Year 9 Science BiE2

Exam content and knowledge organisers

Paper 1 will assess the following content:

Knowledge Organiser Topics:

- 9.04 Energetics
- 9.05 Plant structure and photosynthesis
- 9.08 Rates of reaction
- 9.09 Forces in action

Oak National Academy Topics:

- https://classroom.thenational.academy/units/energetics-and-rates-067a
- https://classroom.thenational.academy/units/forces-in-action-543b
- https://classroom.thenational.academy/units/plants-and-photosynthesis-54c3

Content from year 7 and 8 can also be assessed.

Paper 2 will assess the following content:

Knowledge Organiser Topics:

- 9.01 Matter
- 9.02 Respiration
- 9.03 Waves
- 9.06 The Periodic Table and Reactivity
- 9.07 Organ systems

Oak National Academy Topics:

- https://classroom.thenational.academy/units/matter-64ee
- https://classroom.thenational.academy/units/biological-systems-and-processes-bf5a
- https://classroom.thenational.academy/units/sound-waves-0e79
- https://classroom.thenational.academy/units/reactivity-609c

Content from year 7 and 8 can also be assessed.

Year 9 Physics Knowledge Organiser – Pg 1
Topic 1: Matter

The Particle Model of Matter
Matter is made of particles. The particles can be arranged in different ways and move in different ways. There are three common states of matter in the world:

Solids:
- In solids, particles are arranged very close together because they are attracted strongly to each other.
- The particles cannot move out of their positions, BUT they do vibrate around their fixed positions.

Liquids:
- In liquids, particles are arranged very close together.
- However, they are not in fixed positions: particles in liquids constantly move, flowing past each other.

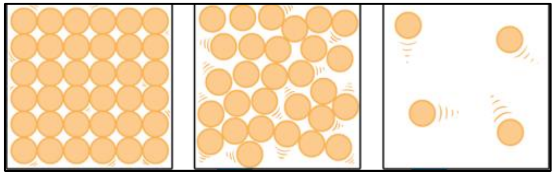
Gases:
- In gases, particles are spread apart from each other with empty space between them.
- Particles in gases constantly move randomly in all directions.

Changes of State
A melting/freezing point is a particular temperature for each particular substance. Changes of state between solid and liquid happen at this temperature (the melting point).
- Solid → liquid is melting. This happens at the substance's melting point.
- Liquid → solid is freezing. This happens at the substance's freezing point, which is equal to its melting point.

A boiling point is a particular temperature for each particular substance. Changes of state between liquid and gas happen at this temperature (the boiling point).
- Liquid → gas is boiling or evaporation. This happens at the substance's boiling point.
- Gas → liquid is condensation. This happens at the substance's boiling point.

Mass is conserved during any change of state, because the number of particles remains exactly the same. Only their arrangement changes.

Key terms	Definitions
matter	Any material/substance/chemical/stuff!
state of matter	Solid, liquid or gas, depending on the arrangement of particles in matter.
particles	The tiny objects that all matter is made from. Particles are **models** for atoms or molecules.
conserve	Keep the same
density	A compound measure for how much mass fits into a certain unit of volume of a substance.
randomly	Unpredictably (all over the place)



2D diagrams of particle arrangements in solids, liquids and gases.

Density

$$density = \frac{mass}{volume}$$

Density
Calculating density allows comparison of different amounts of substances. It is a measure of how much stuff fits in a certain unit of volume.

Solids are denser than liquids. Liquids are denser than gases.

There is an exception: ice (solid water) is less dense than liquid water. This is unusual.

Density explains floating in liquids.
- A substances floats if it is less dense than the liquid.
- A substance sinks if it is more dense than the liquid.

Year 9 Physics Knowledge Organiser – Pg 2
Topic 1: Matter

Internal energy in matter
All matter stores energy. This is called internal energy and it has two parts to it:
- All matter is made of particles that are moving, so matter stores kinetic energy.
- The relative position of particles is a store of potential energy, due to the attraction between particles.

So, internal energy of a substance = kinetic energy of the particles + potential energy of the particles.

Gases have higher internal energy than liquids and solids because:
- The particles move around more: they store more kinetic energy
- The attraction between particles has been overcome and they've moved apart: this has increased the potential energy.

Internal Energy and Changes of State
Heating a substance can do two things, but not at the same time:
1. Raise its temperature
2. Change its state from solid to liquid, or liquid to gas.

1. Temperature increases because heating increases the kinetic energy of particles: they move around more.
2. During changes of state, the temperature of a substance does not change. The heating is overcoming the attraction between particles and moving them apart (increasing the potential energy).

