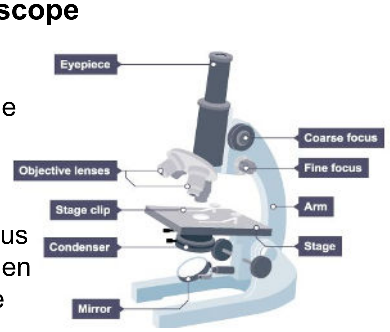
Biology Particles – Year 9

Keyword	Definition
Cell membrane	This organelle controls what enters and exits the cell.
Cell wall	Plant and algal cells have this extra layer to strengthen the cell.
Chloroplast	An organelle found in plant cells. Contains chlorophyll which absorbs sunlight. Site of photosynthesis.
Cytoplasm	Found in all cells. It is where most chemical reactions occur.
Differentiation	The process by which a stem cell turns into a specialised cell.
Diffusion	The spreading out of the particles of any substance in a solution. Or particles of a gas, resulting in a net movement from an area of higher concentration to an area of lower concentration.
Eukaryotic	A cell which contains genetic material enclosed in a nucleus.
Magnification	The action of making a specimen, viewed under a microscope, larger.
Mitochondria	An organelle found in eukaryotic cells. Aerobic respiration occurs here to release energy.
Net movement	Net movement means **the general movement of particles**. So even though the particles are randomly moving into and out of the cell, there could be a net movement of particles into the cell.
Nucleus	An organelle found in eukaryotic cells which contains genetic material. This controls the cell.
Ribosome	An organelle found in all cells. This is where proteins are created.
Stem cell	An unspecialised (undifferentiated) cell.
Vacuole	A large organelle in plant cells which contains cell sap. When full, it makes the cell turgid to give it shape and support.

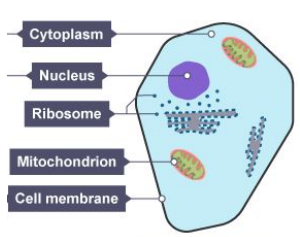
Using a microscope

Always begin viewing the specimen with the lowest power objective lens to see the biggest field of view. Focus the image and then you can increase the magnification.

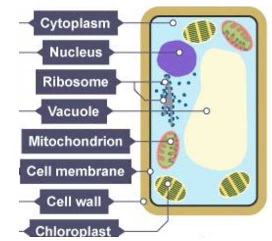


Cell Structure – Eukaryote cells

Animal cell

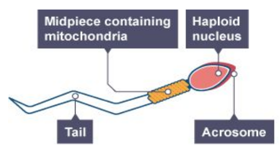


Plant Cell

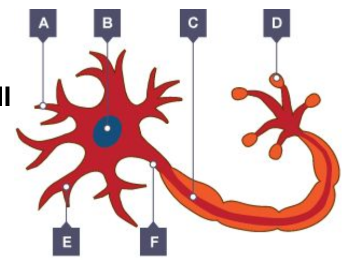


Specialised Animal Cells

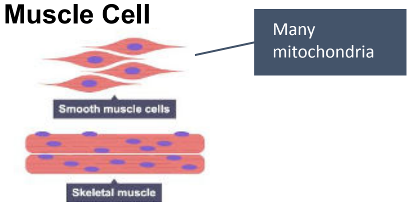
Sperm Cell



Nerve Cell

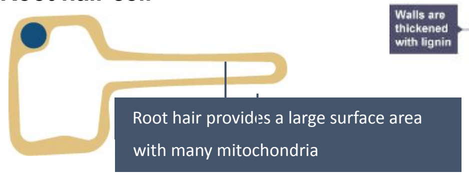


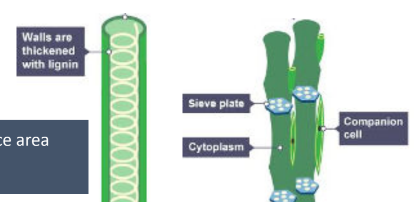
Muscle Cell



Specialised Plant Cells

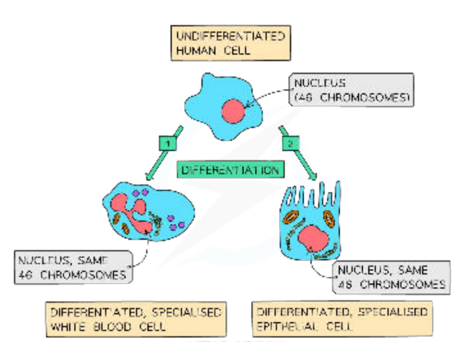
Root hair cell





A common specialised cell feature is having many mitochondria in order to do more aerobic respiration to release energy. This energy is then used to help the cell perform its function.

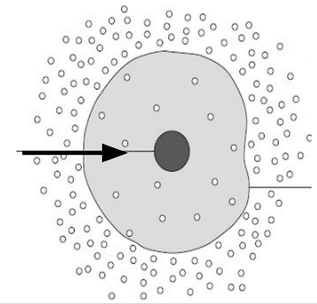
Cell differentiation



- Animal cells differentiate most of their cells in the embryonic stage of development
- Plant cells can differentiate throughout their whole lives.

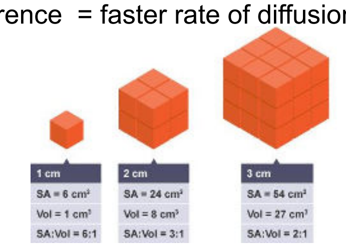
Diffusion

Higher concentration of oxygen outside the cell. **Lower** concentration of oxygen inside the cell. Oxygen will diffuse **into** the cell.



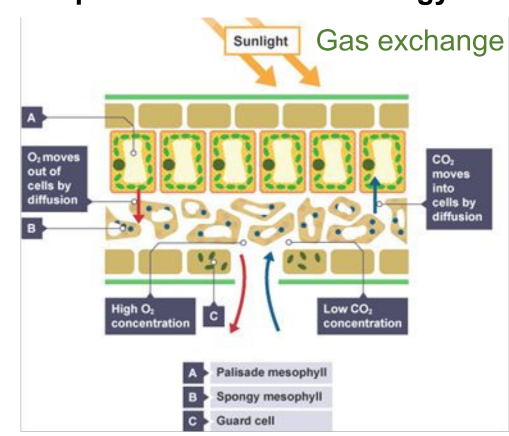
Factors affecting the rate of diffusion

- Temperature – hotter = faster as particles have more kinetic energy.
- Surface area – larger = faster as there is more room for substances to diffuse across.
- Concentration gradient (the difference in concentration between the two areas) larger the difference = faster rate of diffusion



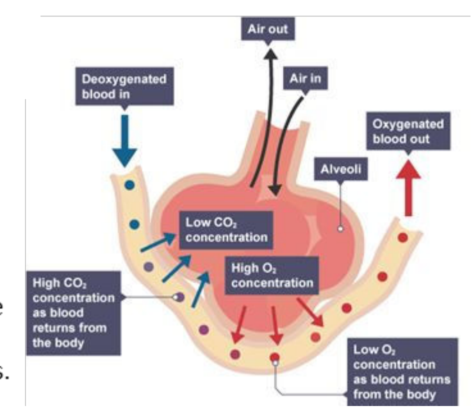
Examples of diffusion in Biology

Gas exchange in a leaf



Alveoli in lungs

Gas exchange between oxygen and carbon dioxide through the cell membranes.



Useful YouTube link

Diffusion

Mathematical Skills:

- *Be prepared to calculate surface area.*
- *Be prepared to calculate percentages to calculate the percentage gain or loss of mass in the osmosis required practical.*

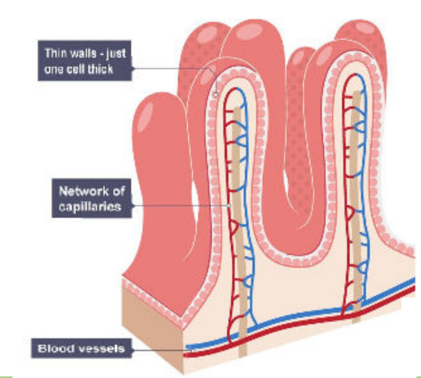
Exchange Surfaces

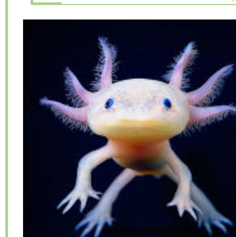
Multicellular organisms require special organ systems to obtain the substances they need to survive such as food, water and oxygen.

Examples of exchanges surfaces are alveoli in lungs, gills in fish, plant leaves, plant root hair cells and villi in small intestine as pictured below.

All exchange surfaces have the following common features which allow the movement of substances into and out of them to happen quickly:

- Large surface area
- Thin diffusion pathway
- High concentration gradient
- In animals – good blood supply
- In animals – well ventilated





The axolotl has external gills which allow it to do gas exchange. This little guy is seen regularly in exams!

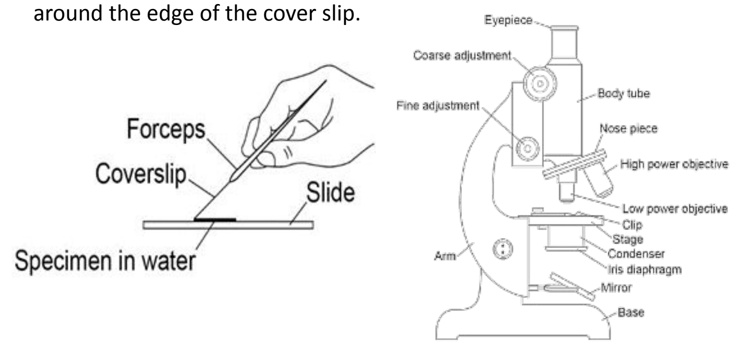
Cells – part 2 - Microscopy

Keyword	Definition
Graticule	A graticule is a small piece of glass with a measurement scale on its surface that fits inside a microscope eyepiece.
Magnification	The action of making a specimen, viewed under a microscope, larger.
Resolution	The ability to distinguish between two close objects. The ability to see the finer detail in the specimen.
Stage micrometer	A stage micrometer is a glass slide that also has a precisely measured scale on its surface. The markings are very accurate – the smallest markings are usually just 0.01mm (10µm) apart. The slide is placed under the microscope lens just like any other slide.

Number	Multiples	Standard form
1000	= 10 x 10 x 10	= 1 x 10^3
100	= 10x 10	= 1 x 10^2
10	= 10	= 1 x 10^1
1	= 1	= 1 x10^0
0.1	= 1÷10	= 1 x 10^{-1}
0.01	= 1÷100	= 1 x 10^{-2}
0.001	= 1÷1000	= 1 x 10^{-3}

Required Practical – Microscopy - Method:

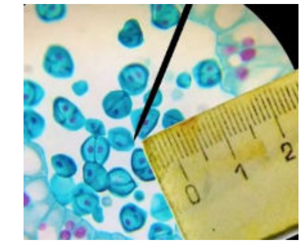
- Use a pipette to put one drop of water onto a microscope slide.
- Separate one of the thin layers of the onion.
- Peel off a thin layer of epidermal tissue from the inner surface.
- Use forceps to place this thin layer on to the drop of water that you have placed on the microscope slide, ensuring the layer is flat.
- Place two drops of iodine solution onto the onion tissue.
- Carefully lower a coverslip onto the slide. Do this by:
    - placing one edge of the coverslip on the slide
    - use the forceps to lower the other edge onto the slide.
- Carefully use a piece of tissue paper to soak up the excess liquid from around the edge of the cover slip.



- Put the slide on the microscope stage.
- Use the lowest power objective lens. Turn the nosepiece to do this.
- The end of the objective lens needs to almost touch the slide. Do this by turning the coarse adjustment knob. Look from the side (**not** through the eyepiece) when doing this.
- Now looking through the eyepiece, turn the coarse adjustment knob in the direction to increase the distance between the objective lens and the slide. Do this until the cells come into focus.
- Now rotate the nosepiece to use a higher power objective lens.
- Slightly rotate the fine adjustment knob to bring the cells into a clear focus and use the high-power objective to look at the cells.

Estimating the size of the cell – using a ruler under a microscope

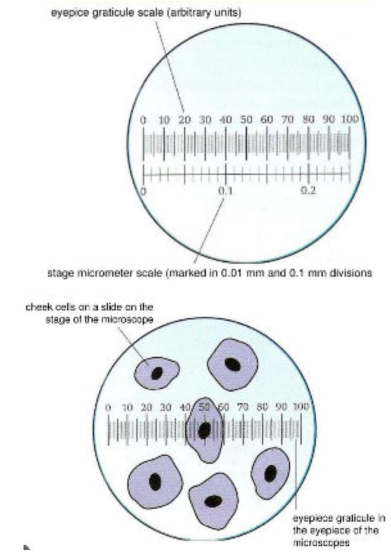
- This microscope looking at cells is at x 400 magnification
- A photo was taken down the eyepiece, with a ruler in view.
- Knowing that every 1mm = 1000µm. The cell being measured in the field of view measures 5mm as depicted below, this means the view is 5000µm.
- This therefore means that one cell in this field of view also measures 5000µm.



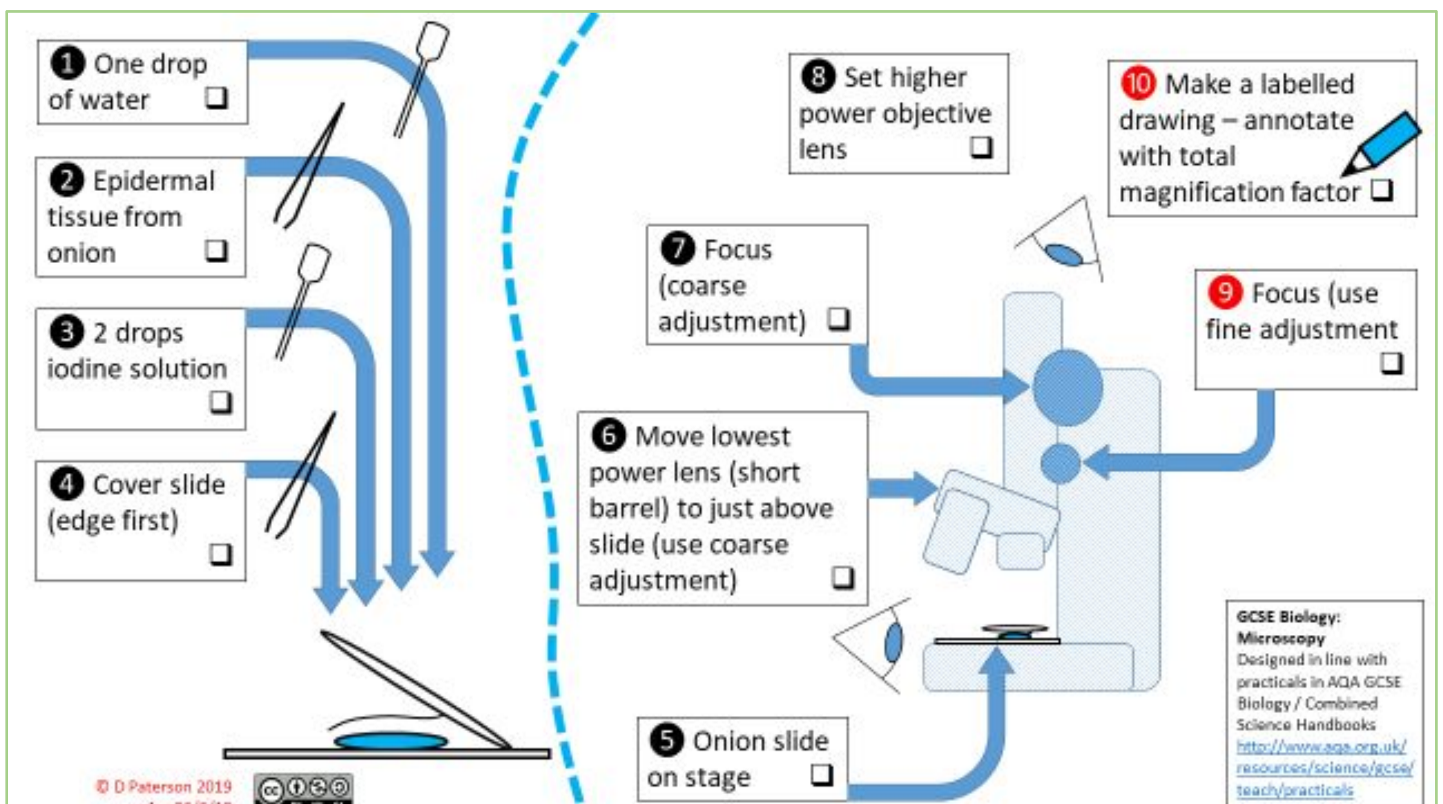
Size of cell - using a graticule and stage micrometer

To calibrate the graticule takes a few steps.

- Place graticule inside the microscope's eyepiece.
- The stage micrometer is placed directly on the stage of the microscope and brought into focus.
- By rotating the eyepiece, both scales can be positioned parallel to each other.
- By comparing them, you'll know exactly how many of the graticule's divisions are equal to an equivalent number of divisions on the micrometer.
- Because you know the exact real distance represented by the micrometer divisions, you also know the real distances the graticule divisions represent at that magnification.
- Now when you switch out the micrometer and put your sample under the lens, you can calculate the actual length of any structure viewed down the same microscope with the same magnification using the eyepiece graticule.



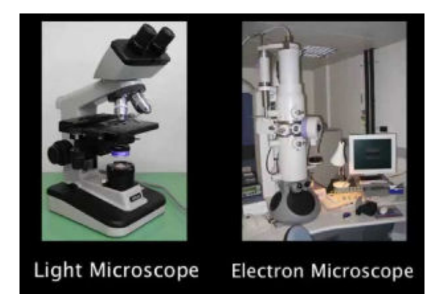
Looking at the cheek cells on the right:
The diameter of the centre cell is 20 divisions on the graticule.
Looking at the slide micrometer we can see that this corresponds to 0.05 mm width



Light vs Electron microscopes

Light microscope

- Uses light waves to produce images
- Low resolution
- Magnification up to x 1500
- Able to observe cells and larger organelles
- 2D image only



Electron microscope

- Uses electrons to produce images
- High resolution
- Magnification up to x 500 000 (2D) and 100 000 (3D)
- Able to observe small organelles
- 2D and 3D images

Orders of Magnitude

- Differences in size are often described as differences in order of magnitude. That's the difference calculated in factors of 10.
- If you increase a number by one order of magnitude, you are multiplying the number by 10.

