Biology

Characteristics & classification of living organisms

Movement	An action by an organism or part of a n organism causing a change in position or place
Respiration	Is the chemical reactions that break down nutrient molecules to release energy for metabolism
Sensitivity	Is the ability to detect and respond to changes in the internal or external environment
Growth	Is a permanent increase in size and dry mass
Reproduction	Is the process that makes more of the same kind of organism
Excretion	Is the removal of waste products of metabolism or products in excess of requirements
Nutrition	Is the taking in of material for energy, growth and development

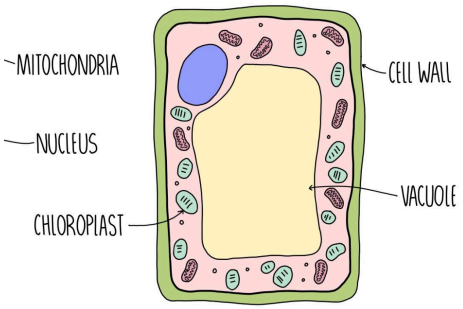
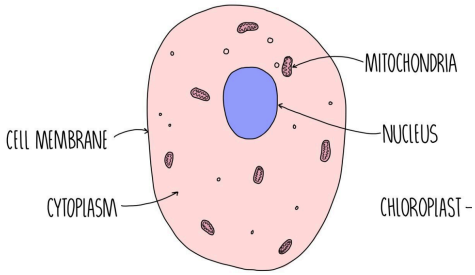
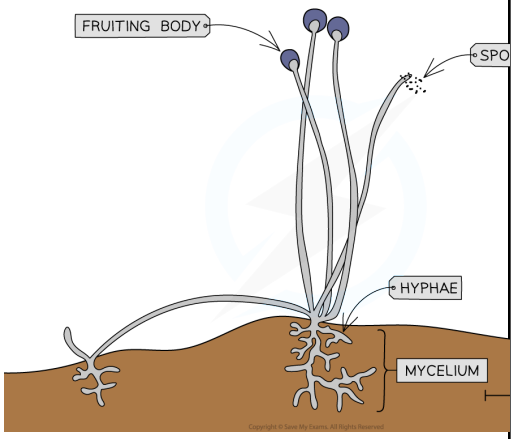
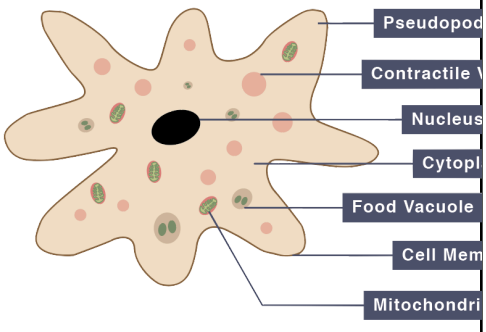
Order of classification (linnaeus classification)

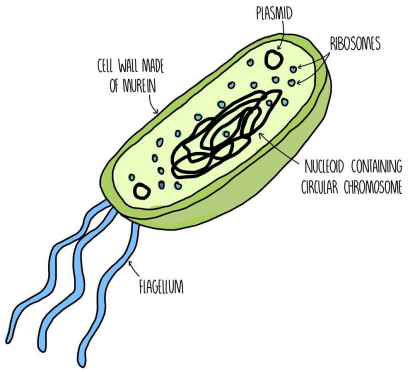
Kingdom → Phylum → Class → Order → Family → Genus → Species

The **binomial naming system** is an internationally agreed upon system in which the scientific name of an organism is made up of two parts containing the genus and the species

- ➔ The classification of organism shows the evolutionary relationships between them
- ➔ The sequences of bases in DNA are a means of a classifications
- ➔ Group of organisms that share a more recent ancestor (are more closely related) have bases sequences in their DNA that is more similar than those who only share a distant ancestor

Dichotomous key use visible features to classify organisms

Plant kingdom	• They are multicellular • Their cells contain cell walls (made of cellulose), nucleus and chloroplasts • They all feed by photosynthesis	
Animal kingdom	• They are multicellular • Their cells contain nucleus • Their cells contain no chloroplasts or cell walls • **Heterotrophs**: feed in organic substances made by other organisms	
Fungus kingdom Yeast and mushrooms	• Usually multicellular • Cells have a nucleus • They have cell walls (not made of cellulose • Do not photosynthesis but feed as saprophytes (on dead or decaying material) or parasites (living material) • Reproduce by forming spores and then dispersing • Most have hyphae and mycelium in structure	
Protoctist kingdom Paramecium and chlamydomonas	• Most are unicellular but some are multicellular • All have a nuclei • May/may not have chloroplast or cell wall • Some feed by photosynthesis and other by organic substances	

Prokaryote kingdom Algae and bacteria	• They are usually unicellular • They have no nuclei instead they have a strand of DNA, floating in the chloroplast • They have a cell wall (not made of cellulose) • They have no mitochondria • They have plasmids	

Vertebrates: having backbone

Mammal	- Fur on the skin - Have a placenta and mammary gland - Have different kinds of teeth - Have external ear (pinna) - Have a diaphragm	Humans, dog, horse etc
Birds	- Skin covered in feather - 2 wings instead of forelimbs - Lay eggs with hard shells on land - Have a beak	Parrots, robbins, skylark etc
Reptiles	- Thick, dry, fixed scales on skin - Lay eggs with soft shells on land	Snake, turtle, iguana etc
Amphibian	- Smooth, moist skin with no scales - Live on both land and water - Lay eggs without shells on in water	Frog, toad, newt etc
Fish	- Gills to breathe - Lay eggs without shells in water - Have fins	Mackerel, shark etc

Arthropods: do not possess a backbone

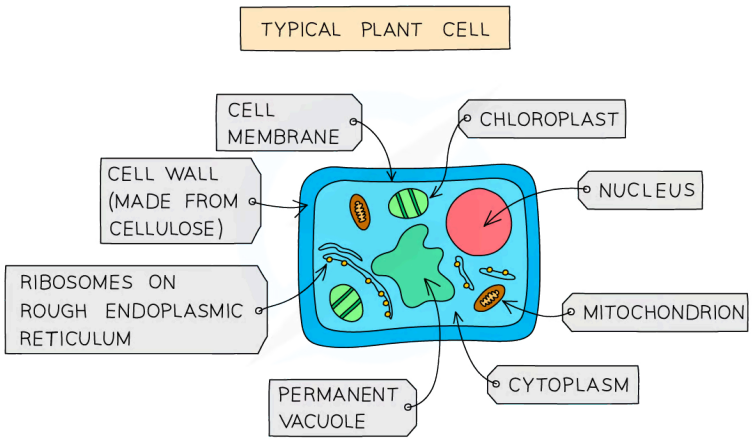
Three standard features:

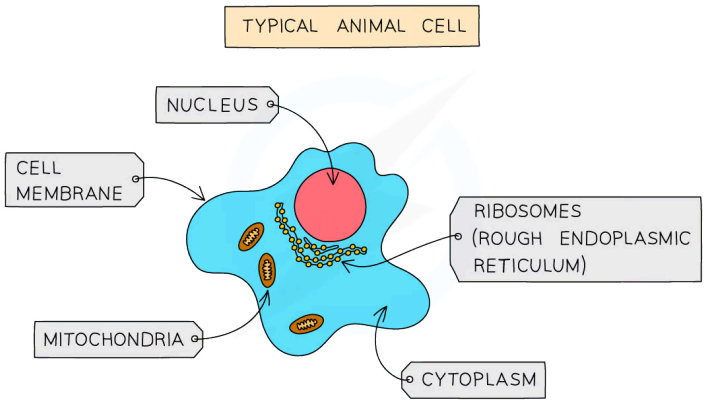
1. Exoskeleton
2. Jointed legs
3. Segmented body

Myriapods	- Body consists of many segments - Each segment having at least one pair of jointed leg - 1 pair of antennae	Centipede, millipede etc
Insects	- 3 part body - head, thorax, abdomen - 3 pairs of jointed legs (6 legs) - 2 pair of wings - Breath through tubes called trachea	Grasshopper, butterfly etc
Arachnids	- 2 part body - cephalothorax and abdomen - 4 pairs of jointed legs (8 legs)	Spider, scorpions etc
Crustacean	- More than 4 pairs of jointed legs - Breathe through chalky exoskeleton made of calcium - 2 pairs of antennae	Crabs, lobsters etc

Cells

Nucleus	• Contains DNA (genetic material) which controls the activity of the cell
Cytoplasm	• A gel like substance composed of water and dissolved solutes • Supports the internal structure of the cell • Site of many chemical reactions (like anaerobic respiration)
Cell membrane	• Holds the cell together separating the inside of the cell from the outside • Controls which substance enter or leave the cell
Ribosome	• Found in the cytoplasm • The site of protein synthesis
Mitochondria	• The site of aerobic respiration (powerhouse of the cell)
Cell wall	• Made of cellulose • Gives the cell extra support, defining its shape
Chloroplast	• Contains the green pigment called chlorophyll that absorbs light energy for photosynthesis
Permanent vacuole	• Contains cell sap (a solution of sugar and salt) in animals and vesicles in animal cells • Used for storage of certain materials • Helps to support the shape of the cell

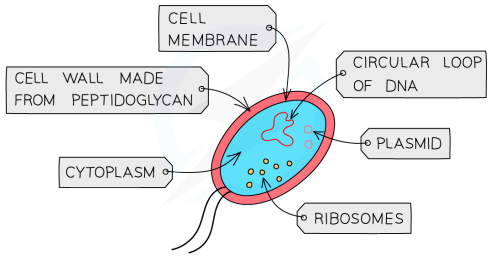




Bacterial cells

They are microscopic single-celled organisms

- They possess a **cell wall** (made of peptidoglycan), **cell membrane, cytoplasm, ribosomes, circular chromosome of DNA and plasmids**
- Some bacteria also have a **flagella** for locomotion
    - ➔ They do NOT have a nucleus, mitochondria, chloroplasts

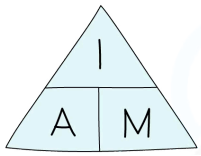


Levels of organisation in an organism

Cells	Basic functional and structural units in a living organism
tissues	Groups of cells of similar structure working together to perform the same function
Organs	Made from different tissues working together to perform the specific functions
Organ system	Groups of organs with related functions, working together to perform body functions

Magnification = image (drawing) size / actual size

Remember: magnification has no unit



UNIT	LENGTH IN mm
1 CENTIMETRE (cm)	10 mm
1 MILLIMETRE (mm)	1 mm
1 MICROMETRE (µm)	0.001 mm

Movement in & out of cells

Diffusion is the net movement of molecules from a region of higher concentration to a region of lower concentration

Molecules move down a **concentration gradient**

- ➔ This happens because particles move randomly at all times. This is known as **brownian motion.**
- ➔ The energy comes from the **kinetic energy** of this random movement of molecules and ions.

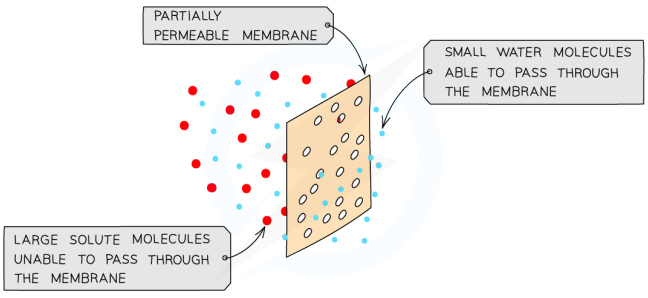
There are 5 major factors affecting the rate of diffusion:

Concentration gradient	The greater the difference in concentration gradient, the quicker the rate of diffusion
Temperature	The higher the temperature, the more kinetic energy the particles will have, so they will move and mix more quickly
Surface area	The greater the surface area the faster the rate of diffusion
Distance	The smaller the diffusion distance the faster the rate of diffusion
Surface area to volume ratio	The bigger a cell, the smaller the surface area to volume ratio. Smaller the surface area to volume ratio the slower the rate of diffusion (and vice-versa)

OSMOSIS

Osmosis is the diffusion of water molecules, from a region of high water potential (dilute solution), to a region of low water potential (concentrated solution) against a partially permeable membrane.

Note: osmosis refers to the movement of water molecules only



Experiments

Immersing plant cells in solutions of different concentrations:

1. Cut cylinder of different root vegetables (such as potato or radish) and weigh them
2. Place them into distilled water and sucrose solutions of different concentrations
3. Leave the cylinders in the solution for 20-30 minutes (controlled variable)
4. Remove and dry them to remove excess liquid
5. Now reweigh

Observation:

- ➔ If the plant tissue gains mass, water must have moved into the cylinder from the solution by osmosis
- ➔ If the plant loses mass, water must have moved out of the cylinder from the solution by osmosis
- ➔ If there is no overall change in mass there must be no net movement at all, implying that the water concentration in the plant and outside the plant is the same

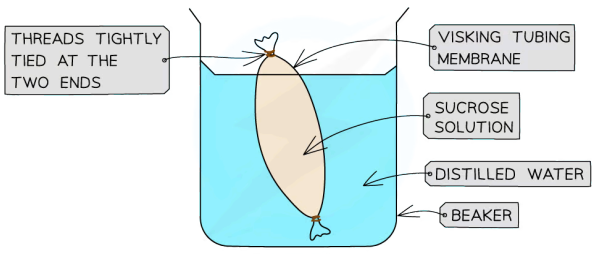
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Using dialysis tubing to investigate osmosis

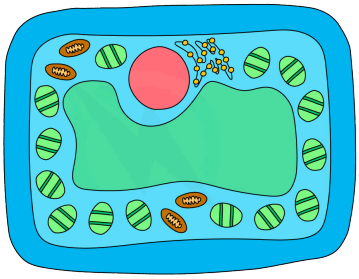
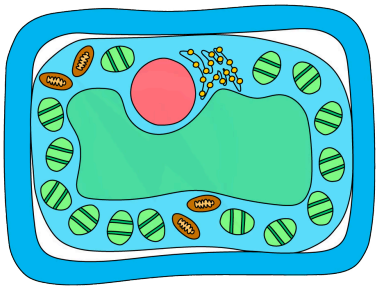
Dialysis tubing (also called visking tubing) is a non-living partially permeable membrane made from cellulose

It allow smaller molecules (like water and glucose) to pass through but not larger molecules (like sucrose)

1. Fill a section of dialysis tubing with concentrated sucrose solution
2. Suspend the tube in a boiling tube of water for a set period of time
3. Note whether the water level outside the tube decrease as water moves into the tubing via osmosis



Osmosis in plant cells

Flaccid or plasmolysed	Turgid
When plant cells are placed in a solution that has low water potential (concentrated) than inside the cell, then water moves out of the plant cell via osmosis ➔ The cell membrane pulls away from the cell wall and the plant cell has become **flaccid or plasmolysed.** This inhibits the plant's ability to support itself and it wilts	When plant cells are placed in a solution that has high water potential (dilute) than inside the cell, then water moves into the plant cell via osmosis ➔ These water molecules push against the cell membrane against the cell wall, increasing the **turgor pressure** making them **turgid**
	

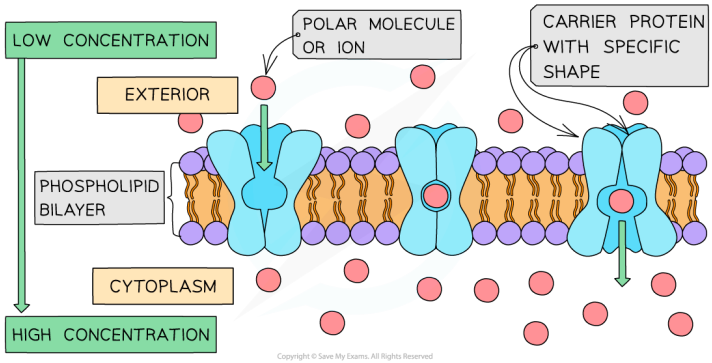
ACTIVE TRANSPORT

Active transport is the movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (against a concentration gradient) using energy from respiration

Active transport happens:

1. **Uptake of glucose** by epithelial cell in the villi of the small intestine and by kidney tubules in the nephron
2. **Uptake of ions** (particularly nitrate) from soil water by root hair cells in plants
    - The nitrate ions enters the carrier proteins
    - The carrier protein changes shape. The energy needed is provided by respiration
    - The change of the shape of the carrier proteins pushes the nitrate ions into cell

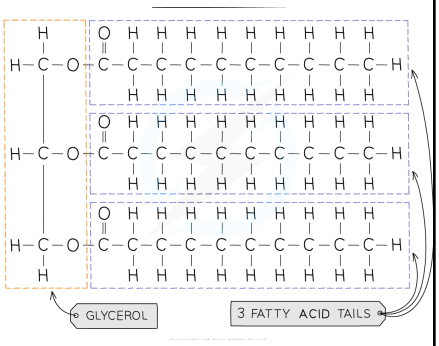
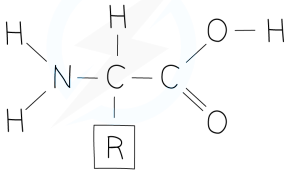
Carrier proteins are protein molecules in cell membranes that can use energy to change shape and move ions into and out of a cell



Process	Description	Substances moved
Diffusion	Substances move from a region of higher concentration to a region of lower concentration	Carbon dioxide, oxygen, water, food, substances, wastes (urea)
Osmosis	Water moves from a region of higher water potential (dilute) to a region of lower water potential (concentrated), across a partially-permeable membrane	Water
Active transport	Substances move against the concentration gradient using energy from respiration	Mineral ions in plants, glucose in epithelial cells in the villi of small intestine and nephron in kidney

Biological molecules

3 main organic compounds (containing carbon) that make up bodies of all living organisms are:

	Carbohydrate	**Lipid (fats and oils)**	**Protein**
Element	Carbon, hydrogen & oxygen	Carbon, hydrogen & oxygen (lesser than carbohydrates)	All contain carbon, hydrogen, oxygen & nitrogen Some contain sulphur
Structure	Smallest molecule is **glucose** (monosaccharide) --- Glucose molecules can link in pairs of 2 to form **sucrose or maltose** (disaccharide) --- Glucose molecules can link three or more times to form **starch or glycogen** (polysaccharide)	Lipids are divided into: ● **Fats** solid at RTP ● **Oils** liquid at RTP Most fats in the body are **triglycerides** ➔ They are made of 1 glycerol : 3 fatty acids	Long chains of **amino acids** (20 different amino acids) ➔ They all contain the **same basic structure** but the **'R' group is different** for each one.
			
