AQA Bioenergetics Knowledge Organiser

Photosynthesis

Photosynthesis is a chemical reaction which takes place in plants. It converts **carbon dioxide** and **water** into **glucose** and **oxygen**. It uses **light** energy to power the chemical reaction, which is absorbed by the green pigment **chlorophyll**. This means that photosynthesis is an example of an **endothermic** reaction. The whole reaction takes place inside the **chloroplasts** which are small organelles found in plant cells.

Plants acquire the carbon dioxide via diffusion through the **stomata** of their leaves. The water is absorbed from the soil through the **roots** and transported to the cells carrying out photosynthesis, via the **xylem**.

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

The glucose made in photosynthesis is used for respiration, stored as starch, fat or oils, used to produce cellulose or used to produce amino acids for protein synthesis.

The Rate of Photosynthesis and Limiting Factors

A **limiting factor** is something which stops the photosynthesis reaction from occurring at a faster rate. **Temperature**, **light intensity** and **carbon dioxide** level are all limiting factors.

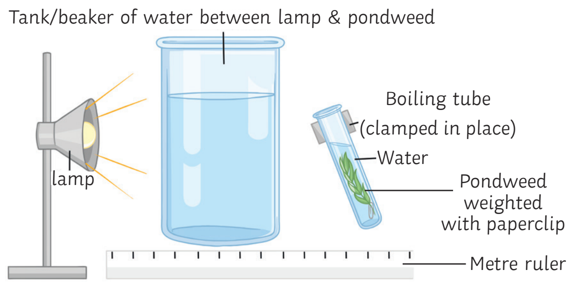
Increasing the temperature of the surroundings will increase the rate of reaction, but only up to around 45°C. At around this temperature, the enzymes which catalyse the reaction become denatured.

Increasing the light intensity will increase the rate of reaction because there is more energy to carry out more reactions.

Increasing the carbon dioxide concentration will also increase the rate of reaction because there are more reactants available.

The Effect of Light Intensity on the Rate of Photosynthesis (RPI)

The amount of light a plant receives affects the rate of photosynthesis. If a plant receives lots of light, lots of photosynthesis will occur. If there is very little or no light, photosynthesis will stop.



Method

1. Measure 20cm^3 of sodium hydrogen carbonate solution and pour into a boiling tube.
2. Collect a 10cm piece of pondweed and gently attach a paper clip to one end.
3. Clamp the boiling tube, ensuring you will be able to shine light onto the pondweed.
4. Place a metre rule next to the clamp stand.
5. Place the lamp 10cm away from the pondweed.
6. Wait two minutes, until the pondweed has started to produce bubbles.
7. Using the stopwatch, count the number of bubbles produced in a minute.
8. Repeat stages 5 to 7, moving the lamp 10cm further away from the pondweed each time until you have five different distances.
9. Now repeat the experiment twice more to ensure you have three readings for each distance.

The **independent** variable was the light intensity.

The **dependent** variable was the amount of bubbles produced. Counting the bubbles is a common method, but you could use a gas syringe instead to more accurately measure the volume of oxygen produced.

The **control** variables were same amount of time and same amount of pondweed. A bench lamp is used to control the light intensity and the water in the test tube containing the pondweed is monitored with a thermometer to monitor and control the temperature.

Interaction of Limiting Factors (HT only)

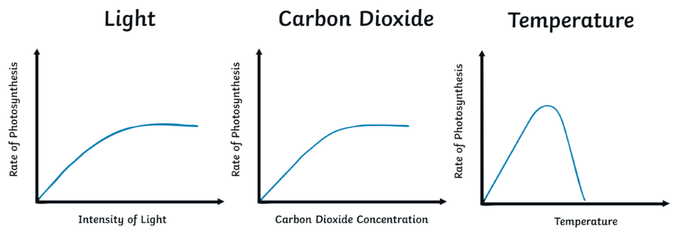
The limiting factor for the reaction will depend on the environmental conditions.

For example:

At night, light intensity is the limiting factor.

In winter, temperature is the limiting factor.

In other conditions, carbon dioxide is usually the limiting factor.



From the graph, you can see that increasing one of the factors will also increase the rate of reaction, but only for so long before it plateaus. This is because another factor will have then become the limiting factor. E.g. you could increase the supply of carbon dioxide, but if there is not enough chlorophyll to absorb the sunlight, then the sunlight will become the limiting factor instead.

Greenhouse Economics (HT only)

To grow plants in the most suitable conditions, a greenhouse can be used.

A greenhouse traps the sun's radiation as heat inside the greenhouse, so that temperature is not a limiting factor for the rate of photosynthesis.

Artificial lighting can be installed in the greenhouse to provide constant light energy and prevent light intensity being a limiting factor.

A paraffin heater can be used in the greenhouse to not only maintain a suitable temperature, but the by-product of the combustion off the paraffin is carbon dioxide.

Enclosing the crops in a greenhouse and regulating all the conditions in this way can be expensive; however, it is often outweighed because the harvest of the crop is much healthier, faster-grown crops. Furthermore, the enclosed conditions mean that disease and pests can be easily controlled and prevented.

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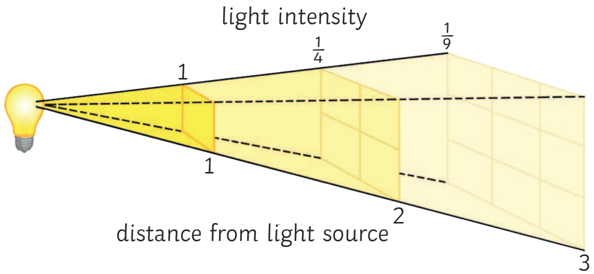
Inverse Square Law and Light Intensity

The **inverse square law** is used to describe the light intensity at different distances from the source.

