

**JURONG WEST SECONDARY SCHOOL
SECONDARY THREE – SCIENCE BIOLOGY
CHAPTER 2: MOVEMENT OF SUBSTANCES**

Learning Outcomes:

Candidates should be able to:

- a) **define diffusion** and **describe** its role in nutrient uptake and gaseous exchange in plants and humans
- b) **define osmosis**, investi gate and **describe** the effects of osmosis on plant and animal tissues

Use the knowledge gained in this section in new situations or to solve related problems.

Lesson Trigger

After a game of floorball, some students apply perfume to smell pleasant.

How has the smell travelled to your nose?

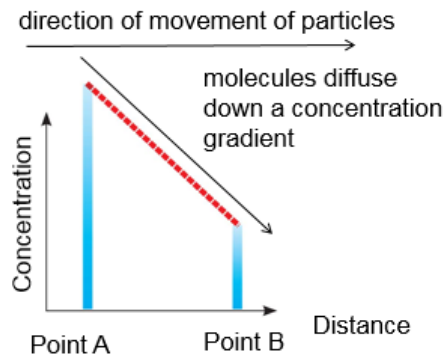
Think of the last time you detected the smell of perfume in a room after PE lesson.



DIFFUSION

Definition: Diffusion is the **net movement** of particles from a region of higher concentration to a region of lower concentration down a concentration gradient till equilibrium is reached.

What is a concentration gradient and how is it related to diffusion?

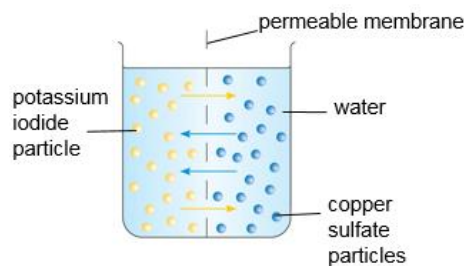


Concentration gradient is the **difference** in concentration between two regions.

- The particles in fluids possess **kinetic** energy.
- Particles will diffuse **down** their concentration gradient.
- The **steeper** the concentration gradient, the **faster** the rate of diffusion.

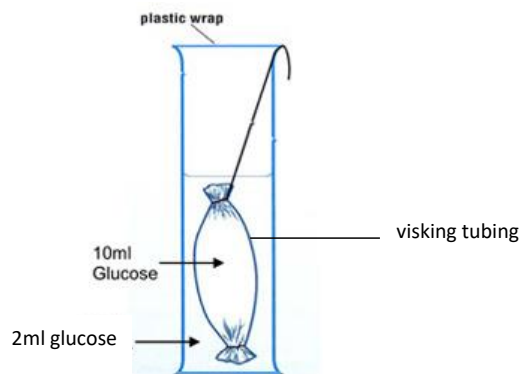
How diffusion occurs

Example 1



- Membrane is partially permeable.
- Particles like potassium iodide and copper sulfate is able to pass through.
- **Explanation:** there is a **net movement** of particles from region of **higher** concentration to a region of **lower** concentration via **diffusion** till equilibrium is reached.

Example 2

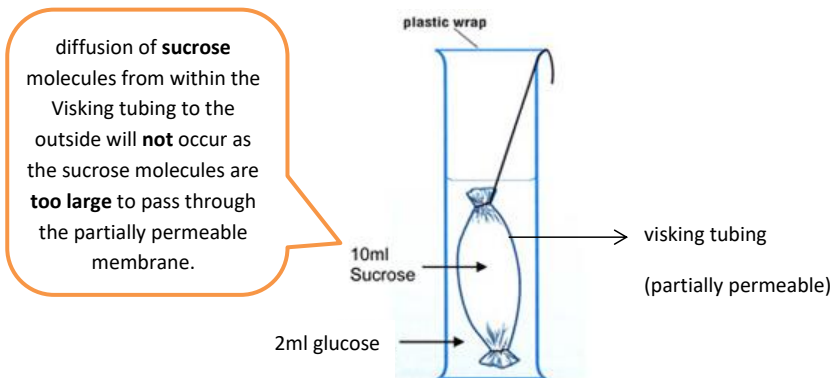


- Visking tubing is partially permeable.
 1. Which side has a higher concentration of glucose?
 - ✓ **Inside Visking tubing**
 2. Which direction will there be a net movement of glucose molecules?
 - ✓ **Ans: There is a net movement of Glucose molecules move out of the visking tubing, as the 10ml glucose solution has higher concentration of glucose, down a concentration gradient**
 3. Will equilibrium be achieved? **(end: 6ml glucose inside and outside visking tubing)**
 - ✓ **Yes**

Explanation (similar to definition. Need to write the location)

- ✓ there is a net movement of glucose molecules
- ✓ from a region of higher concentration inside the visking tubing
- ✓ to a region of lower concentration outside the visking tubing,
- ✓ via diffusion,
- ✓ down a concentration gradient, till equilibrium is reached.

