Transport Across the Cell Membrane Notes

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Chemical reactions happen inside cells. This means that substances must be able to get in and out of cells for these reactions to happen. But, there's an issue. The cell membrane is in the way.

So, substances must be able to get across the membrane. Different substances need different types of transport to move across the cell membrane. The types of transport we look at for GCSE are diffusion, osmosis and active transport.

Let's look at diffusion first 😊

Diffusion

Diffusion: the net movement of a substance from an area of high concentration to an area of low concentration moving down its concentration gradient. It is a passive process meaning we don't need to put in any energy for it to happen.

What provides the energy for diffusion? In short, the particles own kinetic energy. The more kinetic energy the particles have the faster diffusion will happen and the lower the kinetic energy the slower the rate of diffusion.

What substances diffuse across the cell membrane?

1. **Oxygen (O_2)** – diffuses into the cell from the tissue fluid surrounding the cell membrane. There is less O_2 inside the cell as it is used in the process of aerobic respiration.
2. **Carbon dioxide (CO_2)** – diffuses from the cell into the tissue fluid as CO_2 is in higher concentration inside the cell where it is one of the products of aerobic respiration.

There are more examples of substances that can cross the membrane by diffusion, for example ethanol and some hormones, but these don't get asked for in the GCSE so we just use O_2 and CO_2 as the examples 😊

Some Examples of Diffusion in Biology are…

1. **Gas exchange at the alveoli in the lungs.**

- **Oxygen (O_2)** diffuses from the air in the lungs where it is in higher concentration, into the blood where it is in lower concentration.
- **Carbon dioxide (CO_2)** diffuses from the blood where it is in higher concentration, into the air in the lungs where it is in lower concentration.

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2. **Gas exchange for photosynthesis**.

- **Carbon dioxide (CO_2)** diffuses from the air/airspaces between cells of the leaf tissue (spongy mesophyll) where it is in higher concentration into the cells which are doing photosynthesis (palisade cells) where it is in lower concentration.
- **Oxygen (O_2)** diffuses from the leaf tissue (spongy mesophyll) where it is in higher concentration into the airspaces between cells where it is in lower concentration. It then diffuses out of the leaf through the stomata.
  Stomata are small holes in the leaf which are needed for gases to be exchanged.

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3. **Gas exchange for respiration**.

- **Oxygen (O_2)** diffuses into the cell from the tissue fluid surrounding the cell membrane. There is less O_2 inside the cell as it is used in the process of aerobic respiration.
- **Carbon dioxide (CO_2)** diffuses from the cell into the tissue fluid as CO_2 is in higher concentration inside the cell where it is one of the products of aerobic respiration.

As mentioned earlier, oxygen (O_2) and carbon dioxide (CO_2) are the two main substances that we look at when talking about diffusion. If you get stuck and can't remember an example use some type of gas exchange 😊

Factors Affecting Diffusion

As diffusion is a passive process the rate at which it occurs can be affected by the conditions around it. Let's look at each condition that can affect the rate of diffusion.

The rate of diffusion can be increased by having:

1. **A short distance** – diffusion occurs faster when a layer is one cell thick compared to a layer that is three cells thick. The thinner a membrane is the faster the substance can diffuse through.
2. **A large surface area** – a larger surface area through which diffusion can happen increases the diffusion rate.
3. **A large concentration difference** – a greater difference in concentration increases the diffusion rate.
4. **A high temperature**: increases the kinetic energy allowing particles to move faster.
5. **Size of molecules**: larger molecules will diffuse more slowly and smaller molecules will diffuse more quickly.