Tests	**Tests for glucose (reducing sugars)** ➔ **Benedict's solution** ● Add to sample ● Heat at 60 - 70° C for 5 minutes **Positive test:** Blue → orange-red	**Ethanol-emulsion test** Fats and oils dissolve in ethanol but not in water ● Add 2 cm^3 ethanol to sample ● Shake tube to dissolve ● Add equal volume of cold	**Biuret reagent test** ● Add drops to sample **Positive test:** blue → violet

	Test for starch ➔ **Iodine solution** **Positive test:** brown → blue-black	water **Positive test:** cloudy emulsion	

Test for Vitamin C

➔ **DCPIP solution** (1cm^3)

Positive test: Blue → colourless

Enzymes

Enzymes are biological catalysts made of protein that alter the rate of reaction without getting changed or used up themselves

- Enzymes are specific to their particular **substrate** as the **active site** of the enzyme where the substrate attaches is a complementary shape to the substrate.
  - ➔ This is known as **lock and key hypothesis**
- When the substrate moves into the enzyme's active site they form an **enzyme-substrate complex**
- **Active site** is the part of an enzyme molecule to which the substrate temporarily binds before forming the product

Factors affecting enzyme activity

If an enzyme is not provided the optimum conditions for its activity the enzyme loses its shape and the substrate can no longer fit into the denatured enzyme. This is known as **denaturation.**

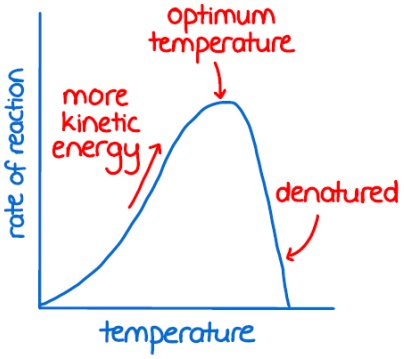
Remember: denaturation is irreversible

1. **Temperature**

   Increasing the temperature from 0° C to **optimum temperature** increases the activity

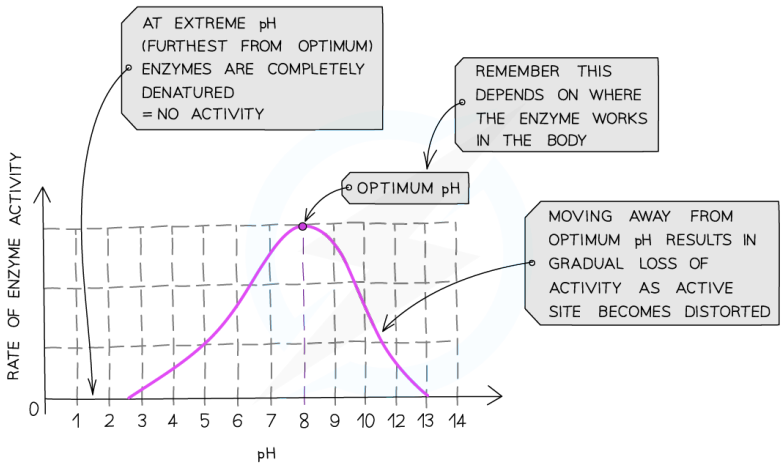
   - ➔ The more energy the molecules have the faster they move and the number of collisions increases. Chance of a successful collision increases.

   This means low temperatures do not denature enzymes, the enzyme activity is just slow.



2. **pH**

   Optimum pH for most enzymes is 7



INVESTIGATIONS

Effect of temperature on Amylase

1. **Starch solution** is heated to a set temperature
2. **Amylase** is added to the starch solution and mixed well
3. **Iodine (test for starch)** is added to the wells of a spotting tile
4. Every minute, droplets of solution are added to a new well of iodine solution
5. This is continued till the iodine stops turning blue-black (meaning no more starch left in solution; amylase has broken it all)
6. Time taken is recorded
7. Experiment is repeated at different temperatures

Effect of pH on amylase

1. Place single drops of iodine solution in a row on a white tile. This will help you observe changes in color on amylase
2. Label a test tube with the pH value you will test (e.g., pH 5, pH 7, etc.).
3. Add 2 mL of amylase solution to the test tube using a syringe.
4. Use another syringe to add 1 mL of buffer solution (a liquid that has a known pH, and that keeps the pH steady all the time) to the same test tube.
5. In another test tube, prepare 2 mL of starch solution.
6. Mix the starch solution with the amylase-buffer mixture. As soon as you mix them, start a stopwatch.
7. Every 10 seconds, use a pipette to take a small drop of the reaction mixture and add it to one of the iodine drops on the tile.
    - If the iodine turns blue-black, starch is still present.
    - If the iodine remains orange-brown, the starch has been fully digested.
8. Perform the same experiment with different pH values by using buffers with varying pH levels.
9. Note the time it takes for the iodine solution to remain orange-brown for each pH. The shorter the time, the better the enzyme works at that pH.

Plant nutrition

Photosynthesis is the process by which plants synthesise carbohydrates from raw materials using energy from light.

Carbon dioxide + water → glucose + oxygen

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

Chlorophyll is the green pigment that is found in chloroplasts which absorbs light energy and transfers it to chemical energy for the synthesis of carbohydrates (glucose)

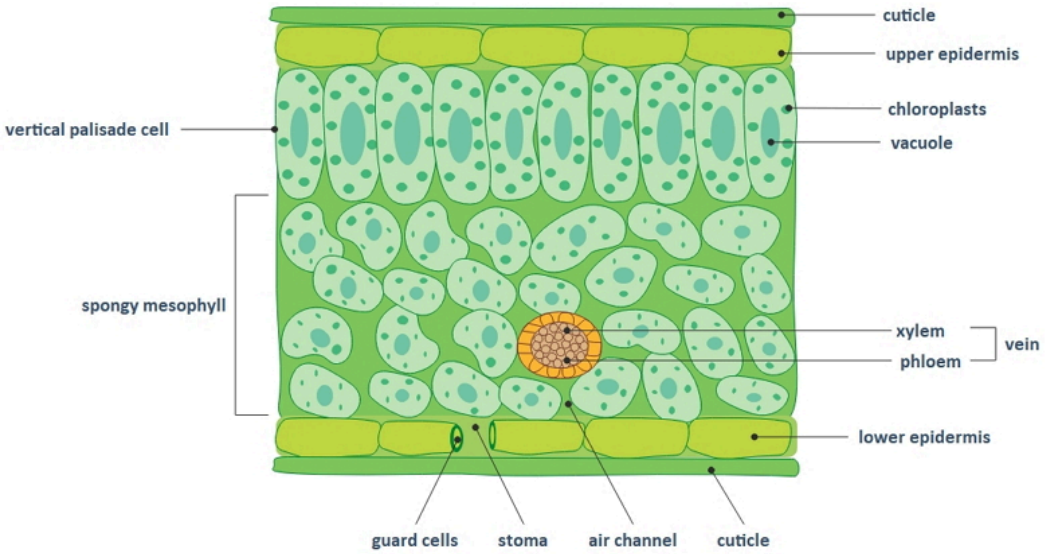
The carbohydrates produced by the plant can be used in the following ways:

1.) Converted into starch that acts as an efficient energy store
2.) Glucose which can be used in respiration to provide energy
3.) Converted to sucrose to be transported across the plant in the phloem
4.) Converted to cellulose to build cell walls
5.) Converted to nectar to entice insects for pollination

'Mineral' is a term used to refer to any naturally occurring inorganic substance
Two other required minerals, other than carbon, hydrogen and oxygen are:

1.) **Magnesium** which is needed for making chlorophyll
    - ☐ Deficiency causes yellowing between the vein of leaves (chlorosis)
2.) **Nitrogen** needed to make amino acids
    - ☐ Deficiency causes stunted growth and yellowing of leaves

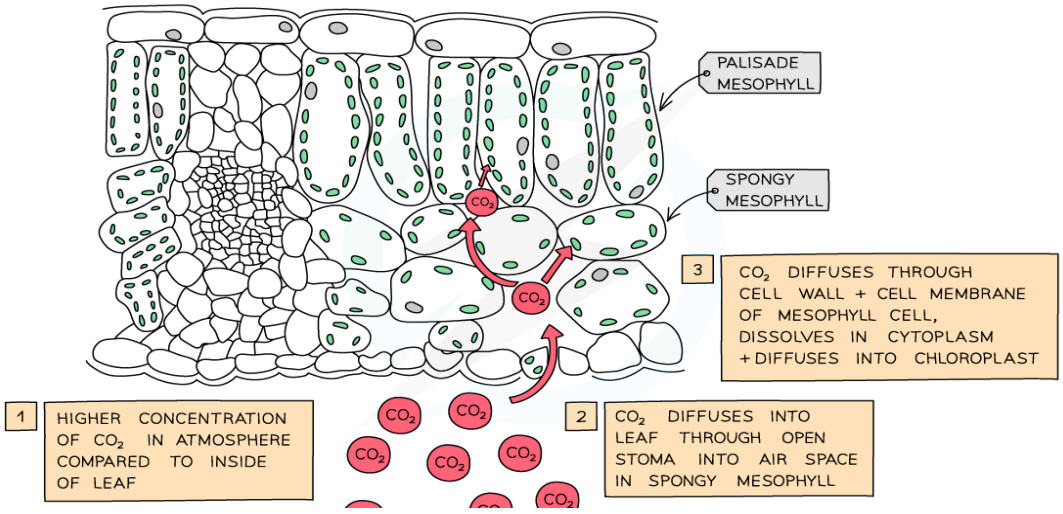
LEAF STRUCTURE



Structure	Description
Upper epidermis	• Thin and transparent to allow light to enter palisade mesophyll layer underneath it • Has a waxy cuticle which acts as a protective layer on top of the leaf prevents water from evaporating
Palisade mesophyll	• Made of tall narrow cell containing many chloroplasts to absorb sunlight • Just beneath the transparent upper epidermis to maximise absorption of light
Spongy mesophyll	• Contains many internal air spaces that increases the surface area to volume ratio for the diffusion of gases • Has vascular bundle (contains xylem & phloem) to transport substances to and from the leaf
Lower epidermis	Contains stomata and guard cells • Stomata is the site of gas exchange in plants. This is the place where carbon dioxide diffuses in and oxygen out. • Guard cells can change their shape, which can open or close the stomata

Pathway of carbon dioxide from the atmosphere into the leaf by diffusion:

Atmosphere → air spaces around spongy mesophyll tissue → leaf mesophyll cell → chloroplast



LIMITING FACTORS

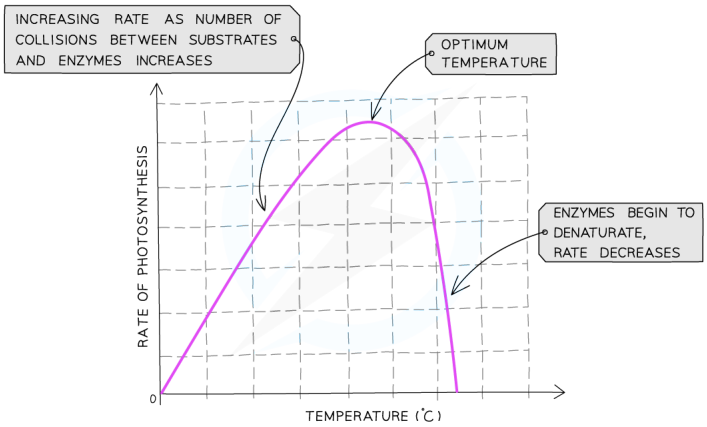
A **limiting factor** is something that is present in the environment in such short supply that it limits life processes.

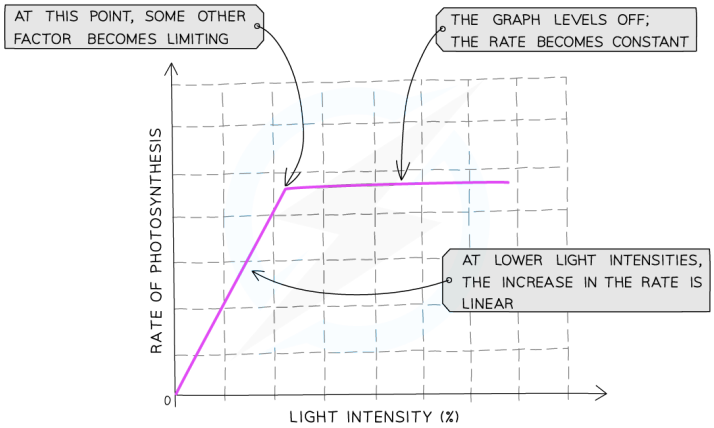
There are 3 main limiting factors of rate of photosynthesis:

1.) Carbon dioxide concentration (graph same as for light intensity)

2.) Light intensity

3.) Temperature





INVESTIGATIONS

There are 2 things that need to be removed from the leaves before investigations:

1.) **Starch:** this ensures that any starch already present in the leaf is used up so that it does not affect the result of the experiments

To destarch a plant:

→ leave the plant in the dark for 48 hours

During this period the plant will not photosynthesize and so use all of its stored starch in respiring

2.) **Chlorophyll**

→ boil the leaf in water and make it permeable (break the cell membrane)

→ Boil the leaf in ethanol and remove the chlorophyll from the leaf, it will be discoloured.

→ Rinse the leaf to soften it

Investigating need for chlorophyll

A **Variegated leaf** may be used - partially green (chlorophyll present) & partially white (chlorophyll absent)

1. Remove starch and chlorophyll from the plant (refer to above given method)
2. Leaf is spread out on a white tile and iodine solution is added

Observation: The parts which had chlorophyll turn blue-black due to the presence of starch and the white part does not.

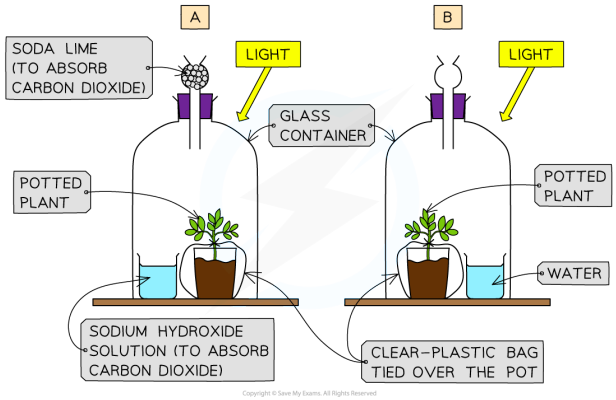
Investigating need for light

1. Partially cover a part of a destarched leaf with aluminium foil and place under sunlight
2. Remove chlorophyll
3. Leaf is placed on a white tile and tested for starch using iodine solution

Observation: covered area (aluminium foil) is deprived of sunlight so no starch is made during photosynthesis using sunlight. Hence, the covered area will remain orange-brown whereas the uncovered area will turn blue black due to the presence of starch

Investigating need for carbon dioxide

1. Destarch 2 plants
2. Place one plant in a bell jar that contains a beaker of sodium hydroxide to absorb CO_2
3. Place the second in a bell jar that a beaker containing water
4. Leave the plants kept under the bell jars exposed to bright light for a few hours
5. Now, remove chlorophyll from the plants
6. Test both plants for starch using iodine solution



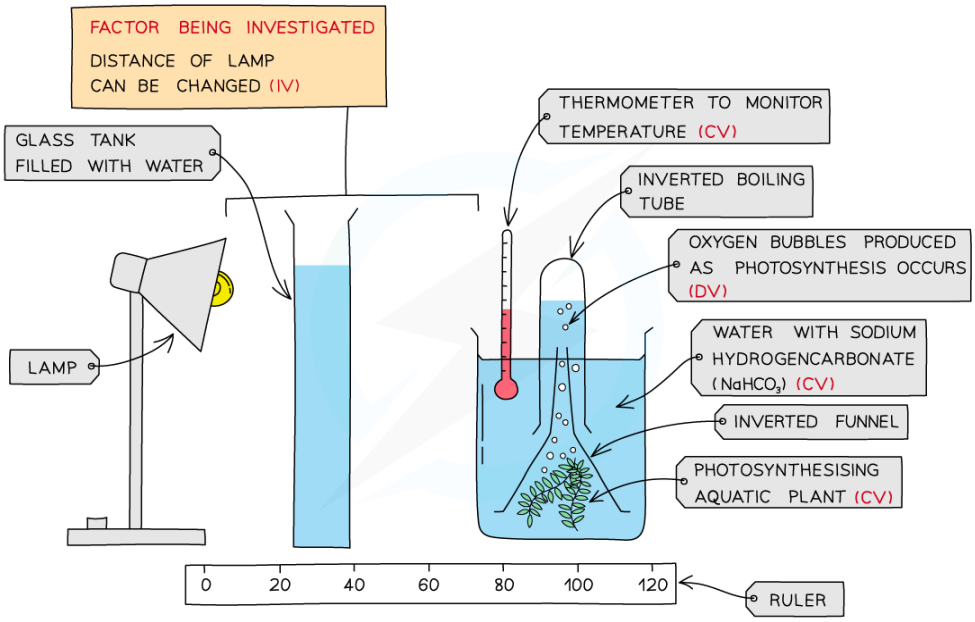
Observation: leaf near water turns blue-black (CO_2 is not absorbed, so photosynthesis is happening) whereas leaf near sodium hydroxide does not turn blue-black (starch is absent due to the lack of CO_2)

Investigating the rate of photosynthesis

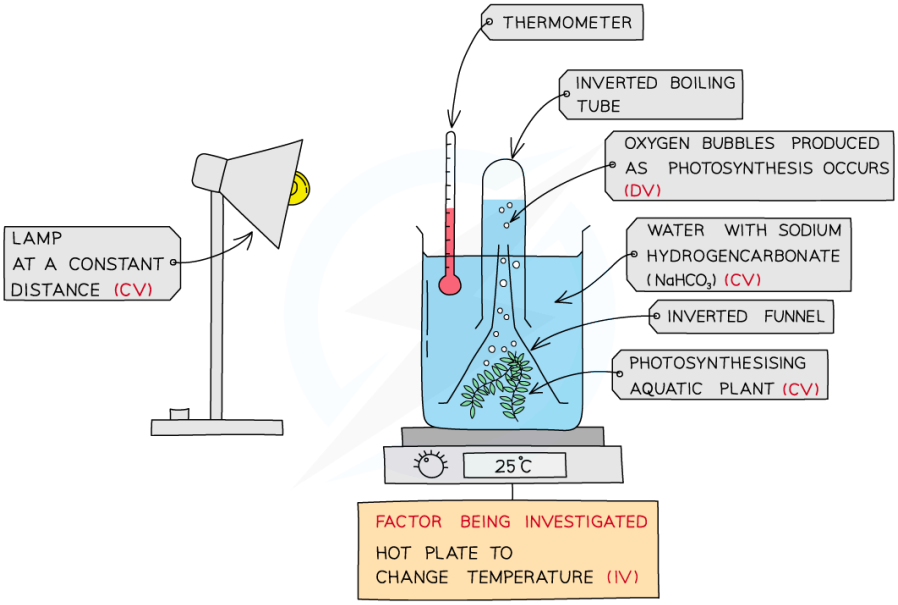
We usually carry out these experiments with the help of aquatic plants because rate of photosynthesis can be easily observed because when these plants release oxygen, bubbles appear

- The number of bubbles produced over a minute can be counted to record the rate

Light intensity:

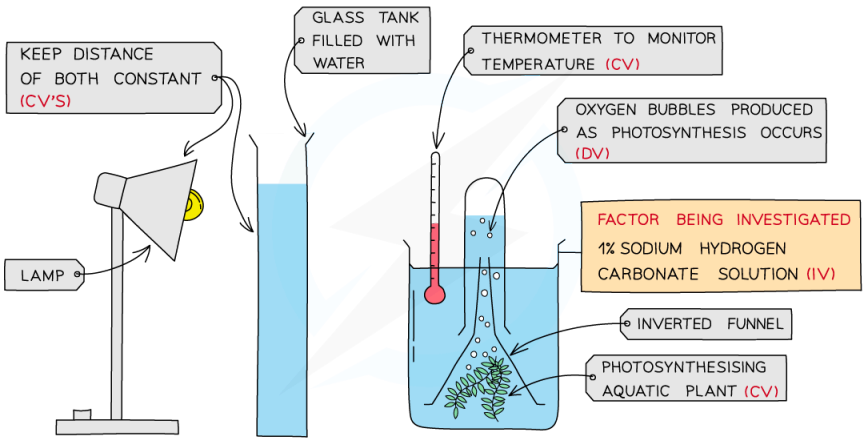


Temperature



Carbon dioxide concentrations

The investigation is done by adding different amount of sodium hydrogencarbonate to the water:



Gas Exchange

Hydrogen carbonate indicator changes colour according to how much carbon dioxide is present

- Purple when there is no carbon dioxide
- Red when there is little carbon dioxide
- Yellow when there is a lot of carbon dioxide

Human Nutrition

A **balanced diet** consists of all the food groups in the correct proportion

Food type	function	sources
Carbohydrate	a source of energy in respiration in cells	Breads, cereals, pasta, rice
Proteins	Growth and repair	Meat, fish, eggs
Lipids	Insulation and energy storage	Butter, oil, dairy products
Fibre	Provides bulk (roughage) for the intestines to push food through it	Vegetables, whole grain
Vitamin C	Essential part of collagen which makes up skin, hair, gums and bones	Citrus fruits,
Vitamin D	Helps the body to absorb calcium and so required for bones and teeth	Butter, egg yolk
Calcium (mineral)	Needed for strong teeth and bones. Also, involved in clotting of blood	Dairy products
Iron (mineral)	Solvent needed for metabolic reactions	Water, juice, fruits

Deficiencies:

Deficiency of	**Disease**	**symptoms**
Vitamin C	scurvy	- Anemia - Exhaustion - Gum ulcerations - swelling
Vitamin D	rickets	- Bone pain - Lack of bone growth - Stunted growth - Soft, weak bones
Calcium	osteoporosis	- Brittle bones & teeth - Poor blood clotting

Iron	anemia	- Decrease of RBCs so tissues do not get enough oxygen delivered to them

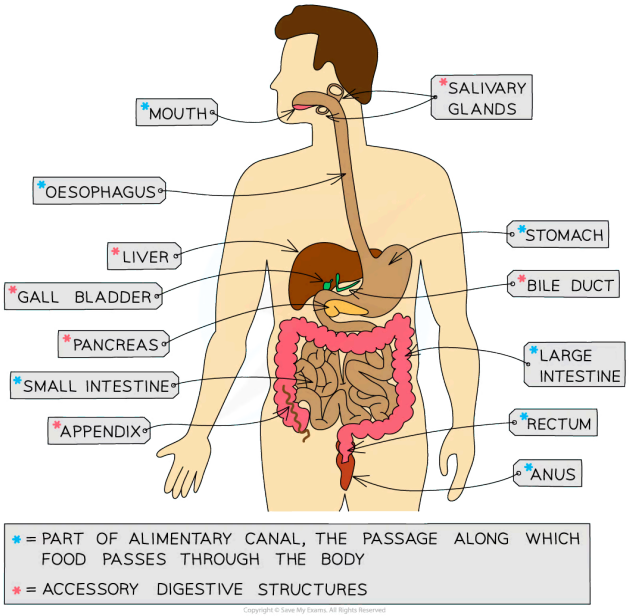
The function of the digestive system is to **digest food** and **absorb the nutrients.**

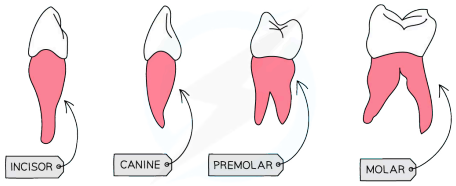
The digestive system carries out:

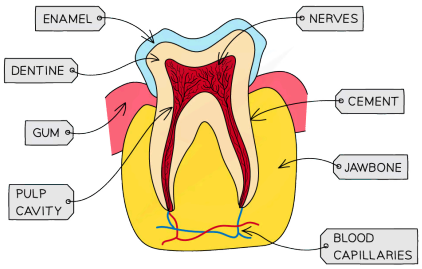
Ingestion	food and drink are taken into the body through the mouth
Mechanical digestion	food is broken down into smaller pieces without chemical change to the food molecules
Chemical digestion	large, insoluble molecules are broken down into small, soluble molecules
Absorption	Small food molecules and ions move through the walls of the intestines into the blood
Assimilation	The nutrients are absorbed by individual cells and used for energy
Egestion	Food that has not been digested or absorbed passes out of the body as faeces

The digestive system consists of:

1. **Alimentary canal:** food passes directly through these organs
2. **Associated organs:** do not form part of the route travelled by food, but are still involved in digestion

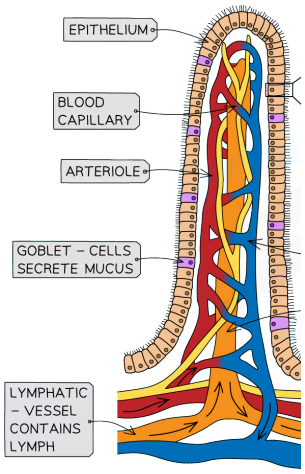


Structure	Function
Mouth Physical digestion	Food is ingested here and the teeth break it down into smaller pieces during mechanical digestion ➔ Teeth increases the surface area of food for the action of enzymes ● **Incisors** - biting and cutting ● **Canines -** tearing and biting ● **Premolars & molars -** chewing and grinding  **Structure:** ● The tooth is embedded in the **gum** ● The part of the teeth that is in the gum is covered with **cement** ● The part of the teeth above the gum is **enamel.** - Bacteria produce acids, which dissolve the enamel and cause decay ● Under the enamel is a layer of **dentine**, which has pulp containing nerves

<table>
<tr><td></td><td>and blood vessels

</td></tr>
<tr><td>Chemical digestion</td><td>➔ The salivary glands secretes saliva which:
• Amylase breaks down starch into maltose
Starch → Maltose
• Lubricates food for easy swallowing</td></tr>
<tr><td>Oesophagus</td><td>Tube connects mouth to the stomach
The walls of the oesophagus contract in a rhythmic manner to force the food downwards. This is called peristalsis</td></tr>
<tr><td>Stomach

Chemical digestion</td><td>Churning of the muscular stomach walls continues the process of mechanical digestion.

The stomach produces gastric juice: pepsin, mucus and hydrochloric acid
➔ Pepsin is a protease with an optimum pH of pH 2 (acidic)
➔ The hydrochloric acid ensures that condition in the stomach to remain within the optimum range for pepsin to work
➔ The stomach walls also have goblet cells which secrete mucus which protects the stomach walls from the hydrochloric acid</td></tr>
<tr><td>Liver</td><td>Bile is produced here.
➔ The gallbladder stores bile
Bile has two main roles:
1. It is alkaline to neutralise the hydrochloric acid which comes from the stomach
2. Breaks down large drops of fat into smaller ones, increasing their surface area, in a process called emulsification. (physical digestion)</td></tr>
</table>

Pancreas	**Amylase (maltase), protease (trypsin)** and **lipase** are produced here before being secreted in the duodenum
Small intestine: duodenum	• The acidic content of the stomach is neutralised by bile here • The neutral condition of the duodenum is the optimum pH (pH 7) for trypsin. ➔ **Trypsin** (protease) breaks down proteins into amino acids ➔ **Maltase** (carbohydrase) breaks down maltose into glucose ➔ **Lipase** breaks down fats into fatty acids & glycerols (1:3)
Ileum  	Food and water are absorbed into the blood via **villi** in the lining of the ileum Adaptations of the villi: 1. **Increased surface area**: presence of villi and microvilli 2. **Thin wall:** single cell thick epithelium, which minimizes the diffusion distance and active transport 3. **Efficient transport system:** a lymphatic vessel in the centre of each villus absorbs fatty acids and glycerol and transports them. 4. **Rich blood supply:** Also has a dense network capillaries within each villus carries absorbed glucose and amino acids into the bloodstream Most water is absorbed here.
Large intestine: rectum	Faeces are stored here priori to egestion
Large intestine: anus	Faeces leave the body via the anus. This is egestion

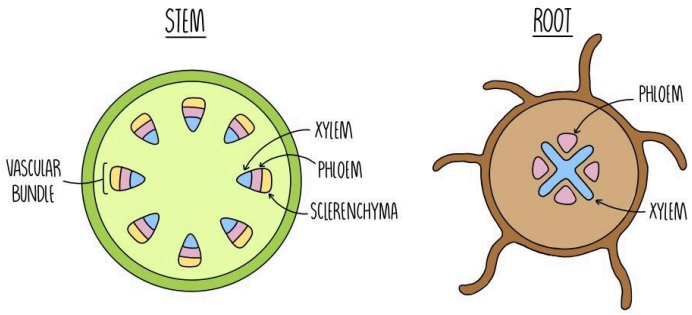
Transport in Plants

Plants contain two types of transport vessel:

1. **Xylem vessel:** transports water and minerals from the roots to the stem and leaves
   Adaptations:
   - Cells joined end to end with no cross walls to form a long continuous tube
   - Cells are dead, without cell contents, to allow free passage of water
   - Outer walls are thick, made with lignin, strengthening the tubes, which helps support the plant
2. **Phloem vessel:** transports sucrose and amino acids made by the plant from photosynthesising leaves to non-photosynthesising regions in the roots and stem

A group of xylem vessels and phloem tubes is called a **vascular bundle.**

Remember: Xylem is always on the inside and phloem is always on the outside

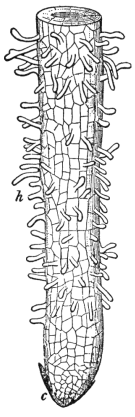


ROOT HAIR CELLS

Structure:

- At the very tip is a protective cap, to protect the root as it grows through the soil
- The rest of the root is covered by a layer of cells called the epidermis

Function:



- Water enters the root hair cells by osmosis as there is a higher water potential outside the cell than in the inside
- Mineral ions are absorbed against their concentration gradient using active transport

Adaptations:

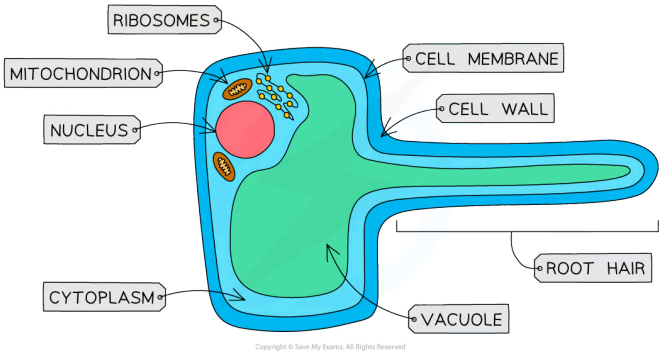
- Increased surface area by long, thin extensions significantly enhance the surface area
- Close contact with soil particles to maximize access to water and dissolved nutrients

Pathway of water movement in plants:

Root hair cell → Root cortex cell → Xylem → Leaf mesophyll cell

➔ Water moves by osmosis into the root hair cells, through the root cortex, and enters the xylem for upward transport to the leaves

➔ The xylem carries water and dissolved nutrients upward to the leaves, where it enters mesophyll cells for photosynthesis



Investigating water movements in plants:

Experiment setup: place a plant in a beaker of dyed water (using food coloring)

Observation:

- ☐ Leaves turn the color of the stained water, demonstrating water uptake
- ☐ Cutting a cross section of the stalk reveals stained regions, identifying the xylem vessels as the pathways of water transport

Conclusion: water is absorbed by root hairs and transported through xylem vessels, demonstrating the plant's water transport system

TRANSPIRATION

Transpiration is the loss of water vapour from plants leaves by evaporation of water at the surface of the mesophyll cells followed by diffusion of water vapour through the stomata.

Functions of transpiration:

1. Transporting mineral ions
2. Providing water to keep the cells turgid in order to support the structure of the plant
3. Providing water to leaf cells for photosynthesis
4. Keeping the leaves cool

Transpiration Stream

➔ Most transpiration occurs at the leaves

➔ Transpiration is caused by evaporation and diffusion of water from the surface of the spongy mesophyll cell

➔ Water diffuses through the stomata to the surrounding air down the concentration gradient

➔ This decreases the concentration of water in the leaf and so decreases the pressure in the leaf

➔ Water is drawn up through the xylem from the roots by **cohesion** to replace the water lost from the leaf

➔ Cohesion between the water molecule helps create a tension enabling water to be pulled upwards

➔ This causes a constant 'transpiration stream' of water

Factors affecting Rate of Transpiration

- **Temperature:** The kinetic energy of the water molecules increases, so they evaporate and diffuse faster from the mesophyll cells, increasing the transpiration rate
- **Humidity:** Low humidity increases the concentration gradient between the leaf and the atmosphere, hence increasing the transpiration rate, while high humidity decreases the gradient, reducing the transpiration rate.
- **Wind Speed:** Removing water molecules from the air surrounding the leaf sets up a steep concentration gradient between the leaf and the air, increasing transpiration

Wilting occurs if water loss (transpiration) exceeds water uptake.

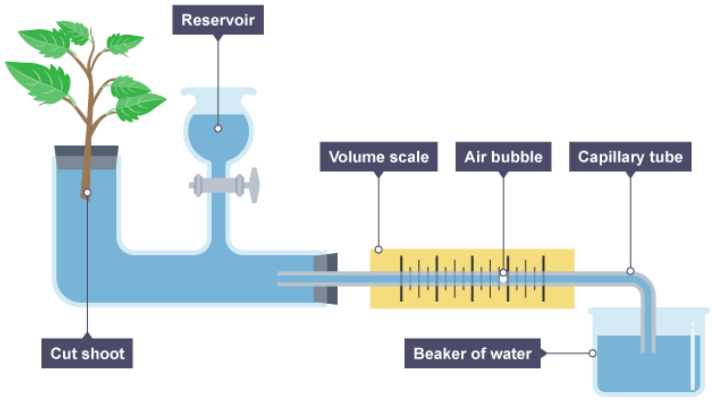
➔ This is when all the cells of the plant are not full of water (flaccid), so the strength of the cell walls cannot support the plant and it starts to collapse.

A **potometer** can be used to investigate the effect of environmental factors on the rate of transpiration

Investigating the rate of transpiration under different environmental factors

1. A single air bubble is introduced into the capillary tubing.
2. The tap on the reservoir is opened to add water to push the air bubble back to zero on the scale.
3. A timer is started and a set time measured.
4. The distance the air bubble has travelled along the scale is recorded.
5. The experiment can be repeated with different environmental conditions.

The faster the bubble moves, the greater the rate of water uptake – and so the greater the rate of transpiration.



TRANSLOCATION

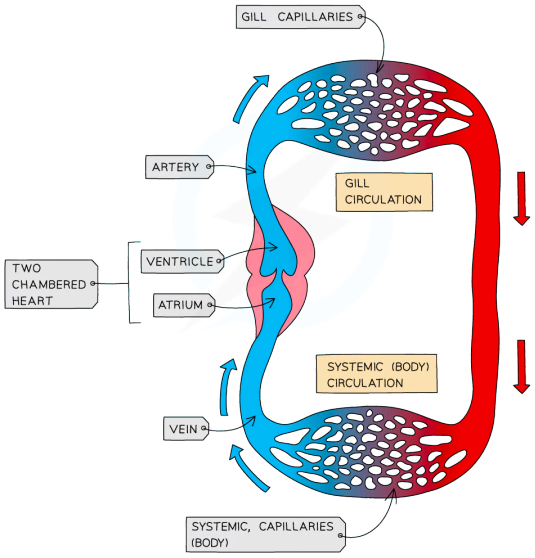
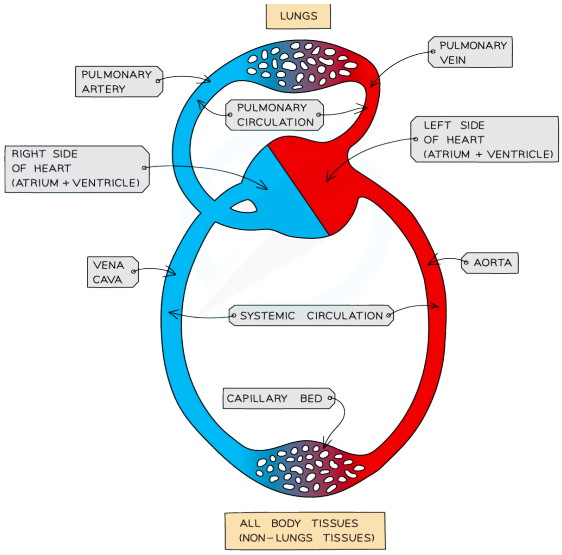
Translocation is the movement of sucrose and amino acids (soluble products of photosynthesis) in the phloem from a region of production (source) to regions of storage or regions of utilisation (sink)

➔ Translocation direction is different in different seasons

Xylem	Phloem
Transports water and mineral ions	Transports sucrose and amino acids
Movement happens by transpiration stream	Movement happens by translocation
One way flow from roots to leaves	Flows in all directions depending on season
Cells in vessel are dead	Cells in vessels are alive

Transport in Animals

The role of the circulatory system is an organ system, which transports blood around the body
Component of the circulatory system include: **Blood vessels, a pump** (heart) & **valves**

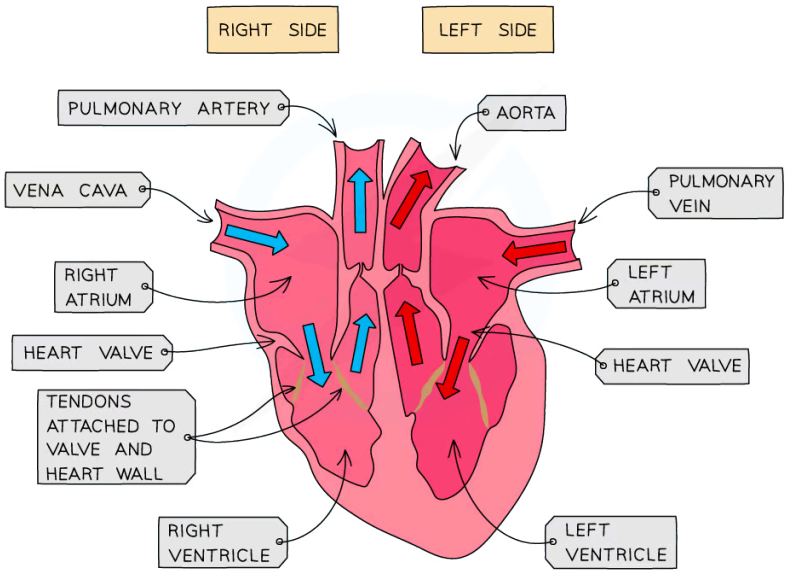
Single - circulatory system	Double - circulatory system
A system in which blood passes through the heart only once on one complete circuit of the body	a system in which blood passes through the heart twice on one complete circuit of the body
Present in fishes (2 chambered heart)	Present in mammals (4 chambered heart)
	

Advantages of double circulatory system:

Blood losses pressure as it passes through the capillaries in the lungs, slowing its flow.