Concentration	Pressure
$concentration = \frac{mass\ of\ solute}{volume\ of\ solvent}$	$pressure = \frac{force}{area}$

Key terms	Definitions
temperature	The measure of the average kinetic energy of particles in a substance.
solution	A type of mixture produced by dissolving a solute in a solvent.
solute	A substance that is dissolved in a solvent.
solvent	The liquid that dissolves a solute to make a solution.
fluid	Collective term for liquids and gases (particles in fluids move around and are not in fixed positions).
Brownian motion	The random motion of small particles in fluids due to their bumping into even smaller particles.

Concentration and Concentration Gradients
- Concentration is the compound measure of how much solute is dissolved in a certain unit of volume of solvent.
- A difference is concentration between two solutions is called a concentration gradient. Solute particles tend to spread from higher concentration to lower concentration (down the concentration gradient), until the concentration is equal throughout the solution. This is called diffusion.
- This can happen across cell membranes.

Pressure
- Pressure is a compound measure of how much force acts on a particular unit of area.
- Pressure increases if the force acting on an area *increases*.
- Pressure increases if the area a force acts on *decreases*.
- The deeper you go in a fluid, the greater the pressure because the column of fluid above pushes down with more force on a certain area.
- Factors that affect pressure: height in a fluid; volume of fluid; temperature of fluid; number of particles in the fluid.

Year 9 Biology Knowledge Organiser – Pg 3
Topic 2: Respiration

Respiration

Respiration is a chemical reaction that occurs in plant and animal cells and transfers energy from food molecules. The organism can then use this energy in several different ways including:

1. To build large molecules from smaller ones
2. To move
3. To keep warm

There are two types of respiration: aerobic and anaerobic.

Aerobic respiration

Aerobic respiration occurs in the presence of oxygen and takes place in the mitochondria. Cells that require a lot of energy (e.g. muscle cells, sperm cells) will have higher numbers of mitochondria so they can release more energy.

Aerobic respiration is shown by the following equation:

glucose + oxygen → carbon dioxide + water

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

Respiration can use different food molecules as the reactant but it is generally shown as glucose. Oxygen and glucose travel to the cells through the circulatory system and the waste products are removed from cells in the same way.

Key Terms	Definition
respiration	A chemical reaction that transfers energy from food molecules so cells can do work.
aerobic	With oxygen.
anaerobic	Without oxygen.
fermentation	Anaerobic respiration that occurs in yeast.
mitochondria	Cell organelle where aerobic respiration occurs.
fatigue	When muscle cells become tired and no longer contract efficiently.

Anaerobic respiration

Anaerobic respiration occurs when there is not enough oxygen present and takes place in the cytoplasm. Much less energy is transferred by anaerobic respiration than by aerobic respiration.

In animals the equation for anaerobic respiration is:

glucose → lactic acid

If lactic acid builds up in muscle cells it causes fatigue. The lactic acid is transported to the liver where it can react with oxygen to produce carbon dioxide and water or be converted into glucose. We continue to have an elevated heart rate and breathing rate after exercise so that oxygen is available to react with the lactic acid that has been removed from our muscles allowing them to work efficiently again.

In plants and yeast the equation for anaerobic respiration is:

glucose → ethanol and carbon dioxide

This process can also be called fermentation and is useful as the ethanol can be used to make alcoholic drinks and the carbon dioxide is what makes bread rise.

Year 9 Physics Knowledge Organiser – Pg 4
Topic 3: Waves

Oscillations produce Waves

Oscillations, for example vibrations, cause waves. Waves travel through matter when the matter continues to oscillate. Waves transfer energy without transferring matter.

There are two ways for matter to oscillate in a wave:

- Longitudinally: parallel to the direction of the wave.
- Transversely: perpendicular to the direction of the wave.

Longitudinal Waves

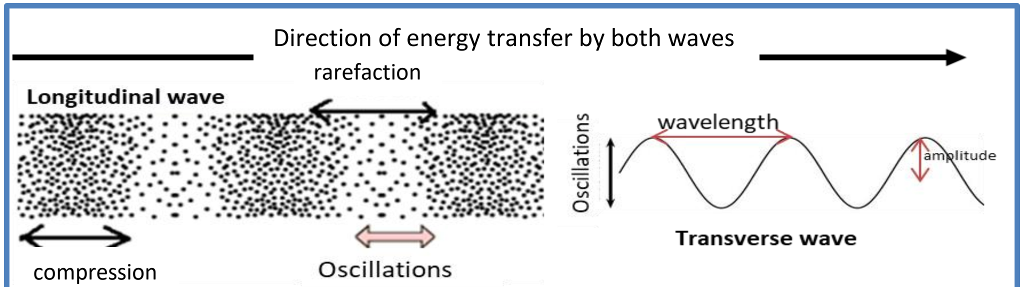
The features of longitudinal waves:

- The oscillations of the wave are parallel to the direction of movement of the wave (see diagram)
- These waves involve oscillations of the particles in a solid, liquid, or gas.
- There are areas of compression and areas of rarefaction.
- One wavelength can be measured from the centre of an area of compression to the centre of the next area of compression.