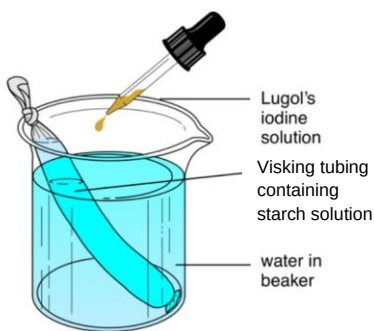
Example 3



Explanation:

- ✓ there is a net movement of glucose molecules (which are small enough)
- ✓ from the region of higher concentration outside the Visking tubing
- ✓ to the region of lower concentration inside the Visking tubing,
- ✓ via diffusion,
- ✓ down the concentration gradient until equilibrium is reached.

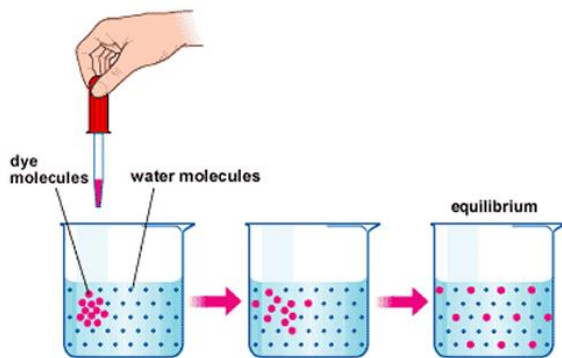
Example 4



With membrane

- Iodine solution contain iodine molecules and water molecules that are small enough to pass through the partially permeable membrane.
- Starch is a large molecule and cannot pass through the partially permeable membrane.
- **Description:**
 - Iodine solution inside the visking tubing turns from yellowish brown (initial colour) to blue black (final colour).
 - Iodine solution outside of the visking tubing remains yellowish brown. **CANNOT WRITE NO CHANGE**
- **Explanation:** There is a net movement of Iodine molecules from a region of higher concentration outside the dialysis tubing to a region of lower concentration inside the tubing via diffusion, down a concentration gradient.

Example 5



Without membrane

- There is a net movement of red dye molecules from a region of higher concentration to a region of lower concentration via diffusion, down a concentration gradient until equilibrium is reached.

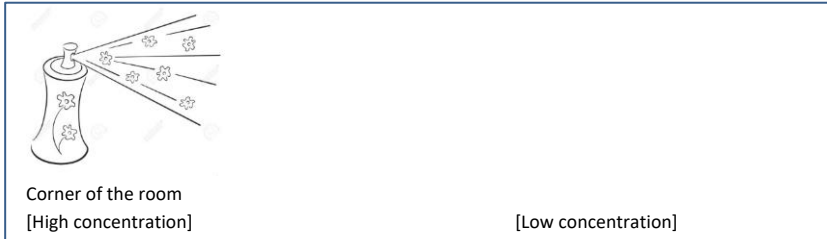
Factors affecting the speed of diffusion

1. State of particles

Speed of diffusion	slow	medium	fast

- Having more energy allows the particles to spread diffuse out randomly at a higher speed.

2. Difference in concentration



- The higher the difference in concentration, the faster the speed of diffusion.