Example:
A person's height = 2 m = 2 × 10^0
The oak tree's height = 20 m = 2 × 10^1

Meaning there is one order of magnitude between the height of a human being (2m) and the height of an oak tree (20 m

Magnification equation

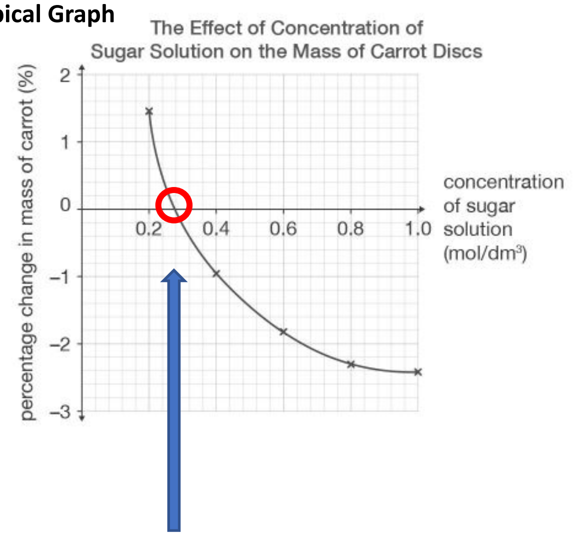
$$\text{Magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

0.1	10^{-1}	deci*	d
0.01	10^{-2}	centi*	c
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	µ
0.000 000 001	10^{-9}	nano	n
0.000 000 000 001	10^{-12}	pico	p

Cells – part 2 - Osmosis

Keyword	Definition
Concentration gradient	Difference in the concentration of a substance between two areas is called the concentration gradient . Bigger the difference, steeper the concentration gradient and the faster the molecules of a substance will diffuse. The direction of diffusion is said to be 'down' or 'with' the concentration gradient.
Hypertonic	The concentration outside of the cell is **higher** than that inside the cell.
Hypotonic	The concentration outside of the cell is **lower** than that inside the cell.
Isotonic	The concentration outside of the cell is **the same** than that inside the cell.
Osmosis	Osmosis - net diffusion of water from a high concentration of water to a lower concentration of water across a semi permeable membrane.
Partially permeable or semi permeable membrane	Small molecules, (e.g., water) can pass through the small holes in the membrane. But larger molecules like sugar cannot pass through the membrane.

Typical Graph



Required Practical – Osmosis – Method

- Using a cork borer, cut three potato cylinders of the same diameter.
- Cut each cylinder to the same length using a ruler and knife (avoid leaving skin on either end).
- Accurately measure and record the length **and** mass of each potato cylinder.
- Measure 10 cm^3 of the distilled water and transfer into the third boiling tube. Label this boiling tube as ***water***.
- Measure 10 cm^3 of the 0.5 M sugar solution and transfer into the first boiling tube. Label this boiling tube as: ***0.5 M sugar***.
- Measure 10 cm^3 of 0.25 M sugar solution and transfer into the second boiling tube. Label this boiling tube as: ***0.25 M sugar***.
- Add one potato cylinder to each boiling tube – it is essential that you know which cylinder is being placed in each tube.
- Leave the tubes for a minimum of 24 hours.
- Remove the potato cores from their tubes and blot dry.
- Re-measure the mass and length of each core and record the results.

Typical results

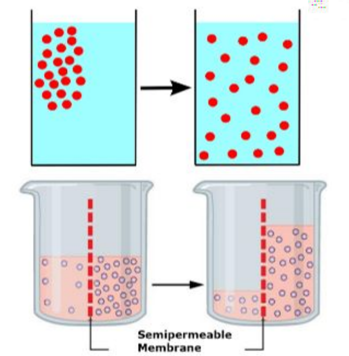
	Distilled Water 0 mol/dm^3 sugar solution	0.25 mol/dm^3 sugar solution	0.5 mol/dm^3 sugar solution
Initial length (mm)	30	30	30
Final length (mm)	35	31	27
Change in length (mm)	+5	+1	-3
Initial mass (g)	2	2	2
Final mass (g)	2.8	2	1.5
Change in mass (g)	+0.8	0	-0.5
Change in mass (%)	+40	0	-25

$$\% \text{ change in mass} = \frac{\text{change in mass}}{\text{initial mass}} \times 100\%$$

Diffusion versus Osmosis

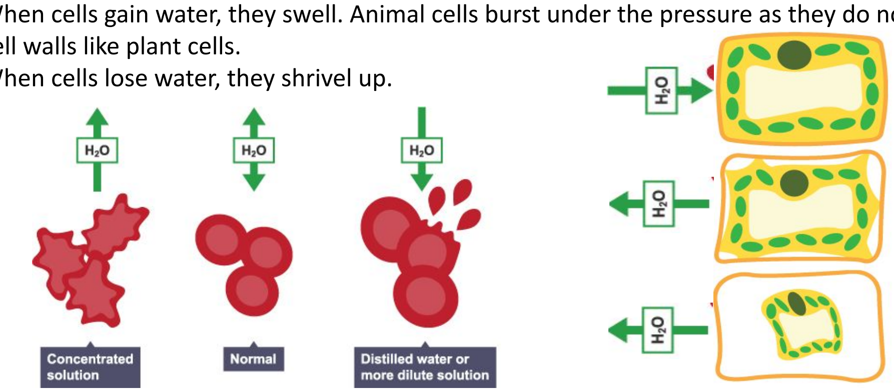
Diffusion (top diagram)
Movement of molecules from a high to a low concentration.
Both solute and solvent move.

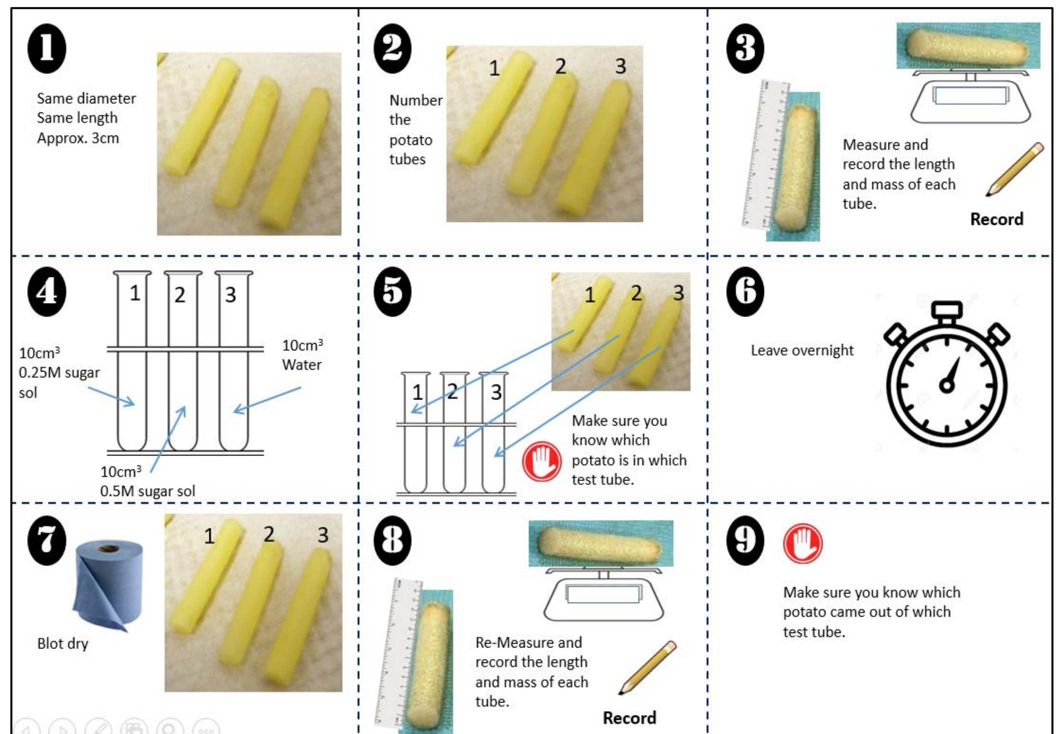
Osmosis (bottom diagram)
Movement of solvent (water) molecules across a semi permeable membrane from a high to a low solvent (water) concentration



Osmosis in Cells

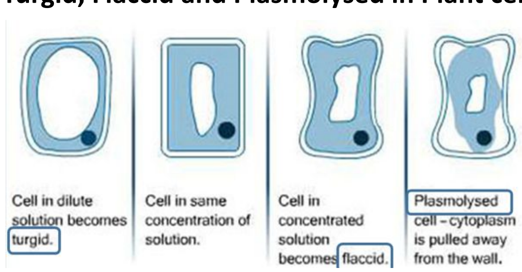
When cells gain water, they swell. Animal cells burst under the pressure as they do not have cell walls like plant cells.
When cells lose water, they shrivel up.



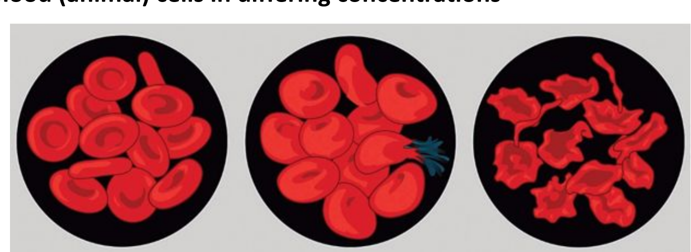


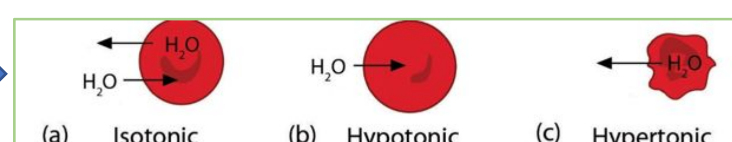
To find the concentration of the potato cells, you must plot your results on a graph like the one above. The point at which your line of best fit intercepts the x axis is the concentration of your cells. This is because this is where there is 0% change in mass meaning the solution would be isotonic in comparison to the cells at this concentration.

Turgid, Flaccid and Plasmolysed in Plant cells



Blood (animal) cells in differing concentrations





Cells – part 2 – Stem cells, Cell cycle and Active transport

Keyword	Definition
Chromosomes	Chromosomes are thin strands of DNA (deoxyribonucleic acid). Chromosomes are in functional pairs in the nucleus . Humans have 46 chromosomes arranged in 23 pairs
Concentration gradient	Difference in the concentration of a substance between two areas is called the concentration gradient . Bigger the difference, steeper the concentration gradient and the faster the molecules of a substance will diffuse. The direction of diffusion is said to be 'down' or 'with' the concentration gradient.
Differentiation	The process by which a stem cell turns into a specialised cell.
Meristem cell	An unspecialised (undifferentiated) cell in a plant.
Mitosis	A part of the cell cycle in which one set of chromosomes is pulled to each end of the cell and the nucleus divides.
Stem cell	An unspecialised (undifferentiated) cell.

Cell Differentiation

- Animal cells differentiate most of their cells in the embryonic stage of development.
- Plant cells can differentiate throughout their whole lives

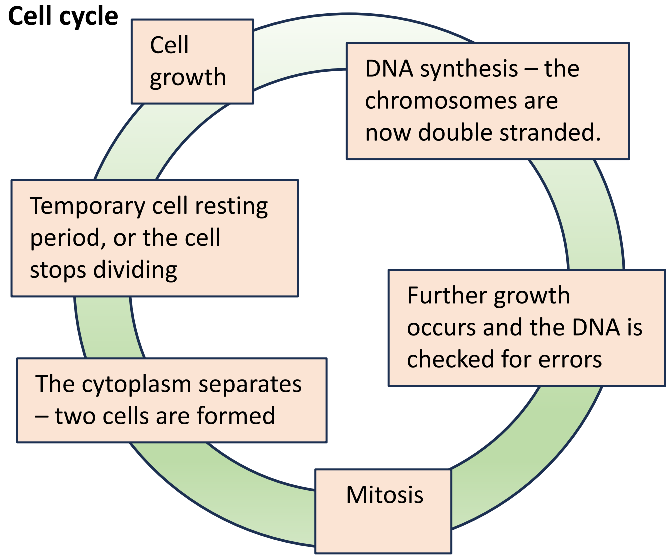
Stem cells

- Embryonic stem cells are the cells that make up the early embryo (2-3 days old).
- Embryonic stem cells have the ability to differentiate into any type of specialised cell.
- Adult stem cells are stem cells found in the bodies of animals which are born, including children.
- An examples of where adult stem cells can be found is within bone marrow.
- Adult stem cells are limited as to which types of cells they can differentiate into depending on where they are found in the body.

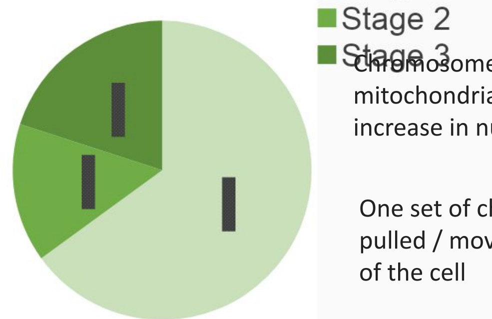
Uses of stem cells

- Embryonic stem cells are the most useful for stem cell treatment as they can be used to differentiate into any type of cell.
- Embryonic stem cells can be created with a cloning technique to make sure the cells have the patients own DNA so the cells are rejected by their body.
- Some people believe that the use of embryonic stem cells for treatment is murder of the potential life.

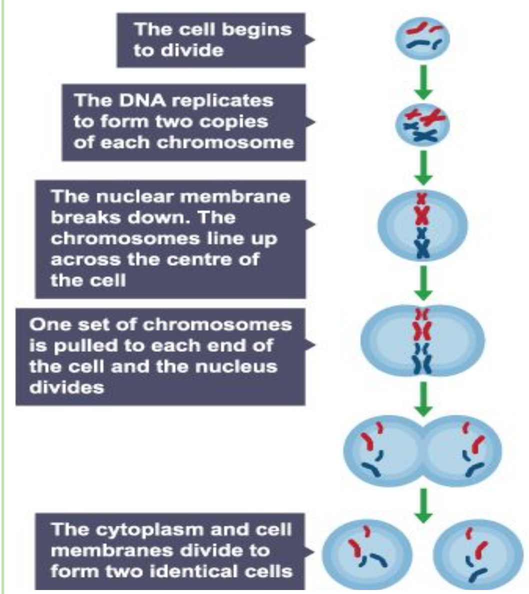
Cell cycle



% of time spent in stage



Mitosis



- When multicellular organisms grow, cells must divide by mitosis to produce two new identical daughter cells
- During mitosis, one chromosome from each set of pairs is pulled to each end of the cell, and a new nucleus forms around each group of chromosomes
- After this, the cytoplasm and cell membranes divide in a process known as cytokinesis. This results in the formation of two genetically identical daughter cells

Linking this to Humans

- A human cell with 46 chromosomes in 23 pairs needs to divide by mitosis:
- Its 46 chromosomes are doubled, so that there are two copies of each of the 46 chromosomes (or 92 chromatids) now in the cell
- The number of ribosomes and mitochondria also increases
- During mitosis, the chromatids are pulled apart, this results in the 46 chromosomes being arranged in 23 pairs moving to each end of the cell
- The cytoplasm and cell membrane divide, forming two new daughter cells

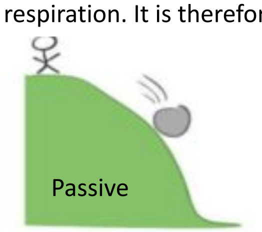
Calculating cell cycle

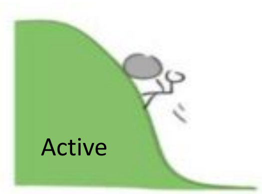
Sometimes you are asked to use observations of how many cells are in each stage of the cell cycle to estimate how long each stage of the cell cycle lasts

$$\text{Length of time in stage} = \frac{\text{observed number of cells in stage}}{\text{total number of cells observed}} \times \text{total length of cell cycle}$$

Active transport

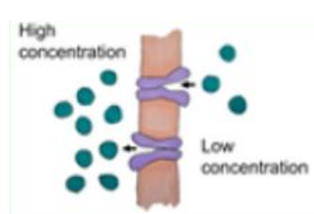
This is the movement of substances from an area of low concentration to an area of high concentration. Active transport moves particles against the concentration gradient. To do this it requires energy transferred from respiration. It is therefore an active process.





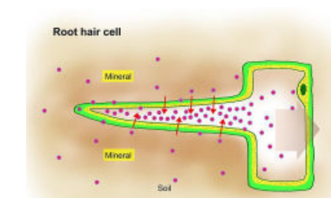
Protein transporters

Often the particles moving in active transport need some help to get across membranes. They often move through carrier proteins; These act like doors that can open and close to let certain substances through. These often require energy to function.



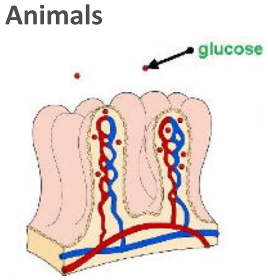
Active transport examples

Plants



Plants require mineral salts such as nitrates for growth. The concentration of nitrates is higher in The plant root cell than it is in the soil solution surrounding it. The plant cannot rely on diffusion as the nitrates would diffuse out of the root cell into the soil. Hence the cells utilise energy to actively transport nitrates across the cell membrane into the root cell, against the concentration gradient.

Animals

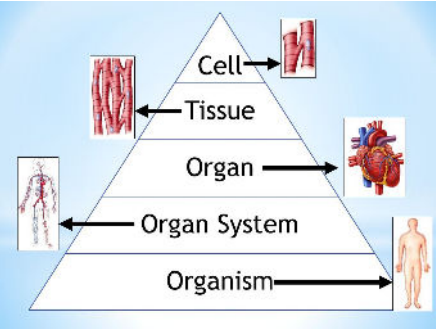


The process of active transport takes place in humans during digestion of food in the small intestine. Food is absorbed by the villi, however, there comes a point where the concentration of food molecules inside the villi increases and at this point no more can **diffuse** in. As more is still required simple sugars, amino acids, vitamins and minerals are **actively transported** into the villi from an area of low concentration to an area of high concentration, against the concentration gradient. The diagram shows glucose which is actively needed by all cells for the process of respiration.