The inverse square law states that: **the intensity of light is inversely proportional to the square distance from the source.**



Light intensity is calculated by the following equation:

$$\text{light intensity} \propto \frac{1}{\text{distance}^2}$$

- The symbol, ∝, means 'is proportional to'.
- Distance is measured in metres, m.

In other words, if an object is moved twice as far away from the light source, the light intensity received is reduced to just one quarter.

Worked example:

If the light source is 10cm from a plant, calculate the light intensity reaching the plant.

1 ÷ (distance^2)
1 ÷ (0.10 × 0.10)
1 ÷ 0.01
= **100 arbitrary units**

If the light source is moved 25cm from the plant, calculate the light intensity reaching the plant.

1 ÷ (distance^2)
1 ÷ (0.25 × 0.25)
1 ÷ 0.0625
= **16 arbitrary units**

Respiration

Respiration is the chemical reaction which occurs inside the **mitochondria** of all living cells to release energy for living functions and processes, e.g. movement, warmth and building larger molecules for growth and repair. The reaction is **exothermic**, meaning that energy is released to the surroundings.

Respiration can be either **aerobic** (using oxygen) or **anaerobic** (without using oxygen).

glucose oxygen carbon dioxide water energy

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$$

In anaerobic respiration, the glucose is not completely oxidised. This means that there is less energy released than in aerobic respiration.

glucose lactic acid energy

$$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3 + ATP$$

In plants and yeast, anaerobic respiration makes some different products. The reaction is also called fermentation and is used in bread-making and beer-brewing.

glucose ethanol carbon dioxide energy

$$C_6H_{12}O_6 \rightarrow C_2H_5OH + CO_2 + ATP$$

Effect of Exercise

When a person exercises, their body (specifically their **muscles**) need much more energy. To release more energy, the amount of respiration reactions occurring has to increase.

The **heart** pumps faster and the **breathing** rate and breath volume all increase to supply more **oxygen** to the muscles via the bloodstream.

If the muscles are not receiving enough oxygen to keep up the demand needed by the respiration reactions, then **anaerobic** respiration begins to occur. This incomplete oxidation of the glucose produces **lactic acid**, which can build up in the muscles and results in an **oxygen debt**.

After long periods of exercise, the muscles can become fatigued and stop contracting. You might experience a pain commonly called a **stitch**.

Metabolism

Metabolism is the combination of all the reactions in a cell or in the body.

Energy released during respiration is used during metabolic processes to synthesise new molecules:

- Glucose is converted to starch, glycogen and cellulose.
- Glycerol and three fatty acids are joined to form a lipid molecule.
- Glucose and nitrate ions are joined to form amino acids.
- Amino acids are joined to form proteins.
- Excess proteins are broken down and released as urea during excretion.

Respiration itself is also a processes which is included in metabolism.

Oxygen Debt (HT only)

During vigorous exercise, the body can begin to carry out **anaerobic respiration** and produces **lactic acid**.

Lactic acid is transported via the bloodstream to the **liver**. The liver converts the lactic acid back into **glucose**. However, **oxygen** is needed to carry out this reaction.

The **oxygen debt** is the amount of the oxygen required by the body to convert the built-up lactic acid back into glucose and remove it from the respiring cells.

AQA GCSE Chemistry (Separate Science) Unit 5 Energy Changes Knowledge Organiser

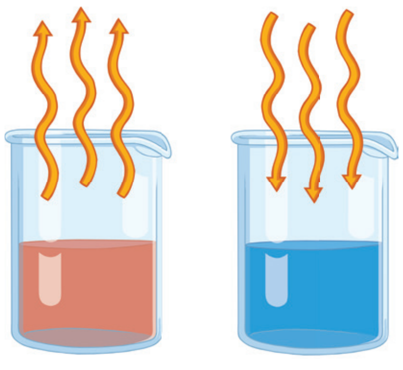
Exothermic and Endothermic Reactions

When a chemical reaction takes place, **energy** is involved. Energy is transferred when chemical **bonds are broken** and when new **bonds are made.**

Exothermic reactions are those which involve the transfer of energy **from the reacting chemicals to** the surroundings. During a practical investigation, an exothermic reaction would show an i**ncrease in temperature** as the reaction takes place.

Examples of exothermic reactions include **combustion, respiration and neutralisation** reactions. Hand-warmers and self-heating cans are examples of everyday exothermic reactions.

Endothermic reactions are those which involve the transfer of energy **from the surroundings to** the reacting chemicals. During a practical investigation, an endothermic reaction would show a **decrease in temperature** as the reaction takes place.



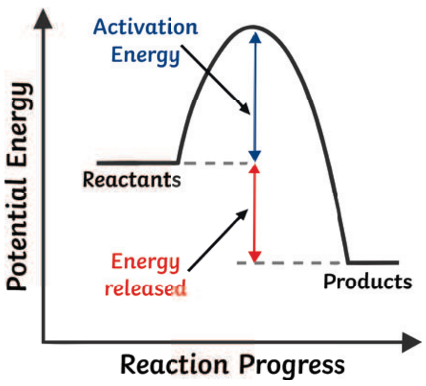
Examples of endothermic reactions include the **thermal decomposition** of calcium carbonate.
Eating **sherbet** is an everyday example of an endothermic reaction. When the sherbet dissolves in the saliva in your mouth, it produces a cooling effect. Another example is **instant ice packs** that are used to treat sporting injuries.

Reaction Profiles – Exothermic

Energy level diagrams show us what is happening in a particular chemical reaction. The diagram shows us the **difference in energy** between the reactants and the products.