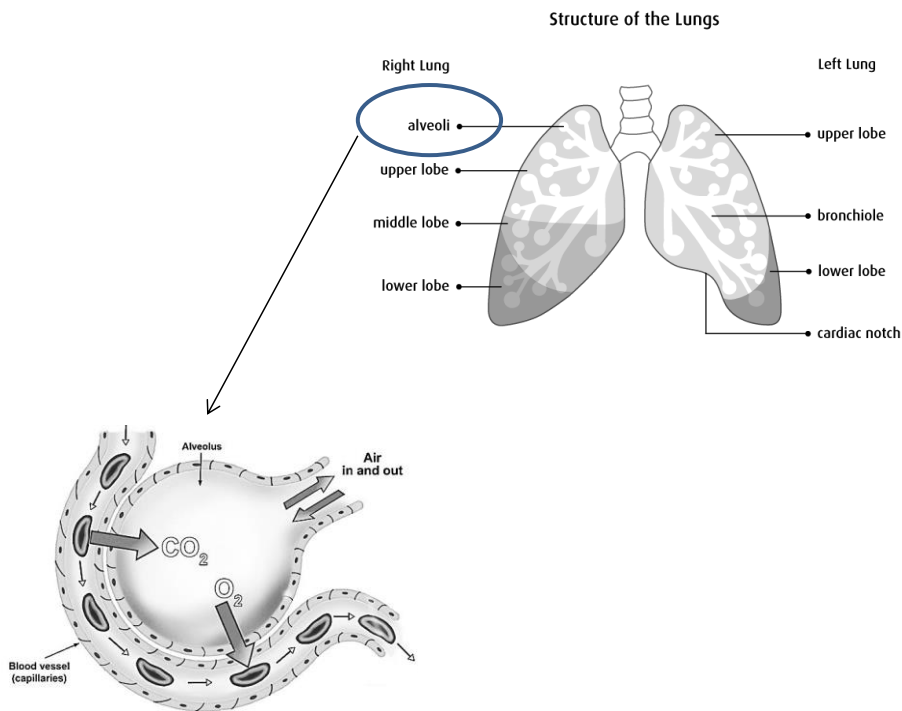
3. Temperature of the particles



- The **higher** the temperature, the more **kinetic energy** the **particles** have, hence they **spread-diffuse** out randomly at higher speed.

What is the importance of diffusion in animals and plants?

1. Gaseous exchange via diffusion in the lungs



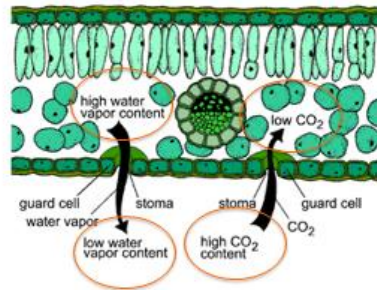
Movement of oxygen

- When we breathe in, air enters the air sacs (alveoli) in our lungs.
- Oxygen concentration thus becomes higher in the alveolus than in the blood within the blood vessel (capillary).
- Oxygen thus enters the blood through diffusion, from the region of higher concentration within the alveolus to the region of lower concentration (blood capillary), down a concentration gradient.

Movement of carbon dioxide

- During respiration in the body cells, carbon dioxide is produced and released as waste.
- Carbon dioxide is carried by the blood to the alveoli.
- The carbon dioxide concentration is higher in the blood capillary than the alveoli.
- Carbon dioxide molecules thus diffuse from the region of higher concentration in the blood capillary to the region of lower concentration in the alveoli, down the concentration gradient.
- Carbon dioxide is then exhaled out from the lungs when we breathe out.

2. Gaseous exchange via diffusion in the plants during photosynthesis



Movement of oxygen

- During day time, plants photosynthesize and release oxygen into the air spaces found in the leaves.
- As a result, these air spaces have a higher concentration of oxygen than the outside atmosphere.
- Oxygen molecules thus move from the region of higher concentration within the air space to the region of lower concentration in the atmosphere through the stomata, down a concentration gradient.

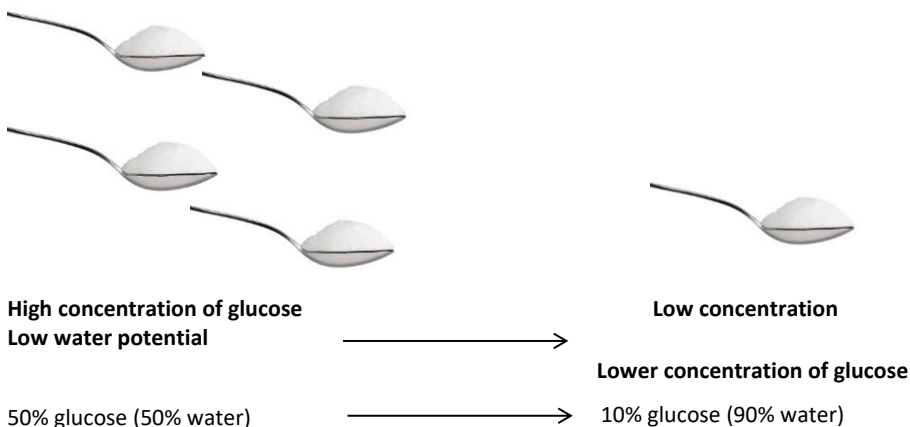
Movement of carbon dioxide

- During day time, plant photosynthesizes and uses carbon dioxide.
- The air spaces within the leaves have a lower concentration of carbon dioxide than the outside atmosphere.
- Carbon dioxide molecules thus move from the region of higher concentration in the atmosphere to the region of lower concentration in the air spaces through the stomata, down a concentration gradient.