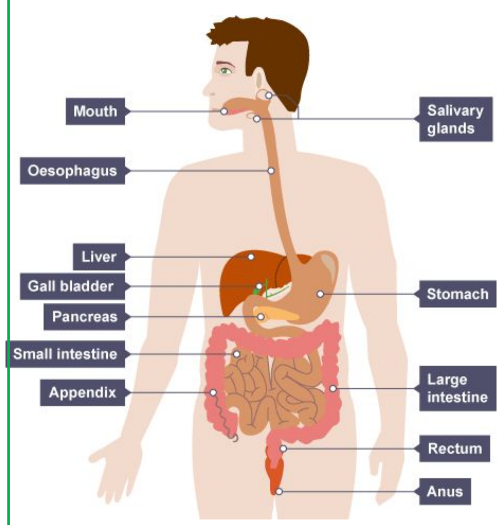
Organisation Part 1

Keyword	Definition
Acid (Hydrochloric)	Found in the stomach. Two functions: 1. Kills pathogens 2. Provides the optimum low pH required for protease.
Amylase	A named carbohydrase enzyme
Aorta	An artery carrying blood from the heart to the body.
Atrium	The upper two chambers of the heart that collect blood from the veins.
Capillary	A type of blood vessel connecting arteries and veins. These surround internal tissues and organs and are the site of exchange of substances between the cells and the blood
Cell	The smallest unit of a living organism.
Enzyme	A protein molecule which speeds up the rate of chemical reactions within living organisms.
Haemoglobin	Inside a red blood cell, carries oxygen to organs and tissues.
Organ	An aggregation of tissues performing specific functions.
Organ system	An aggregation of organs working together to perform an overall function.
Organism	A whole living thing made of collections of organ systems all working together.
Protease	An enzyme produced by the walls of the stomach, the walls of the small intestine and the pancreas. Digests protein into amino acids.
Pulmonary artery	Carries blood from the heart to the lungs.
Pulmonary vein	Carries blood from the lungs to the heart.
Tissue	A group of cells with a similar structure and function.
Vena cava	A vein carrying blood from the body into the heart.
Ventricle	The lower two chambers of the heart that pumps blood out through the arteries.

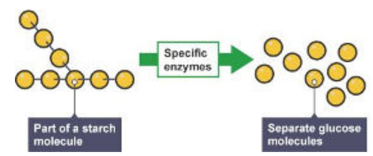
Organisation Principles



Human Digestive System

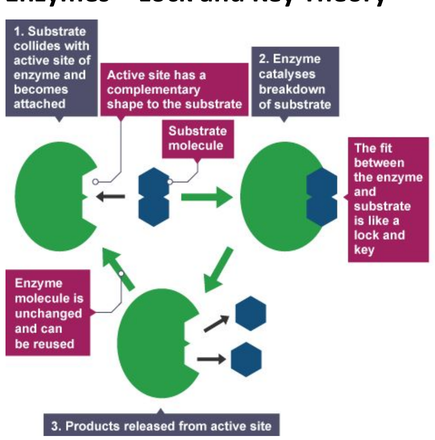


Enzymes and Digestion

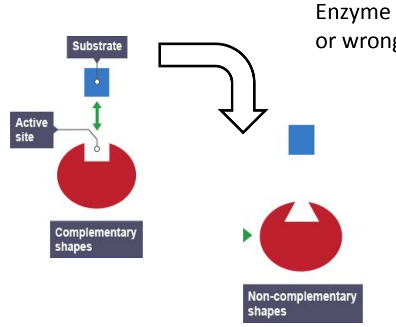


Enzymes help to break large food molecules down into pieces small enough to be absorbed through the walls of the small intestine and into the bloodstream.

Enzymes – Lock and Key Theory

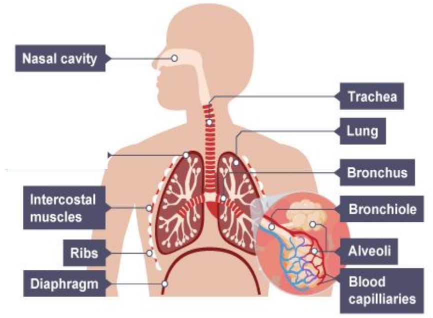


Denaturation



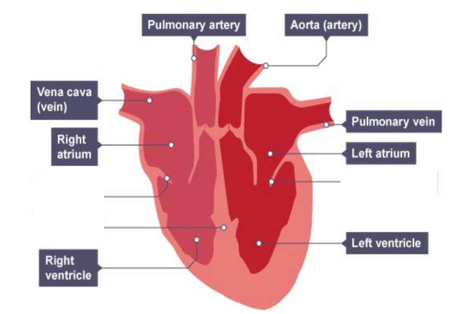
Enzyme too hot or wrong pH

Lung Structure



The lungs have a large surface area because there are on average 480 million alveoli. They are moist to allow the gases to dissolve and diffuse through to the blood vessels. They are one cell thick so have a short pathway for diffusion. They have a large blood supply, that is constantly moving, to allow a concentration gradient to be maintained.

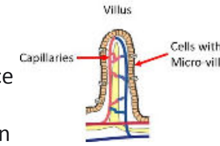
Heart Structure



The circulatory system is known as a double pump system because blood is being pumped to the lungs from the right side, at the same time as blood is being pumped to the bode from the left side.
Cells in the **right atrium** of the heart which control the heart beats are called the natural pacemaker cells.

Products of digestion

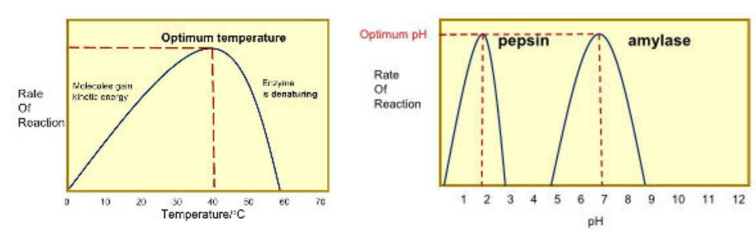
The villi Increase the surface area for absorption



The products of digestion are used to build new carbohydrates, lipids and proteins required by all cells to function properly and grow. Some glucose released from carbohydrate breakdown is used in respiration to release energy to fuel all the activities of the cell

Digestive Enzyme	Where it is produced	Where it functions	What food it breaks down	What it breaks down into
Amylase	Salivary gland, small intestine, pancreas.	Mouth and small intestine	Starch →	Glucose
Protease	Stomach, small intestine, pancreas.	Stomach, small intestine	Protein →	Amino acids
Lipase	Small intestine, pancreas.	Small intestine	Lipids (Fat) →	Fatty acids and glycerol

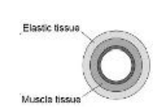
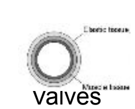
Factors Affecting Enzymes



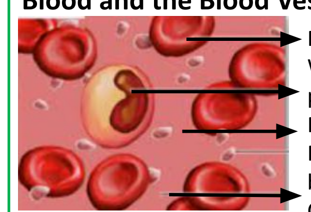
If enzymes get too cold, they work more slowly.
If the temperature increases, the rate of reaction increases up to the optimum (best) temperature. If they get too hot (past the optimum temperature) they will denature and stop working.

Enzymes have an optimum pH. If they go too far below or above their optimum pH they denature and stop working.

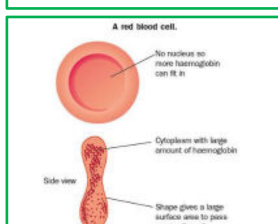
Bile – Bile is made in the liver and stored in the gall bladder. It is alkaline so that it neutralises the acid HCl (hydrochloric from the stomach). It also increases the surface area of the lipid (fat) to make many droplets, this process being called emulsification. The alkaline conditions and the large surface area increases the rate of lipid breakdown, by lipase, in the small intestine.

Type of vessel	Walls	Lumen	Blood pressure	Diagram/ Other features
Capillary	One cell thick – short diffusion pathway.	Small	Low	
Artery (Blood away from heart)	Thick – made of elastic and muscle fibres to withstand pressure.	Small	High	
Vein (Blood to heart)	Thin – made of elastic and muscle fibres.	Large	Low	

Blood and the Blood Vessels



Red blood cells – carry oxygen
White blood cells – destroy pathogens
Platelets – clot blood
Plasma - liquid that carries all the blood cells, hormones, nutrient and CO_2



Useful YouTube links

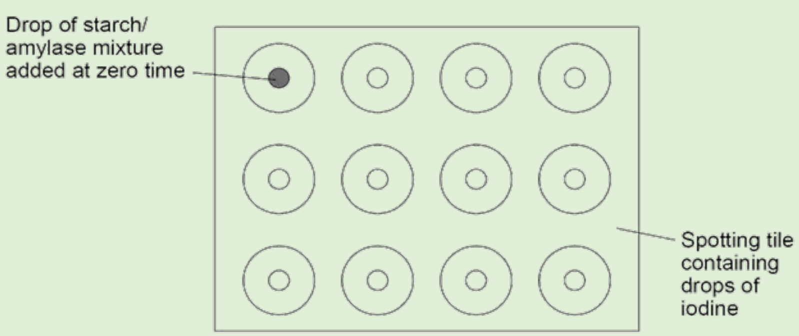
Digestion

Enzymes

Required Practical - Enzymes

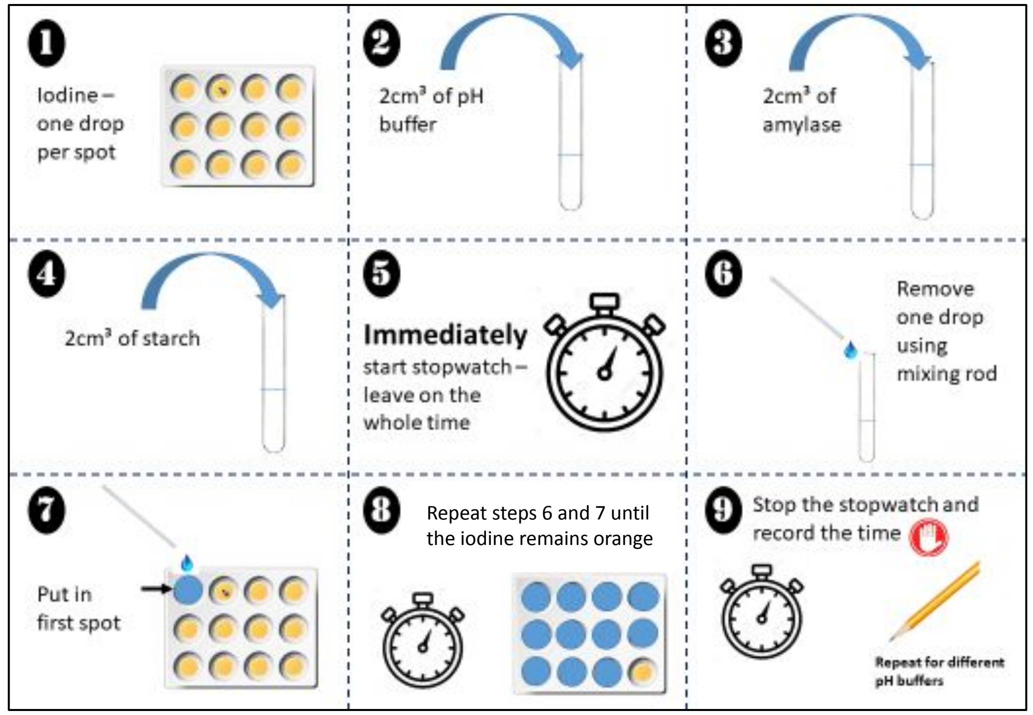
Method

- Place labelled test tubes containing the ***buffered pH solutions***, ***amylase solution*** and ***starch solutions*** in to the water bath. Leave these to allow the solutions to reach 25 °C
- Place one drop of iodine solution into **each** well on the spotting tile.
- Using a pipette, add 2cm^3 of one of the ***buffered pH solutions*** to a test tube.
- Use the pipette to place 2 cm^3 of ***amylase*** into the same test tube.
- Use a different pipette to add 2 cm^3 of the ***starch solution*** to the test tube containing the amylase/buffer solution.
- **Immediately** start the stop clock and leave it on throughout the test.
- Mix using a glass rod / clean pipette.
- After 30 seconds, remove one drop of the mixture with a glass rod.
- Place this drop on the first depression of the spotting tile with the iodine solution. The iodine solution should turn blue-black indicating the presence of starch.
- **Dispose of the excess solution in the pipette and replace the empty pipette into the test solution.**
- Use the pipette to remove one drop of the mixture every 30 seconds. Put each drop onto the iodine solution in the **next** well on the spotting tile. Empty the pipette of excess solution after each drop. Continue until the iodine solution and the amylase/buffer/starch mixture remain orange for 2 consecutive wells.
- Repeat the procedure with solutions of other pHs.

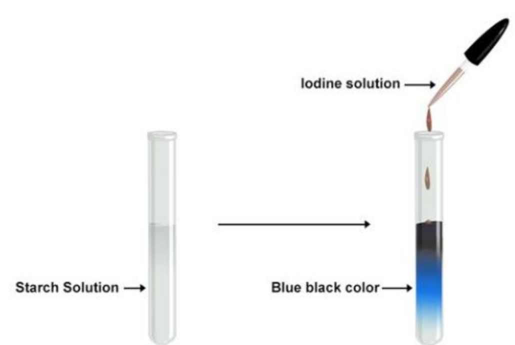


Equipment:

- test tubes
- a test tube rack
- water bath
- spotting tiles
- 5cm^3 measuring cylinder
- pipettes
- a stop clock
- starch solution
- amylase solution
- buffered pH solutions with an allocated pipette
- iodine solution



Testing for the presence of starch



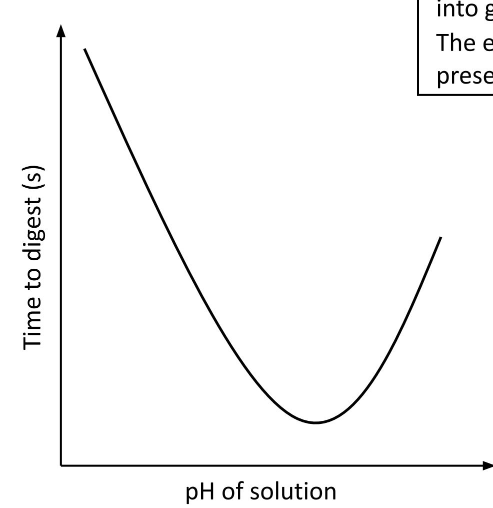
Right at the very start, the solution of amylase, starch and pH buffer turns blue/black with iodine as starch hasn't had time to be broken down by the amylase enzyme.

As time progresses, the amylase breaks the starch into glucose. When tested with iodine, if no starch is present due to being fully broken down into glucose, the solution will remain orange.

Typical Results

pH of solution	Time taken to completely digest starch (s)
3	300
4	270
5	150
6	90
7	30
8	150

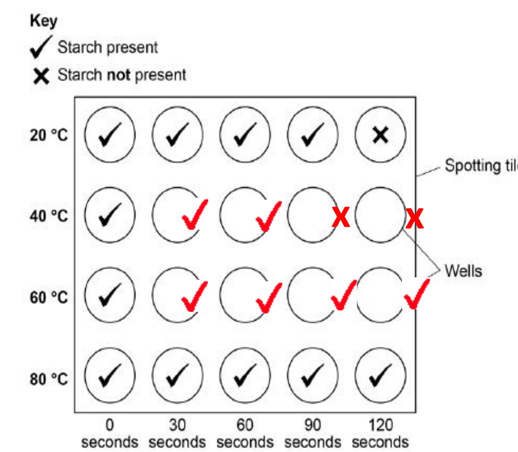
Typical Graph



Typical Exam Question

Even though the required practical investigates how pH affects the rate of enzyme activity, the exam board do sometimes change it in the question to investigate how temperature affects enzyme activity. Here is an example question. The answer is in red.

Q1. The temperature of the human body is 37 ° C.
The diagram below shows the results of the investigation at 20 °C and at 80 °C
Complete the diagram to show the results you would expect at 40 °C and at 60 °C
You should write a tick or a cross in each well of the spotting tile.



As 40°C is the closest temperature to the optimum of 37°C, the starch is digested the quickest here. The reason there are two crosses at the end is due to the fact that all the starch had been broken down into glucose by the enzyme amylase.
The enzyme at 60°C has denatured so the starch is present the whole time.

Useful YouTube links:

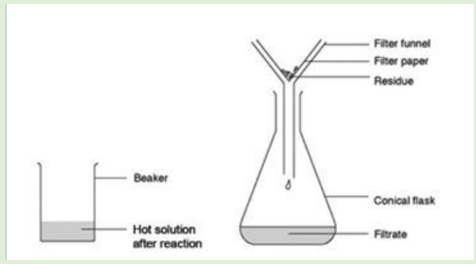
Practical Demo
Enzymes Theory

Required Practical – Food Tests

Methods:

Preparing a sample for testing

- Use a pestle and mortar to grind up a small sample of food to be tested.
- Transfer the ground up food into a small beaker.
- Then add distilled water and stir the mixture so that some of the food dissolves in the water.
- Filter using a funnel with filter paper to obtain as clear a solution as possible (repeat filtration may be required).
- The final solution should be collected in a conical flask and the residue disposed of.



Testing for protein (Option 1)

- Add approximately 2 cm^3 of your test solution to a test tube.
- Add 2 cm^3 of the Biuret solution to the test tube.
- Gently shake the test tube to mix the solutions.

Testing for protein (Option 2)

- Add approximately 2 cm^3 of your test solution to a test tube.
- Add 1 cm^3 copper sulfate solution to the test tube.
- Add 1 cm^3 sodium hydroxide solution to the test tube.
- Gently shake the test tube to mix the solutions.

Testing for Carbohydrates:

1. Starch

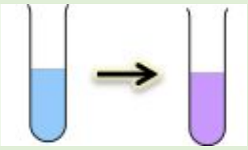
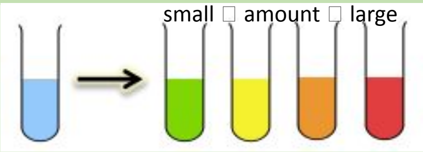
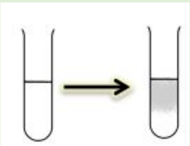
- Add approximately 3 cm^3 of your test solution to a test tube.
- Add 5 drops of iodine solution to the test tube and gently mix.

2. Simple sugars

- Add approximately 5 cm^3 of your test solution to a test tube.
- Add 10 drops of the Benedict's solution to the test tube.
- Place the test tube in a water bath set at 70-80 °C
- Leave for 5 minutes

3. Testing for lipids

- Add approximately 5 cm^3 of your test solution to a test tube.
- Add 3 drops of ethanol then 3 drops of water to the test tube.
- Gently shake the tube to mix the solutions.

	Protein	Carbohydrate	Simple sugar	Lipid
				
Method	Add 2cm3 of Biuret solution to the food solution.	Add 5 drops of iodine to the food solution.	Add 10 drops of benedict's reagent to the liquid sample. Heat the sample in a hot water bath	Add 3 drops of ethanol to the food solution. Then add 3 drops of water to the sample and shake gently.
Positive result	Biuret turns from blue to lilac in the presence of protein.	Iodine turns from orange to blue/black in the presence of starch.	Benedict's reagent goes through a series of colour changes depending on the amount of reducing sugar present. It turns from blue to green, yellow, orange, and a brick red precipitate may form	The test turns from colourless to a cloudy white emulsion if lipids are present.