Transverse Waves

The features of transverse waves:

- The oscillations of the wave are at right angles to the direction of the wave.
- The oscillations can be in matter, like longitudinal waves, or in the electromagnetic field (these oscillations form electromagnetic waves).
- Transverse waves have peaks and troughs.
- The amplitude of a transverse wave is the maximum distance of the wave from the centre.



Key Terms	Definitions
oscillation	A rhythmic, back and forth or up and down movement from a rest position (e.g. vibration).
wave	A whole series of oscillations that allows transfer of energy.
medium	The matter that is oscillating to produce a wave.
longitudinal wave	A wave made from oscillations parallel to the direction of the wave.
compression	A part of a wave where matter is made more dense by the oscillations of the wave.
rarefaction	A part of a wave where matter is made less dense by the oscillations of the wave.
sound	A type of wave caused by vibrations of matter.
pitch	The highness/lowness of a sound.
intensity	The volume of a sound.
frequency	The number of oscillations in a wave per second. This is also the number of waves passing a point per second.
transverse wave	A wave made from oscillations at right angles to the direction of the wave.
wavelength	The length of one complete wave - from one point on one wave to the equivalent point on the next wave.

Sound compared to Electromagnetic Waves (e.g. Light)

Sound	EM Waves, like light
Requires a medium to travel	Does **not** require a medium – can travel in a vacuum
Involves **longitudinal** oscillations (vibrations) of **particles** in matter	Involves **transverse** oscillations of the electromagnetic **field**
Travels faster in more dense media	Travels slower in more dense media

Both sound and EM waves show all the behaviours on the next page.

Year 9 Physics Knowledge Organiser – Pg 5
Topic 3: Waves

Behaviours of all Waves

Waves can travel through all sorts of media, and different things (usually a mixture of the below) can happen at the boundary between different media:

- Transmission of the wave: it travels through the new medium
- Refraction of the wave: it travels through the new medium but changes direction at the boundary due to a change in speed of the wave
- Reflection of the wave; reflected sound waves are called echoes
- Absorption of the wave by the new medium, warming it up.

Diffraction occurs when a wave reaches a gap in a medium that it cannot pass through. The wave goes through the gap then spreads out after the gap. Diffraction is most noticeable when the gap in the boundary is similar in size to the wavelength of the wave.
Superposition occurs when two or more of the same kind of waves are travelling together. The waves can add up or cancel each other out depending on how they line up.

Using Sound Waves

We can hear sound waves due to the adaptations of our ears.

1. The eardrum vibrates thanks to a sound wave hitting it.
2. The eardrum vibrates tiny bones in the inner ear.
3. These bones cause the cochlea to vibrate, which in turn vibrates the hair cells inside.
4. These vibrations produce electrical impulses that travel along the auditory nerve to the brain, where we interpret the sound.

Sounds can be produced by loudspeakers, which are simply vibrating cones. The pattern and frequency of the vibrations (oscillations) determines the sound. Microphones have a vibrating diaphragm inside, which transfers the sound wave into an electrical signal in a circuit. Humans can hear sounds with frequencies from 20 Hz to 20 000 Hz. Sound with frequencies higher than 20 000 Hz is called ultrasound. Ultrasound is very useful, for example:

- Prenatal scans of unborn children
- Ultrasonic cleaning of fragile objects
- Breaking up deposits called kidney stones to prevent harm.

Key Terms	Definitions
transmission	The travelling of a wave. We say a wave is 'transmitted' through a medium.
incident wave	A wave heading towards the boundary between media.
reflection	When a wave bounces back from a boundary between media at the same angle as which it hit the boundary.
absorption	When the energy a wave transfers goes into heating a material.
refraction	When a wave changes direction at the boundary between media due to a change in speed.
diffraction	The spreading out of a wave after it passes through a gap.
superposition	The adding up or cancelling out of waves that travel together.
ultrasound	Sound too high pitched (too high frequency) to hear
hertz (Hz)	The unit for frequency, meaning 'waves per second'

Using Electromagnetic Waves

The huge range (spectrum) of electromagnetic waves is grouped into seven smaller ranges. The EM spectrum includes visible light, that we can see, but most EM waves, we cannot see.