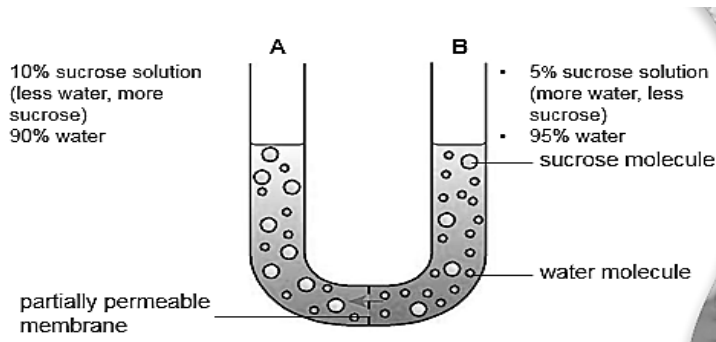
OSMOSIS

Definition: Osmosis is the net movement of **water molecules** from a region of **higher water potential** to a region of **lower water potential**, down a **water potential gradient**, through a **partially permeable membrane**.

Water potential



How osmosis occurs



- **Sucrose molecules** are **too large** to pass through the partially permeable membrane
- **Water potential** in **B** is **higher** than in **A**
- **Explanation:** There is a **net movement of water molecules from a region of higher water potential (B) to a region of lower water potential (A) via osmosis** across the partially permeable membrane till equilibrium is reached.
- There is a rise in level as solution in A as a result.

Effects of osmosis on animal and plant tissues

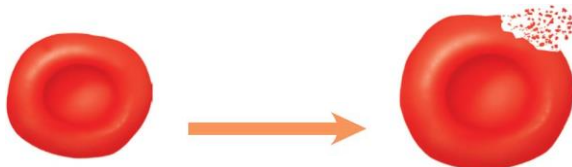
What happens to a cell in a solution with higher water potential than the surrounding solution- cell sap / cytoplasm?

1. Plant cells – Surrounding solution has higher water potential than cell sap



- Cell sap has a lower water potential than the surrounding solution.
- The surrounding solution is thus known as a **hypotonic** solution.
- **Explanation:**
 - There is a net movement of water molecules
 - from the region of higher water potential in the surrounding solution
 - to the region of lower water potential in the cell sap,
 - via osmosis
 - across a partially permeable membrane
- The plant cell expands and becomes **turgid**.
- Cell wall of the plant cell prevents it from bursting.

2. Animal cells - Surrounding solution has higher water potential than the cytoplasm



- Animal cell has a **lower water potential** than the surrounding solution.
- **Explanation:**
 - There is a net movement of water molecules into the cytoplasm.
 - from the region of higher water potential in the solution
 - to the region of lower water potential in the cell
 - via osmosis,
 - across a partially permeable membrane.
- Cell **expands** and eventually **burst** as the animal cell does not have cellulose cell wall

Commented [PLX1]: Videos:

Red blood cells under microscope: hypotonic and hypertonic
<https://www.youtube.com/watch?v=A8cl6FkcG4c>

Red blood cells bursting:
<https://www.youtube.com/watch?v=OYoaLzobQmk>

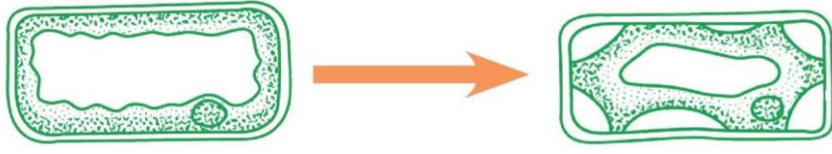
Plant cells with chloroplasts in salt water:
<https://www.youtube.com/watch?v=FHUK4ClpHAQ>

Red onion osmosis
<https://www.youtube.com/watch?v=lv7eGCPVaAk>

Red onion microscopy experiment
https://www.youtube.com/watch?v=rE_Ma6o_J-E

3. Plant cells – Surrounding solution has lower water potential than cell sap

- Cell sap has a **higher water potential** than the surrounding solution.
- Explanation:
 - There is a net movement of water molecules
 - from a region of higher water potential in the cell sap
 - to a region of lower water potential in the surrounding solution
 - via osmosis,
 - across a partially permeable membrane.
- The **large central vacuole shrinks**.
- As a result, the cytoplasm and **plasma membrane** pulls away from the **cellulose cell wall**.
- Cell becomes **plasmolysed**.
- **Process: plasmolysis**