Food tested	Result of test (positive / negative)			
	Starch	**Simple sugar**	**Protein**	**Lipids**
Meat	X	X	✓	✓
Egg	X	X	✓	✓
Bread	✓	X	X	X
Milk	X	✓	X	✓
Biscuit	✓	✓	X	X
Haribo	X	✓	X	X

Food Group	Reagent	Negative	Positive
Protein	Biuret	Blue	**Lilac**
Protein	Sodium hydroxide + copper sulfate	Blue	**Lilac**
Lipids	Ethanol	Colourless	**Cloudy white**
Starch	Iodine	Orange	**Blue/black**
Sugar	Benedicts	Blue	**Red**

You must memorise the information in this table to be able to answer any exam questions on testing nutrients in foods.

Useful YouTube links:

Practical Demo

Food test Mambo Which colours are inaccurate?

Organisation Part 2

Keyword	Definition
Aorta	An artery carrying blood from the heart to the body.
Atrium	The upper two chambers of the heart that collect blood from the veins.
Benign	Not harmful in effect
Cancer	A disease in which some of the body's abnormal cells grow uncontrollably and spread to other parts of the body
Carcinogen	A substance that causes cancer
Causal mechanism	How one factor influences another through a biological process and shows a link.
Coronary arteries	Arteries which surround and supply the heart.
Malignant	Dangerous to health
Mitosis	Cells divide and produce identical copies for growth or to replace old or damaged cells.
Pacemaker	A group of cells located in the right atrium that coordinate the contraction of the heart muscle ensuring it regulates the heart rate.
Plaque	A build up of deposits inside the lumen of a blood vessel. Such as fatty substances, cholesterol, cellular waste products, and calcium.
Ventricle	The lower two chambers of the heart that pumps blood out through the arteries.

Health and disease

Health is the state of physical and mental wellbeing.
Diseases can be communicable or non-communicable.
Communicable diseases are caused by diseases causing microorganisms called pathogens which can spread between individuals or individuals and animals.
e.g. Covid, measles, chickenpox
Non communicable diseases are not caused by pathogens and their effects on health tend to be longer lasting.
e.g. asthma, CHD, most cancers, diabetes, heart disease

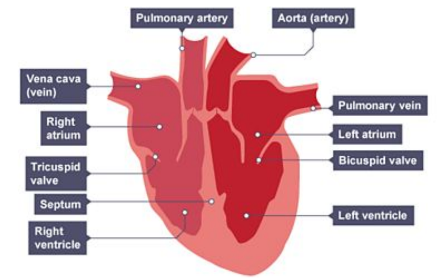
Other factors such as diet, stress and life situations can also have an effect on physical and mental health.
Eating a balanced diet maintains good health whereas a poor diet can lead to obesity, diabetes, poor mental health or deficiencies.
Stress can lead to cardiovascular issues (increase of blood pressure, increasing the risk of CHD) and poor mental health.
Living conditions, place where someone lives and income can have a massive effect on health. The standard of healthcare they can afford or is accessible to them , also the quality of the food they can buy.

Risk Factors

Risk factors can be linked to an increased rate of disease such as substances in a persons body or in the environment.
A causal mechanism has been proven for some risk factors, but not others.
Examples are:
- The effects of diet, smoking and exercise on cardiovascular disease.
- Obesity as a risk factor for Type 2 diabetes.
- The effect of alcohol on the liver and brain function.
- The effect of smoking on lung disease and cancer.
- The effects of smoking and alcohol on unborn babies.

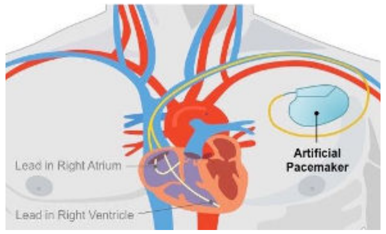
However many diseases are caused by a number of things (factors) interacting.

Heart Structure

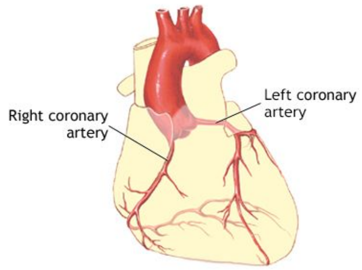


The heart is made of cardiac muscle – and of course needs a large supply of blood to deliver oxygen and glucose (for respiration) and remove waste products such as carbon dioxide.

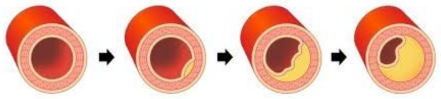
The natural resting heart rate is controlled by a group of cells located in the right atrium that act as a pacemaker. Artificial pacemakers are electrical devices used to correct irregularities in the heart rate



The blood is delivered to the heart by the coronary arteries which branch from the aorta.



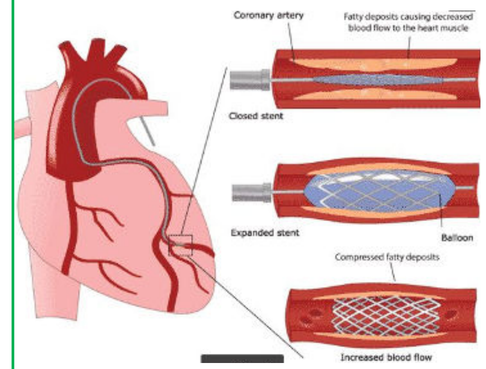
In coronary heart disease (CHD) layers of fatty material build up inside of the coronary arteries. The fatty material comes from cholesterol in our diet (animal products eaten) and cholesterol produced by the liver.



The build up of 'plaque' in the coronary arteries causes the artery to narrow, which in turn restricts blood flow. The artery wall also becomes less elastic. Partial blockage creates a restricted blood flow and results in severe chest pains called angina. Complete blockage means that area of the heart cannot respire aerobically, leading to a heart attack.

Heart disease – treatments

Stents



A stent is a small metal tube used to open the coronary arteries by squashing the fatty deposits therefore allowing blood to flow more easily.

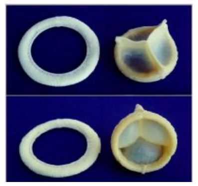
Statins

Statins reduce blood cholesterol levels which slows down the rate of fatty material deposited.

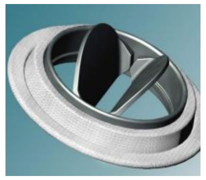
Heart valves

In some people heart valves may become faulty, because of old age, illness or a heart attack. The valves can stiffen, and no longer open fully, so reducing the volume of blood pumped by the heart. They may develop a leak which would cause blood to flow from the ventricles to the atria, or from the arteries back into the ventricle.
Either way, the heart will be less effective at pumping oxygenated blood around the body.

Faulty heart valves can be replaced during surgery using biological or mechanical valves.



Biological valves from cows or pigs



Mechanical valves

Heart transplants

In the case of heart failure a donor heart, or heart and lungs can be transplanted. Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest as an aid to recovery.
However, waiting lists for organs are long and not immediately available, so a short-term solution (or long-term solution if necessary) involves replacing the heart with an artificial one made from plastic and metal.

Cancer

When a cell becomes **cancerous**, it begins to grow and divide uncontrollably. New cells are produced – even if the body does not need them. A group of cancerous cells produces a growth called a **tumour**.
There are two types of tumour - **benign** and **malignant**.

Type of tumour	Characteristics
Benign	Grows slowly; usually grow within a membrane, so can easily be removed; does not invade other parts of the body
Malignant	Grows quickly; invades neighbouring tissues and can spread to other parts of the body in the bloodstream; as the tumour grows, cancer cells detach and can form secondary tumours in other parts of the body - this is called metastasis.

Infection and Response – Communicable Disease

Keyword	Definition
Antibodies	Proteins produced by some white blood cells (lymphocytes) which target a specific pathogen according to the antigen it carries.
Antibiotics	A group of medicines that help to cure bacterial disease by killing infective bacteria inside the body.
Antibiotic Resistance	The ability of bacteria to survive exposure to antibiotics. Occurs as a result of mutations in genes.
Antigen	A protein marker on the surface of a substance (often a pathogen) that triggers an immune response.
Antitoxin	A chemical which cancels out toxins released by pathogens.
Dosage	The most effective amount of drug needed to treat or cure the disease.
Double blind trial	During drug trials, some patients are given a placebo, neither the doctors nor patients know who received the real drug.
Droplet Inhalation	When a disease is spread through coughs and sneezes.
Efficacy	The ability of a drug to cure a condition or relieve symptoms.
Lymphocyte	A type of white blood cell that produces antibodies and antitoxins.
Painkiller	A type of drug that treats the symptoms but does not kill pathogens.
Pathogens	Disease causing microorganism
Phagocytosis	The process by which some white blood cells (phagocytes) engulf pathogens before digesting and destroying them.
Placebo	A fake 'treatment', that does not contain the drug, used as a control in testing new drugs.
Toxicity	The ability of a drug to poison the body.
Vector	Any organism which carries a pathogen and can spread it to another organism e.g., mosquitoes are vectors for malaria.

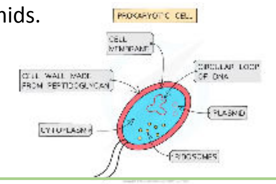
Pathogens

Virus	**Live and reproduce rapidly inside cells, causing cell damage. Unaffected by antibiotics. Difficult to develop drugs that kill viruses without damaging body's tissues.**
Bacteria	Reproduce rapidly inside body. May produce toxins (poisons) that damage tissues and make us ill. Can be treated with antibiotics, although the emergence of strains resistant to antibiotics is of great concern.

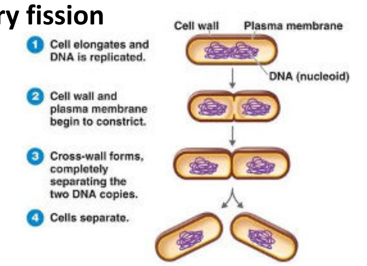
Prokaryotic cells

Bacterial cells (prokaryotic cells) are much smaller in comparison to eukaryotic cells. They have cytoplasm and a cell membrane surrounded by a cell wall.

The genetic material is not enclosed in a nucleus. It is a single DNA loop and there may be one or more small rings of DNA called plasmids.



Binary fission



Bacteria multiply by simple cell division (binary fission) as often as every 20 minutes if they have enough nutrients and a suitable temperature

Human Defence

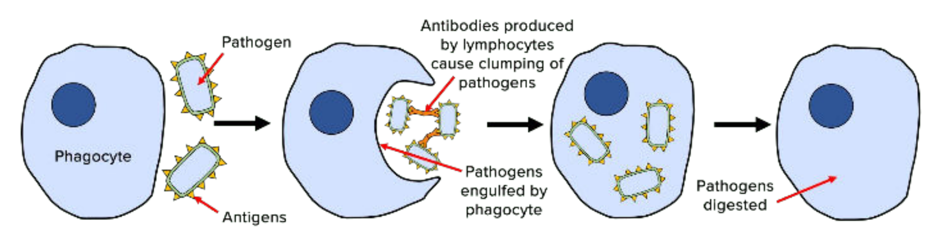
Skin	**A physical barrier to prevent pathogens entering body.**
Scabs	Form over cuts to maintain a physical barrier.
Stomach Acid	Acid destroys pathogens ingested in food / drink.
Mucus	Lines airways to trap pathogens.
Cilia	Tiny hairs lining the trachea and bronchi to trap pathogens and move mucus.
Tears	Contain chemicals to kill pathogens.

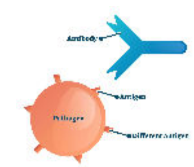
Types of Human – and Plant -Disease

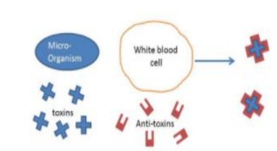
Pathogen	Disease	Infects	Symptoms	Spread by	Prevention/treatment
Virus	Measles	Human	Fever Red skin rash Can be fatal if complications arise	Droplet Inhalation	Most children vaccinated against measles.
	HIV	Human	Initial flu-like illness Later stages (AIDS) occurs when immune system is so badly damaged it cannot deal with other infections or cancer. Fatal.	Exchange of body fluids e.g.. blood or semen by: Unprotected sex Sharing of needles by drug users	Progression of illness can be slowed with antiretroviral drugs.
	Tobacco Mosaic Virus (TMV)	Plants	"Mosaic" pattern of discolouration on the leaves. Stunted growth	Direct Contact	Remove infected leaves and burn Sterilise gardening tools and gloves.
Bacteria	Salmonella	Human	Fever Abdominal cramps Vomiting Diarrhoea	Ingestion of food prepared in unhygienic conditions.	Cook food thoroughly in hygienic conditions. Take fluids to prevent dehydration. UK vaccinates poultry against Salmonella to control the spread.
	Gonorrhoea	Human	Thick yellow/green discharge from vagina or penis. Pain when urinating.	Sexually transmitted	Antibiotics (if not resistant) Use of barrier contraception e.g.. condoms.
Fungi	Rose Black Spot	Plants	Black spots on leaves Stunted growth	Water or carried by wind.	Fungicides. Removing and destroying the affected leaves.
Protist	Malaria	Human	Recurrent episodes of fever Can be fatal	Mosquito bite	Drugs to kill / prevent parasite. Prevent vectors from breeding and use of mosquito nets to avoid being bitten.

Human Defence – White Blood Cells

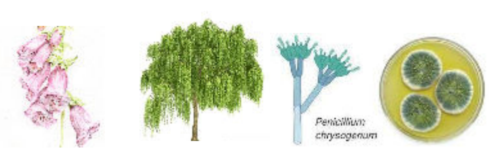
Non-specific defence	**Phagocyte performing phagocytosis to destroy pathogens.**
Specific defence	Antibodies cause pathogens to stick together, making it easier for phagocytes to perform phagocytosis.
Specific defence	Antitoxins neutralise toxins produced by pathogens. Each antitoxin works for a specific toxin.



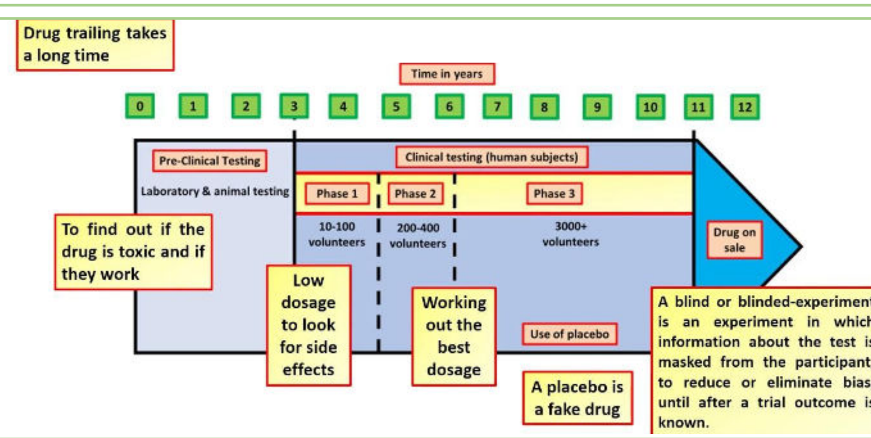




Discovering and developing drugs



Drug	Digitalis	Aspirin	Penicillin
Use	Heart drug	Painkiller	Antibiotic
Origin	Foxgloves	Willow trees	*Penicillium* mould, discovered by Alexander Fleming

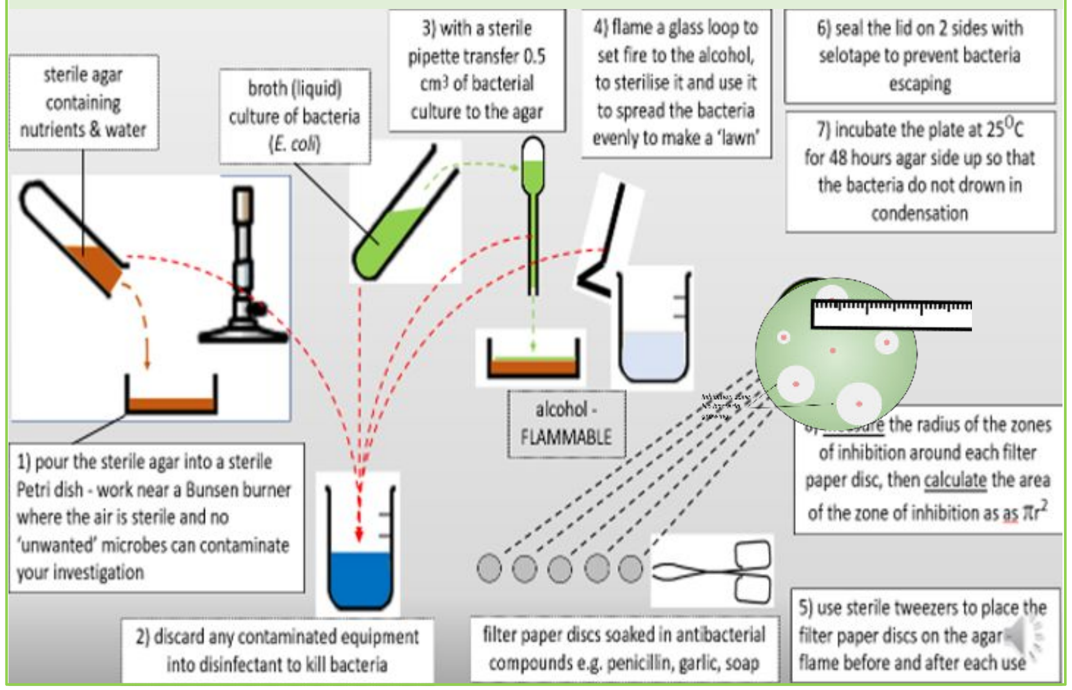


New medical drugs must be tested and trialled before being used to check that they are safe and effective. New drugs are extensively tested for toxicity, efficacy and dose. Preclinical testing is done in a laboratory using cells, tissues and live animals. Clinical trials use healthy volunteers and patients: • Very low doses of the drug are given at the start of the clinical trial. • If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug. • In double blind trials, some patients are given a placebo.

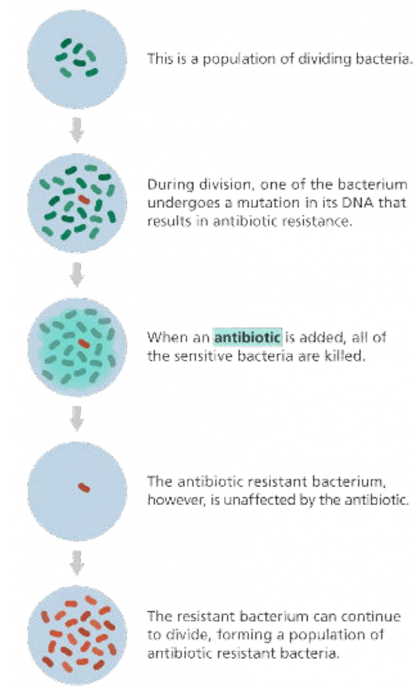
Infection and response – Plants, Antibiotic resistance, Vaccination and Monoclonal antibodies.