Long wavelength → Short wavelength

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

Low frequency → High frequency

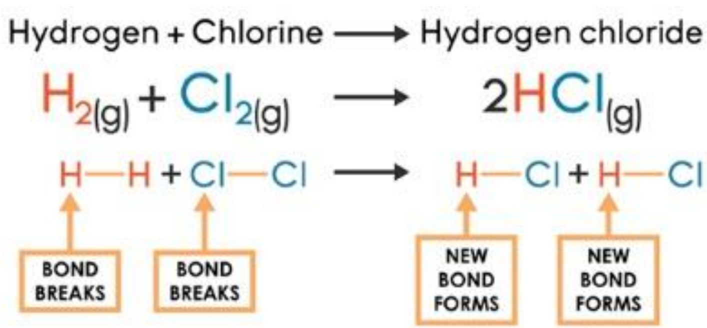
EM waves all travel at the 'speed of light', which is 300 000 000 m/s in a vacuum. We can produce all types of EM wave. This can be useful, for example:

- Radio waves are used to transmit radio and TV signals
- Microwaves are used for WiFi signals
- Infrared waves transfer heat
- Ultraviolet light is used for tanning beds
- X-rays are used for diagnosis of broken bones
- Gamma rays are used for radiotherapy, a type of cancer treatment.

Year 9 Chemistry Knowledge Organiser – Pg 6
Topic 4: Energetics

Chemical Reactions

In a chemical reaction there are reactants, these are the chemicals that you start with. In a chemical reaction products are made, this is what you will finish with. In a chemical reaction chemical bonds in the reactant particles are broken and new bonds in the products are made.
We represent chemical reactions using both word and symbol equations.
For example:



Using the Law of conservation of mass, we know that the total number of each element in the reactants must equal the number of the same element in the products. A small number after an element symbol tells you how many of that type of atom are in the substance bonded together.

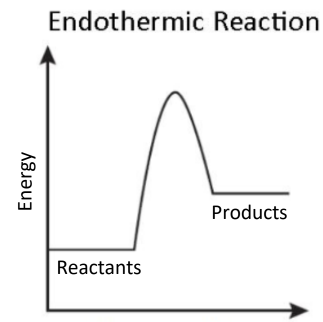
Bond Making and Breaking

Breaking bonds requires energy and making bonds releases energy.
When more energy is taken in from the surroundings than given out in a reaction we call this an endothermic reaction.
An example of a Endothermic reaction is the reaction between citric acid and sodium hydrogen carbonate used in sports injury packs that instantly get colder without being put in the freezer.
When more energy is released to the surroundings than taken in in a reaction we call this an exothermic reaction.
An example of a exothermic reaction is the oxidation reaction of iron which make hand warmers get hot.

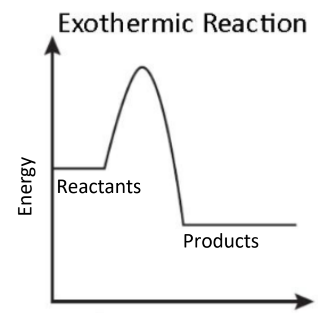
Key Terms	Definitions
chemical reaction	The breaking of bonds in reactants and making of bonds to for products.
reaction profile	A graph which shows the energies of the products and reactants in a chemical reaction
exothermic	A reaction that gives out energy to the surroundings
endothermic	A reaction that takes energy in from the surroundings
thermal decomposition	A chemical reaction where heat is used to break down a substances
combustion	A chemical reaction where a fuel reacts with oxygen to make carbon dioxide and water
oxidation	A chemical reaction where an element or compound reacts with oxygen

Energy profile diagrams

We can use an energy profile diagram to show the relative energies in a reaction.



This is the reaction profile of an endothermic reaction, the energy of the products is higher than that of the reactants. The difference in energy is taken in from the surroundings.



This is the reaction profile of an exothermic reaction, the energy of the products is lower than that of the reactants. The difference in energy is released as heat to the surroundings.

Year 9 Chemistry Knowledge Organiser – Pg 7
Topic 4: Energetics

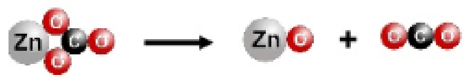
Key Terms	Definitions
thermal decomposition	A chemical reaction where heat is used to break down a substances
combustion	A chemical reaction where a fuel reacts with oxygen to make carbon dioxide and water
oxidation	A chemical reaction where an element or compound reacts with oxygen

Thermal Decomposition

Thermal decomposition is a chemical reaction where heat is used to break down a substance. Thermal decomposition is an endothermic reaction - it takes in more energy than it releases. As thermal decomposition is endothermic that means more energy is used breaking bonds than making them in the reaction. For example:

Zinc Carbonate → Zinc Oxide + Carbon dioxide

$ZnCO_3 \rightarrow ZnO + CO_2$



Calcium Carbonate → Calcium Oxide + Carbon dioxide

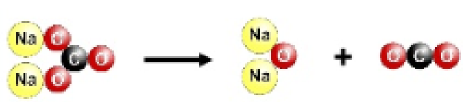
$CaCO_3 \rightarrow CaO + CO_2$

Magnesium carbonate → Magnesium Oxide + Carbon dioxide

$MgCO_3 \rightarrow MgO + CO_2$

Sodium carbonate → Sodium Oxide + Carbon dioxide

$NaCO_3 \rightarrow NaO + CO_2$

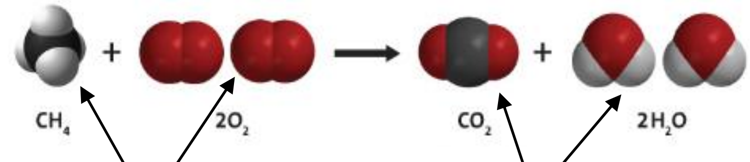


Combustion

Combustion is a chemical reaction where a fuel reacts with oxygen to make carbon dioxide and water. Combustion is an exothermic reaction, it gives energy into the surroundings. As combustion is exothermic that means more energy is being released making bonds than used breaking bonds.

For example: methane + oxygen → carbon dioxide + water

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$



Break these bonds

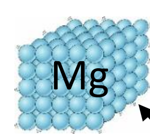
Make these bonds

Oxidation

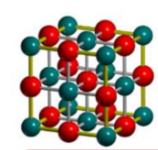
Oxidation is where an element or compound reacts with oxygen. Oxidisation reactions are mostly exothermic reactions, giving energy to the surroundings. As oxidation reactions are exothermic that means more energy is being released making bonds than used breaking bonds.

For example: Magnesium + Oxygen → Magnesium Oxide

Mg + Oxygen → MgO



O=O



Break these bonds

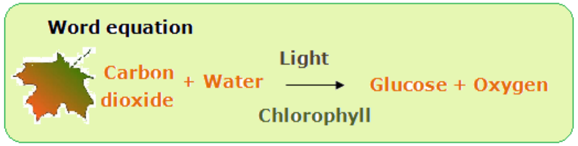
Make these bonds

Year 9 Biology Knowledge Organiser – Pg 8
Topic 5: Plants & photosynthesis

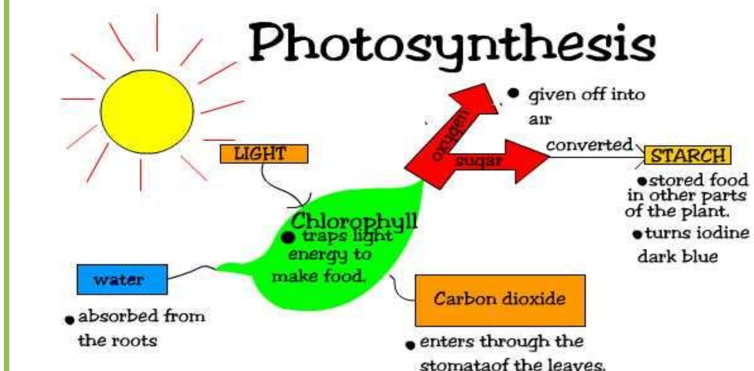
Key Terms	Definitions
osmosis	Movement of water from a high concentration to a low concentration through a partially permeable membrane
diffusion	Movement of particles from a high concentration to a low concentration until they are evenly spread out
active transport	Movement of particles against a concentration gradient
transpiration	The process by which plants lose water, as vapour, from their leaves through the stomata.
chlorophyll	Green pigment in leaves, needed for photosynthesis, kept inside chloroplast

Photosynthesis

- Plants use photosynthesis to make food (glucose) using energy from the sun

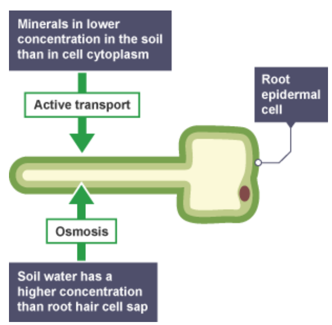


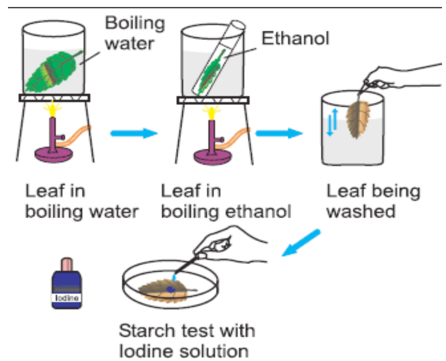
- The plant takes in water through the roots and carbon dioxide through the leaves via stomata
- Photosynthesis takes place in the chloroplasts which contain chlorophyll to absorb the light from the sun
- The glucose made in photosynthesis is stored as starch
- We can use iodine to test for starch; if starch is present the iodine will turn black
- Limiting factors for photosynthesis are light, temperature & CO_2 concentration