Active Transport

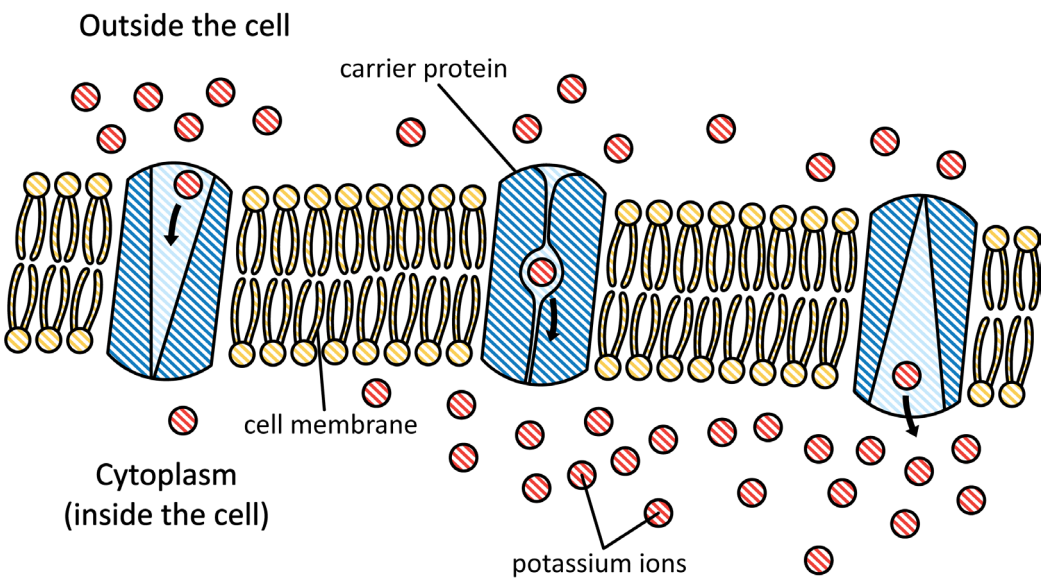
Active transport: is the movement of a substance across a cell membrane **against** its concentration gradient, moving from lower concentration to higher concentration using energy.

Special proteins within the cell membrane called carrier proteins allow the substances to pass through the membrane. Think of them as little pumps that pump the substances into the cell against the concentration gradient.

The energy for active transport comes from ATP generated in aerobic respiration (in mitochondria).
Examples of Active Transport:

1. Mineral ion uptake by root hair cells – plants need to absorb mineral ions (like nitrates) from the soil. The concentration of these ions is often higher inside the root hair cell than in the soil, so the plant must use energy to actively transport them into the cell against the concentration gradient.
2. Reabsorption of glucose, amino acids and salts by the proximal convoluted tubule of the nephron in the kidney.
3. Sodium/potassium pump in cell membranes (especially nerve cells).

The figure below shows active transport occurring across a cell membrane.



Key: represents the movement of an ion through the carrier proteins.

Osmosis

Osmosis: the movement of water through a partially permeable membrane from an area of higher water concentration to an area of lower water concentration. Osmosis is a special example of diffusion.

A partially permeable membrane: a barrier that permits the passage of some substances but not others; it allows the passage of the solvent molecules but not some of the larger solute molecules.

Some examples of osmosis are:

1. Absorption of water by plant roots.
2. Absorption of water by the colon of the digestive system.

Special note: When the concentration of water is the same on both sides of the membrane, the movement of water molecules will be the same in both directions. There will be no net movement of water molecules.

Before we look at the effect of osmosis on plant and animal cells let's first explain the different types of solutions 😊 These are hypotonic, isotonic and hypertonic. There's a golden rule to remember that will make understanding and learning these so much easier 😊

The golden rule: the names **hypo**, **iso**, and **hyper** always describe the amount of solutes (like salt or sugar) in the solution surrounding the cell. So, not in the cell, outside it!

Hypotonic solution: has a **lower concentration of solutes** and a higher water concentration than the cell's cytoplasm. This means that water moves **into** the cell by osmosis, from the higher water concentration outside of the cell to the lower water concentration inside.

Isotonic solution: has the same concentration of solutes and water as the cell's cytoplasm.
Water molecules move **into and out of the cell at the same rate**. There is **no net movement** of water.

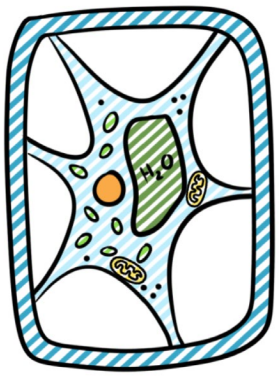
Hypertonic solution: has a **higher concentration of solutes** and a lower water concentration than the cell's cytoplasm. Water moves **out** of the cell by osmosis, from the higher water concentration inside the cell to the lower water concentration outside.

