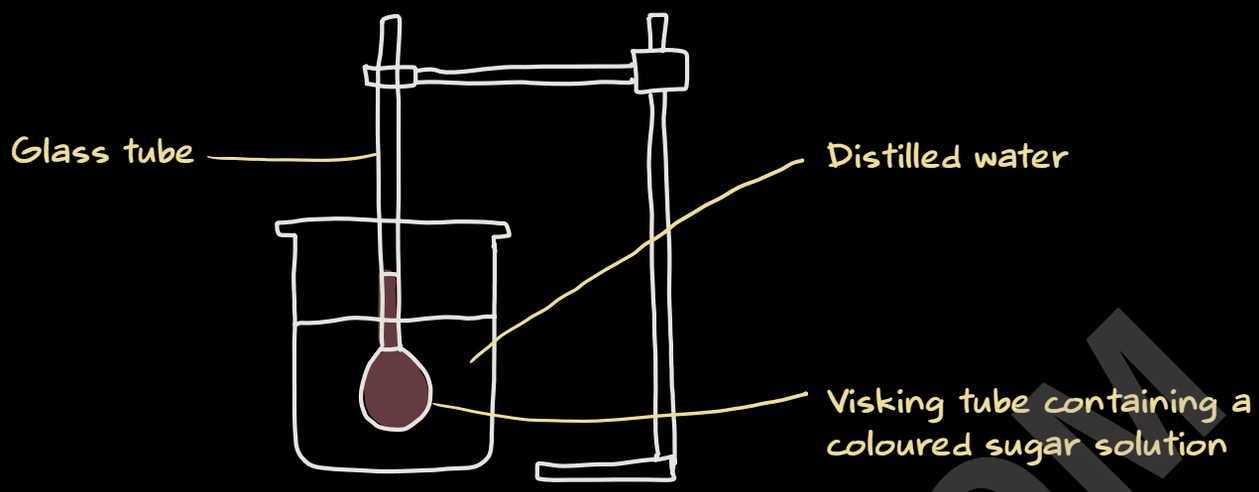
The pant cell will become flaccid and plasmolysed.

Summary table

Cell type	Distilled water	Isotonic solution	Concentrated solution
Animal cell	Swell and burst	Maintain normal size and shape	Shrink
Plant cell	Turgid	Flaccid	Flaccid and plasmolysed

Practical investigation of osmosis

Investigation of osmosis using a dialysis tube



- Result: the coloured sugar solution will move up the glass tube.
- Explanation:
  - Water diffuses from distilled water into the visking tubing bag by osmosis, pushing the coloured sugar solution up the glass tube.

Measuring water potential in plant tissue

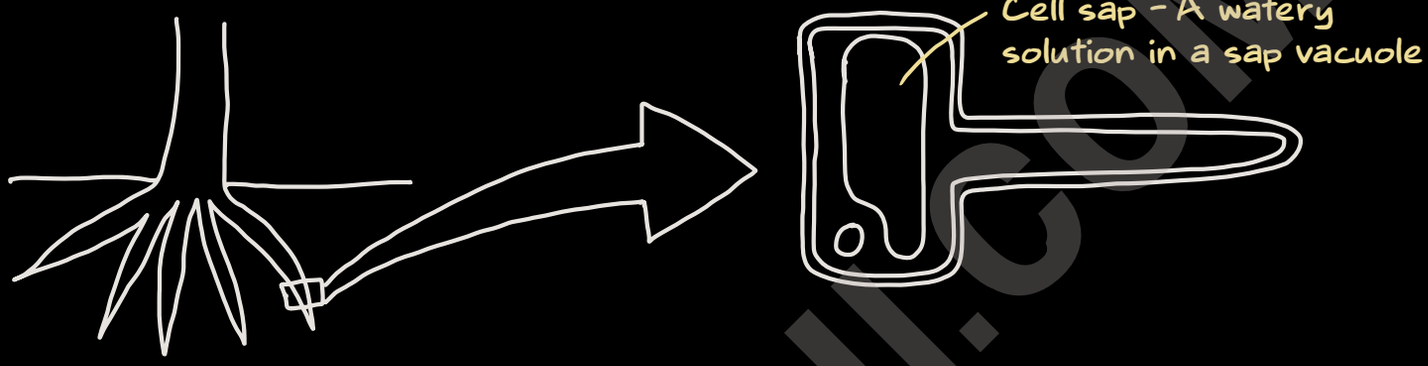
Method

1. Cut potato pieces into a uniform size.
2. Weigh the initial mass of each potato piece.
3. Prepare a series of salt solutions with increasing concentrations from 1% to 5% in 1% increments.
4. Place 3 potato pieces into each salt solution and let them soak for 20 minutes.
5. Re-weigh the potato pieces after removing them from the salt solutions.
6. Calculate the change in mass by subtracting the initial mass from the final mass for each potato piece and express the change as a percentage.
7. Plot a line graph showing the percentage change in mass vs. salt concentration.
8. Determine the x-intercept of the line graph. The x-intercept represents the salt concentration at which there is no change in potato tissue mass. This concentration corresponds to the water potential of the cytoplasm in the potato cells.