Roots

- Plants absorb all their water in the roots by osmosis and keep water moving constantly through the plant by losing water as vapour from stomata in the leaves – transpiration
- Root hair cells increase the surface area for absorption of water.
- Root hair cells have a thin cell wall to allow water to pass through by osmosis easily
- Root hair cells don't contain chloroplasts as they are not performing photosynthesis
- Root hair cells absorb minerals through active transport. This requires an input of energy from the cell





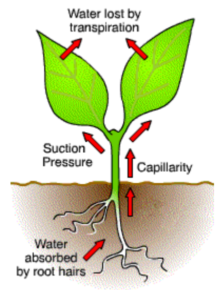
Leaves can be tested for starch using iodine.

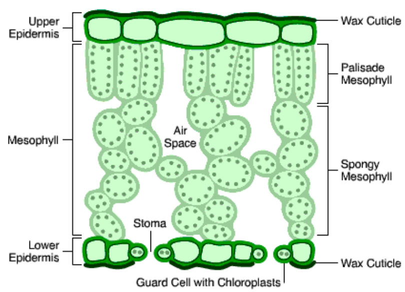
1. The leaf is boiled in water to break open cells
2. Boiled in ethanol to remove the chlorophyll
3. Testing with iodine. Blue/black is a positive result.

Year 9 Biology Knowledge Organiser – Pg 9
Topic 5: Plants & photosynthesis

Leaf adaptations

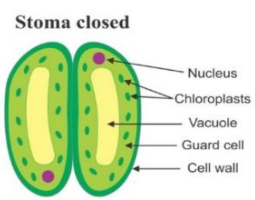
- Large surface area to absorb lots of light
- The upper epidermis has a waxy coating to prevent water loss and damage and contains no chloroplasts so light can pass through
- The cells in the palisade layer are towards the top of the leaf and are packed with chloroplasts. They are long & thin to use all the light up.
- There are small holes on the under side of the leaf called stomata, these allow carbon dioxide into the leaf and oxygen out of the leaf
- The stomata are opened and closed by the guard cells

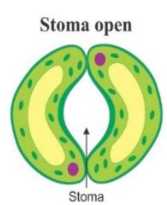




Stomata, guard cells and transpiration

- Stomata allow the gases of photosynthesis to enter or leave the leaf. They need to be open to allow photosynthesis to take place. They also allow water vapour to leave through transpiration
- Transpiration is the upward flow of water up from the roots and out of the leaf. It causes more water to be drawn up from the roots
- Guard cells control the opening and closing of stomata. This is useful in dry conditions, because the plant can conserve water instead of losing lots of it through transpiration.
- Factors that speed up transpiration will also increase the rate of water uptake from the soil e.g light, temperature, wind, humidity

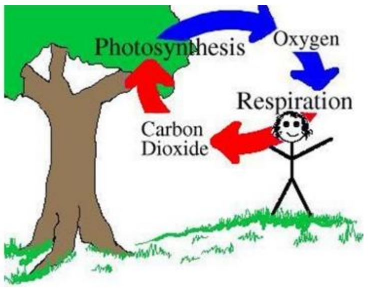




Key Terms	Definitions
epidermis	Type of plant tissue that covers the surface of a plant
palisade mesophyll	Tissue in the leaf where photosynthesis takes place
spongy mesophyll	Tissue in the leaf with air spaces between cells – specialised for gas exchange
xylem	Narrow tubes in the roots, stem and leaves, which transport water and mineral ions up the plant from the roots. One way flow. Made from dead cells.
phloem	Living vessel that carries food from the leaves to the rest of the plant in a two way flow
stomata	Pores which open & close on the underside of leaves, the holes through which gases are exchanged.
Guard cells	In pairs, guard cells form the stomata on leaves. They can open and close the stomata as required by the plant.