- ➔ In fish, the low pressure blood just continues around the fish's body. This means that blood travels much more slowly in a fish's body.
- ➔ In mammals,blood is returned to the heart, where the blood pressure is increased again. Any tissues that are metabolically active need a lot of oxygen as quickly as possible. This delivery is much more effective if the blood is in high pressure.

THE MAMMALIAN HEART



Right side	**Deoxygenated blood**	Left side	**Oxygenated blood**
Enters heart from body:	Vena cava	Enters heart from lungs:	Pulmonary vein
Leaves heart to lungs:	Pulmonary artery	Leaves heart to body:	Aorta

Adaptations of the heart:

- Ventricles have thicker muscle walls than the atria because they have to pump blood out of the heart and so need to generate a higher pressure.
- The left ventricle has thicker muscle walls than the right ventricles as it has to pump blood at high pressure around the entire body, whereas the right ventricle has to pump blood a shorter distance (till the lungs).
- The septum separates the two sides of the heart, preventing mixing of oxygenated and deoxygenated blood

Heart rate (measured in beats per minute, bpm) can be monitored using:

1. Electrocardiograph (ECG)
2. Measuring pulse rate
3. Listening to the sound valves closing using a stethoscope

VALVES

Prevents blood from flowing backwards.

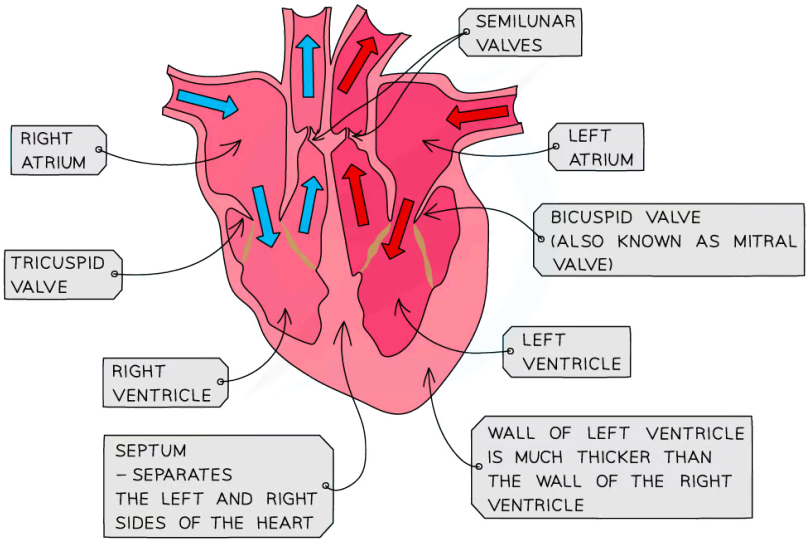
Atrioventricular valves: valve between atrium and ventricles, allows blood to flow from the atrium to the ventricle but not the other way.

- ➔ The valve on the right side is called **tricuspid valve**
- ➔ The valve on the left side is called **bicuspid valve** (or **mitral valve**)

Remember: open when the atria contract and close when the ventricles contract.

Semilunar valves (or e-way valve):valve between the ventricles and the arteries (the only that arteries have valves), allows blood to flow from the ventricles to the arteries but not the other way round.

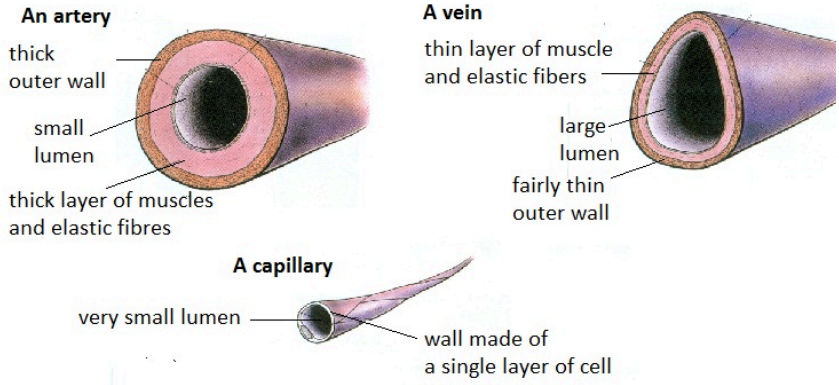
Remember: open when the ventricles contract.



BLOOD VESSELS

	Function	Structure
Arteries	• Carries blood away from the heart. • Transports oxygenated blood (exception: pulmonary artery)	**Thick & strong containing muscle and elastic tissue** ➔ Strength and elasticity needed to withstand the high pressure blood pumped from the heart
Veins	• Carries blood to the heart. • Transports deoxygenated blood (exception: pulmonary vein)	**Quite thin, containing less muscle and elastic tissue** ➔ No need for strong walls as most of the blood

		pressure has been lost . **Wide lumen** ➔ Offers less resistance to blood flow **Contains valves** ➔ prevent backflow
Capillaries	• Connects arteries and veins • Carries blood to the cells of tissues. • Transport oxygenated blood from the arteries to the cells and deoxygenated blood from the cells to the veins.	**Thin walls & Very narrow lumen** (one RBC wide) ➔ Thin walls and narrow lumen bring blood close to the cells decreasing the diffusion distance **Leaky walls** ➔ Blood plasma can leak out, forming tissue fluid



Circulation around the body:

Organ	Towards organ (oxygenated blood)	Away from organ (deoxygenated blood)
Heart	Vena cava & pulmonary vein	Pulmonary artery & aorta
Liver	Hepatic portal artery	Hepatic portal vein
Kidney	Renal artery	Renal vein

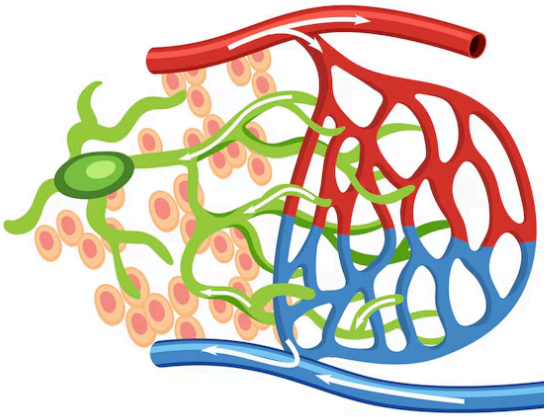
COMPONENTS OF BLOOD

Component	Function	Structure
Red blood cells	Transport oxygen to cells in the form of oxyhaemoglobin	• Biconcave discs that increases the surface area and so speeds

		up diffusion of oxygen in and out of RBC ● No nucleus provides more space for the protein haemoglobin
White blood cells	Part of body's immune system, defends against infections caused by pathogenic microorganisms Two main types: phagocytes & lymphocytes	● Large cells containing a big nucleus. ● Different types have slightly different structures and functions
Plasma	Important in transporting carbon dioxide, digested food (nutrients), urea, mineral ions, hormones and heat energy	Straw coloured liquid
Platelets	Involved in helping the blood to clot ➔ Platelets release chemicals that cause soluble fibrinogen proteins to convert insoluble fibrin and form a mesh across the wound, trapping the red blood cells - forming a clot	Fragments of cells

LYMPHATIC SYSTEM

The lymphatic system is formed from a series of tubes which flow from tissues back to the heart.



Lymph nodes are small clusters of lymphatic tissue found throughout the lymphatic system (especially in the neck and armpits)

➔ Lymphocytes are found in the lymph nodes

Main functions of lymphatic system:

1. Returns fluid to heart
2. Helps large molecules (like hormones, lipids) to enter the blood
3. Remove foreign material in lymph helping the immune system

CORONARY HEART DISEASE (CHD)

The heart is made of cardiac muscle tissue

- ➔ Coronary arteries supply the cardiac muscle cells with nutrients and removes waste products
- ➔ If a coronary artery becomes completely/partially blocked by fatty deposits called **'plaques'** (formed from cholesterol), the arteries are no longer eleatic and cannot stretch to accommodate blood flow, leading to coronary heart disease.

If the coronary artery is:

- **Partially blocked**, it creates a restricted blood flow to the cardiac muscle cells and results in severe chest pains called **angina**
- **Completely blocked,** the cells in the area cannot respire so they don't contract, leading to a **heart attack**

Risk factors for coronary heart disease are:

Poor diet:	eating more saturated fat increases cholesterol levels, increasing chances of plaque buildup
Stress:	hormone production increases causing blood pressure to increase and leading to increasing chance of blockage
Smoking:	nicotine in cigarettes cause blood vessels to become narrow, increasing blood pressure causing the buildup of fat globules
Genetic predisposition:	history of CHD in a person's family increases chances of CHD in person
Age:	CHD chances increases as we grow up
Gender:	males are more likely to develop CHD than females

Prevention:

- Quit smoking
- Reduce animal fats in diet and increase fruit and vegetable consumption because animal fat is known to have higher cholesterol levels
- Exercise regularly helps in weight loss and decrease blood pressure

Treatment

1. **Aspirin** can be taken daily to reduce the risk of blood clots

2. **Angioplasty:**
   - ➔ A narrow catheter (tube) is threaded through the groin up to the blocked vessel.
   - ➔ A tiny balloon inserted into the catheter, pushed up the blood vessel and then inflated
   - ➔ Flattens the plaque against the wall of the artery, clearing the blockage
   - ➔ To keep the artery clear, a stent (piece of metal/plastic mesh) is also inserted
   - ➔ Sometimes the stent is coated with a drug that slowly releases medication to further prevent buildup of plaque

3. **Coronary bypass surgery:**
   - ➔ A piece of blood vessel is taken from the patient's leg/arm/chest and used to create a new passage for the blood flow, bypassing the blocked area

Respiration

Respiration is the process of breakdown of nutrient molecules (specifically glucose) to release energy stored within the bonds of these molecules.

- Like all metabolic reactions, respiration also involves the action of enzymes.

Uses of energy released in respiration:

1. Contracting muscles
2. Transmitting nerve impulses
3. Active transport
4. Growth
5. Cell division
6. Protein synthesis
7. Maintaining a constant body temperature

Respiration is of 2 types: Aerobic and anaerobic

Aerobic respiration

Aerobic respiration is the metabolic reaction taken place in the mitochondria of the cell, which uses oxygen to break down nutrient molecules (specifically glucose) to release energy within the bonds of the molecules

- It is the complete breakdown of glucose to release a relatively large amount of energy

Glucose + oxygen → carbon dioxide + water

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

Anaerobic respiration

Anaerobic respiration is the metabolic reaction that takes place in the cytoplasm of the cell, which breaks down nutrient molecules without using oxygen

- It is incomplete breakdown of glucose to release a relatively smaller amount of energy
- Yeast and humans can respire anaerobically, but the product is different

In yeast:

Glucose → alcohol + carbon dioxide

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

We use these products in the processes of:

1.) Brewing

2.) Bread making

In humans:

When you are doing vigorous exercise:

- The heart and lungs supply oxygen to the muscles
- Eventually a limit is reached when the heart and lungs can no longer do this
- But the muscles continue to contract, requiring more energy
- Extra energy can be provided by anaerobic respiration:

Glucose → lactic acid

- This is called building up an '**oxygen debt**'
    - **Oxygen debt** is the oxygen required to remove excess lactic acid in muscle during anaerobic respiration.

When you stop running:

- You will have a lot of lactic acid in your muscles and blood.
- This lactic acid must be broken down because it lowers the pH of the cells and can cause the denaturing of the enzymes
- So when blood passes through the liver, the liver cells conduct aerobic respiration.
- The waste products of aerobic respiration of lactic acid are carbon dioxide and water

Lactic acid + oxygen → carbon dioxide + water

- This is the reason why we continue to breathe heavily and our heart beat remains high
- This is known as '**repaying the oxygen debt**'

Difference between aerobic and anaerobic respiration:

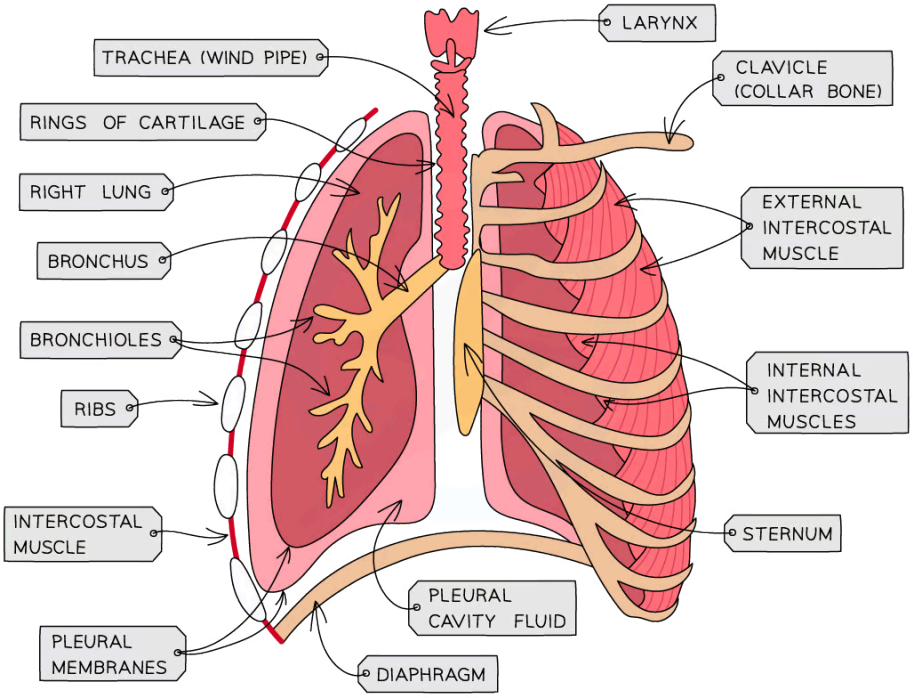
Aerobic respiration	**Anaerobic respiration**
Breakdown of glucose with using oxygen	Breakdown of glucose without using oxygen
Complete breakdown	Incomplete breakdown
Releases relatively large amount of energy	Releases relatively low amount of energy
Products are carbon dioxide and water	Products in yeast: carbon dioxide + ethanol Products in animals: lactic acid
Happens in Mitochondria	Happens in cytoplasm

Gas exchange

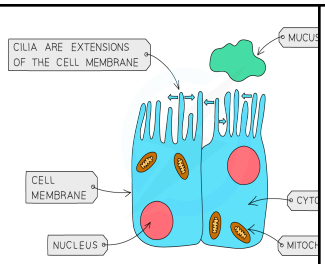
Composition of inhaled and exhaled air:

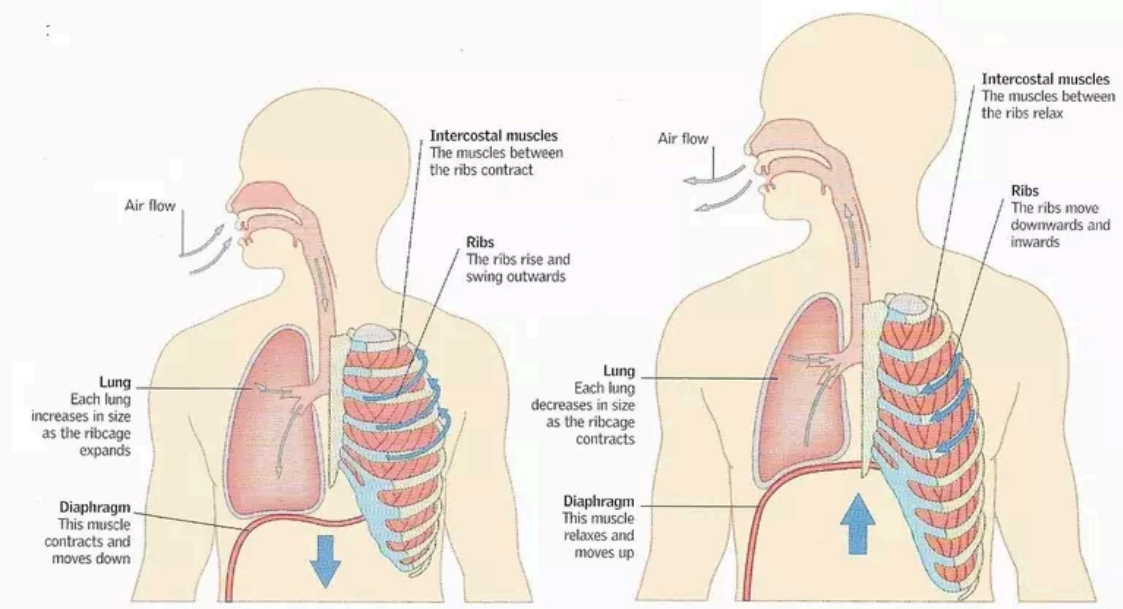
Gas	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Water vapour	0.2 - 4%	5 - 7%
Nitrogen	78%	78%

Breathing system



Structure	Description
Nose & Mouth	• Cells called cilia have very tiny hair-like projections in the nose that trap dust particles in the air and push mucus up the passages towards the nose and throat. • Goblet cells make a liquid containing water and mucus

	• The water helps to moisten the nose and the mucus helps in trapping bacteria and dust
Larynx	Also known as the voice box, when air passes across
Trachea	Windpipe that connect the nose and mouth to the lungs • The rings of cartilage present on the trachea supports the airways and helps to prevent the trachea from collapsing when the air pressure inside the tube drops
Bronchi	Large tubes branching off the trachea with one bronchus for each lung
Bronchioles	Bronchi split to form smaller tubes called bronchioles which connect to the alveoli
Alveoli	Tiny air sacs where gas exchange takes place **Features of gas exchange surfaces:** 1.) Large surface area for faster diffusion of gases across the surface 2.) Thin walls to shorten the diffusion distance 3.) Good ventilation to maintain the diffusion gradient 4.) Good blood supply to maintain a high concentration gradient so diffusion occurs faster
Ribs	Bone structure that protects internal structures like the lungs
Intercostal muscles	Muscles between the ribs which control their movement causing inhalation or exhalation • There are two types of intercostal muscles: external and internal • They both work as antagonistic pairs while inhaling/exhaling
Diaphragm	Sheet of connective muscle and tissue at the bottom of the thorax that helps in changing the volume of the thorax during inhalation or exhalation.



Diseases & Immunity

A **pathogen** is a disease causing organism

An organism in which the pathogen lives and breeds is called **host**

Transmissible diseases are diseases caused by a pathogen that can be passed from one host to another.