In an exothermic reaction, the **reactants** are at a **higher** energy level than the products.

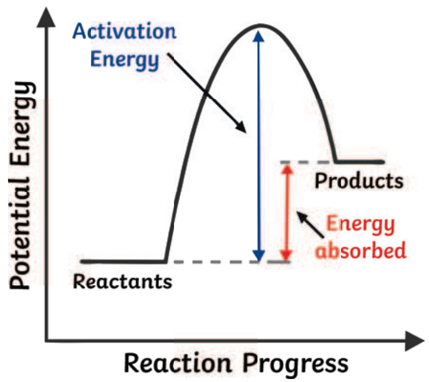
In an **exothermic** reaction, the difference in energy is **released** to the surroundings and so the **temperature** of the surroundings **increases**.



Reaction Profiles – Endothermic

In an **endothermic** reaction, the **reactants** are at a **lower** energy level than the products.

In an **endothermic** reaction, the difference in energy is **absorbed** from the surroundings and so the **temperature** of the surroundings **decreases**.



Activation Energy – the minimum amount of energy required for a chemical reaction to take place.

Catalysts – increase the rate of a reaction. Catalysts provide an alternative pathway for a chemical reaction to take place by **lowering** the activation energy.

Bond Making and Bond Breaking

In an **endothermic** reaction, energy is needed to break chemical bonds. The **energy change (ΔH)** in an endothermic reaction is **positive.**

You may also find, in some textbooks, **ΔH** referred to as the **enthalpy change.**

In an **exothermic** reaction, energy is needed to form chemical bonds. The **energy change (ΔH)** in an exothermic reaction is **negative.**

Bond energies are measured in **kJ/mol.**

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Calculations Using Bond Energies (Higher Tier Only)

Bond energies are used to calculate the change in energy of a chemical reaction.

Calculate the change in energy for the reaction: $2H_2O_2 \longrightarrow 2H_2O + O_2$

The first step is to write the symbol equation for the reaction. Once you have done this, work out the bonds that are breaking and the ones that are being made.

2H–O–O–H ⟶ 2H–O–H + O=O

Bond	Bond Energy kJ/mol
H-O	464
O-O	146
O=O	498

On the **left-hand side** of the equation, the **bonds are breaking.**

There are two **O–H** bonds and one **O–O** bond.

So 464 + 146 + 464 = 1074

There are two moles of H_2O_2 therefore the answer needs to be multiplied by two.

So 1074 × 2 = 2148

On the **right-hand** side of the equation, the **bonds are made.**

There are two **H–O** bonds

So 464 + 464 = 928

Two moles of H_2O are made therefore the answer needs to be multiplied by two.

So 928 × 2 = 1856

There is also one **O=O** bond with a bond energy of 498

So 1856 + 498 = 2354

ΔH = sum (bonds broken) – sum (bonds made)

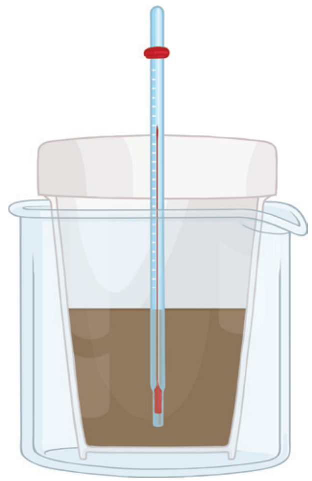
ΔH = 2148 – 2354 = -206 kJ/mol

The reaction is exothermic as ΔH is negative.

Required Practical

Aim

To investigate the variables that affect temperature changes in reacting solutions, e.g. acid plus metals, acid plus carbonates, neutralisations and displacement of metals.



Equipment

- polystyrene cup
- measuring cylinder
- thermometer
- 250cm^3 glass beaker
- measuring cylinder
- top pan balance

Method

Reaction between a metal and an acid.

1. Gather the equipment.
2. Place the polystyrene cup inside the beaker. This will prevent the cup from falling over.
3. Using a measuring cylinder, measure out 30cm^3 of the acid. Different acids such as hydrochloric or sulfuric acid may be used. Pour this into the polystyrene cup.
4. Record the temperature of the acid using a thermometer.
5. Using a top pan balance, measure out an appropriate amount of the solid (for example, 10g) or use one strip of a metal such as magnesium.
6. Add the solid to the acid and record the temperature. You may choose to record the temperature of the acid and metal every minute for 10 minutes.

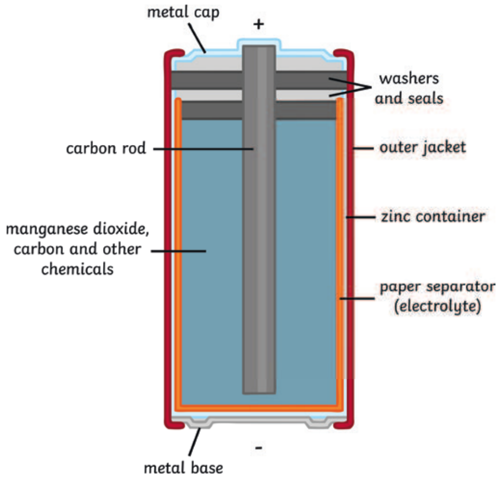
Chemical Cells

A chemical cell converts **chemical energy** into **electrical energy.** More than one cell connected in series is called a battery.

There are two types of chemical cell, **rechargeable** and **non-rechargeable.**

Non-rechargeable cells will produce a **voltage** until the chemicals inside are used up. Once this occurs, the cell is no longer useful and can then be recycled.