Keyword	Definition
Antibiotic Resistance	The ability of bacteria to survive exposure to antibiotics. Occurs as a result of mutations in genes.
Antigen	A protein marker on the surface of a substance (often a pathogen) that triggers an immune response.
Chlorosis	Scientific term for 'yellowing'. Chlorotic leaves are pale, yellow or pale white.
Hybridoma	Lymphocytes are combined with a particular kind of tumour cell to make a hybridoma cell. The hybridoma cell can both divide and make the specific antibody.
Lymphocyte	White blood cells which attack pathogens by producing antibodies.
Tumour cells	When a cell becomes cancerous , it begins to grow and divide uncontrollably. New cells are produced – even if the body does not need them. A group of cancerous cells produces a growth called a tumour .
Monoclonal antibodies (MABs)	Antibodies are found naturally in our blood and help us to fight infection. MAB therapies mimic natural antibodies but are made in a laboratory. Monoclonal means all one type. So, each MAB therapy is a lot of copies of one type of antibody.
Pathogen	Disease causing microorganism
Vaccination	Vaccination involves introducing small quantities of dead or inactive forms of a pathogen into the body to stimulate the white blood cells to produce antibodies.
Zone of inhibition	It is a clear circular area around antimicrobial discs in which bacteria are unable to grow

Biology only: Investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition



Antibiotic resistance



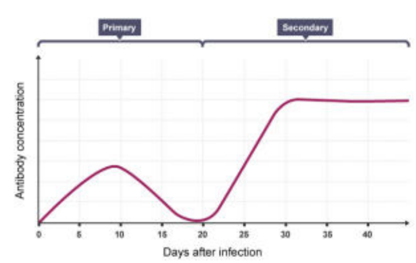
Bacteria can evolve rapidly because they reproduce at a fast rate.
Mutations of bacterial pathogens produce new strains.
Some strains might be resistant to antibiotics, and so are not killed.
They survive and reproduce, so the population of the resistant strain rises. The resistant strain will then spread because people are not immune to it and there is no effective treatment e.g., MRSA

To reduce the rate of antibiotic resistant strains developing:

- doctors should not prescribe antibiotics inappropriately, such as treating non-serious or viral infections
- patients should complete their course of antibiotics, so all bacteria are killed, and none survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted.

Vaccination

Inject small amount of dead or inactive pathogen (containing specific antigens).
White blood cells produce antibodies until correct antibody identified.
Antibodies attach to and clump pathogens together.
White blood cells engulf the pathogens. Phagocytosis occurs.



Primary exposure (following vaccination):

- Antibodies increase slowly as white blood cells must produce different antibodies in order to find the correct one to match the antigen on pathogen.

Secondary exposure (re-infection by "live" pathogen):

- White blood cells recognise same antigen and produce correct antibodies rapidly.
- Greater quantities of antibodies produced to prevent infection.

Plant disease – Biology only

Diseases can cause

- stunted growth
- spots on leaves
- areas of decay (rot)
- growths
- malformed stems or leaves
- discolouration
- presence of pests

Identification can be made by:

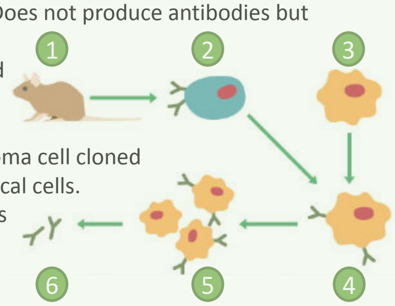
- reference to a gardening book or website
- taking plants to a lab to identify the pathogen
- using kits that contain monoclonal antibodies.

Plant defences - Biology only

Physical defence	-Cellulose cell walls. -Tough waxy cuticle on leaves. - Layers of dead cells around stems which fall off.
Chemical defence	- Antibacterial chemicals. - Poisons to deter herbivores.
Mechanical defence	- Thorns and hairs deter animals. - Leaves which droop or curl when touched. - Mimicry to trick animals.

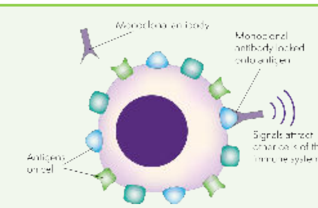
Monoclonal antibodies – Biology only

- Mouse vaccinated to start production of antibodies.
- Lymphocyte: Produces specific antibodies but cannot divide.
- Tumour cell: Does not produce antibodies but divides
- Cells are fused to from a hybridoma.
- Single hybridoma cell cloned to make identical cells.
- Large amounts of monoclonal antibodies collected.



Uses of monoclonal antibodies - Biology only

- Pregnancy tests
- Measure levels of hormones or other chemicals in blood
- Detect pathogens
- Locate specific molecules in cells
- Treating cancer



Monoclonal antibodies in treating cancer:

A. Antibody attaches to antigens of cancer cell inhibiting growth hormone's ability to attach, this slows growth of cancer cell.
B. Antibody attaches to antigens of cancer cell and signals to white blood cells to destroy cancer cell.
C. The monoclonal antibody can be bound to a radioactive substance, a toxic drug or a chemical which stops cells growing and dividing. It delivers the substance to the cancer cells without harming other cells in the body.

Issues of monoclonal antibodies:

- More side effects than expected.
- Not widely used.

Plant mineral deficiencies

Mineral Ion	Function	Deficiency
Mg^{2+} magnesium	Needed to make chlorophyll	Yellowing between the veins(chlorosis)
NO_3^- nitrate	Source of N to make amino acids (to build proteins)	Stunted growth and yellowing of leaves

Bioenergetics: Respiration

Keyword	Definition
Aerobic	The presence of oxygen.
Anaerobic	The absence of oxygen.
Ethanol (alcohol)	A product of anaerobic respiration in plant or yeast cells.
Exothermic	A reaction that transfers energy to the surroundings.
Fermentation	Anaerobic respiration in plant and yeast cells, producing carbon dioxide.
Glucose	A simple sugar used by most organisms for cellular respiration.
Lactic acid	The product of anaerobic respiration in animal cells.
Metabolism	The sum of all the chemical reactions in a cell or the body.
Mitochondria	An organelle found in eukaryotic cells. Aerobic respiration occurs here to release energy.
Oxygen	A reactant of aerobic respiration, oxygen is required for the oxidation of glucose in aerobic respiration.

Response to exercise

More energy required by muscle cells

↓

More respiration occurs in mitochondria to provide energy

↓

More oxygen and glucose required | **More carbon dioxide produced**

↓

Heart rate increases to provide more oxygen and glucose to muscle cells, and remove more carbon dioxide from the muscle cells

↓

Breathing rate increases to bring more oxygen into the body, and remove more carbon dioxide from the body

- If insufficient oxygen can be delivered to the respiring cells, the cells will begin to respire **anaerobically**.

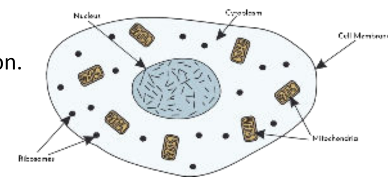
Aerobic respiration

- Aerobic respiration is respiration in the **presence of oxygen**.
- Takes place in the **mitochondria** of eukaryotic cells, or in the cytoplasm of prokaryotic cells, to release energy.
- Aerobic respiration is represented by the following equation:

Glucose + Oxygen → Carbon dioxide + Water

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

- Respiration is an **exothermic** reaction. It transfers energy from the chemical store of glucose into other stores for use in processes such as:
  - Active transport.
  - Muscle contraction.
  - Growth.
  - Protein synthesis.
  - Cell division.
  - Nerve impulses.



- Respiration also transfers energy to the thermal stores of animals (hence they feel warm).

Anaerobic respiration

- Anaerobic respiration is respiration in the **absence of oxygen**.
- Takes place in the cytoplasm of cells.
- Whilst still releasing energy for cellular processes, it is much **less efficient** than aerobic respiration since the glucose is not fully oxidised.
- Therefore, less energy is released from each glucose molecule.

Anaerobic respiration in animal cells

Glucose → Lactic acid

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

Anaerobic respiration in plant and bacteria cells

Glucose → Ethanol + Carbon dioxide

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Uses of anaerobic respiration in industry

- Anaerobic respiration in yeast is also known as fermentation. It is used in the brewing of alcoholic drinks such as wine or beer.
- The carbon dioxide that is produced in anaerobic respiration in yeast can be used to make bread rise.

HT: Removing lactic acid

- Lactic acid is transferred through the body by the blood to the **liver.**
- In the liver, lactic acid is **converted back to glucose** and stored as glycogen or used in respiration.
- Alternatively, lactic acid can be oxidised to carbon dioxide and water:

Lactic acid + Oxygen → Carbon dioxide + Water

- The oxygen required to remove the lactic acid is known as the **oxygen debt**.

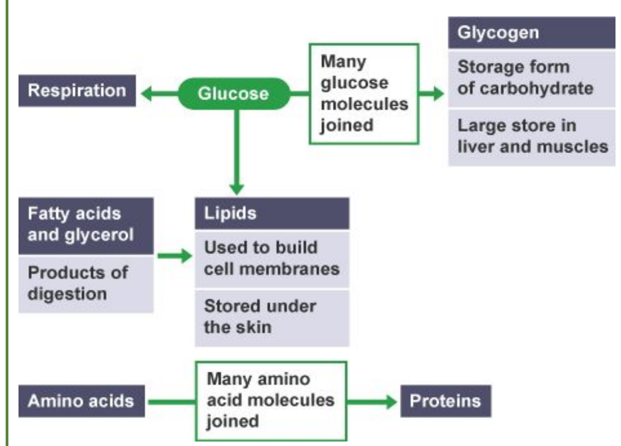
Metabolism

- **Metabolism is the sum of all of the chemical reactions in a cell or body**.
- Chemical reactions can build up large molecules, or break them down into small ones.
- The chemical reactions are all controlled by enzymes.

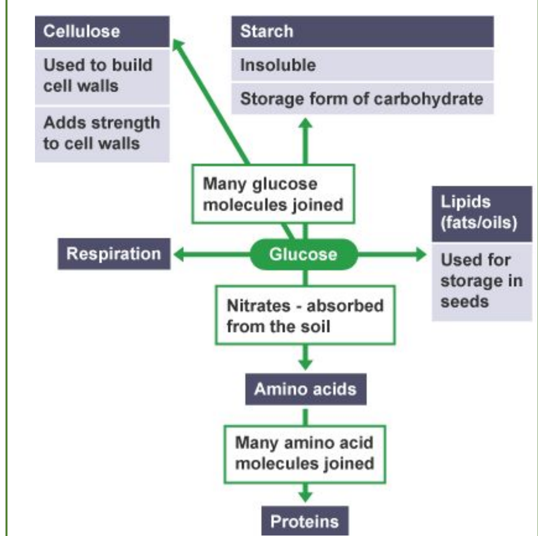
Note: Photosynthesis is NOT a metabolic reaction.

- All of the chemical reactions are summarised in the flow diagrams below.

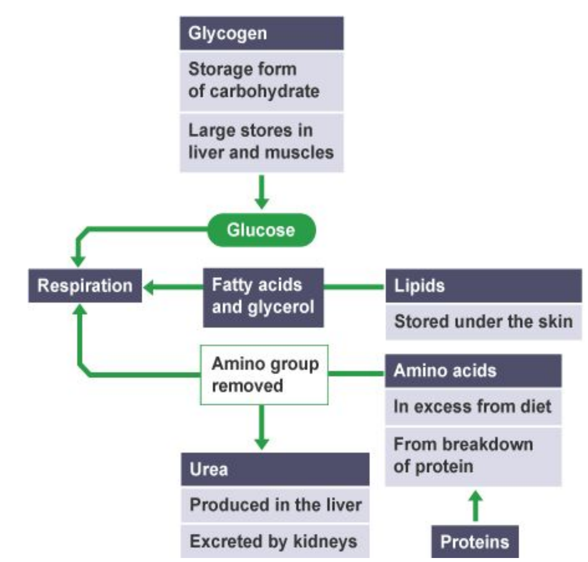
Reactions that build up products of digestion



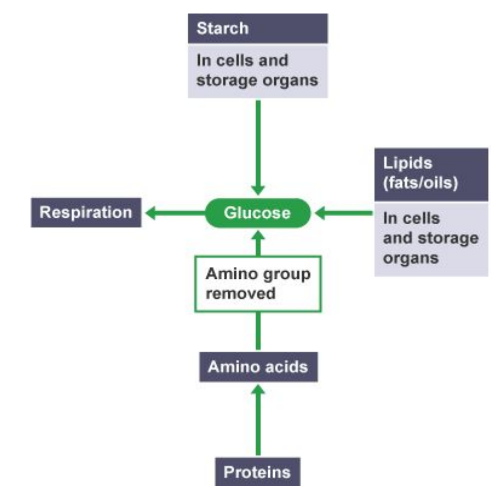
Reactions that build up molecules in plants after photosynthesis has produced glucose



Reactions that break down compounds



Reactions that break down molecules



Compare and contrast:

Aerobic respiration releases 2872 kJ of energy per mole of glucose, anaerobic respiration only releases 118 kJ energy per mole of glucose.

Useful YouTube links:

Respiration | Exercise | Metabolism

Bioenergetics : Photosynthesis

Keyword	Definition
Carbon dioxide	Reactant in photosynthesis.
Chlorophyll	Green pigment in chloroplasts where photosynthesis takes place.
Chloroplast	Organelle which is packed full of chlorophyll. T
Endothermic	A reaction that transfers energy into the reactants from the surroundings. Energy from the Sun is transferred by light into the chemical store (glucose) of the plant.
Glucose	A product of photosynthesis. The main energy source in respiration. The starting molecule for many other materials that plants need to live such as starch, cellulose, amino acids and lipids.
Oxygen	A product in photosynthesis.
Water	Reactant in photosynthesis.

Photosynthesis

- Photosynthesis is a chemical reaction by which plants make their own food.
- It is represented by the following equation:

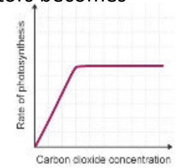
carbon dioxide + water –> glucose + oxygen

$$6CO_2 + 6H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6O_2$$

- Photosynthesis occurs in the **chloroplasts** of plant or algal cells.
- Chloroplasts are packed with a green pigment called **chlorophyll**.
- Since photosynthesis transfers light energy into the reactants, it is an **endothermic** reaction.

Carbon dioxide concentration

At low carbon dioxide concentrations, increasing the level will increase the rate of photosynthesis, until one of the other three factors becomes limiting.
At this point the rate of Photosynthesis remains constant.



Factors affecting the rate of photosynthesis

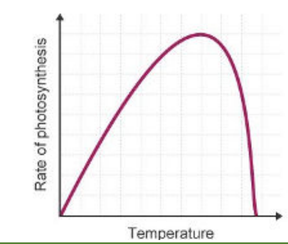
The factors that affect the rate of photosynthesis in a plant are:

- Light **intensity**.
- Temperature.
- Carbon dioxide **concentration**.
- Amount of chlorophyll.

Note: Water is NOT considered a limiting factor of photosynthesis.

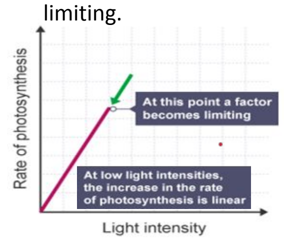
Temperature

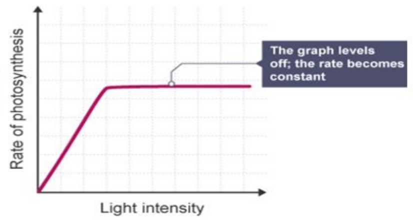
Photosynthesis is controlled by **enzymes**.
At low temperatures, the rate of photosynthesis is limited because of the low numbers of collisions between enzyme active sites and the substrates (carbon dioxide and water).
At high temperatures, the enzymes **denature** causing the rate of photosynthesis to decrease rapidly.



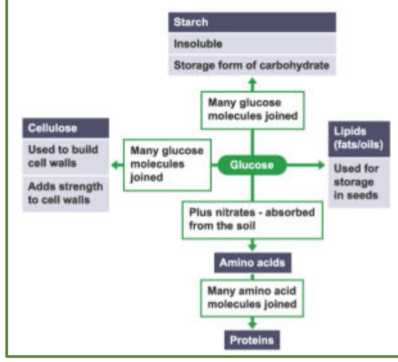
Light intensity

- At low light intensities, the plant will not have sufficient light energy to photosynthesise quickly.
- Therefore, increasing the light intensity increases the rate of photosynthesis, until one of the other three factors becomes limiting.





Uses of glucose



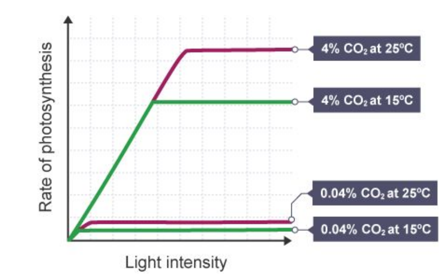
Amount of chlorophyll

Plants with more chlorophyll are able to absorb more light, so photosynthesise more.
Exam hint: you will rarely see 'amount of chlorophyll' as the dependent variable in a question difficult to change or measure).

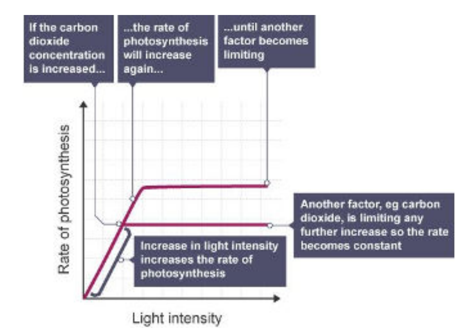
However, it may become the limiting factor when the graph levels off.

HT: Interacting limiting factors

You will likely face a question that combines several factors on the same graph. For instance, this graph shows the effect of increasing light intensity at two different carbon dioxide concentrations.

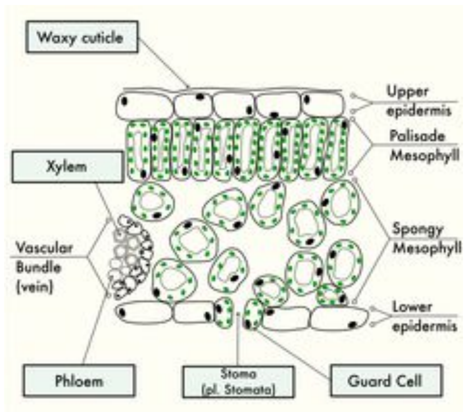


Or, three factors could be represented.