The entry of a pathogen into the body is called **infection**

Pathogens are transmitted:

1.) **Directly:** by coming in contact with any fluid in the infected person's body
2.) **Indirectly:** via contaminated surfaces, food, animals and infected droplets in air

The body's defences against pathogens are:

1.) **Hair in the nose:** traps dust particles
2.) **Mucus:** traps pathogens which can be removed from the airway by coughing, sneezing
3.) **Stomach acid (Hydrochloric acid:** Kills pathogens in food
4.) **Skin:** provides a mechanical barrier from pathogens and if broken, clots form
5.) **White blood cells**

Methods for controlling the spread of diseases:

1.) A clean water supply
2.) Hygienic food preparation

➔ Keeping food cold to prevent pathogens from growing/reproducing

➔ Cooking food to the correct temperatures to kill pathogens

➔ Covering food to prevent contamination through flies

3.) Good personal hygiene

4.) Waste disposal

5.) Sewage treatment

Active immunity	**Passive Immunity**
Long-term, slow acting defence of the body provided by the production of antibodies against a pathogen.	Short-term, fast acting defence against a pathogen by antibodies acquired from another individual
Gained by: ● Taking vaccination ● Getting infected with pathogen	**Gained by:** ● By breastmilk ● Getting injected antibodies

Immune response is the reaction of the body to the presence of antigen, involving the production of antibodies

Antigens

- Molecules (proteins) found on the surface of cell membranes
- Each pathogen has its own antigens, which have specific shapes
- Lymphocytes recognize 'foreign' antigens, such as those on pathogens and respond

Antibodies

- Protein molecule produced by lymphocytes in response to specific foreign antigens
- Complementary in shop to antigens of pathogens
- Attach to antigens, causing agglutination, making it easier for phagocytes

The role of antibodies:

1. **Agglutination:** Antibodies clump pathogenic cells together, restricting their movement
2. **Signaling phagocytes:** Antibodies release chemicals that attract phagocytes to the site of infection

VACCINATION

How vaccines work?

Introduction of pathogens:

➔ Vaccines contain a dead or weakened form of the disease-causing pathogen

Immune response:

➔ Lymphocytes recognize the antigens and produce complementary antibodies

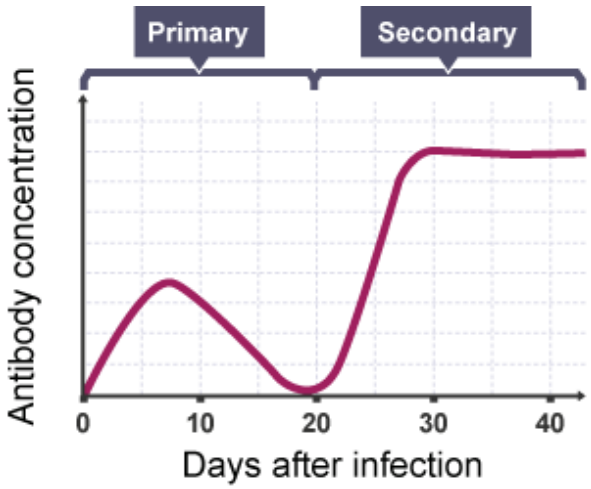
➔ Antibodies carry out agglutination and signal phagocytes target them

Formation of memory cells:

➔ Memory cells are created during this response and remain in the blood

➔ These cells ensure a faster and stronger immune response if the same antigen is encountered again. This immunity is long-lasting

Memory cells are long-lived cells produced by the division of lymphocytes that have contacted their antigen and respond if the same pathogen enters the body for a second attack.



If a large percentage of the population is vaccinated, it provides protection for the entire population because there are very few places for the pathogens to breed. This is known as **herd immunity**

➔ Herd immunity prevents **epidemics** and **pandemics** from occurring in populations

Case study: Cholera

A disease caused by the bacterium **vibrio cholerae.**

Effects of severe diarrhoea

- Significant water and ion loss disrupts normal tissue and organ functions, leading to diarrhoea
- Can eventually lead to death if left untreated

Treatment

➔ Oral rehydration therapy: a drink containing small amounts of dissolved salts and sugar

How does cholera lead to diarrhoea?

1. Bacteria attach to the walls of the small intestine
2. They produce a toxin
3. The toxin stimulates the cell lining the intestine to release chloride ions from inside the cells into the lumen of the intestine
4. The chloride ions accumulate in the lumen of the small intestine and lower the water potential there
5. Once the water potential is lower than that of the cells lining the intestine, water starts to move out of the cells into the intestine, by osmosis
6. Large quantities of water are lost from the body in watery faeces (diarrhea)
7. The blood contains too little chloride ions and water

Drugs

A **drug** is any substance taken into the body that modifies or affects chemical reactions in the body

ANTIBIOTICS

Antibiotics are chemical substances made by certain bacteria or fungi that affect the working of bacterial cells, either by disrupting their structure or function or by preventing them from reproducing

How is antibiotic resistance developed?

- Natural selection can give rise to bacterial populations that are resistant to antibiotics
- Antibiotic resistance can increase in bacterial populations as follows:
    - a random mutation can give rise to a new bacterial allele that codes for antibiotic resistance
    - when the bacterial population is exposed to an antibiotic any individuals without the resistance allele die, while those with the resistance allele survive
    - the surviving bacteria are more likely to reproduce, passing on their resistance alleles to their offspring

- over several generations the frequency of the resistance allele increases, eventually resulting in an antibiotic resistant strain of bacteria

How to prevent antibiotic resistance?

1. Only take antibiotics when absolutely essential
2. When prescribed a course, ensure that the entire course is completed

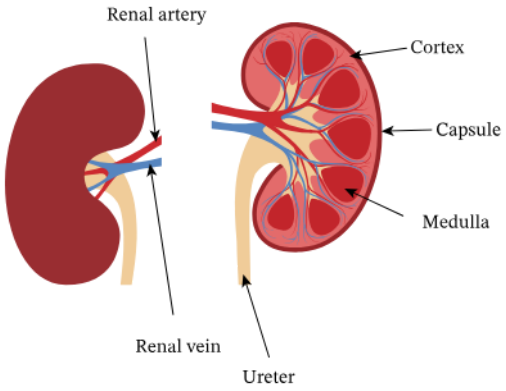
Excretion

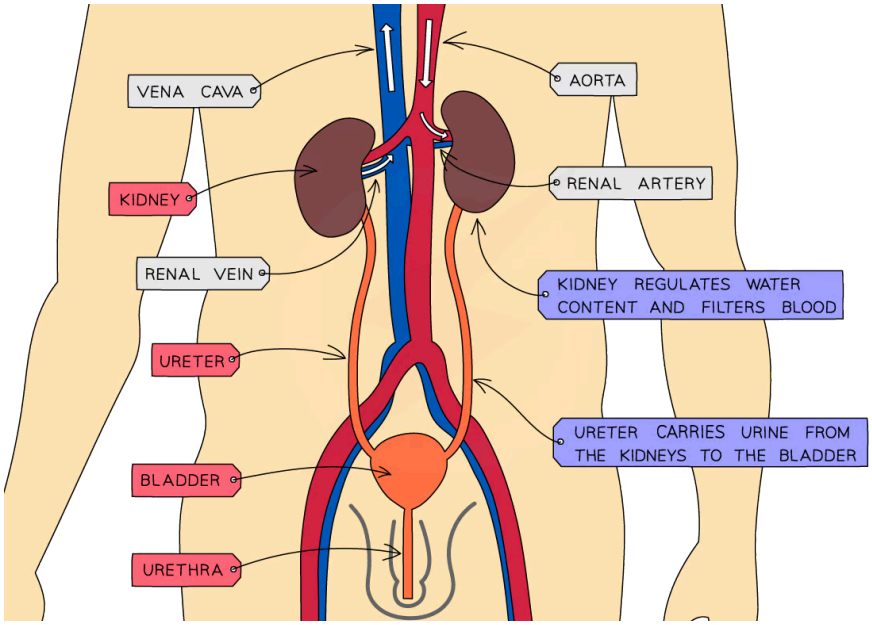
Excretion is the process of removal of metabolic waste, toxic material and substances in excess of requirements

The human excretory system includes **lungs and kidneys** (liver also has a vital role):

- Carbon dioxide must be removed because it dissolves in blood to form a weak acid, lowering the pH of cells and the blood, reducing the activity of enzymes.
- The kidney also removes urine which is a solution of urea, excess water and salts.

Structure	**Explanation**
Kidney	Two bean-shaped organs that filter the blood Their main functions are: 1.) To regulate the -water content of the blood (vital for maintaining blood pressure) 2.) To excrete the toxic wastes of metabolic reactions and substances in excess of requirements Structure: ● Made of two parts: **cortex** and **medulla** ● Kidneys are made up of thousands of tiny tubules called **nephrons** ● Each nephron starts in the cortex, loops down into the medulla and back up.

	
Ureter	Tube connecting the kidney to the bladder
Bladder	Organ that stores the urine
Urethra	Tube that connects the urethra to the exterior; urine is released

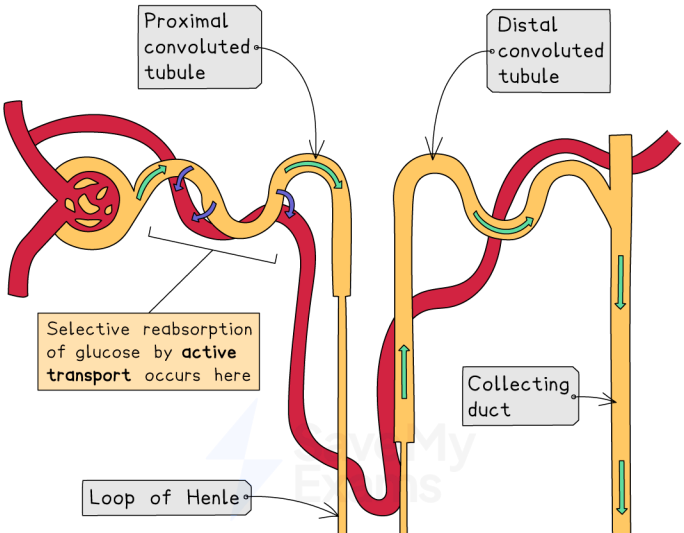


THE NEPHRON

Urine formation involves 2 necessary steps:

1. **Ultrafiltration:**

- Blood flows into the kidney from the renal artery
- This artery divides into tiny, coiled capillaries called **glomerulus**



- The capillaries keep getting narrower as they get further into the glomerulus which increases the pressure on the blood moving through them
- High blood pressure in the glomerulus forces small molecules called the filtrate (glucose, water, urea and salts) out of the glomerulus into **Bowman's capsule.**

2. **Selective Reabsorption:**

   After the filtrate enters the bowman's capsule:

   I. **Reabsorption of glucose**
   - Glucose is the first to be absorbed at the proximal (first) convoluted tube.
   - It is absorbed by active transport by the help of many mitochondria present in the nephron
   - This absorption cannot take place anywhere else in the nephron because the gates that facilitate the active transport are only present in the PCT

In diabetes, not all of the glucose filtered can be reabsorbed into the PCT so it ends up in urine.

   II. **Reabsorption of salts**
   - Necessary salts are absorbed in the Loop of Henle
   - Reabsorbed back in the blood by diffusion and active transport

   III. **Reabsorption of water**
   - Reabsorbed from the collecting dust (depending on requirement) by osmosis

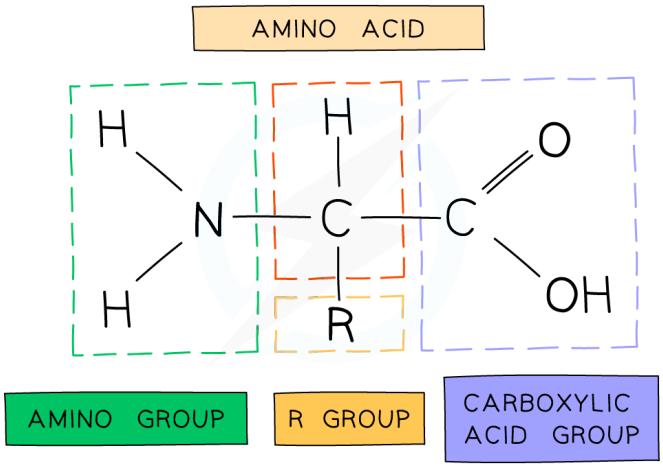
Component	Reabsorbed in	Reabsorbed by
Glucose	Proximal (first) convoluted tube	Active transport
Salt	Loop of Henle	Active transport & diffusion
Water	Collecting dust	Osmosis
Urea	Not reabsorbed	—

URINE FORMATION

- The liver makes urea from excess proteins and amino acids
- Amino acids are absorbed into the blood capillaries in the villi in your ileum
- These blood capillaries join up to the hepatic portal vein, which takes the amino acids to the liver
- It is wasteful to excrete amino acids because they contain energy which, if not required now, might be needed later
- So the part containing energy is kept, and turned into carbohydrates
- The rest is the part containing nitrogen, which is turned into ammonia.

- This is highly toxic and so is converted into urea.
- Urea is dissolved in the plasma and is taken to the kidneys to be excreted.

Deamination is the removal of the nitrogen containing part of the amino acid to form urea.



The toxic consequences of high urea levels are:

1. Cell death
2. Reduced response to insulin, leading to diabetes
3. Deposits inside blood vessels

Homeostasis

Homeostasis is defined as the maintenance of a constant body temperature

- **Set point** is the normal value or range of values for a particular parameter
- **Negative feedback** is a mechanism that detects a move away from the set point and brings about the actions that take the value back towards the set point

Controlling blood glucose concentration

Pancreas secrete two hormones:

Insulin	When glucose levels are high, it decreases blood glucose concentration ➔ The liver cells use some glucose in respiration and store some glucose as glycogen. The blood glucose concentration falls
Glucagon	When glucose levels are low, it increase blood glucose concentration ➔ The liver breaks down glycogen into glucose and releases it into the blood

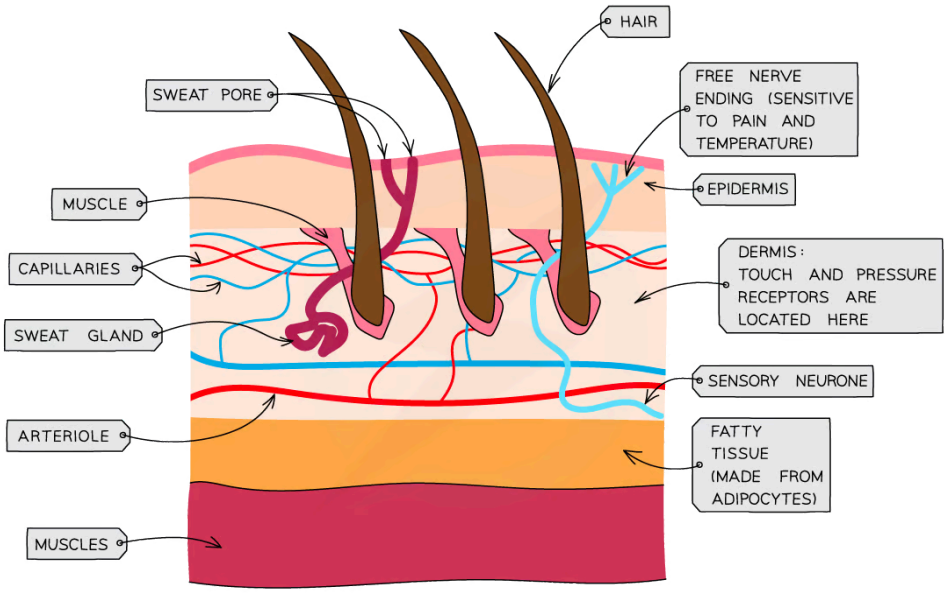
Controlling body temperature

A constant body temperature of 37^{o} C helps enzymes to work at the optimum rate.
A part of the brain called the **hypothalamus** regulates the internal temperature, as it contains receptors which are sensitive to the temperature of the blood

- The skin also has receptor cells which are sensitive to temperature and sends impulses to the brain via the sensory neuron
- The brain responds to this information by sending nerve impulses by the motor neurons to the effectors in the skin to maintain the temperature by:

When temperature rises:	**When temperature falls:**
Sweat glands secrete more sweat. The water in the sweat the evaporates taking heat from the skin, thus cooling the body	**Sweat glands reduce secretion**. Sweating helps to cool the body down, so it is not required when you want warmth.
The erector muscles in the skin relax so that **hair**	The erector muscle in the skin contracts so **hair**

lie flat on the skin, allowing heat to leave the skin by radiation into the air	**stands up.** This traps a thicker layer of air, acting like an insulator
Vasodilation: arterioles supplying the capillaries near the surface of the skin become wider - dilated. Lot of blood is near the surface of the skin so heat is readily lost	**Vasoconstriction:** arterioles supplying the capillaries near the surface of the skin become narrower. Reduces the amount of heat lost by radiation



Hormones

Hormones are chemicals that are produced by a gland and carried in the blood, which alter the activities of their specific target organs.
The glands that produce hormones in animals are known collectively as the **endocrine system.**

Hormone	Source	Role	Effect
Insulin	pancreas	Decreases blood glucose concentration	The liver cells use some glucose in respiration and store some glucose as glycogen.
Glucagon	pancreas	Increases blood glucose concentration	The liver breaks down glycogen into glucose and releases it into the blood
Adrenaline	Adrenal gland	Prepares body for vigorous action (a fight or flight response)	1. Heart rate increases to supply oxygen to brain and muscles more rapidly 2. Breathing rate increases so that more oxygen can enter the lung 3. Pupils dilate so that more light can enter the eye to see danger more clearly
Testosterone	testes	Main sex hormone in males	Development of secondary sexual characteristics in males

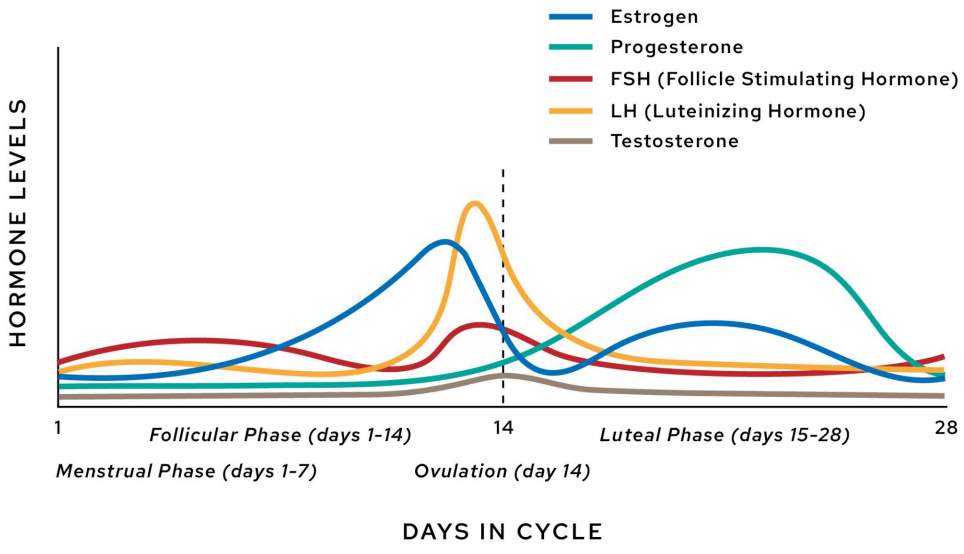
MENSTRUAL CYCLE

The loss of broken down uterus lining through the vagina is called **menstruation**

There are 4 main hormones involved in the menstrual cycle of a woman:

Hormone	Secreted by	Function

Follicle stimulating hormone (FSH)	Pituitary gland	• Causes an egg to mature • Triggers ovaries to produce oestrogen
Oestrogen	Ovaries	• Causes the lining of the uterus (endometrium) to become thick • Stops the pituitary gland from releasing more FSH
Luteinising hormone (LH)	Pituitary gland	Instead of releasing FSH the pituitary gland now releases LH • Triggers ovulation (day 14) - the ovary releases the egg
Progesterone	Corpus luteum - follicle from which the egg was released	• Maintains and thickens the lining of the uterus • Inhibits FSH and LH production • If fertilisation does not occur levels drop and menstruation occur



Plant hormones

Plants respond to stimuli by the hormone **auxin**

In plants there are 2 types of tropisms or growth responses:

Response	Description	Auxin role:
Phototropism:	a growth response by a plant, in which part of a plant grows towards or away from the direction from which light is coming	• If the sun shines on the right side of a plant's shoot, auxins accumulate on the dark opposite left side. • Auxins accumulating makes cells on the left side grow faster than cells on the right. • When the left side of the shoot starts growing faster than the right side, the shoot will start to bend to the right side towards sunlight.
Gravitropism:	a growth response in which part of a plant grows towards or away from gravity	• Made in the shoot tip • Then, it diffuses through the plant from the shoot tip • Auxin is unequally distributed in response to light and gravity • Auxin stimulates cell elongation

Coordination & Response

Stimuli are changes in the environment that can be detected by organisms.
Receptors are cells or groups of cells that detect stimuli
Effectors are parts of the body that respond to stimuli (usually muscles or glands)
The way in which receptors detect stimuli and then pass information to the effectors is called **coordination.**

The human nervous system consists of:

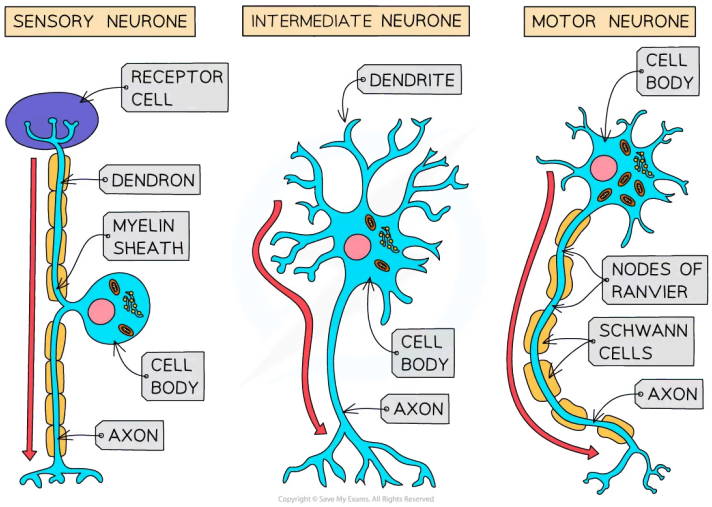
- **Central nervous system (CNS):** made up of the brain and spinal cords
- **Peripheral nervous system (PNS) :** the nerves outside the brain and the spinal cord

A bundle of neurons is known as a **nerve**
A **neuron** is a specialised cell for conducting electrical impulses rapidly.
A **nerve impulse** is an electrical signal that rapidly passes along an axon.
Adaptive features of neurons:

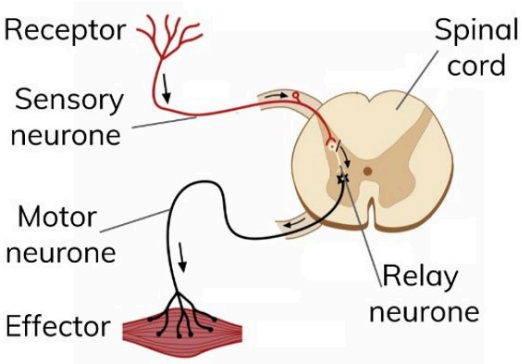
1.) Have a long fibre called axon that helps in wasting less time in transferring nerve impulses
2.) The axon is insulated by at sections with a myelin sheath this means the electrical impulses jump from one node to another
3.) The cell body contains many extensions called dendrites ensuring connections to many other neurons.

There are 3 main types of neurons:

1.) **Sensory neurons** carry impulses from receptors to the CNS (brain / spinal cord)
2.) **Relay neurons** are found inside the CNS and connect sensory and motor neuron
3.) **Motor neurons** carry nerve impulses from the CNS to the effector (muscles/glands)



Reflex arc is the pathway along which the nerve impulses transmit through the sensory, relay and motor neuron.



There are 2 types of responses:

Voluntary response one where you make a conscious decision, coordinated by the brain to carry out a particular action.
Involuntary response (or **reflex**) one that does not involve the brain as the coordinator and is an automatic and rapid response to a stimulus. Involuntary actions are: • Automatic • Rapid • protective

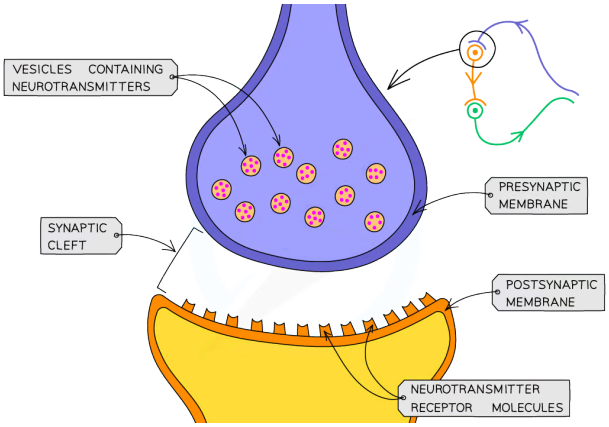
A SYNAPSE

Neurons never touch each other. The junction (gaps) between them is called a **synapse**

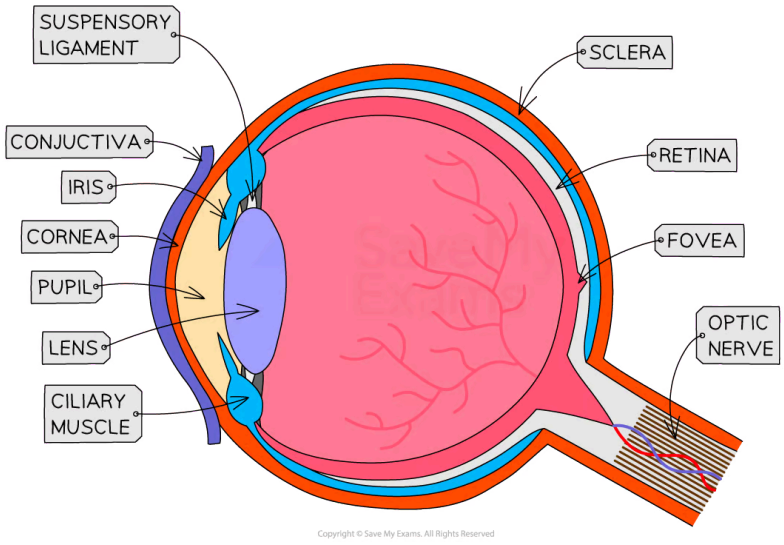
Neurotransmitter: is a chemical stored in the vesicles at the end of the neuron which diffuses across the synaptic cleft and sets up an electrical impulse in the next neuron.

Process:

1.) An impulse arrives at the end of the presynaptic neuron
2.) This causes the vesicles carrying neurotransmitters to move towards the cell membrane of the presynaptic neuron.
3.) These vesicles fuse with the membrane and release the neurotransmitters into the synaptic cleft. The neurotransmitter diffuse across a concentration gradient
4.) The neurotransmitters attach to the receptor protein on the membrane of the postsynaptic neuron, which is complementary to the shape of the neurotransmitter molecule
5.) This triggers an impulse which travels along the postsynaptic neuron. The process repeats



THE EYE



Structure	Function
Cornea	Transparent covering at the front of the eye that refracts (bends) light
Iris	Muscle that controls how much light enters the pupil. ● This is the coloured part of the eye In the middle of the iris is a gap called **pupil.**
Lens	Transparent disc that changes shape to focus light onto the retina
Retina	Layer of light receptor cells that detect light intensity and colour. There are two types of receptor cells in retina: **1.) Rods:** sensitive to light (even dim) but do not detect colour **2.) Cones:** sensitive to light of different colour but only function in bright light **Fovea** is a part of the retina filled with cones, where light is focused when you look directly at an object. **The blind spot** is the part of the retina where optic nerve leaves and there are no receptor cells
Optic nerve	Sensory neuron that carries electrical impulses from the eye to the brain

THE PUPIL / IRIS REFLEX (example of involuntary or reflex action)

The pupil reflex occurs due to changes in the **iris muscles**

The iris muscles contains (antagonistic):

- ☐ The **circular muscles** are arranged in circles around the pupil
- ☐ The **radial muscles** radiate outwards from the edge of the pupil

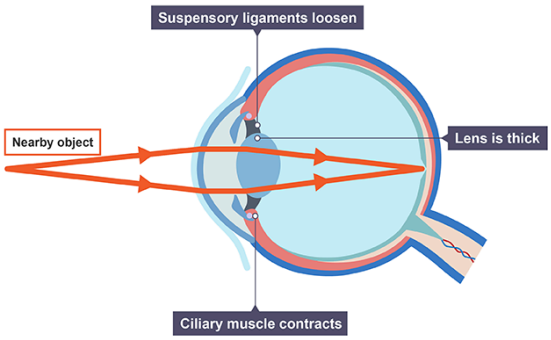
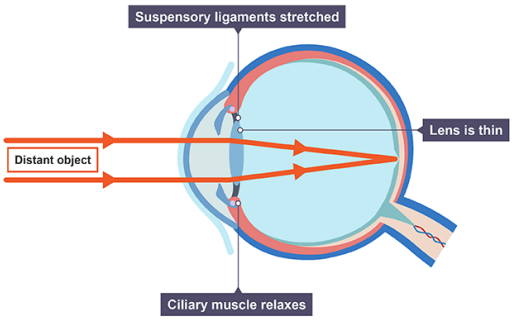
In **dim light** the pupil dilates (enlarges) in order to allow as much light into the eye as possible ● The radial muscle contracts ● The circular muscle relaxes ● Pupil dilates
In **bright light** the pupil constricts in order to prevent too much light to enter and damage the eye ● The radial muscle relaxes ● The circular muscle contracts ● Pupil constricts

ACCOMODATION

Accomodation is the term used to describe the way in which the eye focuses on near or distant objects.

Accomodation occurs by changing the shape of the lens,which is controlled by:

Ciliary muscles and **suspensory ligaments** (antagonistic pair)

Near objects	**Distant objects**
• Suspensory ligament relax • Ciliary muscles contract • Lens is more rounded • More light refracted 	• Suspensory ligament contract • Ciliary muscles contract • Lens becomes thinner • Less light is refracted 

Nervous system	Endocrine system
Made up of neurons	Made up of glands
Information transmitted in the form of nerve impulses	Information transmitted in the form of chemicals called hormones
Impulses transmitted along neurons	Chemicals carried in the blood plasma
Impulses travel very quickly, so action is fast	Chemicals travels more slowly, so action is slower
Effect of a nerve impulse usually lasts for a very short time	Effect of a hormone may last longer

Reproduction

There are two types of reproductions:

1.) **Asexual reproduction** is the process resulting in genetically identical offspring from one parent to another

Advantages	Disadvantages
1.) Fast: no need to find a mate **2.)** Genetically identical offspring. So good characteristics are kept	**1.)** No genetic variation **2.)** Harmful genes transferred **3.)** Prone to extinction because of no variation thus no adaptation abilities

2.) **Sexual reproduction** is the process of fusion of the nuclei of two gametes (sex cells) to form a zygote and the production of offspring that are genetically different from each other.

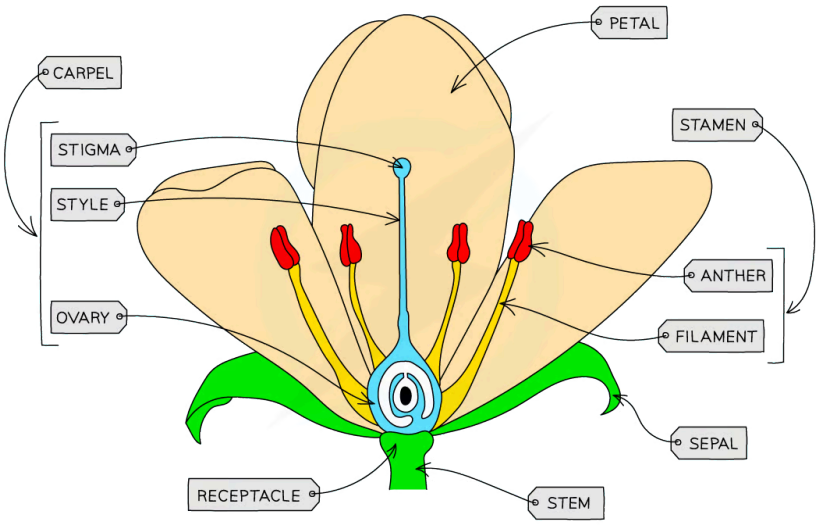
Advantages	Disadvantages
3.) Increases genetic variation **4.)** The species can adapt to new environments due to variation, giving them a survival advantage **5.)** Disease is less likely to affect population	**4.)** Takes time and energy to find a mate **5.)** Difficult for isolated members of the species to reproduce

Reproduction in plants:

Flowers are the reproductive organs of plants: role is to make gametes and ensure fertilisation

Structure of a flower:

Structure	Description
Sepal	Protects unopened flower
Petals	Coloured structures that attract insects or birds to a flower
Anther	Produces and releases pollen
Filament	Provides support to the anther
Stigma	Sticky top of the female part of the flower which collects pollen grains
Style	A tube that connects the stigma and ovary
Ovary	Contains the ovules
Ovules	Structures inside the ovary that contains the female gamete



POLLINATION

The process by which pollen is transferred from the male part of the flower to the female part of the flower is known as **pollination.**

Pollination is of two types: **cross & self**

Self pollination	Cross pollination
The transfer of pollen grains from the anther of one flower to the stigma of the same flower or a different flower on the same plant.	The transfer of pollen grains from the anther of a flower to the stigma of a flower on a different plant of the same species
Advantages: 1. Slight genetic variation 2. High chance of successful pollination 3. Fast and saves time	**Advantages:** 1. Higher genetic variation 2. Quick to adapt to the surrounding 3. Less susceptible to disease
Disadvantages: 1. Susceptible to the same disease as parent	**Disadvantages:** 1. Reliance on pollinators 2. Wastage of pollen

Insect pollinated	Wind pollinated
Bright petals	Dull petals
Scent and nectar are produced	No scent and nectar
Pollen generated in moderate amounts. It is spiky/sticky; large in size	Pollen generated in huge amounts. It is smooth and light
Anther is held firmly within the flower so that they brush against the insect	Anther dangling outside the flower to release pollen grains easily into the wind
Sticky stigmas to catch pollen grains when insects brush past	Feathery stigma outside the flower to catch airborne pollen grains

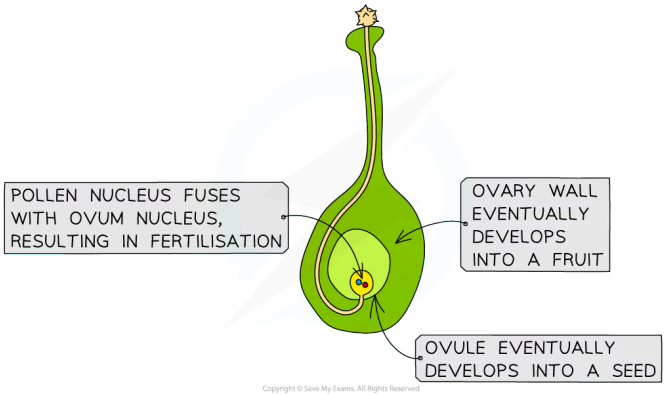
FERTILISATION

Fertilisation is the fusion of a pollen nucleus with an ovum nucleus

- The male gametes are in pollen grains.
- The female gametes are in ovules.

The process:

1.) Pollen tube growing from a pollen grain
2.) Pollen tube/grain releases enzymes to digest a pathway through the style
3.) The ovule is surrounded by protective layers called integuments. At one end of the ovule there is a hole called the micropyle
4.) The pollen tube grows through the micropyle, into the ovule
5.) Pollen nucleus travels down the pollen tube
6.) Fertilisation occurs: pollen nucleus fuses with ovum nucleus and a zygote is formed



GERMINATION

Germination is the start of growth in the seed

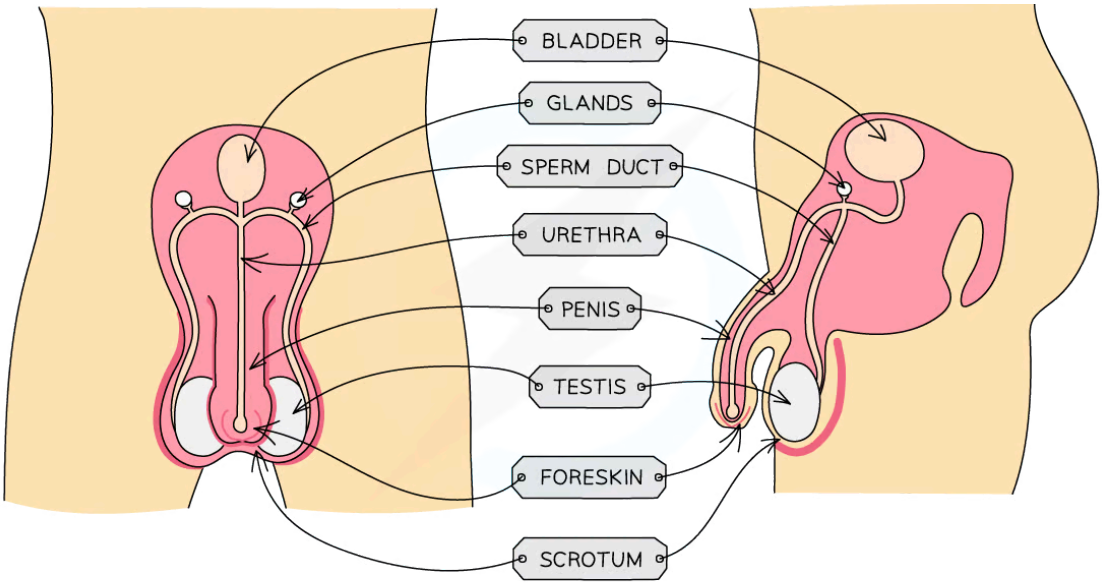
Three factors are required for successful germination:

1. **Water -** allows seed to swell up and the enzymes in the embryo to start working for growth
2. **Oxygen** to provide energy that can be released for germination
3. **Temperature** must be suitable for the enzymes to work (at optimum temperature)

Reproduction in Humans:

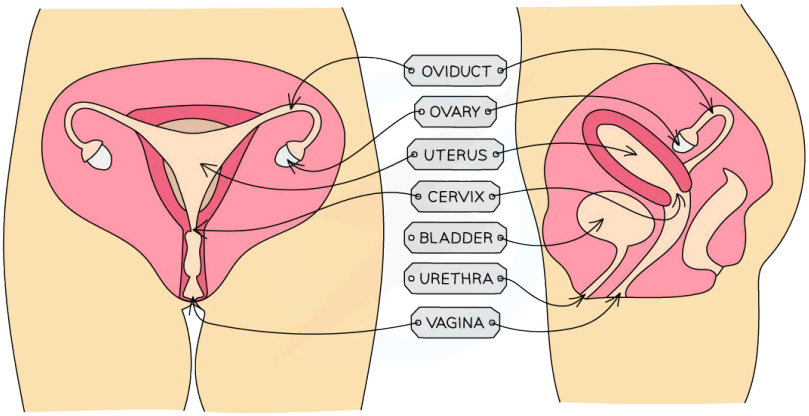
The male reproductive system

Structure	**Function**
Testis	Produces sperm (male gametes) and testosterone (hormone)
Scrotum	The sac that contains the testes & provides a suitable temperature.
Prostate gland	Produces fluid called semen that provides sperm cells with nutrients
Sperm duct	Sperm are carried away from each testis in this tube. This duct joins up with the urethra, located just below the bladder
Urethra	Carries semen, sperm and urine out of the body. A ring of muscles in the urethra prevents the urine and semen from mixing
Penis	Expels urine and delivers sperm into the vagina during sexual intercourse.