Rechargeable cells and batteries can be recharged multiple times. An electrical current is passed backwards through the cell. This works by **reversing** the chemical reactions and the cell or battery can then be used again to produce more electricity. Mobile phones contain rechargeable batteries.

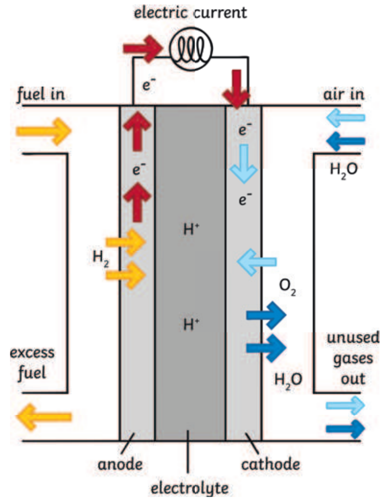


Fuel Cells

Fuels cells work differently to chemical cells in that they need to be supplied with a fuel and oxygen. The constant supply of these two ingredients will allow a fuel cell to produce a voltage continuously.

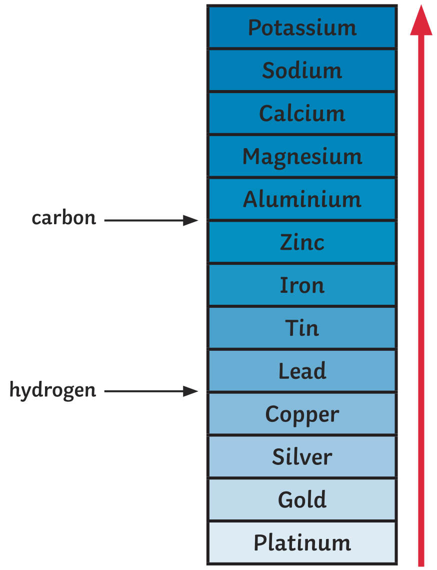
Inside the fuel cell, hydrogen is **oxidised** electrochemically; the fuel is **not combusted.** This allows the reaction to take place at a lower temperature.

Hydrogen-oxygen fuel cells are an alternative to rechargeable batteries and cells as the only product that is produced is water.



Voltage

The voltage of a cell is affected by the combination of metals used inside it. The bigger the difference in the **reactivity** of the two metals, the bigger the **voltage** produced. For example, if the metals used inside the cell are magnesium and zinc, then the voltage produced will be **small** as the two metals are **close together** in the **reactivity series.** By comparison, if magnesium and copper are used, then the voltage produced will be **larger** as the metals are **further apart** in the **reactivity series.**



Ionic Equations

hydrogen + oxygen ⟶ water

$2H_2 + O_2 \longrightarrow 2H_2O$

At the **cathode:** $2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^-$

At the **anode:** $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$

In the fuel cell, **oxygen** is being **reduced** (reduction is the gaining of electrons) whilst **hydrogen** is being **oxidised** (oxidation is the loss of electrons). Oxidation and reduction happen simultaneously – this is called a **redox reaction.**

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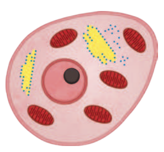
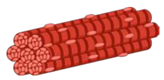
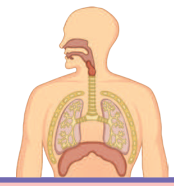
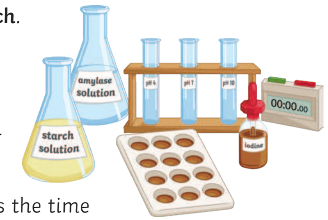
Principles of Organisation

				
cell	**tissue**	**organ**	**organ system**	**organism**
Cells are the basic building blocks of all living things.	A group of cells with a similar structure and function is called a tissue.	An organ is a combination of tissues carrying out a specific function.	Organs work together within an organ system.	Organ systems work together to form whole living organisms.

Food Tests (Required Practical)

What are you testing for?	Which indicator do you use?	What does a positive result look like?
sugar	Benedict's reagent	Once heated, the solution will change from blue-green to yellow-red.
starch	iodine	Blue-black colour indicates starch is present.
protein	biuret	The solution will change from blue to pink-purple.
lipid	sudan III	The lipids will separate and the top layer will turn bright red.

Effect of pH on the Rate of Reaction of Amylase (Required Practical)



Iodine is used to test for the presence of **starch**. If starch is present, the colour will change to blue-black.

The **independent variable** in the investigation is the pH of the buffer solution.

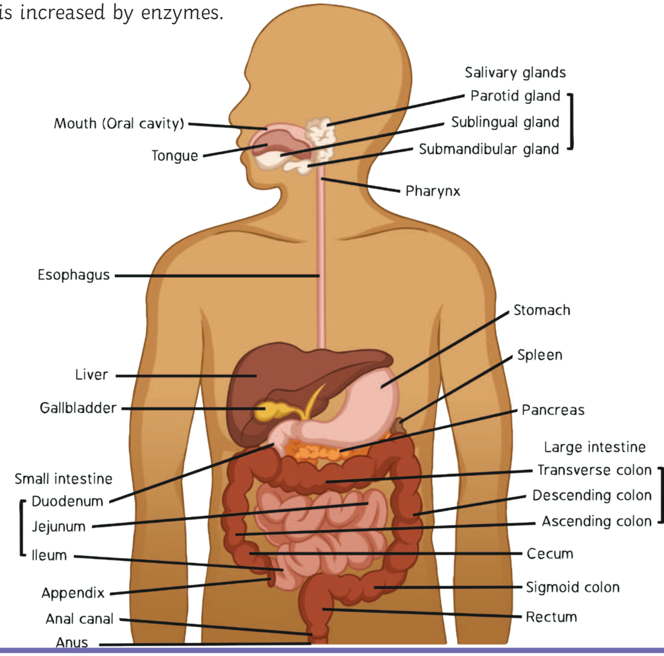
The **dependent variable** in the investigation is the time taken for the reaction to complete (how long it takes for all the starch to be digested by the amylase).