Carbon dioxide and oxygen

- The balance of oxygen and carbon dioxide in the atmosphere is maintained through respiration in plants and animals and by photosynthesis in plants .
- Plants produce oxygen during respiration. They produce much more oxygen during photosynthesis than they consume in respiration, this is how the oxygen consumed by plants and animals is replenished in the air

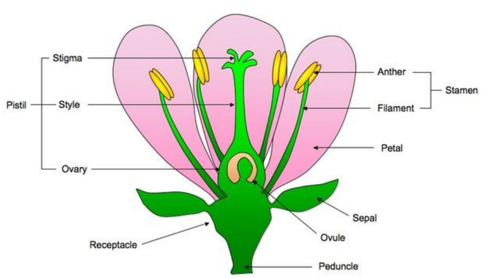


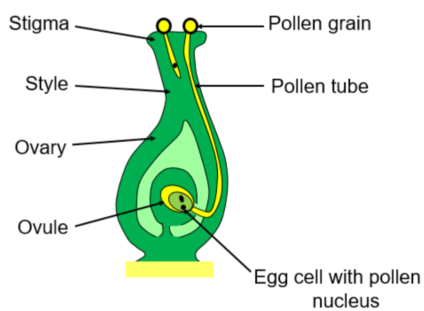
- Recently the balance of oxygen & CO_2 has been upset, CO_2 levels are rising due to deforestation & burning fossil fuels leading to global warming

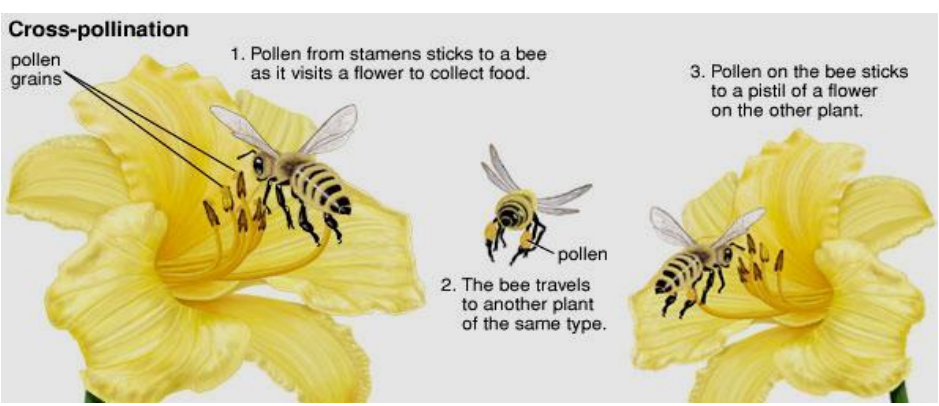
Year 9 Biology Knowledge Organiser – Pg 10
Topic 5: Plants & photosynthesis

Pollination and food security

- Pollination is the transfer of pollen from a male part of a plant to a female part of a plant.
- Insects, birds, bats and the wind are responsible for the transfer of pollen
- Each pollen grain grows a pollen tube down to the ovule
- The nucleus of the male pollen grain is sent down to meet the nucleus of the female ovule and the two nuclei fuse at fertilisation







Key Terms	Definitions
pollination	Pollination is the transfer of pollen from a male part of a plant to a female part of a plant, enabling later fertilisation and the production of seeds, most often by an animal or by wind
pollen	Male sex cell in plants
ovule	Contains the female egg cell in plants
pollen tube	The male gamete pollen is sent down the pollen tube to meet the female gamete in the ovule
pesticide	A chemical sprayed on crops to kills pests

Bee decline

- Bees are critical pollinators in both the human and animal food chains
- The diversity of bees and their numbers has severely declined in recent years
- Our diets are full of foods which depend on bee pollination
- Colony collapse disorder (CCD) or vanishing bee syndrome is the mysterious and rather dramatic die-off of domesticated honeybees in Europe and North America

- The reasons for decline could be destruction of bee habitats, pests, diseases caused by parasites and fungi, poor bee nutrition due to intensive farming, global warming and misuse of pesticides

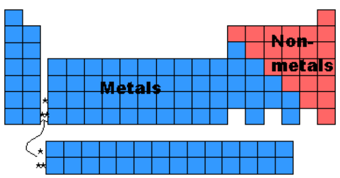
- To prevent further decline farmers can : - plant more flowers, (bees prefer flowers that are blue, purple or yellow), reduce pesticide usage, provide bee habitats, preserve hedgerows, grow a variety of crops

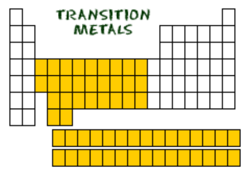
Year 9 Chemistry Knowledge Organiser – Pg 11
Topic 6: The Periodic Table and Reactivity

Key Terms	Definitions
metal	An element that forms a positive ion
non-metal	An element which forms a negative ion
reactivity series	A table which ranks metals on relative reactivity

Metals and Non-Metals

- Metals are found on the left-hand side of the periodic table, the majority of elements are metals.
- When metals react, they lose electrons to form positive ions.
- When non-metals react they gain electrons to form negative ions.