Structure of a leaf

Tissue	Function
Epidermis	Protective layer on the top and bottom of the leaf. Waterproof to avoid water loss.
Palisade Mesophyll	Made of tightly packed, long column shaped cells with lots of chloroplasts in order to carry out photosynthesis.
Spongy Mesophyll	Cells are loosely structured allowing for air spaces for gas exchange. Lots of chloroplasts present.
Guard cells and stomata	The stoma are the holes through which carbon dioxide and oxygen exchange places. The guard cells open and close to control gas exchange and water loss.



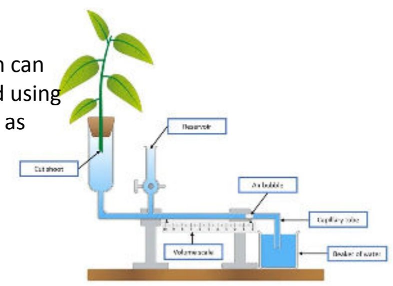
Transpiration and factors affecting its rate.

The evaporation of water from the leaves through the stomata.

The rate of transpiration is affected by:

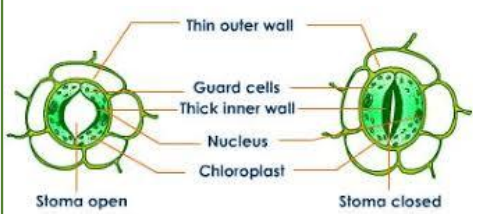
- Temperature – warmer = faster
- Humidity – more humid = slower
- Air movement – more = faster
- Light intensity – higher = faster

Transpiration can be measured using a potometer as pictured.



Water is absorbed by the plant root hair cells due to losing water via transpiration. So the air bubble will move along the capillary tube. The speed at which it moves can be measured and this gives a measurement to the rate of transpiration.

Structure and function of stomata



The **stomata** control gas exchange in the leaf. Each stoma can be open or closed, depending on how **turgid** its **guard cells** are.
The stomata can open and close to:

- control water lost by transpiration
- allow gas exchange

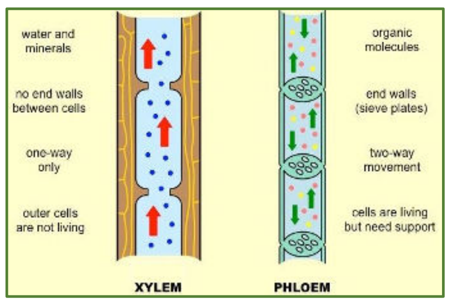
Diffusion of carbon dioxide into the leaf for photosynthesis and oxygen and water vapour out of the leaf, is greatest when the stomata are open during the day.
Stomata are found mainly on the lower surface of the leaf to reduce water loss by transpiration.

Xylem

The **xylem** is a tissue which transports water and minerals from the roots up the plant stem and into the leaves.
Xylem consists of dead cells. The cells that make up the xylem are adapted to their function:

- They lose their end walls so the xylem forms a continuous, hollow tube.
- They become strengthened by a substance called **lignin**. Lignin gives strength and support to the plant.

Transport in the xylem is a physical process. It does not require energy.



Phloem

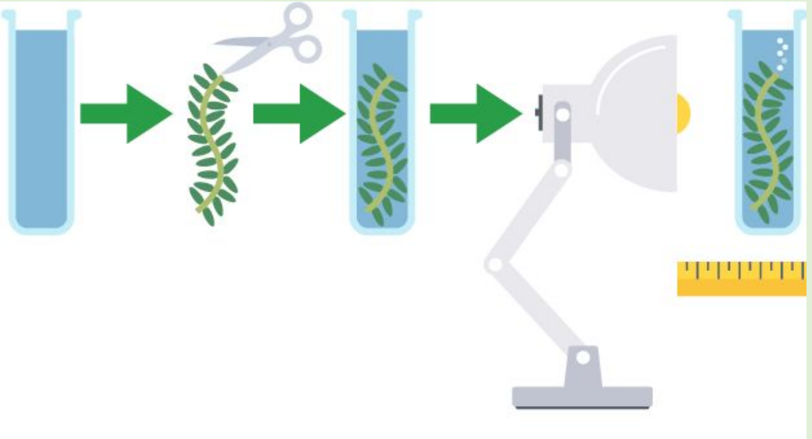
The **phloem** moves food substances (sucrose) produced by photosynthesis to where they are needed for processes such as growing, storage or developing seeds Transport in the phloem is called **translocation** moving up and down the stem. Translocation requires energy as it is an active process.
Phloem consists of living cells. The cells that make up the phloem are adapted to their function:

- **Sieve tubes** - specialised for transport and have no **nuclei**. They have perforated ends so **cytoplasm** connects one cell to the next. Sucrose and amino acids are translocated within the living cytoplasm of the sieve tubes.
- **Companion cells** - transport of substances in the phloem requires energy. One or more companion cells attached to each sieve tube provide this energy. A sieve tube is completely dependent on its companion cell(s).

Required Practical – Rate of Photosynthesis

Method

- Set up a boiling tube containing 20 cm^3 of **sodium hydrogen carbonate solution** (1%). Allow the tube to stand for a few minutes and shake to disperse any air bubbles that might form.
- Cut a piece of **pondweed**, *Cabomba*, about 8 cm long.
- Use forceps to place the pondweed in the boiling tube carefully. Ensure the pondweed is fully submerged in the sodium hydrogen carbonate solution.
- Position the boiling tube so that the pondweed is 10 cm away from the light source. Allow the boiling tube to stand for five minutes.
- Count the **number of bubbles** emerging from the cut end of the stems **in one minute**. Repeat the count five times and record your results in a table.
- **Calculate the average** number of bubbles produced **per minute**.
- **Repeat** the experiment at **increasing distances** away from the light source.



Variables

- **Independent Variable:** the distance between the light source and the pondweed, measured using a **ruler**.
- **Dependent Variable:** the rate of oxygen produced per minute, measured by counting the number of bubbled produced by the plant in one minute (measured with a stop clock).
- **Control Variables:**
  - Concentration of sodium hydrogen carbonate solution (this provides the carbon dioxide to the pondweed, so effectively maintains the carbon dioxide concentration).
  - Temperature: this can be maintained by keeping a heat screen between the light source and the pondweed. A low energy or LED light bulb can also reduce the amount of heat that the bulb emits.
  - Amount of pondweed: use the same piece each time.

Risks

Care must be taken when handling the electrical lamp. Ensure that hands are dry.

Useful YouTube links:

Required practical

Measuring the rate of photosynthesis

- The rate of a chemical reaction can be measured in two ways:
  1. Measuring how quickly the reactants are used up.
  2. Measuring how quickly the products are formed.

Measuring the rate at which water or carbon dioxide are used by a plant is difficult. However, there are a number of ways to measure the amount of oxygen or glucose that a plant uses:

Counting bubbles of oxygen produced by pondweed.

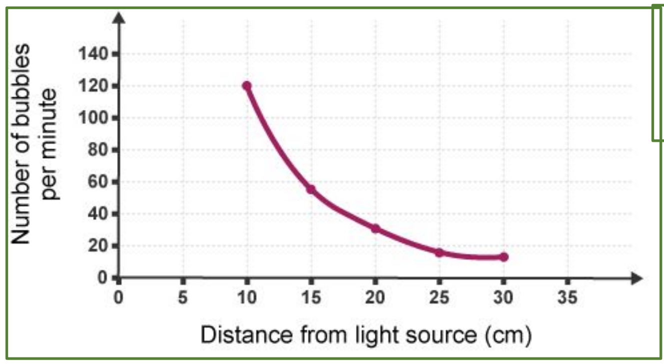
Counting the number of fruit, flowers or leaves that a plant produces, since these are built using glucose.

Exam hint: *when presented with a graph or table of data, they may not explicitly indicate the rate of photosynthesis. However, it may be implied by something else, such as the number of tomatoes produced in a week.*

Results

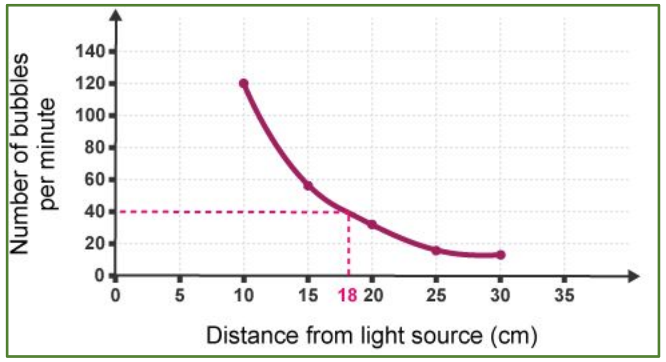
Distance	Rate
10 cm	120
15 cm	54
20 cm	30
25 cm	17
30 cm	13

- Note: Rate = number of bubbles produced per minute.
- The results can be plotted on a graph.



Remember: the ***dependent variable*** *always goes on the* ***x axis****.*

- When you are asked to determine the rate of photosynthesis at an unknown light intensity, use a ruler on your graph like so:

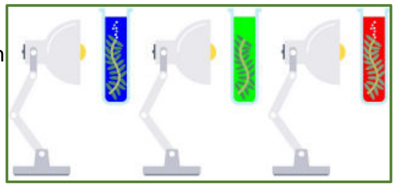


- When the pondweed is 18 cm away from the light source, rate of photosynthesis is 40 bubbles per minute.

Alternatives to Light Intensity

You may be asked to change a different factor. e.g. Colour or wavelength of light:

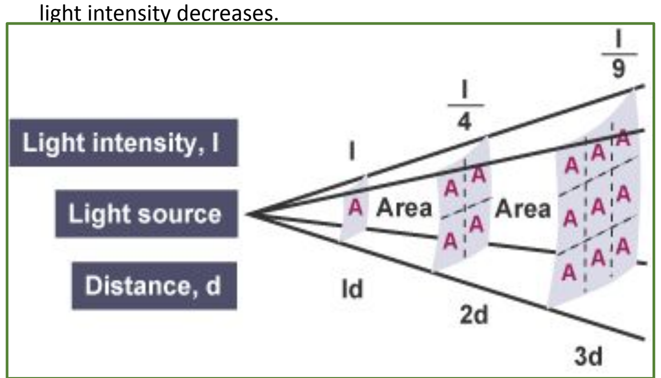
- Different coloured films can be placed between the bulb and the pondweed.
- The number of bubbles of oxygen in one minute is measured.
- The distance of the lamp from the pondweed will now need to be kept the same.



Read the question carefully, do not assume that it is asking you directly about the practical you have done in lesson.

HT: Inverse Square Law (Mathematical skills)

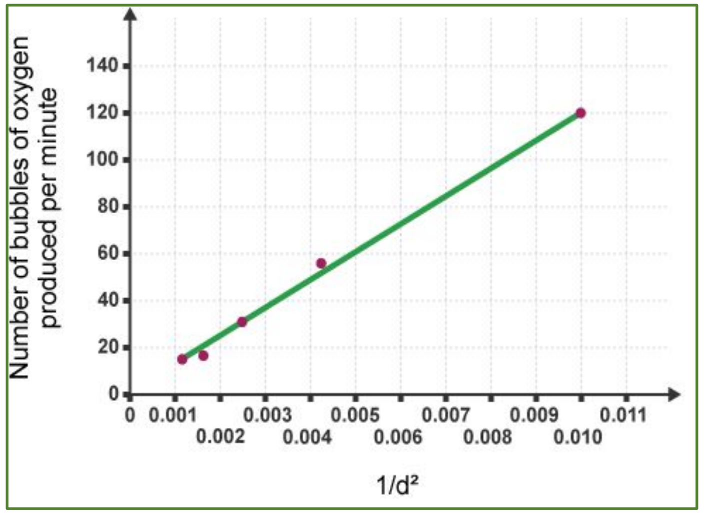
- As the distance between a light source and plant increases, the light intensity decreases.



- The light intensity is **inversely proportional** to the square of the distance, hence the **inverse square law**.
- Light intensity is inversely proportional to distance squared, or d^2.
- Therefore:

  Light intensity = $\frac{1}{d^2}$

Distance	$\frac{1}{d^2}$	Rate
10 cm	0.0100	120
15 cm	0.0044	54
20 cm	0.0025	30
25 cm	0.0016	17
30 cm	0.0011	13

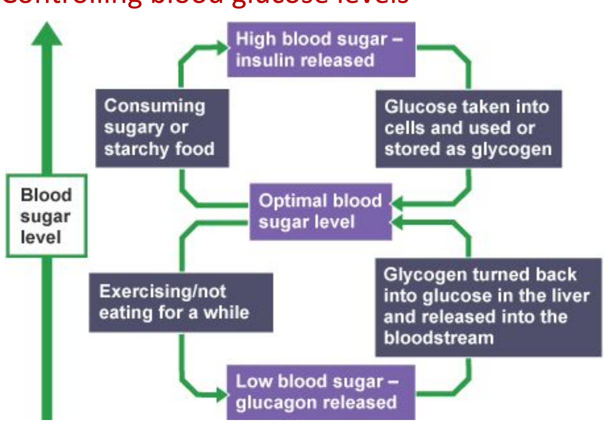


- The graph gives a straight line, therefore the relationship is **inversely proportional.**

Homeostasis

Keyword	Definition
Chemical Response	Uses hormones which travel in the bloodstream to a target organ to make slow, longer lasting changes.
CNS	(Central Nervous System) The brain and spinal cord.
Endocrine System	Composed of glands which secrete (release) chemicals called hormones into the bloodstream.
Glycogen	The long-term store of sugar in the body. Made and stored in the liver and muscles.
Homeostasis	The regulation of the internal conditions of a cell or organism to maintain optimum conditions (best) conditions for function in response to internal and external changes. For example, temperature, water levels, blood glucose concentration.
Insulin	Hormone made in the pancreas that reduces glucose levels in the blood.
Nervous Response	Uses electrical impulses in nerves to make fast, short-lived changes.
Neurone (nerve cell)	Carries electrical impulses from one end to the other.
Reflex Arc	A nervous response that is fast and automatic for protection. Does not involve the conscious brain.
Synapse	A gap between two neurones across within a chemical must diffuse to trigger an electrical impulse in the next neurone.
Type 1 Diabetes	Pancreas fails to produce sufficient (enough) insulin. Uncontrolled high blood glucose levels treated with insulin injections.
Type 2 Diabetes	When poor diet and obesity cause body cells to not respond to insulin anymore. Controlled with balanced diet and exercise.

Controlling blood glucose levels

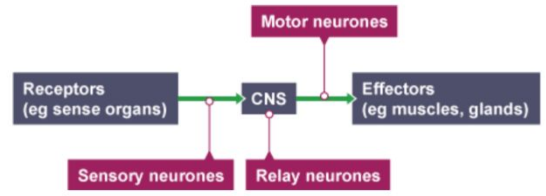


Diabetes

Type 1 diabetes is a disorder in which the pancreas fails to produce sufficient insulin. It is characterised by uncontrolled high blood glucose levels and is normally treated with insulin injections. 23 In Type 2 diabetes the body cells no longer respond to insulin produced by the pancreas. A carbohydrate-controlled diet and an exercise regime are common treatments. Obesity is a risk factor for Type 2 diabetes.

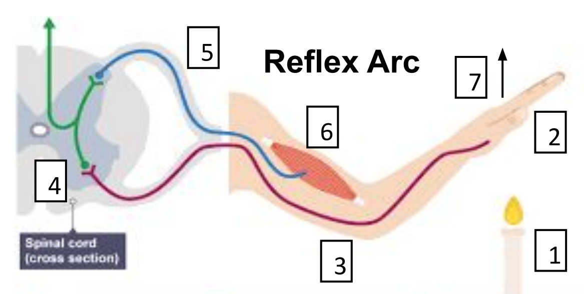
Human nervous system

The nervous system enables humans to react to their surroundings and to coordinate their behaviour.

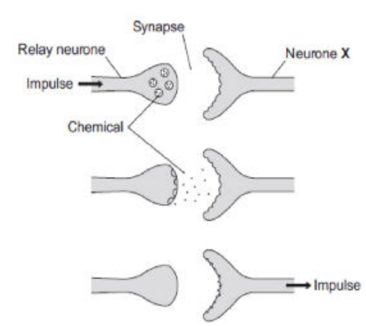


1. Stimulus	A change to the environment.
2. Receptor	Cells which detect stimuli.
3. Sensory neurone	A neurone that carries electrical impulses from receptors to the CNS.
4. Co-ordination centre	Receives and processes information from the receptors.
5. Motor neurone	A neurone that carries electrical impulses from the CNS to the effectors.
6. Effector	Muscles and glands which bring about responses to restore optimum levels.
7. Response	The action that occurs as a result of a stimulus.

Reflex actions



Spinal cord contains relay neurone (green) which carries electrical impulses from the sensory neurone to the motor neurone.



The neurotransmitters diffuse (move down a concentration gradient) across the synapse. The neurotransmitters bind to receptors on the next neurone. The presence of the neurotransmitter causes the production of an electrical impulse in the next neurone.

Useful YouTube links:

Reflex Arc

Controlling Blood Glucose

Menstrual Cycle

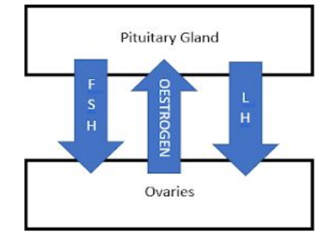
AQA

Human reproduction and the menstrual cycle

During puberty reproductive hormones cause secondary sex characteristics to develop. At puberty eggs begin to mature and one is released every 28 days.

Testosterone is the main male reproductive hormone. Produced by the testes, it stimulates sperm production.

The diagram to the right summarises the interactions between the hormones involved in the menstrual cycle **(HT)**



FSH (follicle stimulating hormone)	Pituitary gland	Causes an egg to mature in an ovary. Stimulates the ovaries to release oestrogen
Oestrogen	Ovaries	Stops FSH being produced (so that only one egg matures in a cycle). Repairs, thickens and maintains the uterus lining. Stimulates the pituitary gland to release LH.
LH (Luteinising hormone)	Pituitary Gland	Triggers ovulation (the release of a mature egg)
Progesterone	Ovaries	Maintains the lining of the uterus during the middle part of the menstrual cycle and during pregnancy.

Artificial control of fertility

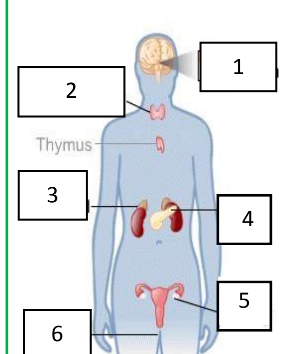
Oral	Inhibits FSH so no eggs mature.
Injection/Implant/Patch	Contains progesterone inhibits maturation and release of eggs.
Barrier (e.g. condom)	Prevents sperm reaching egg.
Intrauterine device	Prevents implantation of an embryo or releases a hormone.
Spermicide	Kills sperm.
Abstinence	Prevents sperm meeting the egg.
Surgical sterilisation	Prevents sperm meeting the egg.