Method:

1. Use the marker pen to label a test tube with the first value of pH buffer solution (pH 4) and stand it in the test tube rack.
2. Into each well of the spotting tiles, place a drop of iodine.
3. Using a measuring cylinder, measure 2cm^3 of amylase and pour into the test tube.
4. Using a syringe, measure 1cm^3 of the buffer solution and pour into the test tube.
5. Leave this to stand for five minutes and then use the thermometer to measure the temperature. Make a note of the temperature.
6. Add 2cm^3 of starch solution into the test tube, using a different measuring cylinder to measure, and begin a timer (leave the timer to run continuously).
7. After 10 seconds, use a pipette to extract some of the amylase/starch solution, and place one drop into the first well of the spotting tile. Squirt the remaining solution back into the test tube.
8. Continue to place one drop into the next well of the spotting tile, every 10 seconds, until the iodine remains orange.
9. Record the time taken for the starch to be completely digested by the amylase by counting the wells that were tested positive for starch (indicated by the blue/black colour change of the iodine). Each well represents 10 seconds of time.
10. Repeat steps 1 to 8 for pH values 7 and 10.

The Digestive System

The purpose of the digestive system is to break down large molecules into smaller, soluble molecules, which are then absorbed into the bloodstream. The rate of these reactions is increased by enzymes.



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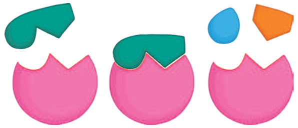
Enzymes



An enzyme is a biological **catalyst**; enzymes speed up chemical reactions without being changed or used up.
This happens because the enzyme lowers the **activation energy** required for the reaction to occur. Enzymes are made up of chains of amino acids folded into a globular shape.

Enzymes have an **active site** which the **substrate** (reactants) fits into. Enzymes are very specific and will only catalyse one specific reaction. If the reactants are not the complimentary shape, the enzyme will not work for that reaction.
Enzymes also work optimally at specific conditions of pH and temperature. In extremes of pH or temperature, the enzyme will **denature**. This means that the bonds holding together the 3D shape of the active site will break and the active shape will deform. The substrate will not be able to fit into the active site anymore and the enzyme cannot function.

Enzyme	Reactant	Product
amylase	starch	sugars (glucose)
protease	protein	amino acids
lipase	lipid	glycerol and fatty acids

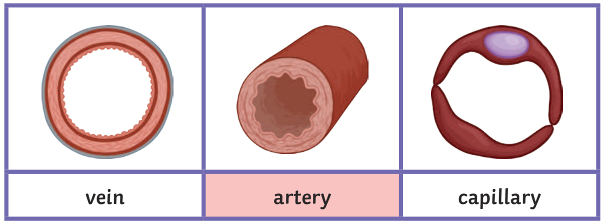
The products of digestion are used to build new carbohydrates and proteins and some of the glucose is used for respiration.

Bile is produced in the **liver** and stored in the gall bladder. It is an **alkaline** substance which **neutralises** the hydrochloric acid in the stomach. It also works to **emulsify** fats into small droplets. The fat droplets have a higher **surface area** and so the rate of their digestion by lipase is increased.

The Heart and Blood Vessels

The **heart** is a large muscular organ which **pumps blood** carrying oxygen or waste products around the body. The **lungs** are the site of **gas exchange** where oxygen from the air is exchanged for waste carbon dioxide in the blood. Oxygen is used in the **respiration** reaction to release energy for the cells and carbon dioxide is made as a waste product during the reaction.

glucose + oxygen ⟶ carbon dioxide + water + [energy]



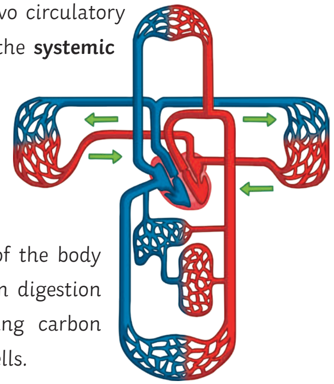
The three types of blood vessels, shown above, are each adapted to carry out their specific function.

Capillaries are narrow vessels which form networks to closely supply cells and organs between the veins and arteries. The walls of the capillaries are only **one cell thick**, which provides a short **diffusion pathway** to increase the rate at which substances are transferred.

The table below compares the structure and function of arteries and veins:

	Artery	Vein
direction of blood flow	away from the heart	towards the heart
oxygenated or deoxygenated blood?	oxygenated (except the pulmonary artery)	deoxygenated (except the pulmonary vein)
pressure	high	low (negative)
wall structure	thick, elastic, muscular, connective tissue for strength	thin, less muscular, less connective tissue
lumen (channel inside the vessel)	narrow	wide (with valves)

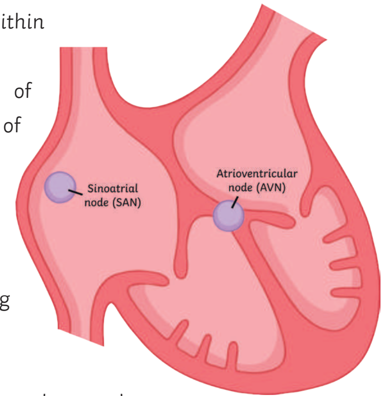
The Heart as a Double Pump



The heart works as a **double pump** for two circulatory systems; the **pulmonary** circulation and the **systemic** circulation.
The pulmonary circulation serves the lungs and bring deoxygenated blood to exchange waste carbon dioxide gas for oxygen at the **alveoli**.
The systemic circulation serves the rest of the body and transports oxygen and nutrients from digestion to the cells of the body, whilst carrying carbon dioxide and other waste away from the cells.
The systemic circulation flows through the whole body. This means the blood is flowing at a much higher pressure than in the pulmonary circuit.