Osmosis in Plant Cells

Plant cells have a strong cellulose cell wall on the outside of the cell membrane. This supports the cell and stops it bursting when it gains too much water by osmosis.

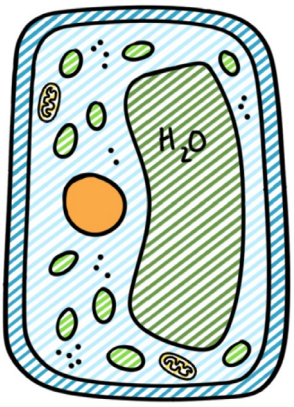
The figure below shows what happens when there is too little, just right and too much water in a plant cell 😊

Too little water… called **Plasmolysed.**



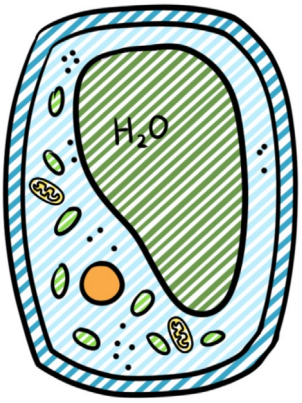
In a **hypertonic** solution

Just too little … called **flaccid.**



In an **isotonic** solution

Normal … called **Turgid.**



In a **hypotonic** solution

Plasmolysis: occurs when a plant cell is in a solution with a lower water concentration (a more concentrated solution) than its cytoplasm. Water moves out of the cell by osmosis, causing the vacuole to shrink and the cell membrane to pull away from the cell wall.

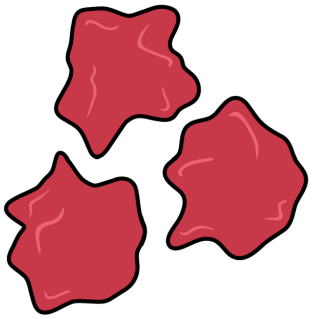
Flaccid: osmosis is still occurring but there is no net movement of water into or out of the cell.

Turgid: there is the normal amount of water in the cell. Water has moved into the cell by osmosis as the surroundings have a higher water concentration than the cell.

Osmosis in Animal Cells

Animal cells do not have a cell wall. They change size and shape when put into solutions that are at a different concentration to the cell contents. If too much water enters an animal cell it will burst.

Too little water… called **Crenated.**

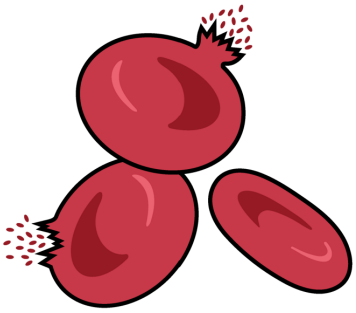


In a **hypertonic** solution

Just right … called **Normal.**

In a **isotonic** solution

Too much … called **Lysis.**



In a **hypotonic** solution

Crenated: when there is very little water in the cell this causes the cell to become very misshaped.

Normal: describes where there is the normal amount of water in the cell. Osmosis is still taking place but there is no net movement of water into or out of the cell.

Lysis: <u>the bursting of a cell</u>. This can be due to too much water in the cell.

Osmosis Calculations

Exam questions on the topic of osmosis could have percentage change calculations as part of them. These are just typical percentage change questions where an object has either gained or lost mass due to a loss or gain of water.

$$\textbf{Percentage change} = \frac{\boldsymbol{Final\ Mass - Initial\ Mass}}{\boldsymbol{Initial\ Mass}} \times 100$$

Check out the examples below 😊

Example 1: A cylinder of potato has a mass of 5 g before it is placed into a concentrated solution and 3.5 g when it was removed.

$$\textbf{Percentage change} = \frac{3.5-5}{5} \times 100$$

$$\textbf{Percentage change} = -30\%$$

Example 2: A cylinder of potato has a mass of 4 g before it is placed into a dilute solution and 4.75 g when it was removed.

$$\textbf{Percentage change} = \frac{4.75-4}{4} \times 100$$

$$\textbf{Percentage change} = +18.75\%$$