Infertility treatments (Higher tier)

1. Giving mother FSH and LH to stimulate maturation of eggs.
2. Eggs are collected from the mother and fertilised by sperm from the father in the lab.
3. The fertilised eggs develop into embryos.
4. At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother's uterus.

Possible consequences of IVF:
Emotionally and physically stressful.
Poor success rate.
Can lead to multiple births, which is a risk to both babies and mother.

Endocrine system



1. Pituitary Gland	Master gland which secretes several hormones.
2. Thyroid	Produce thyroxine to stimulates the basal metabolic rate to play an important role in growth and development.
3. Adrenal Glands	Produce adrenaline (fear or stress) to raise heart rate and boost delivery of oxygen and glucose to the brain and muscles.
4. Pancreas	Monitors blood glucose concentration. Produces insulin to lower blood glucose concentration and glucagon to raise blood glucose concentration.
5. Ovaries	Produces oestrogen.
6. Testes	Produces testosterone and stimulates sperm production.

Homeostasis Required Practical's

Plan and carry out an investigation into the effect of a factor on human reaction time.

Reaction time is the time taken to respond to a stimulus; reactions are usually very quick responses typically taking less than a second to occur.
Reaction time can be affected by factors such as **age**, **stress** or **use of drugs** (such as caffeine).
You could investigate the effect of **background noise** or consumption of **caffeine** on how quickly a person catches a ruler.
Reaction time can be measured in this way using the principle that the further down the length a ruler is caught, the slower an individual's reaction time
The experiment can be repeated several times to calculate a **mean distance** caught and this can be linked to a **reaction time.**
The process is then repeated after a condition is changed (the person drinks a can of caffeinated drink or must repeat the experiment when loud background music is playing)

- Remember to only change one factor (independent variable) in your investigation

There are many **control variables** that should be considered in this experiment such as:

- The person catching the ruler using their dominant hand each time
- Dropping the same ruler from the same height each time, with the ruler held in the same direction.
- If the effect of caffeine is being investigated then none should have been consumed before the start of the experiment, or the room is silent for the first run if background noise is being altered

You could carry out a reaction time investigation using a computer; which is more precise as it removes human error.

After the results have been recorded, the point at which the ruler was caught needs to be converted into a time. This is done using a ruler reading to reaction time chart as shown below.

Ruler Reading (mm)	Reaction Time (s)	Ruler Reading (mm)	Reaction Time (s)	Ruler Reading (mm)	Reaction Time (s)	Ruler Reading (mm)	Reaction Time (s)	Ruler Reading (mm)	Reaction Time (s)
10	0.05s	210	0.21s	410	0.29s	610	0.35s	810	0.41
20	0.06s	220	0.22s	420	0.30s	620	0.36s	820	0.41
30	0.08s	230	0.22s	430	0.30s	630	0.36s	830	0.41
40	0.09s	240	0.22s	440	0.30s	640	0.36s	840	0.41
50	0.10s	250	0.23s	450	0.31s	650	0.36s	850	0.42
60	0.11s	260	0. 23s	460	0.31s	660	0.37s	860	0.42
70	0.12s	270	0.23s	470	0.31s	670	0.37s	870	0.42
80	0.13s	280	0.24s	480	0.32s	680	0.37s	880	0.42
90	0.14s	290	0.24s	490	0.32s	690	0.38s	890	0.43
100	0.14s	300	0.25s	500	0.32s	700	0.38s	900	0.43
110	0.15s	310	0.25s	510	0.33s	710	0.38s	910	0.43
120	0.16s	320	0.26s	520	0.33s	720	0.38s	920	0.43
130	0.16s	330	0.26s	530	0.33s	730	0.39s	930	0.44
140	0.17s	340	0.26s	540	0.34s	740	0.39s	940	0.44
150	0.18s	350	0.27s	550	0.34s	750	0.39s	950	0.44
160	0.18s	360	0.27s	560	0.34s	760	0.39s	960	0.44
170	0.19s	370	0.28s	570	0.34s	770	0.40s	970	0.45
180	0.19s	380	0.28s	580	0.35s	780	0.40s	980	0.45
190	0.20s	390	0.28s	590	0.35s	790	0.40s	990	0.45
200	0.21s	400	0.29s	600	0.35s	800	0.40s	1000	0.45

Example: three students played a computer game which measured their reaction time to click when they wanted a character to carry out an action.
Their results were recorded in the table below:

Attempt	Time in milliseconds		
	Student 1	Student 2	Student 3
1	273	285	275
2	269	281	486
3	271	279	282
4	262	278	276
5	265	277	276
Mean	268	280	319

The lowest reaction time belongs to the person with the fastest reaction time – in this example, student A has the fastest reaction time (268 milliseconds) and student B the slowest (280 ms)

Anomalous result, should not be included in the mean

This mean is incorrect as anomaly has been included. The correct mean should be (275 +282 +276 + 276) / 4 = 277 (to 3 significant figures)

Biology only

Investigate the effect of light or gravity on the growth of newly germinated seedlings. Record results as both length measurements and as careful, labelled biological drawings to show the effects.

Method 1. Effect of light

1. Set up three petri dishes containing cotton wool soaked in equal volumes of water.
2. Put ten mustard seeds in each dish.
3. Put the dishes in a warm place. They must not be disturbed or moved.
4. Allow the mustard seeds to germinate. Water daily with equal volumes of water to each dish.
5. Each dish should have the same number of seedlings after the seeds have geminated. Remove excess seedlings from any dish
6. Measure the height of each seedling in mm.
7. Move the petri dishes into position.
 Put one on a windowsill in full sunlight.
 Put the second one in partial light.
 Put the third one in darkness.
8. Measure the height of each seedling every day, for at least five consecutive days.
9. Record the heights in a table like this one: Have three tables, one for each condition grown in.

Full Sunlight

Day	Height of Seedling (mm)								
	1	2	3	4	5	6	7	8	Mean
1	2	4	3	4	1	5	3	2	
2	5	6	6	6	5	7	8	4	
3	7	8	8	8	6	10	10	6	
4	8	10	11	12	10	11	13	6	
5	10	12	14	16	15	18	19	20	
6	12	14	17	18	19	21	24	22	
7	18	19	22	25	27	29	32	26	

Partial Sunlight

Day	Height of Seedling (mm)								
	1	2	3	4	5	6	7	8	Mean
1	2	4	3	3	2	2	4	2	
2	5	7	6	7	5	7	8	9	
3	8	10	9	11	9	9	11	11	
4	10	12	12	14	13	13	14	15	
5	12	15	14	17	16	15	17	18	
6	16	18	19	21	20	20	21	22	
7	19	24	26	27	28	29	31	30	

No Sunlight

Day	Height of Seedling (mm)								
	1	2	3	4	5	6	7	8	Mean
1	2	3	5	2	3	3	2	4	
2	5	6	7	6	6	4	7	9	
3	10	11	12	11	12	11	13	13	
4	14	15	16	15	16	17	17	18	
5	17	20	21	22	22	23	23	21	
6	22	26	27	27	28	30	31	32	
7	24	29	32	34	34	36	37	36	

Analysis and conclusion
a. Calculate the mean height of the seedlings each day.
b. Plot a graph with: 'Mean height in mm' on the y-axis. and 'Day' on the x-axis.
c. Write a conclusion to state and explain your results, include reference to hormones and their distribution in your answer.

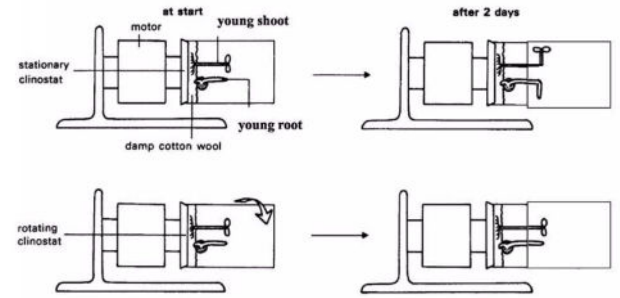
Method 2. Effect of Gravity

To show the effects of **geotropism**, some seedlings are grown as normal, while another set can be grown on a clinostat perpendicular to the ground (continually rotating them).
A clinostat uses rotation to negate the effects of gravity on roots and shoots.
The angle of rotation can be altered by the metal arm on the side of the base.
The clinostat is plugged in and turns at 4 revolutions per hour.

Results should be collected by sketching the seedlings and noting the effects of tropisms on them.
Carefully measure the height of the seedlings.

- In the first petri dish **all radicles (roots) will have grown downwards** (positive gravitropic response) regardless of which way they were initially facing (horizontal, up or down) and **all plumules (shoots) will have grown upwards** (negative gravitropic response)
- In the second petri dish, all radicles and all plumules have all grown **neither up nor down** but straight outwards in whichever direction they were placed as the effect of gravity has been cancelled out by the revolving of the clinostat - they have shown no gravitropic response at all.

The experiment needs to be done in a lightproof box to **control the effect of light** on the growth of the seedlings. Light is a control variable when investigating gravity



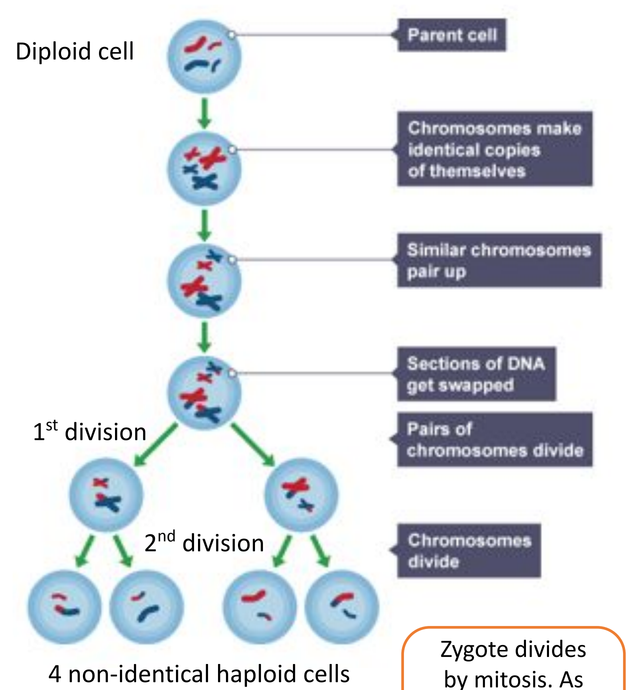
The image opposite shows a stationary clinostat (top diagrams) and a rotating clinostat (bottom diagrams).

It can be seen in the diagram on the bottom right, that the root is not growing down, but is pointing out to the right. Likewise, the shoot is also growing out to the right. The shoot and the root has not had the effect of gravity acting on them.

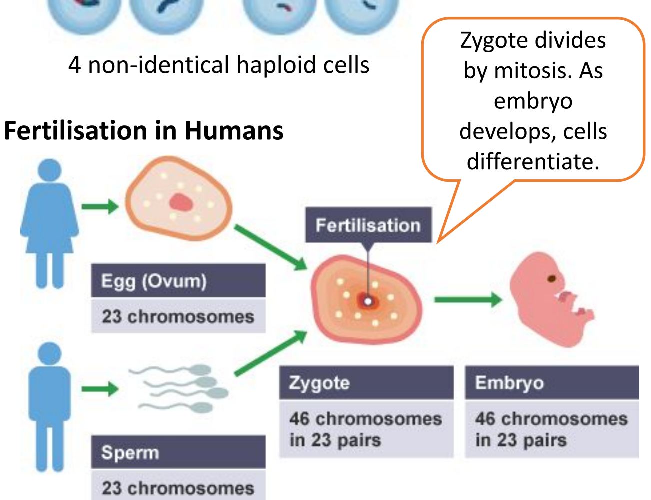
Inheritance

Keyword	Definition
Allele	Different forms of the same gene.
Chromosome	The structure made of DNA on which genes are found.
Diploid cell	A cell that contains two (full) sets of chromosomes.
DNA	A polymer made up of two strands forming a double helix.
Dominant allele	This allele is always expressed, even if only one copy is present.
Fertilisation	The fusion of gametes to restore the full number of chromosomes.
Gamete	Sex cells with half the number of chromosomes which are formed by meiosis. (Sperm, ova, pollen)
Gene	A small section of DNA on a chromosome. Each gene codes for a particular sequence of amino acids, to make a specific protein.
Genome	The entire genetic material of an organism.
Genotype	The alleles that an organism has for a particular characteristic, usually written as letters.
Haploid cell	A gamete that contains one set of chromosomes.
Heterozygous	A genotype in which the two alleles for a particular characteristic are different e.g. Bb
Homozygous	A genotype in which the two alleles for the characteristic are identical e.g. BB or bb
Phenotype	The visible characteristics of an organism which occurs as a result of its genes.
Recessive allele	This allele is only expressed if two copies are present (therefore no dominant allele present).

Meiosis



Fertilisation in Humans



Inherited disorders

Polydactyly (having extra fingers or toes) is caused by a **dominant** allele.

Cystic fibrosis (a disorder of cell membranes) is caused by a **recessive** allele.

Types of reproduction

Sexual reproduction involves the joining (fusion) of male and female gametes. There is mixing of genetic information which leads to variety in the offspring.

Asexual reproduction involves only one parent and no fusion of gametes. There is no mixing of genetic information. This leads to genetically identical offspring (clones). Only mitosis is involved.

Some organisms reproduce by both methods depending on the circumstances:

- Malarial parasites reproduce asexually in the human host, but sexually in the mosquito.
- Many fungi reproduce asexually by spores but also reproduce sexually to give variation.
- Many plants produce seeds sexually, but also reproduce asexually by runners such as strawberry plants, or bulb division such as daffodils.

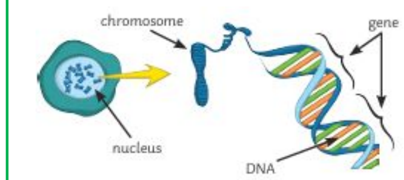
Advantages of sexual and asexual reproduction [Biology only]

Sexual	Asexual
Produces variation in the offspring.	Only one parent needed.
If the environment changes variation gives a survival advantage by natural selection.	Many identical offspring can be produced when conditions are favourable.
Natural selection can be speeded up by humans in selective breeding to increase food production.	Faster than sexual reproduction.
	More time and energy efficient as do not need to find a mate.

HT Protein Synthesis [Biology only]

Proteins are synthesised on ribosomes, according to a template. Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order.
When the protein chain is complete it folds up to form a unique shape. This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen.
Mutations occur continuously. Most do not alter the protein, or only alter it slightly so that its appearance or function is not changed.
A few mutations code for an altered protein with a different shape. An enzyme may no longer fit the substrate binding site or a structural protein may lose its strength.
Not all parts of DNA code for proteins. Non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.

DNA



The Human Genome

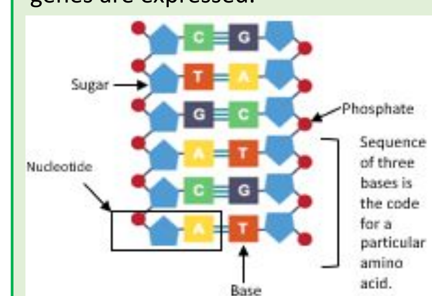
The whole human genome has now been studied and this will have great importance for medicine in the future.

Understanding the human genome has been important for:

- the search for genes linked to different types of disease
- understanding and treatment of inherited disorders
- the use in tracing human migration patterns from the past.

DNA structure [Biology only]

The DNA polymer is made up of repeating nucleotide units. Not all parts of DNA code for proteins. Non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.



In the complementary strands a C is always linked to a G on the opposite strand and a T to an A.

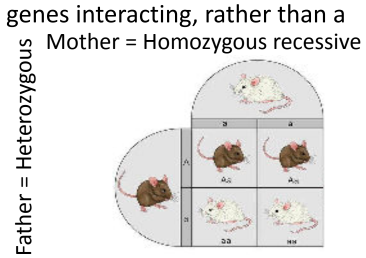
Sex determination

22 chromosome pairs control characteristics only, but the 23rd pair carries the genes that determine sex. Females are XX and males are XY. Note that all sex alleles have a capital letter.

Genetic inheritance

Some characteristics are controlled by a single gene, such as: fur colour in mice; and red-green colour blindness in humans. Each gene may have different forms called alleles Most characteristics are a result of multiple genes interacting, rather than a single gene.
Example:
Brown fur allele is dominant (A).
White fur allele is recessive (a).

Offspring: Genotype – 50% Aa, 50% aa.
Phenotype – 50% brown fur, 50% white fur.



Useful YouTube links:

Variation and Evolution

Keyword	Definition
Evolution	A change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species.
Extinction	When there are no remaining individuals of a species still alive. Can be caused by new predators, new diseases, new successful competitors.
Genetic engineering	A process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.
Genetically modified (GM)	Organisms whose genetic material has been altered using genetic engineering methods.
Selective breeding	The process by which humans breed plants and animals for particular genetic characteristics.
Variation	Differences in the characteristics of individuals in a population.

Fossils

Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks.
Fossils may be formed:
(1) from parts of organisms that have not decayed because conditions needed for decay are absent
(2) when parts of the organism are replaced by minerals as they decay
(3) as preserved traces of organisms, such as footprints, burrows and rootlet traces.

Many early forms of life were soft-bodied and left few traces behind. This is why scientists cannot be certain about how life began on Earth.

Classification

Carl Linnaeus' system:
Kingdom, Phylum, Class, Order, Family, Genus, Species.

Species named by binomial system (Genus species, e.g. *Panthera leo*).

New models of classification proposed because:
(1) evidence of internal structures became more developed due to improvements in microscopes
(2) the understanding of biochemical processes progressed.

'Three- domain system' developed by Carl Woese:
- archaea (primitive bacteria usually extremophiles)
- bacteria (true bacteria)
- eukaryotes (plants, animals etc)

Variation

Variation may be due to differences in:
- the genes they have inherited (e.g. eye colour)
- the conditions in which they have developed (e.g. accents)
- a combination of genes and the environment (e.g. height).