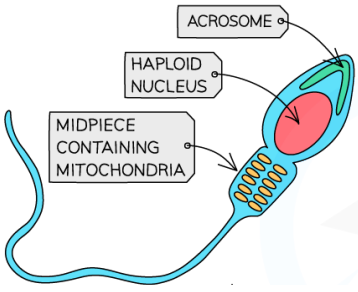
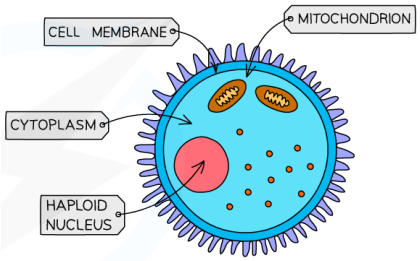
Female reproductive system

Structure	Function
Ovary	Produces egg cells (female gametes) and hormones - oestrogen & progesterone
Oviducts	Site of fertilisation and tube that connects the ovaries to the uterus
Uterus	Muscular bag with soft lining (endometrium). The fertilised egg (zygote) will be implanted here.
Cervix	Ring of muscles at the lower end of the uterus to keep the developing foetus in place during pregnancy
Vagina	The muscular tube that leads to the inside of a woman's body where the penis enters during sexual intercourse



THE GAMETES

Adaptations:

Sperm (male gamete):	**Egg (female gamete):**
1. Has a flagellum that enables it to swim towards the egg 2. Contains enzyme (acrosome) in the head region which digests a route into the egg 3. Contains many mitochondria to provide energy from movement	Cytoplasm contains energy store to provide energy for cell division in the developing zygote Jelly-like coating that hardens to make an impenetrable barrier after fertilisation to prevent more sperm entering the cell.
	

Difference between an egg and sperm cell:

Sperm	Egg
Very small in size	Relatively bigger in size than sperm
Capable of locomotion	Not capable of locomotion

Elongated and streamlined	Round cell
Produced every day in huge number (millions per day)	Thousands of immature egg in each ovary but only one is released per month

FERTILISATION

Fertilisation is the fusion of nuclei of the male gamete (sperm cell) with the nuclei of the female gamete (egg cell).

In humans it occurs in the oviduct.

Pregnancy:

After fertilisation:

IMPLANTATION

- The zygote travels towards the uterus for 3 days. During this duration the zygote will divide several times to form a ball of cells known as an **embryo.**
- After 3 days, when the embryo reaches the uterus, it embeds itself in the thick lining of the uterus. This is called **implantation.**

GESTATION

- The embryo continues to grow and develop for 9 months. This period is called **gestation**
  - ➔ After 12 weeks, the embryo has developed most of its organs and a placenta is formed. Now the embryo is called a **foetus.**
  - ➔ The remaining time is used for the foetus to grow and develop.

  During the gestation period the foetus' grows and developed by gaining the following substances from its mother: **Glucose, oxygen, water, amino acids and fats**

Role of placenta:

- The placenta is the site for the diffusion of these substances. It is adapted by having a large surface area (presence of villi) and thin wall to shorten the diffusion distance for efficient diffusion.

  Remember: the mother's blood is present in the lining of the uterus.
  The mother and foetus' blood never mix because they run opposite to each other
- The placenta also acts as a barrier against pathogens getting inside the foetus' blood.

Role of the umbilical cord:

- Attaches the foetus to the placenta

Blood vessel	Content	Movement
Umbilical artery	Urea & Carbon dioxide	foetus' blood → mother's blood
Umbilical vein	Oxygen, glucose, amino acids, fats	mother's blood → foetus' blood

Role of Amniotic sac:

- The amniotic sac contains **amniotic fluid** (made from mother's plasm).
  - ➔ This fluid provides cushion and protects the foetus during development.

SEXUALLY TRANSMITTED INFECTIONS (STIs)

Unprotected sexual intercourse can lead to the transfer of pathogens via exchange of body fluids. Infections passed on in this way are known as **sexually transmitted infections**

Example: HIV (Human immunodeficiency virus) causes **AIDS** (acquired immunodeficiency disease)
Transmission: unprotected sexual intercourse, blood transfusion, organ transplant, sharing a needle with an infected person
How it affects the immune system: • First symptom would be a mild-flu • The virus infects a certain type of lymphocyte • Normally lymphocytes seek out and destroy pathogens by producing antibodies • However, HIV avoids being recognised and destroyed by lymphocytes by repeatedly changing its protein coat • It then infects a certain type of lymphocytes reducing its number and multiplies • This decreases the body's ability to carry out an immune response and fight off infections, eventually leading to AIDS (and even death)

Controlling the spread of STIs

- Limiting the number of sexual partners an individual has
- Not having unprotected sex, but making to always use a condom
- Getting tested if unprotected sex or sex with multiple partners has occurred
- Raising awareness by education programmes

Inheritance

Inheritance is the transmission of genetic information from generation to generation

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Chromosomes are made of DNA, which contains genetic information in the form of genes

- **Haploid:** a cell with a single set of chromosomes (like gametes)
- **Diploid:** a cell with a complete set of chromosomes (like zygotes)

Humans have 23 pairs (46 chromosomes) of chromosomes

➔ **22 pairs are autosomes:** responsible for growth and repair

- ➔ **1 pair is sex cell:** responsible for reproduction
  - ☐ For females this chromosome is XX
  - ☐ For males this chromosome is XY (gender of offspring depends on male)

DNA (Deoxyribonucleic acid) is a molecule that contains genetic information in the form of genes

- The structure of a DNA is called ‘double helix’
- It is made of smaller molecules called nucleotides
- Each nucleotide contains a base

There are 4 bases - A, C, G & T

- ➔ A (adenine) always pairs with T (thymine)
- ➔ C (cytosine) always pairs with G (guanine)

DNA controls the function of the cells by **controlling the production of protein through gene expression**

PROTEIN SYNTHESIS

Protein synthesis is the process by which cells make proteins.

Protein synthesis involves 2 main stages: **transcription** and **translation**

Transcription (occurs in the nucleus)	The messenger RNA ‘copy’ the base sequence on the DNA	➔ The DNA molecule unwinds and the two strands separate ➔ mRNA (messenger RNA) is formed by copying the base sequence on the DNA ➢ mRNA is a molecule that carries the genetic code from the DNA in the nucleus to the ribosome in the cytoplasm. ➔ mRNA leaves the nucleus
Translation (occurs in the cytoplasm)	The process when the ribosome ‘reads’ the base sequence and assembles the required amino acids	➔ The mRNA molecule attaches to a ribosome, which “reads” the genetic code in mRNA ➔ The ribosome links the amino acids together in the order specified by the mRNA sequence

	in the specific order is called **translation.**	

Expression of a gene means whether the gene has been transcribed or translated in a particular cell

- ➔ Most genes are not expressed because it would be a waste of energy and other resources in the cell. Only the genes whose proteins are vital to the cell's functions are expressed
- ➔ These proteins may be **enzymes, antibodies, receptors for neurotransmitters**

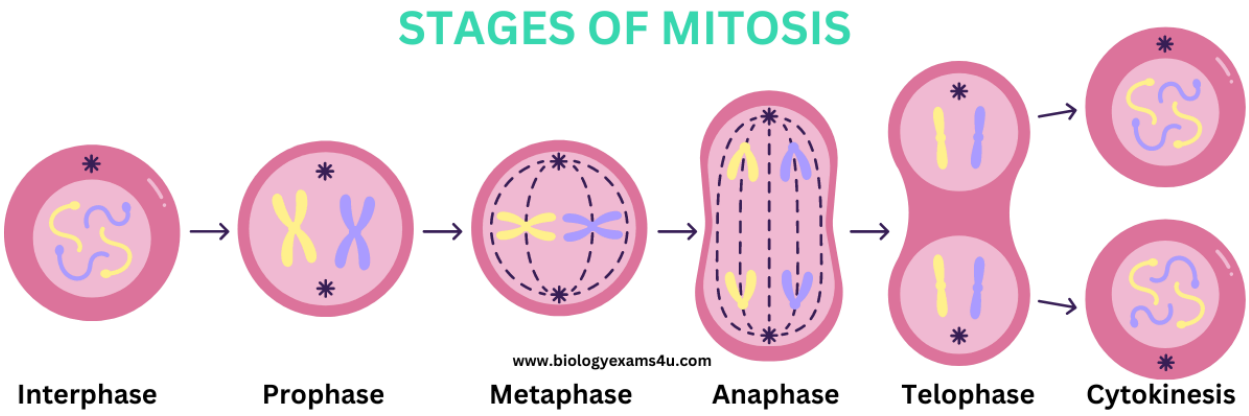
MITOSIS

Mitosis is a form of nuclear division giving rise to genetically identical cells

- Repair and replacing old damaged tissue
- Growth
- Asexual reproduction giving rise to genetically identical cells

How does it happen?

- ➔ Just before mitosis takes place, each of the chromatid in the parent cell are copied
- ➔ The DNA is replicated to ensure each daughter cell receives a complete copy of the genetic material
- ➔ The chromosomes line up along the nucleus
- ➔ The copies of each chromosome separate so that each copy of the chromosome is pulled to opposite poles
- ➔ The cell membrane constricts in the middle and the nucleus is separated, giving rise to two genetically identical daughter cells



Stem cells are unspecialised cells that divide by mitosis to produce daughter cells that can become specialised for specific functions

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MEIOSIS

Meiosis is a type of nuclear division that reduces the chromosome number by half giving rise to 4 genetically diverse haploid cells

- Produces gametes (sex cells)
- Increases genetic variation

Mitosis	Meiosis
2 daughter cells are produced	4 daughter cells are produced
Daughter cells are genetically identical to each other and the parent cell	Daughter cells are genetically different from each other and the parent cell
Diploid (same as parent cell)	Haploid (half of parent cell)
Autosomes participate: responsible for repair, growth and asexual reproduction	Sex cells (gametes) produced: responsible for reproduction
One cell division occurs	Two cell division occur

GENES & ALLELES

Gene a length of DNA that codes for a particular sequence of amino acids, to make a specific protein

Allele an alternative form of a gene

- **Homozygous** organism having two identical allele of a particular gene
- **Heterozygous** organism having two different allele of a particular gene

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- **Dominant allele** is the allele that is expressed
- **Recessive allele** is the allele that is only expressed in the absence of a dominant allele

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- **Genotype** the genetic makeup of an organism, containing of all the allele present

- **Phenotype** the observable features of an organism as a result of the expression of the expression of particular alleles of the gene

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A monohybrid cross is the genetic mix of two individuals which determines a characteristics controlled by the genes

- Determined using a **punnett square.**
- **Pedigree diagrams** are family tree diagrams used to trace pattern of inheritance of a specific characteristic through generations of a family

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Test cross is a breeding experiment used to describe whether an organism ‘s genotype is homozygous dominant or heterozygous dominant.

- Conducted by breeding the organism with a **homozygous recessive organism**

The offspring are observed for their traits:

➔ If all show the dominant trait, the unknown organism is homozygous dominant

➔ If few show a mix of dominant and recessive, the unknown organism is heterozygous

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Codominance is the situation where neither allele is recessive and both allele are expressed in the phenotype when they are present

Example - blood group

➔ Allele I^A and I^B are codominant but both are dominant to I^O

GENOTYPE	PHENOTYPE
$I^A I^A$ OR $I^A I^O$	A
$I^B I^B$ OR $I^B I^O$	B
$I^A I^B$	AB
$I^O I^O$	O

SEX-LINKED CHARACTERISTICS

Some genes are located in the sex chromosomes. A characteristic which comes from one of these genes is referred to as a **sex-linked characteristic.**

X-linked characteristics are more common in male than females because:

- A female has 2 X chromosomes
  - ➔ A female may be a **carrier** (individuals who are unaffected but can pass it to the next generation) having a faulty gene on one X chromosome and a normal gene on the other
- A male has only 1 X chromosome
  - ➔ However, whatever allele the male inherits for an X-linked gene will determine his characteristic - even if the allele is recessive.

Y-linked characteristics only occurs in males

Variation & Selection

Variation is defined as differences between individuals of the same species

There are two types of variation:

1. **Genetic variation:** the differences in characteristics caused by difference in genes

   Genetic variation can be caused by a variety of sources:

   - **Meiosis**
   - **Random mating**
   - **Random fertilisation**

- **Mutations:** random genetic changes to the base sequence of DNA which sometimes result in new alleles being formed.

  The rate of mutation can be increased by:

  ➔ Chemicals (such as tar in tobacco)

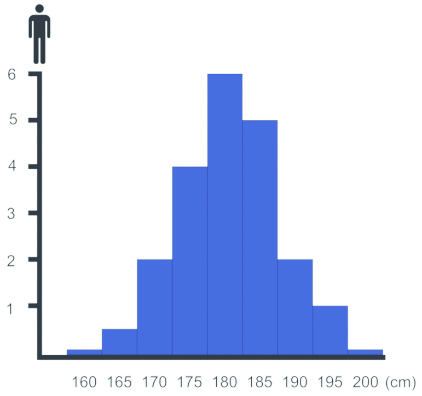
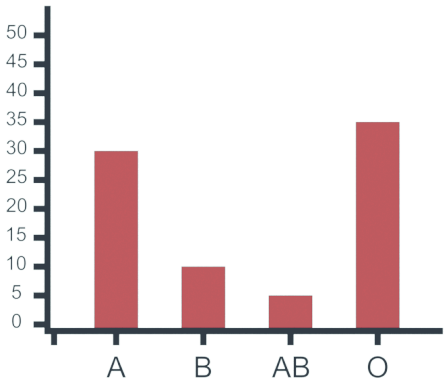
  ➔ Ionising radiation (gamma and X-rays)

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2. **Phenotypic variation:** the difference in features between individuals of the same species

Phenotypic variation can be caused by 2 main ways: **genetic** and **environmental factors**

Phenotypic variation can be classified into 2 types:

Continuous variation	**Discontinuous variation**
When there are many small degrees of differences for a particular characteristic.	When there are distinct differences for a particular characteristics
Range of phenotypes between two extremes	Discrete number of categories - no 'in betweens'
Caused by environment and genetic factors	Caused by genetic factor alone
Example: height, mass, foot size	Example: blood group, gender, ability to roll tongue
	

ADAPTIVE FEATURES

Adaptive features are inherited functional features that help the organism by increasing its fitness

Fitness is the ability of an organism to survive and reproduce in the environment in which it is found

- ➔ **Xerophytes** are plants adapted to live in very dry climates
- ➔ **Hydrophytes** are plants adapted to live in very wet conditions

	Xerophytes	**Hydrophytes**
Leaf cuticle	Thick waxy cuticle - makes leaf waterproof and prevents water loss	Thin waxy cuticle - as there is no need to prevent water loss
Roots	Spread widely and/or penetrate deeply into the soil in search of water	May hang in the water Sometimes grow in the mud but not deeply
stomata	Osmotic changes in the guard cells cause a stoma to open/close to control transpiration	There is no need to close the stomata when it is hot as the plant has more water than it needs
Stomatal density	Underside of leaves as it is usually cooler than the upper side, so less water is lost through evaporation	Upper and lower (both) mainly on the upper side for easy gas exchange and getting more sunlight for photosynthesis

SELECTION

There are 2 types of selection: **natural and artificial (also called selective breeding)**

A process in which individuals with advantageous features (or the best adaptive features) are more likely to survive, reproduce and pass on their alleles to the next generation is called **natural selection**

1. **Variation** individuals in a species show a range of variation caused by differences in genes or environmental factors
2. **Overproduction** when organisms reproduce they produce more offspring than the environment is able to support

3. **Competition for food and resources**: individuals which are best adapted to the environment have a higher chance of survival and more chances to reproduce
4. **Alleles that confer useful adaptations more likely to be passed on:** individuals with better adaptations are more likely to survive and produce many offspring, which inherit these alleles

This is known as **evolution.**

Theory was put forward by **charles darwin** became known as '**survival of the fittest'**

Selective breeding or natural selection is the process of selecting individuals with desirable characteristics and breeding them together

Natural selection	**Artificial selection**
Occurs naturally	Occurs only with human intervention
Results in development of population with features that are better adapted to their environment and survival	Results in development which are more useful to humans and not necessarily to survival of the individuals
Usually takes a long time to occur	Tales less time as only individuals with the desired features are bred and allowed to reproduce

Organisms and their environment

The sun is the main source of energy input to biological systems

A **food chain** shows the transfer of energy from one organism to the next, starting with a producer

Plants (producers) → grasshoppers (primary consumers) → flycatcher (a secondary consumer)

➔ The arrows in a food chain show the transfer of energy from one trophic level to the next

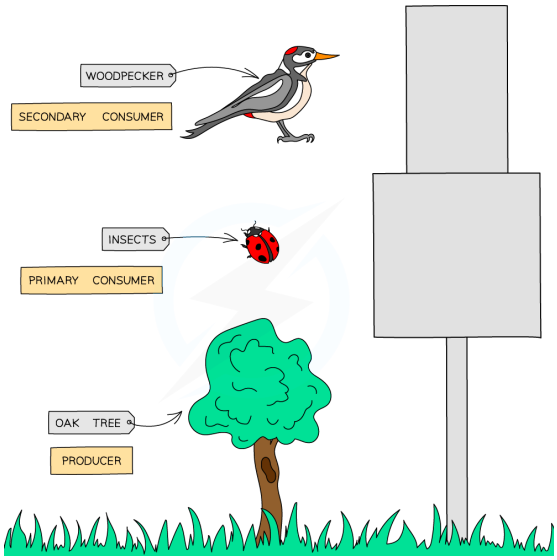
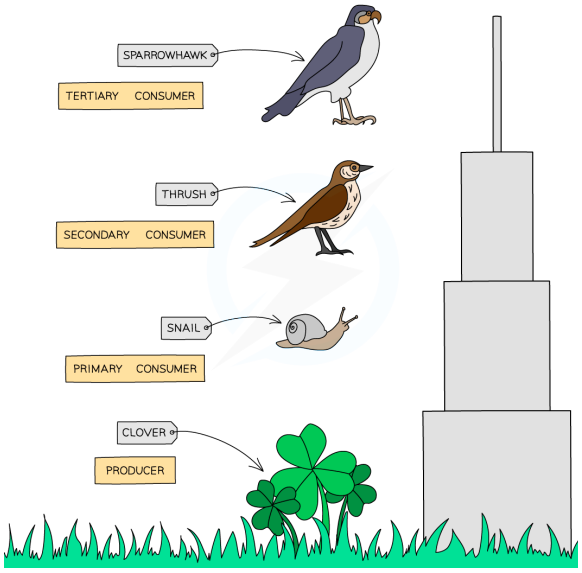
A **food web** is a network of interconnected food chains