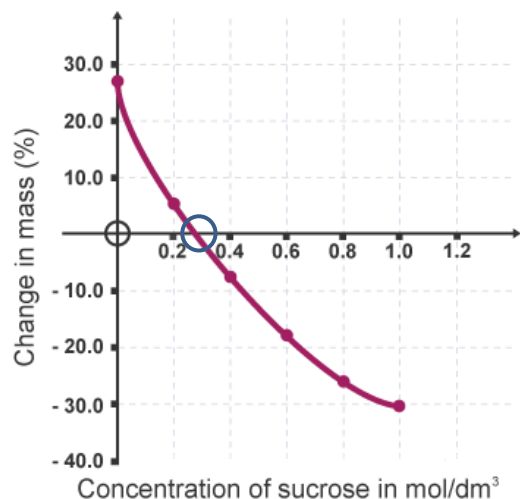


4. Animal cells – Surrounding solution has a lower water potential than the cytoplasm



- Cell cytoplasm has a **higher water potential** than the surrounding solution.
- **Explanation:**
 - There is a net movement of water molecules
 - from a region of higher water potential in the cell
 - to a region of lower water potential in the surrounding solution
 - via osmosis,
 - across a partially permeable membrane.
- Cell shrinks in size and becomes **crenated**.

5. Solution has the same water potential as the plant cell.



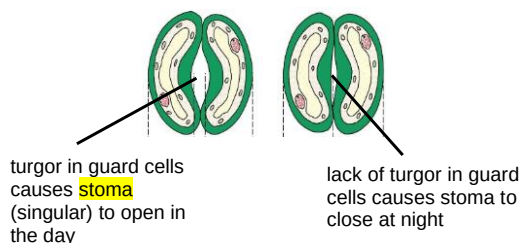
	Concentration of sucrose in mol/dm ³		
	0.0 – 0.2 mol/dm ³	0.3 mol/dm ³	0.4 – 1.0 mol/dm ³
Mass	There is an increase in mass.	There is 0% change in mass.	There is a decrease in mass.
Movement of water molecules	Net movement of water molecules into cell. There is a gain in overall number of water molecules. Explanation: The water potential of the sucrose solution is higher than the water potential in the potato cells.	Explanation: There is <u>no net movement of water molecules</u>. The <u>water potential</u> in the cell sap of the potato cells is the <u>same</u> as the <u>water potential</u> of sucrose solution	Net movement of water molecules out of cell. There is a loss in overall number of water molecules. Explanation: The water potential of the potato cells is higher than the water potential of the sucrose solution.
Resultant size of cell	There is an increase in size of cell.	There is no change in size of the cell.	There is a decrease in size of cell.

Four strips are cut from fresh potato. The length of each strip is measured. One strip placed in water, the others in different concentrations of sugar solution. After an hour, the strips are measured again. The results are shown in the table. Which liquid is water? (N2003/1/2)

	Original length of strip / mm	Final length of strip / mm
A	75	75
B	78	85
C	82	80
D	86	87

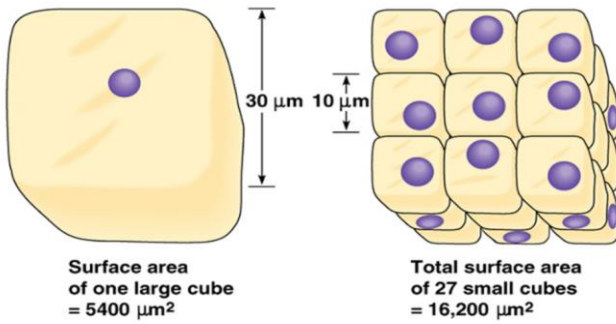
Why is **turgor** important in plants?

- Turgor plays an important role in maintaining the shape of soft tissues in plants.
 - It keeps herbaceous (non-woody) **plants firm and upright**.
 - Loss of turgidity causes the plant to wilt.
- Changes in turgor (due to movement of water by osmosis) also cause the movements of certain plant parts. e.g. stomatal opening



- Plasmolysis causes tissues to become limp or flaccid.
- When cells of a plant become flaccid, the plant wilts.
- Water may be added to the soil to dilute the soil solution to keep the plant firm and upright.

What does **surface area to volume ratio** mean for a cell?



- The **larger the surface area to volume ratio**, the **faster** the rate of movement of substances into or out of the cell.
- Some cells have adapted to better absorb materials (by increasing surface area to volume ratio).
 - Root hair cells
 - **Epithelial cells** of small intestine
 - Red blood cells