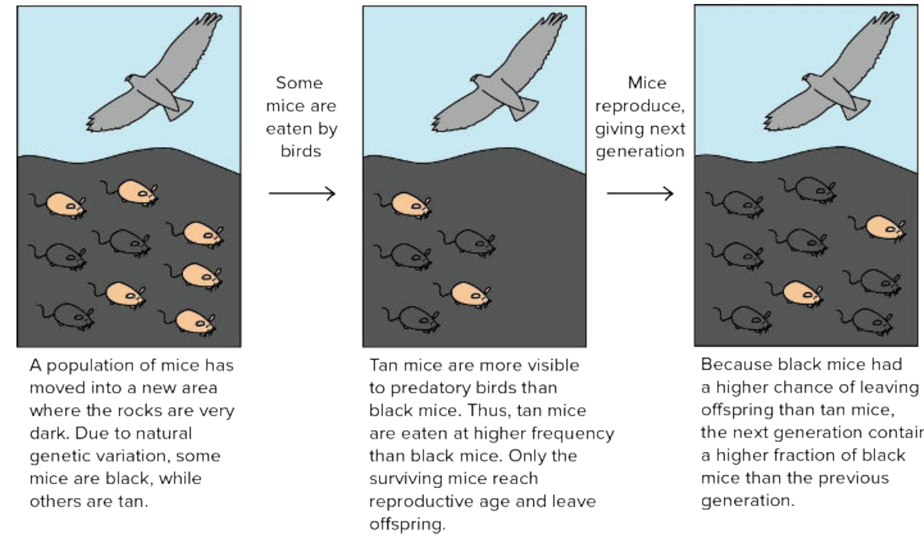
Variants arise from mutations that occur continuously. However, most have no effect on the phenotype; some influence phenotype; very few determine phenotype

Evidence for Evolution

The theory of evolution by natural selection is now widely accepted. Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in genes.
There is further evidence in:
1. The fossil record
2. The knowledge of how resistance to antibiotics evolves in bacteria.

Evolution by Natural Selection

All species of living things have evolved from simple life forms that first developed more than three billion years ago.



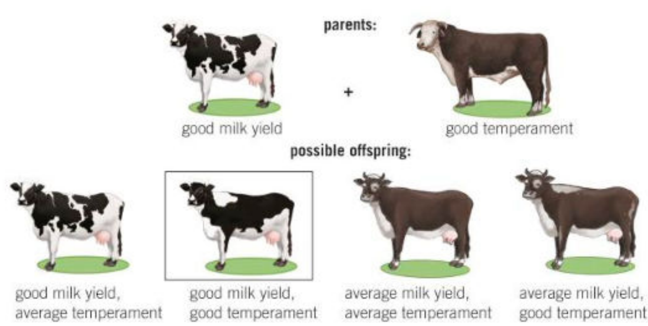
If two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring, they have formed two new species.

Genetic engineering

Plant crops have been genetically engineered (GM crops) to be resistant to diseases or to produce bigger better fruits.

Bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.

(HT only) Process of Genetic Engineering:



Benefits:
- GM crops include ones that are resistant to insect attack or to herbicides.
- GM crops generally show increased yields.
- Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.

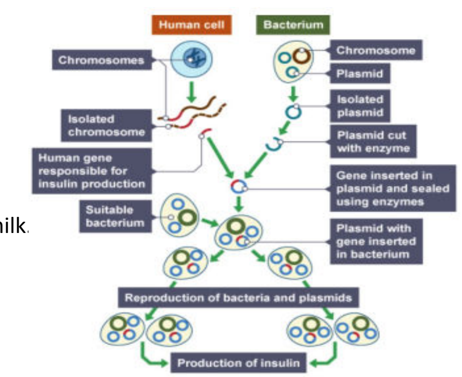
Concerns:
- The effect of GM crops on populations of wildflowers and insects.
- Some people feel the effects of eating GM crops on human health have not been fully explored.

Selective breeding

1. Choose parents with the desired characteristic and breed together.
2. From the offspring those with the desired characteristic are bred together.
3. This continues **over many generations** until all the offspring show the desired characteristic.

The characteristic can be chosen for usefulness or appearance:

- Disease resistance in food crops.
- Animals which produce more meat or milk.
- Domestic dogs with a gentle nature.
- Large or unusual flowers.



Selective breeding can lead to 'inbreeding' where some breeds are particularly prone to disease or inherited defects.

Extinction

Extinctions occur when there are **no remaining individuals of a species still alive**
Species that are **poorly adapted** to their environment are **less likely to survive and reproduce** compared to species that are well adapted to their environment

Factors that can lead to extinction

New diseases, new predators, better adapted and successful competitors, changes to the environment over time, single catastrophic events

Useful YouTube links:

Selective breeding
Genetic engineering

Ecology Part 1

Keyword	Definition
Abiotic	Non-living elements of an ecosystem, such as climate, temperature, water, and soil type.
Adaptations	A feature of an organism which helps it to survive.
Biomass	The mass of living tissues (or recently dead tissues that have not yet been decomposed) that a plant or animal is made up of
Biotic	Living elements of an ecosystem, such as plants and animals.
Community	All the organisms that live in a habitat (plants and animals).
Competition	Contest between organisms wanting similar resources
Ecosystem	The living organisms in a particular area, together with the non-living components of the environment.
Food chain	A sequence of feeding relationships between organisms, showing which organisms eat what and the movement of energy through trophic levels.
Habitat	The place where an organism lives
Interdependence	All organisms that live in an ecosystem depend upon each other, for food, protection, shelter, etc, in order to survive.

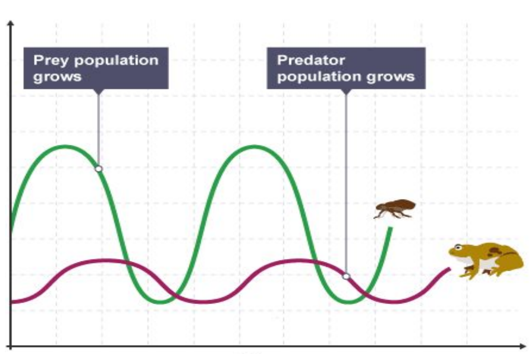
Levels of organisation

Photosynthetic organisms are the producers of biomass

Feeding relationships within a **community** can be represented by **food chains**. These then add together to make food webs for a habitat.

All food chains begin with a **producer** which synthesises molecules. This is usually a green plant or alga which makes glucose by photosynthesis.

Producers are eaten by primary consumers, which in turn may be eaten by secondary consumers and then tertiary consumers.
Consumers that kill and eat other animals are **predators**, and those eaten are **prey**.



In a stable community the numbers of predators and prey rise and fall in cycles.

Communities and competition

An **ecosystem** is the interaction of a **community** of living organisms (**biotic**) with the non-living (**abiotic**) parts of their environment.

To survive and reproduce, organisms require a supply of materials from their surroundings and from the other living organisms there.
Plants in a **community** or **habitat** often compete for light and space, and for water and mineral ions from the soil. Animals often compete for food, mates and territory. Within a **community** each species depends on other species for food, shelter, pollination, seed dispersal etc. If one species is removed it can affect the whole community.

This is called **interdependence**. A stable community is one where all the species and environmental factors are in balance so that population sizes remain fairly constant.

Abiotic and Biotic factors

Abiotic	Biotic
Non-living factors that affect a community	**Living factors that affect a community**
Light intensity	Availability of food
Temperature.	
Moisture levels.	New predators arriving
Soil pH, mineral content.	
Wind intensity and direction.	New pathogens
Carbon dioxide levels for a plant.	One species outcompeting another so numbers are no longer sufficient to breed
Oxygen levels for aquatic organisms.	

Adaptations

Survival of the fittest means survival of those best adapted.
Adaptations make organisms better suited to their **ecosystem** and provide them with a better chance of survival and reproduction. The adaptations that arise from competition are essential for the process of **evolution**.

Adaptations to the environment in plants
Structural adaptations such as spines to stop animals eating them.
Behavioural adaptations such as plant shoots grow quickly towards the light to maximise photosynthesis.
Physiological adaptations such as poisons for defence.

Adaptations to the environment in animals
Structural adaptations such as sharp claws to catch prey or dig burrows
Behavioural adaptations such as mating rituals or hunting in a pack.
Physiological adaptations such as the production of venom.

How materials are cycled

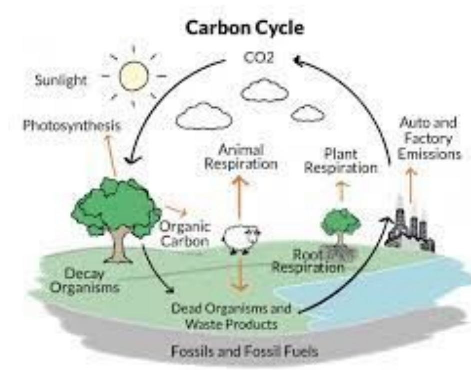
How materials are cycled in an ecosystem

Atoms exist in different forms or compounds at different times in history and cycle between them. We can see this cycling in the element carbon and the compound water. Just as rocks can cycle between igneous, sedimentary and **metamorphic**, carbon and water can exist in different forms at different times.

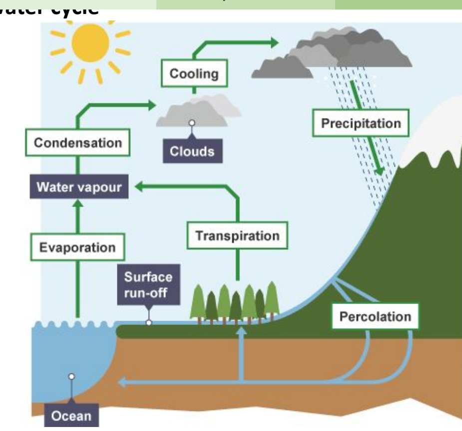
Other elements and compounds also exist in cycles.

Decomposers are bacteria and fungi, which break down dead organisms in a process called decomposition or rotting. They do this by releasing **enzymes** onto the dead matter and afterwards, consume the broken-down substances. They form a vital role in the recycling of matter. When organisms die and **decompose** plants absorb the broken-down nutrients through their roots.

Carbon is an essential element for life on Earth and parts of each of the cells in our bodies are made from it. The carbon cycle shows how atoms of this element can exist within different compounds at different times.



Process	Carbon starts as	Carbon ends as
Photosynthesis	Carbon dioxide	Glucose
Respiration	Glucose	Carbon dioxide
Combustion (burning)	Fuel (e.g. methane or wood)	Carbon dioxide



Biodiversity and maintenance

Biodiversity is specifically the number of different species. An area with large populations of few species is not biodiverse.

Areas like tropical rainforests have millions of different **species** and are very **biodiverse**. Other areas like the Polar Regions have far fewer species and are less biodiverse.

Interdependence

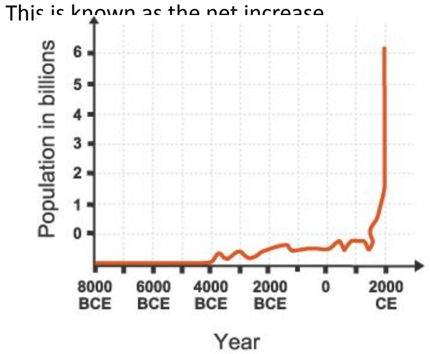
If the numbers of one species are affected, there are almost always knock-on consequences. A simple **food chain** is:

algae → zooplankton → sand eel → puffin → arctic skua

If the numbers of zooplankton are reduced by pollution, such as plastic waste, then more algae will grow, and the population of other consumers will fall.

Ecosystems with higher biodiversity are more stable as they can easily adjust to changes as they don't depend on one resource.

Activities that create air and water pollution, are reducing biodiversity in many ecosystems. Conservation of species and habitats by charities, governments and individuals helps to maintain the range of biodiversity.
The number of people alive now is at a record level and is increasing. In 2012, the
human **population** exceeded seven billion for the first time.
Each year about 75 million more people are born than die. This is known as the net increase



Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity.
These include:
• breeding programmes for endangered species
• protection and regeneration of rare habitats
• reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop
• reduction of deforestation and carbon dioxide emissions by some governments
• recycling resources rather than dumping waste in landfill.

Ecology Part 1

Keyword	Definition
Biodiversity	The variety of plant and animal life in the world or in a particular habitat, a high level of which is usually considered to be important and desirable.
Carbon sink	A carbon sink is a type of carbon pool that has the capability to take up more carbon from the atmosphere than it releases.
Deforestation	The action of clearing a large area of trees
Ecosystem	The living organisms in a particular area, together with the non-living components of the environment.
Food chain	A sequence of feeding relationships between organisms, showing which organisms eat what and the movement of energy through trophic levels.
Greenhouse effect	The greenhouse effect is the process through which heat is trapped near Earth's s urface by substances known as 'greenhouse gases.'
Quadrat	A square frame of known area used for sampling the abundance and distribution of slow or non-moving organisms.
Sustainable	Able to be maintained at a certain rate or level
Transect	A line created, for instance, with a tape measure, along which sampling occurs.

Land use

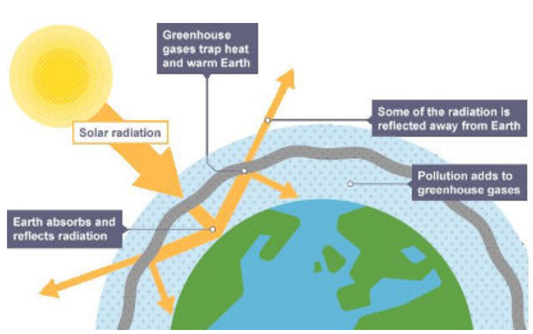
The larger the human population gets, the more land we require. More houses must be built, more resources found, more food must be grown, and more waste is produced. This often means less space and fewer resources for other animals and plants. **Biodiversity** is significantly reduced when land is cleared for human uses.

Peat bog destruction

Bogs are very wet areas of land without trees in which many types of moss grow. Here **decomposition** is very slow, and peat is formed from partially decayed plants. It is a **non-renewable** energy resource.

Peat bogs are a very important store of carbon. We call them **carbon sinks**. If all the peat was removed and burned this would quickly release a huge volume of carbon dioxide into the atmosphere and contribute to the **greenhouse effect**.

Global warming



The effects of global warming include:

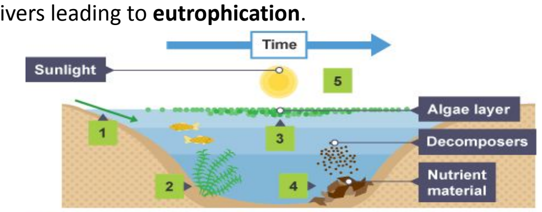
- melting of the polar ice caps
- weather patterns will change with more unusual weather
- animals will migrate towards the poles to find habitats with suitable temperatures
- tropical diseases may become more common in other regions
- many species will become **extinct**

Waste management

As the human **population** increases, the volume of waste and **pollution** that is produced also increases. Polluting an **ecosystem** harms or kills the organisms that live within it.

Modern society consumes more, which means humans manufacture more products and replace them more often. This consumption is not **sustainable**. Many natural materials, including fossil fuels, will soon run out.

Water pollution
In some parts of the world, open sewers can lead into water courses, such as streams and rivers, which can cause serious illness in humans that may drink the contaminated water. Some farmers use too many fertilisers, which can run off fields during heavy rain. This can pollute nearby streams and rivers leading to **eutrophication**.



1. Nutrient load up: excessive nutrients from fertilisers are flushed from the land into rivers or lakes by rainwater.
2. Plants flourish: these pollutants cause aquatic plant growth of algae, duckweed and other plants.
3. Algae blooms, oxygen is depleted: algae blooms prevent sunlight reaching other plants. The plants die and oxygen in the water is depleted.
4. Decomposition further depletes oxygen: dead plants are broken down by bacteria decomposers, using up even more oxygen in the water.
5. Death of the ecosystem: oxygen levels reach a point where no life is possible. Fish and other organisms die.

Air pollution
Combustion of fossil fuels and other fuels releases carbon dioxide. This contributes to the **greenhouse effect** and leads to **global warming**. It also releases sulfur dioxide and nitrogen oxides which can cause acid rain. Air pollution can also be caused by tiny particulates from smoke which can cause **smog**.

Land pollution
The rubbish we throw out that is not **recycled** goes into a land fill. These are huge holes in the ground into which our rubbish is dumped. Some things like batteries cannot be put into **landfill sites** because of the toxic chemicals they contain. They must be recycled.

Deforestation

Large-scale deforestation in tropical areas has occurred to:

- provide land for cattle and rice fields
- grow crops for biofuels

The increase in the human **population** and development of industrial machinery has meant that much larger areas have been cleared.

In the last 75 years we have cut down over half of the world's rainforests. Scientists estimate that 32 000 hectares of rainforest are destroyed each day.

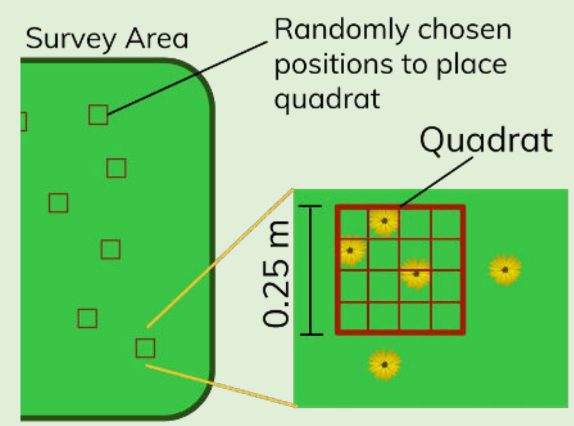
Required Practical – Measure the population size of a common species in a habitat

Aim

To measure the species richness on the school field in areas in which the grass is regularly and irregularly cut.

Method

- Choose a starting point on the school field in an area where the grass is often cut
- use **random** numbers to generate a set of coordinates to place your first **quadrat**
- count the number of different plant **species** within this quadrat (the species richness)
- return to your starting position and repeat steps two and three a further 14 times using different random numbers
- repeat steps one to four for a part of the school field which the grass is infrequently cut
- compare your results by calculating a **mean** for each location



Variables

- **Independent Variable:** location of quadrat
- **Dependent Variable:** the number of different plant species
- **Control Variables:** size of the quadrat

Scientific calculations

Mean

The mean is the most common type of average we use. To calculate the mean, you add all the values together and divide by the total number of values.

Median

To calculate the median, a set of numbers are placed in increasing order of size. The median is the middle number in the list.

Mode

The mode is the value that appears the most often. In the shade, the mode is four because there are three values of four. In the sun, it is five because there are three values of five.

Results

Quadrat number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of plants species (cut)	1	2	1	2	3	1	3	1	1	1	2	3	2	1	1
No. of plants species (uncut)	3	2	4	6	1	1	1	4	5	3	6	4	5	3	4

What are the totals and means for the two different locations?

A total of 25 and a mean of 1.7 on cut school field and a total of 52 and a mean of 3.5 on uncut school fields.

What conclusions can you draw here?
The mean of the number of plant species in the cut school field is lower than on the uncut school field. There is a mean of 1.7 different species per quadrat on the cut grass. The number of plant species per quadrat on the uncut field is over twice this at 3.5. Therefore, there is greater species richness on the school field in uncut areas.

What limitations might there be in drawing these conclusions?
The two students only placed 15 quadrats. Completing more would allow them to be more confident in their conclusions.