Food webs are more realistic way of showing connections between organisms within an ecosystem as:

➔ Animals rarely exist on just one type of food source

➔ They show interdependence - how the change in one population can affect others

The **trophic level** is the position of an organism in an food chain, food web, pyramid of biomass or numbers

PYRAMID OF NUMBERS	**PYRAMID OF BIOMASS**
The pyramid of numbers is a diagram in which the width of the bar at each trophic level shows the relative number of organisms at that level in the food chain	A pyramid of biomass shows how much mass the creatures at each level would have without including all the water that is in the organisms (their 'dry mass')
Remember: A pyramid of numbers **is always pyramid shaped**. ● This is because the size of the organism must also be considered (but not drawn based on size). Example an oak tree is enough to feed many smaller organisms.	**Remember:** a pyramid of biomass is **always pyramid shaped** ● This is because mass if organisms has to decrease as you go up a food chain
	

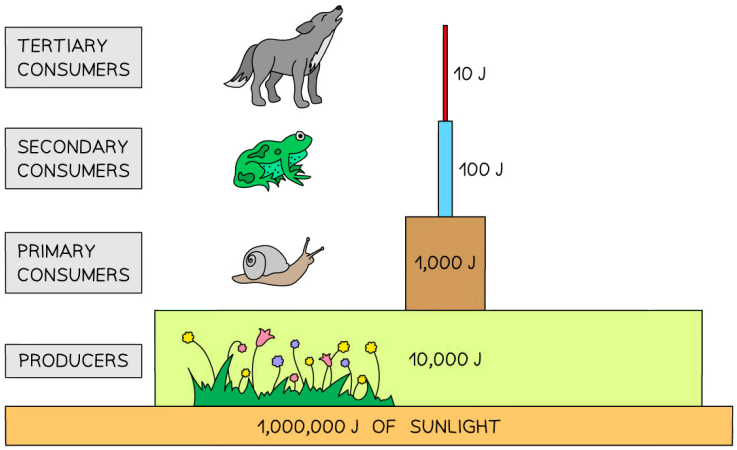
Note: pyramids of biomass provides a much better idea of **quantity** of the plan or animal at each level of a food chain and therefore are a better way of representing interdependence

PYRAMIDS OF ENERGY

The majority of the energy an organism receives gets lost or used through:

1. **Making waste products**
2. **As movement**
3. **As heat**
4. **As undigested waste**

The inefficient loss of energy (1/10 at each level) at each trophic level explains why food chains are rarely more than 5 organisms long



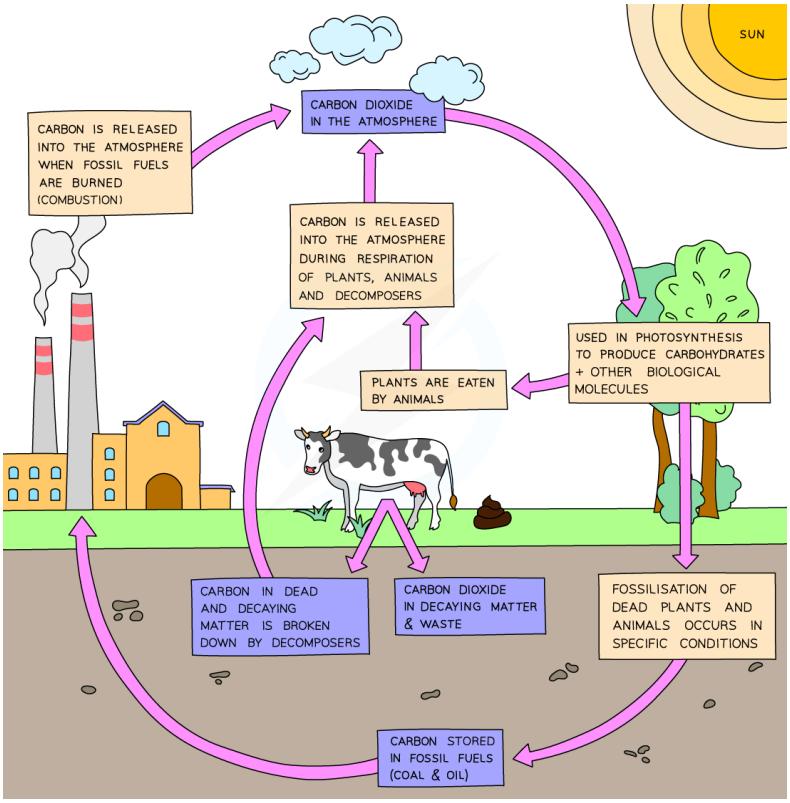
- This is also the reason why it is more efficient for humans to consume plant-based diet than animal-based diet as it is higher in energy

THE CARBON CYCLE

Carbon is present in the atmosphere in the form of carbon dioxide, which makes up about 0.04% of the air

- Carbon dioxide is taken in by the plants during **photosynthesis**. Here carbon is transferred from carbon dioxide to other molecules such as proteins and carbohydrates
- These molecules are passed through the food chain when consumers eat plants
- These consumers **respire** releasing carbon dioxide back into the atmosphere
- Carbon in dead and decaying matter is broken down by the decomposers in **decomposition**
- These decomposers also **respire** releasing carbon into the atmosphere
- Carbon dioxide can be trapped in dead organisms.
- These organism turn to fossil fuels over thousands of years

- When this fuel is burned during **combustion** large amounts of carbon dioxide is released back into the atmosphere



THE NITROGEN CYCLE

Nitrogen is used to make **amino acids, DNA and ATP** (molecule that releases energy)

Nitrogen (N_2) is a very stable gas, so neither plants nor animals can absorb it from the air

- The process of converting atmospheric nitrogen to ammonia and other related (usable) compounds is called **nitrogen fixation**

Three ways in which nitrogen can be converted into usable form are:

1. **Lightning:**
   - ➔ Makes some of the nitrogen gas in the air to combine with oxygen by splitting the N_2 triple covalent bond:

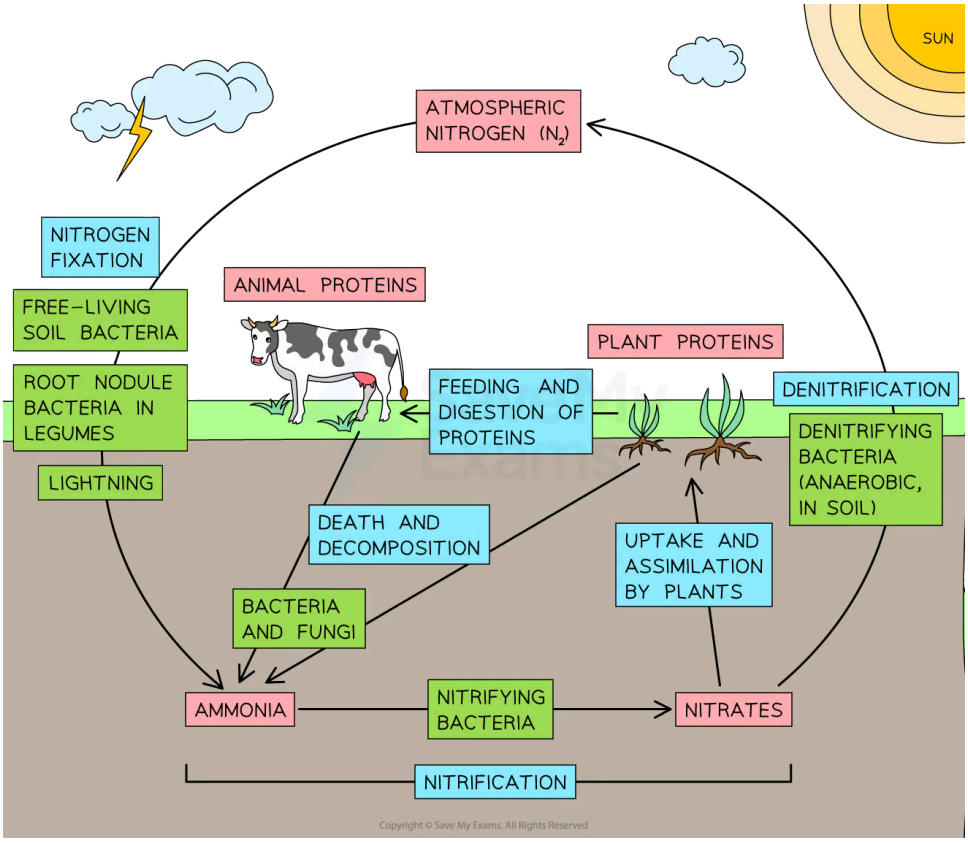
     $N_2 + O_2 \rightarrow$ **Nitrogen oxides** (NO, NO_2 and N_2O)
   - ➔ These nitrogen oxides combine with rainwater to form:

     NO/ NO_2/N_2O + $H_2O \rightarrow$ **nitrates** (NO_3^-)
   - ➔ Plants absorb nitrogen from the soil in the form of **nitrates** and use it to build proteins
2. **Artificial fertilisers:**
   - ➔ Nitrogen and hydrogen react in the **haber's process** forming ammonia

➔ Ammonia is used to make ammonium compounds and nitrates sold as **fertilisers**

3. **Biologically:**

Nitrogen fixation	Nitrogen fixing bacteria like **rhizobium and azotobacter** are found on the root nodules of leguminous plants. ➔ These bacteria **convert nitrogen to ammonia** $N_2 \rightarrow NH_3$ (ammonia)
Nitrification	The **nitrifying bacteria** turns these ammonia into nitrates. ➔ Changing ammonia into nitrates is called **nitrification** NH_3 (ammonia) $\rightarrow NO_2^-$ (nitrites)$\rightarrow NO_3^-$ (nitrates) Some of the nitrates travel up the root through active transport
Decomposition	Dead plant and animal matter contain nitrogenous waste, which releases ammonia over time while **decomposition**. ➔ **Nitrification** occurs
Denitrification	While some of nitrates are converted back to atmospheric nitrogen by **denitrifying bacteria** in the process of **denitrification** (conversion of nitrates back to nitrogen gas)



POPULATION

A **population** is a group of organisms of one species, living in the same area at the same time

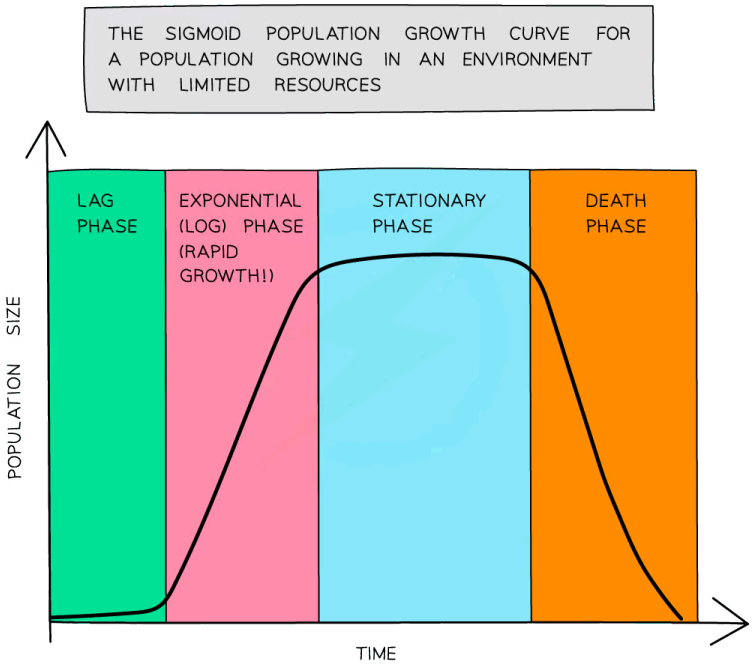
A **community** is all of the populations of different species in an ecosystem

An **ecosystem** is an unit containing the community of organism and their environments interacting together

Population growth in most organisms are controlled by 3 factors:

1. Food supply
2. Predation
3. Diseases

A typical growth curve for a population:



Lag phase	Organisms are adapting to their environment before reproducing so very few organisms
Log phase (exponential phase)	Food supply is abundant, birth rate is rapid and death rate is low. So growth is exponential **Birth rate > Death rate**
Stationary phase	Population becomes steady (plateau) due to a factor in the environment that becomes a limiting factor **Birth rate = Death rate**
Death phase	Population decreases because food supply is short (or any other factor) **Birth rate < Death rate**

Human influences on ecosystems

Modern technology has drastically increased food supply

1. **Agricultural machinery** to use in larger land areas has improved efficiency
2. **Chemical fertilizers** to improve yield
3. **Insecticides and herbicides** are chemicals that kill off unwanted insects and weed species ensuring less damage is done and reducing competition
4. **Selective breeding** animals and plants which produce a larger yield are selectively bred to produce breeds that reliably produce high yields

MONOCULTURE

Monoculture farming means that on a given agricultural land only one species of a crop is grown

Advantages	Disadvantages
● Using machinery to cultivate a large uninterrupted area of land can be done more efficiently than tending several small separate fields ● A large area of the crop can be treated with the same herbicides or pesticides ● A uniform crop is likely to be grown at the same height and ripen at the same time so it can be easy to harvest ● More profitable for the farmer as the yield is uniform in size and quality so it is easier to sell	● Biodiversity is very low. So cannot support multiple species ● Increase in pest populations as if a pest feeds on a particular crop, farming it in a large area means ample food supply for the pest leading to increase in population ● Farmers try to reduce the quantities of these pests by spraying pesticides. This causes harmless insects being killed as well. Also sometimes upon repeated usage of the same pesticide, the pest can become resistant, reducing effectiveness

LIVESTOCK FARMING

Livestock farming involves the rearing of animals for food, leather or wool.

In **intensive livestock farming** large number of livestock are kept in the same area that would not be able to support more than a very small number of animals

Advantages	Disadvantages
● It takes up less land than extensive livestock farming ● Provide more food for people in a cheaper amount in comparison to extensive farming	● Welfare issues for the livestock as it may suffer in crowded situations ● Disease can spread more easily ● Waste from the intensive farming unit can pollute environment around ● Large quantities of food and water are needed to sustain the population. This is mostly taken from the surrounding so other plants and animals cannot live there

HABITAT DESTRUCTION

Animal habitat destruction is a big issue that exists today. Whilst habitats can be destroyed naturally i.e. tsunami, earthquakes etc, a lot of it cause solely from human activity:

- Increased area for food crop growth, livestock production, and housing
- Extraction of natural resources (such as trees)
- Marine pollution

Deforestation is the permanent destruction of forests in order to make the land available for other uses.

There are many undesirable effects of deforestation:

1. Loss of habitat for animals living in the forest
2. Reduction of food resources and breeding grounds of animals, potentially leading to extinction
3. Soil erosion due to the lack of soil support from tree roots
4. Less photosynthesis leading to increased atmospheric CO_2 levels and thus contributing to the greenhouse effect
5. Reduction of rainfall due to less plants to transpire water in the water cycle

POLLUTION

Pollution is the presence in or introduction into the environment of a substance which has harmful or poisonous effects.

Land & water pollution

Insecticides	Insecticides are used to kill pests to enhance crop yields but they can often also kill other harmless animals. ● For example, DDT was used to kill mosquitoes but it also remained in the environment and was absorbed into food chains resulting in bioaccumulation which killed a lot of other good animals. DDT is now banned.
Eutrophication	A chain of events caused by addition of extra plant nutrients to water, frequently due to run-off from the land, resulting in a decrease in the concentration of dissolved oxygen for aerobic respiration 1. Runoff of fertilisers from farmland enters the water, causing increased growth of algae and water plants 2. This algae bloom blocks sunlight so water plants on the bottom start to die 3. The algae also starts to die when competition for resources intensifies 4. As plants and algae die, decomposing bacteria increases 5. This bacteria uses the dissolved oxygen for aerobic respiration 6. Concentration of dissolved oxygen decreases and aquatic organisms such as fishes insects are unable to breathe and die
Untreated sewage	Sewage is untreated organic waste produced along with household and industrial waste material. Dumping untreated sewage into the environment can lead to a lot of problems such as: ● Eutrophication ● Death of aquatic animals due to pathogens in the sewage ● Spread of waterborne diseases which can infect people by drinking polluted water
Nuclear fall-out	This is a leak from a nuclear power station. Radioactive particles can get carried into the environment and settle. Organisms then absorb these particles which can result in cancer.

Chemical waste	Inorganic waste (i.e. nickel, aluminium, lead, mercury) that are dumped into water bodies can lead to the bioaccumulation of these (heavy) metals. These heavy metals are persistent (do no break) so they can build up in food chains, poisoning the top carnivores
Plastics	Plastics can not only physically trap and harm animals, but they can deteriorate into smaller pieces (microplastics) and be consumed by them too. To make matters worse, toxic gases are produced when plastics are burned.

Air pollution

Greenhouse effect	The earth contains several different gases that act like a blanket, keeping the earth warm. They are called **greenhouse gases.** ***Examples***: carbon dioxide, methane, chlorofluorocarbon (CFCs). ● Carbon dioxide allows short wavelength (visible light) radiation to pass through. ● The ground becomes warm by absorbing the radiation and emits longer wavelengths, infrared radiation. ● Carbon dioxide does not let all of this infrared radiation pass through. Much of it is kept in the atmosphere, making the atmosphere warm ● This gradual warming of the atmosphere over many years is referred to as global warming
Acid rain	Acid rain is caused by the release of nitrogen oxides and/or sulphur dioxides into the atmosphere These two gases can react with rain water to produce acid rain

SUSTAINABILITY

Sustainable development is defined as the development providing for the needs of an increasing human population without harming the environment

A **sustainable resource** is one which is produced as rapidly as it is removed from the environment so that it does not run out

CONSERVATION

Extinction is the dying out or extermination of a species

An **endangered species** is at risk of becoming extinct

Some factors that may lead to extinction are:

- Climate change
- Habitat destruction
- Hunting
- Pollution
- Introduction of non-native species that may outcompete native species

Endangered species can be helped by conservation measures such as:

- ➔ Education programmes to raise awareness
- ➔ Captive breeding programmes: **artificial insemination** and **in-vitro fertilisation**
- ➔ Monitoring and legalizing protection of the species and of their habitats
- ➔ Seed bank as a conservation measure for plants - seeds of endangered plants are stored for later plantation

Artificial insemination: allows large numbers of offspring to be produced without the need for conventional sexual intercourse

In-vitro fertilisation: allows gametes with known alleles to be used to ensure the next generation remains biodiverse

Biotechnology and Genetic modification