Importance of osmosis in living organisms

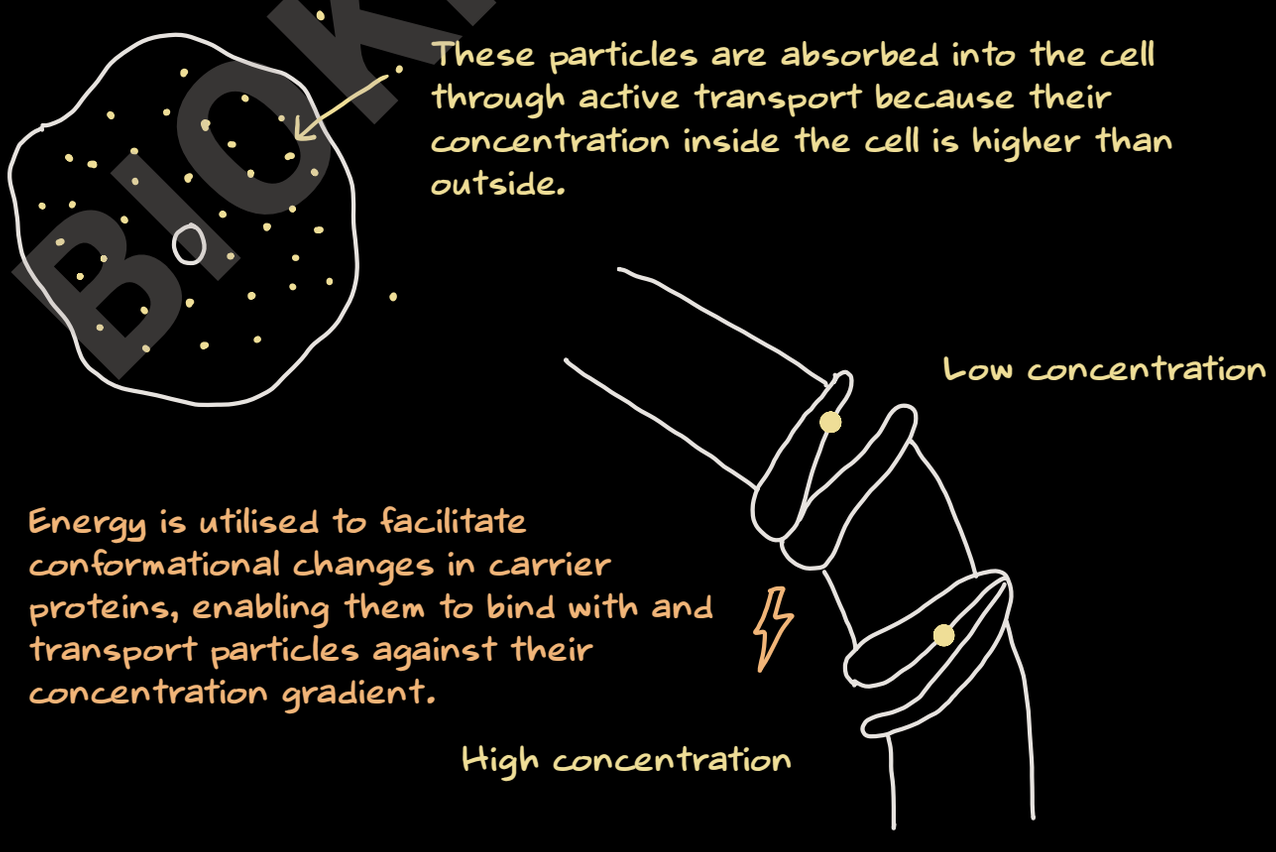
Absorption of water into root hair cells

- Root hair cells contain a cell sap with a low water potential, creating a gradient that attracts water from the surrounding soil, which has a higher water potential.
- As a result, water is absorbed into the root hair cells via osmosis, helping the plant to take up water and nutrients from the soil.



Active transport

Active transport = movement of particles from a low to high concentration across cell membranes using energy and carrier proteins



Importance of active transport

Absorption of minerals into root hair cells

- It allows for the movement of minerals against a concentration gradient, from an area of lower concentration (the soil) to an area of higher concentration (the cytoplasm of root hair cells).
- This process requires the use of protein pumps or carriers to actively transport the minerals, which helps maintain the necessary balance of minerals in the plant cells.