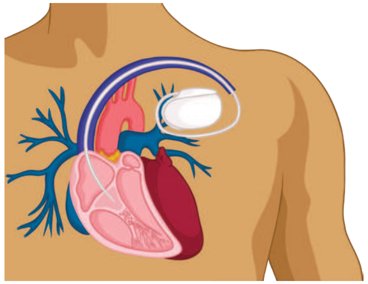
The Heart as Pacemaker

The rate of the heart beating is very carefully, and automatically, controlled within the heart itself.
Located in the muscular walls of the heart are small groups of cells which act as pacemakers. They produce electrical impulses which stimulate the surrounding muscle to contract, squeezing the chambers of the heart and pumping the blood.



The **sino-atrial node (SAN)** is located near the right atrium and it stimulates the atria to contract.
The **atrio-ventricular node (AVN)** is located in between the ventricles and stimulates them to contract.

Artificial pacemakers can be surgically implanted into a person if their heart nodes are not functioning correctly.



Coronary Heart Disease

Coronary heart disease is a condition resulting from **blockages** in the **coronary arteries**. These are the main arteries which supply blood to the heart itself and they can become blocked by build-up of **fatty deposits**.

In the UK and around the world, coronary heart disease is a major cause of many **deaths**.

The main symptoms can include **chest pain**, **heart attack** or **heart failure**. Yet, not all people suffer the same symptoms, if any at all.

Lifestyle factors can increase the risk of a person developing coronary heart disease.

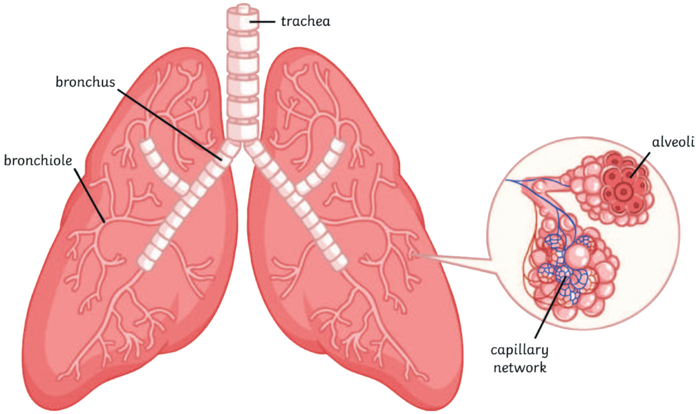
Diet – a high-fat diet (containing lots of saturated fat) can lead to higher cholesterol levels and this cholesterol forms the fatty deposits which damage and block the arteries.

Smoking – chemicals in cigarette smoke, including nicotine and carbon monoxide, increase the risk of heart disease. Carbon monoxide reduces the amount of oxygen which can be transported by the red blood cells and nicotine causes an increased heart rate. The lack of oxygen to the heart and increased pressure can lead to heart attacks.

Stress – prolonged exposure to stress or stressful situations (such as high pressure jobs) can lead to high blood pressure and an increased risk of heart disease.

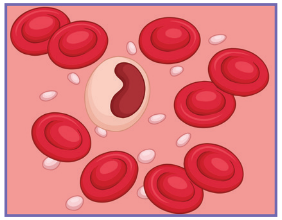
Drugs – illegal drugs (e.g. ecstasy and cannabis) can lead to increased heart rate and blood pressure, increasing the risk of heart disease.

Alcohol – regularly exceeding unit guidelines for alcohol can lead to increased blood pressure and risk of heart disease.



Blood

Blood is composed of red blood cells (erythrocytes), white blood cells and platelets, all suspended within a plasma (a tissue).



The **plasma** transports the different blood cells around the body as well as carbon dioxide, nutrients, urea and hormones. It also distributes the heat throughout the body.

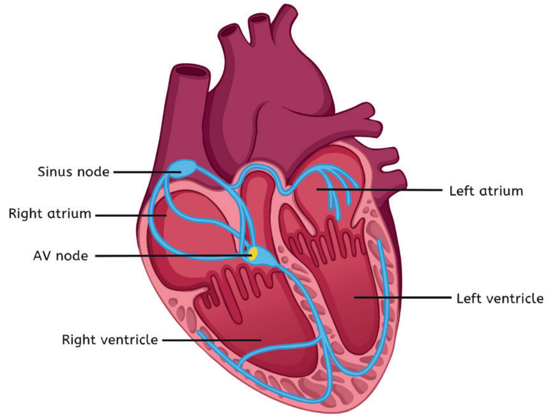
Red blood cells transport oxygen attached to the haem group in their structure. It has a biconcave shape to increase surface area and does not contain a nucleus so it can bind with more oxygen molecules.

White blood cells form part of the immune system and ingest pathogens and produce antibodies. **Platelets** are important blood clotting factors.

at the lungs

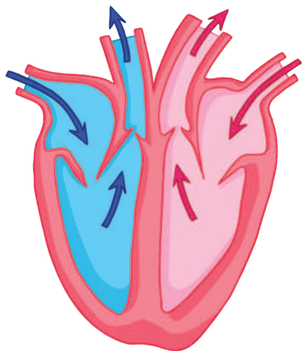
haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin

at the cells



The **right atrium** receives deoxygenated blood via the **vena cava**. It is then pumped down through the valves into the right ventricle. From here, it is forced up through the **pulmonary artery** towards the **lungs** where it exchanges carbon dioxide for oxygen. The oxygenated blood then enters the **left atrium** via the **pulmonary vein** and down into the left ventricle. The muscular wall of the **left ventricle** is much thicker so it can pump the blood more forcefully out of the heart and around the entire body, via the **aorta**.

The blood only flows in **one direction**. This is because there are **valves** in the heart which close under pressure and prevent the backward flow of blood.



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Rate Calculations for Blood Flow

The number of beats the heart performs each minute is called the **pulse** (or heart rate).

It is easily measured by counting the number of beats in a given time, e.g. 15s, and finding the total beats **per minute**.

Typically, a lower resting pulse rate indicates a greater level of physical **fitness**. During exercise, and for some time after, the pulse rate increases while the heart is working to provide more **oxygen** to the muscles.

Cardiac output is a measure of the volume of blood pumped by the heart each **minute**. **Stroke volume** is a measure of the volume of blood pumped from the heart each **contraction** (heart beat).

Cardiac output (cm^3/min) = heart rate (bpm) × stroke volume (cm^3/beat)

Cancer

Cancer is the result of **uncontrolled** cell growth and division. The uncontrolled growth of cells is called a **tumour**.

Benign Tumour	Malignant Tumour
• Usually grows slowly. • Usually grows within a membrane and can be easily removed. • Does not normally grow back. • Does not spread around the body. • Can cause damage to organs and be life-threatening.	• cancerous • Usually grows rapidly. • Can spread around the body, via the bloodstream. • Cells can break away and cause secondary tumours to grow in other areas of the body (metastasis).

Plant Tissues, Organs and Systems

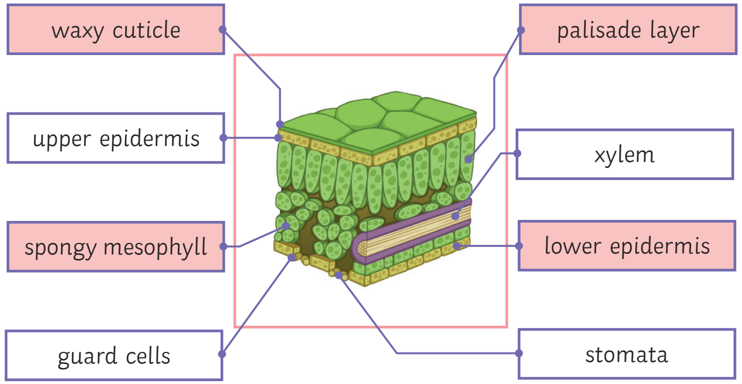
Leaves are plant organs and their main function is to absorb sunlight energy for use in **photosynthesis**. Within the cells are small organelles called **chloroplasts** which contain a green pigment called **chlorophyll**. This is the part of the plant which absorbs the sunlight and where photosynthesis occurs.

$$\text{carbon dioxide} + \text{water} \xrightarrow{\textbf{sunlight}} \text{oxygen} + \text{glucose}$$

Leaves are adapted to carry out their function. Leaves are typically flat and thin with a large **surface area**. This means they have a maximum area to absorb the sunlight and carbon dioxide. The **thin** shape reduces the distance for **diffusion** of water and gases.

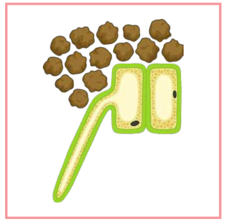
Leaves contain vessels called xylem and phloem. The **xylem** transport water and dissolved minerals toward the leaves. The **phloem** transport glucose and other products from photosynthesis around the plant.

The large **air spaces** between the cells of the spongy mesophyll layer allow for the diffusion of gases. **Carbon dioxide** enters the leaves and **oxygen** exits the leaves.



The **guard cells** are specially adapted cells located on the underside of the leaf. They are positioned in pairs, surrounding the **stomata** (a small opening in the epidermis layer). The guard cells change shape to open and close the stomata, controlling the rate of **gas exchange** in the leaf.

Root Hair Cells

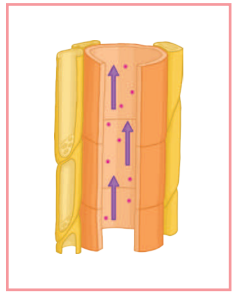


Plants absorb water by **osmosis** through the root hair cells of the roots. Dissolved in the water are important minerals for the plant's growth and development, which are absorbed by **active transport**.

The **root hair cells** are adapted to their function with the following features:

- Finger-like projection in the membrane increases the **surface area** available for water and minerals to be absorbed across.
- The narrow shape of the projection can squeeze into small spaces between soil particles, bringing it closer and reducing the distance of the **diffusion pathway**.
- The cell has many **mitochondria**, which release energy required for the active transport of some substances.

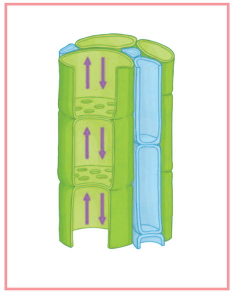
Xylem and Phloem



Xylem vessels transport **water** through the plant, from roots to leaves. They are made up of **dead**, lignified cells, which are joined end to end with no walls between them, forming a long central tube down the middle. The movement of the water, and dissolved minerals, along the xylem is in a **transpiration** stream.

Xylem vessels also provide **support** and **strength** to the plant structure. They are found in the middle of roots so they aren't crushed within the soil. They are found in the middle of the stem to provide strength and prevent bending. In the leaves, they are found in **vascular bundles** alongside the phloem and can be seen as the veins which network across the leaf.

Phloem vessels transport **food** such as dissolved sugars and glucose from photosynthesis. The food is transported around the plant to where growth is occurring (root and shoot tips), as well as to the organs which store the food. The transport occurs in **all directions** throughout the plant. The cells making up the phloem tube are **living**, with small holes in the walls where the cells are joined.



Transpiration and Translocation

Transpiration is the loss of water, by **evaporation** and **diffusion**, from the leaves of the plant. Water is a cohesive molecule and as it evaporates, there is less water in the leaf, so water from further back moves up to take its place. This, in turn, draws more water with it. This is the **transpiration stream**.

Transpiration occurs naturally as there is a tendency for water to diffuse from the leaves (where the concentration is relatively high) to the air around the plants (where the concentration is relatively low), via the **stomata**.

Environmental factors can change the rate at which transpiration occurs:

- Increased **light intensity** will increase the rate of transpiration because light stimulates the stomata to open. The leaf will also be warmed by the sunlight.
- Increased **temperature** will cause the water to evaporate more quickly and so increase the rate of transpiration.
- Increased **humidity** (moisture in the air) will reduce the rate of transpiration. Whereas if the air becomes drier, the rate increases. A greater concentration gradient will increase the rate of diffusion.
- If the **wind speed** increases, then the rate of transpiration also increases. This is because as the water surrounding the leaves is moved away more quickly, the concentration gradient is increased.
- If the **water content** in the soil is decreased, then the rate of absorption in the roots decreases. This causes the stomata to become flaccid and close, reducing transpiration. If the loss of turgor affects the whole plant, then it will wilt.

Disease Interactions

Having one type of illness can often make a person more susceptible to another type of illness:

- immune disorders → increased risk of infectious disease
- viral infection of cells → increased risk of cancer
- immune reactions → can trigger allergies
- very poor physical health → increased risk of depression or other mental illness

Health and Disease

Health is the state of being free from **illness** or **disease**. It refers to **physical** and **mental** wellbeing.

Disease and lifestyle factors, such as diet, stress, smoking, alcohol consumption and the use of illegal drugs, can all impact the health of a person.

Some conditions are associated with certain lifestyle choices:

- Liver conditions are associated with poor **diet** and prolonged excessive **alcohol** consumption.
- Lung cancer is associated with **smoking**.
- Memory loss, poor physical health and hygiene are associated with the use of illegal or recreational **drugs**.
- Obesity and diabetes are associated with poor diet.
- Anxiety and depression are associated with **stress** and prolonged excessive alcohol consumption.

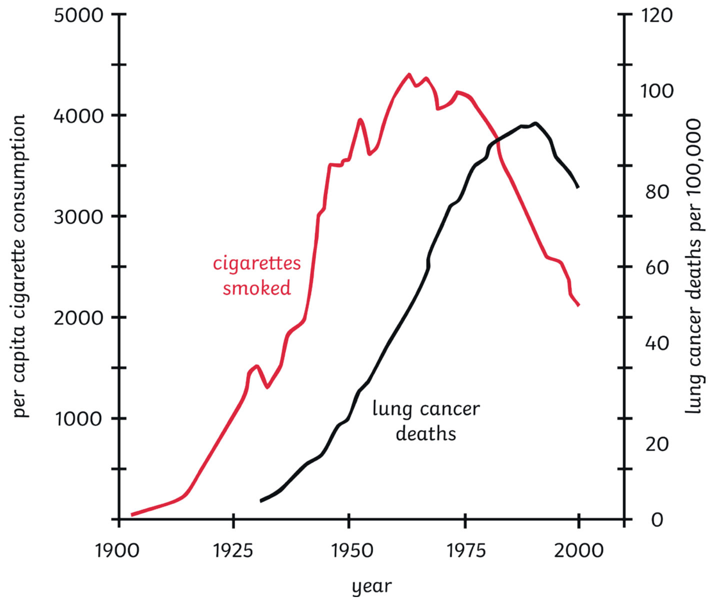
There can often be correlations between some factors and types of illness or specific diseases.

For example, in the graph shown to the right, there is a positive correlation between the number of cigarettes smoked and the number of lung cancer deaths.

However, there are other factors which can contribute to the development of lung cancer e.g. working with asbestos, genetic predisposition.

This means that although the evidence in the graph gives a strong indication that smoking is a cause of lung cancer, it cannot be stated that **'smoking will cause lung cancer'**. Not every person who smokes will develop lung cancer and not every person who develops lung cancer will be a smoker.

Therefore, it can be stated that **smoking increases the risk of lung cancer**.



Heart Disease (Treatments)

There are a range of medical treatments for heart disease.

Treatment	Description	Advantages	Disadvantages
statins	**Drugs** used to lower cholesterol levels in the blood, by reducing the amount produced in the liver.	• Can be used to prevent heart disease developing. • Improved quality of life.	• Long-term treatment. • Possible negative side-effects.
stents	**Mechanical device** which is used to stretch narrow or blocked arteries, restoring blood flow.	• Used for patients where drugs are less effective. • Offers long-term benefits. • Made from metal alloys so will not be rejected by the patients body. • Improved quality of life.	• Requires surgery under general anaesthetic, which carries risk of infection.
heart transplant	The entire organ is replaced with one from an organ **donor** (a person who has died and previously expressed a wish for their organs to be used in this way).	• Can treat complete heart failure in a person. • extended life • Improved quality of life. • Artificial plastic hearts can be used temporarily until a donor is found.	• Requires major surgery under general anaesthetic, which carries risks. • Lack of donors available. • Risk of infection or transplant rejection. • Long recovery times.