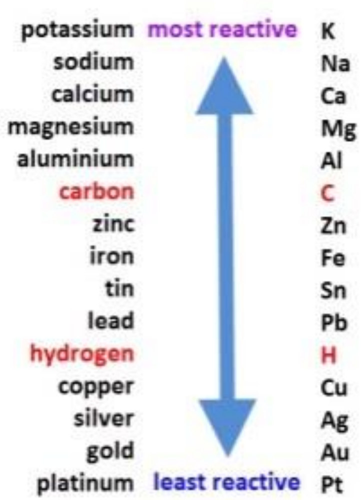




- Metals can be divided into the main group metals that are found in groups 1,2 or 3.
- Transition metals are found between groups 2 and 3. Transition metals can form different positive ions.

Reactivity of Metals

- The easier it is for a metal to form a positive ion, the more reactive it is.
- The reactivity series shows the metals in order of their reactivity compared to each other.



Reactivity of Metals with Water

- Some metals will react with water for example sodium, lithium, potassium and calcium.
- Magnesium will react with steam.
- Metals below magnesium do not react with water.
- When a metal reacts with water it produces a metal hydroxide and hydrogen gas:

Metal + Water → Metal Hydroxide + Hydrogen

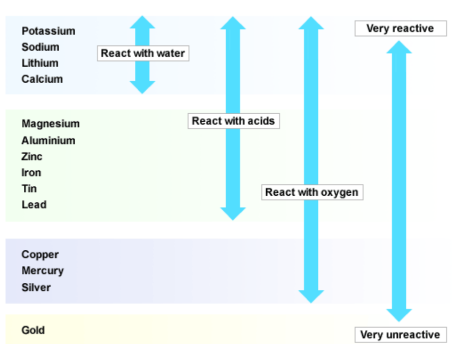
Reactivity of Metals with Acid

- More metals will react with acid than water.
- When a metal reacts with acid, a salt and hydrogen gas are made:

Metal + Hydrochloric acid→ Metal Chloride + Hydrogen

- Metals below lead do not react with common acids.

Reactivity summary



Year 9 Chemistry Knowledge Organiser – Pg 12
Topic 6: The Periodic Table and Reactivity

Key Terms	Definitions
native metals	A metal which does not need to be extracted from its compound
reduction	When an atom when an atom loses an oxygen atom
electrolysis	The breaking down of a substance using electricity
ore	A metal ore is a compound found in rock, dug out of the ground, that contains enough metal that it is economical to extract it.

Displacement reaction of metals

- A more reactive metal will displace a less reactive metal from its compound.
- This is because a more reactive metal is more stable as an ion.
- For example iron will displace coper form its compounds as it is more reactive.

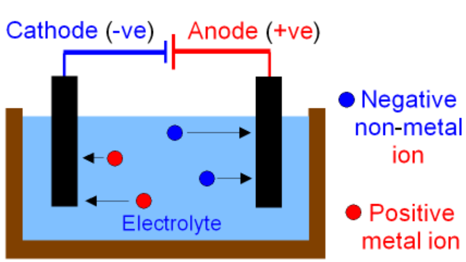
Copper Sulphate + Iron → Iron Sulphate + Copper

Extraction of metals

- Pure metals are required for a wide variety of uses.
- Most metals are found in compounds in the Earth's crust. We call these compounds ores.
- Gold and platinum do not require extraction as they are so unreactive. They are found as native metals.

Extraction of very reactive metals

- Some metals can not be extracted using carbon because they are more reactive these carbon.
- Electrolysis is used to extract these metals.
- For electrolysis to happen the compound has to be molten, so that the ions can move. This means the process requires a lot of energy and is expensive.
- The positive metal ions are then attracted to the negative electrode.



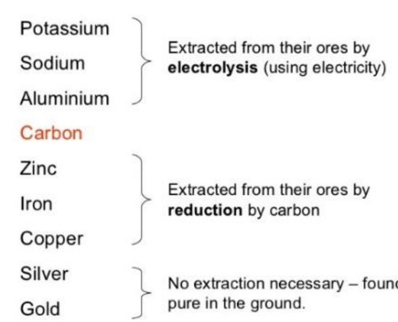
Extraction using carbon

- Carbon is found between zinc and aluminium in the reactivity series.
- Carbon can displace elements that are below it from their compounds. This means they can be used to extract some metals from their ores.
- Carbon can be used to extract metals from zinc downwards
- Example: Lead Oxide + Carbon → Lead + Carbon Dioxide

$$PbO_2 + C \rightarrow Pb + CO_2$$

- This reaction is an example of a reduction reaction as the lead has lost oxygen.
- This reaction requires high temperatures and can therefore be expensive

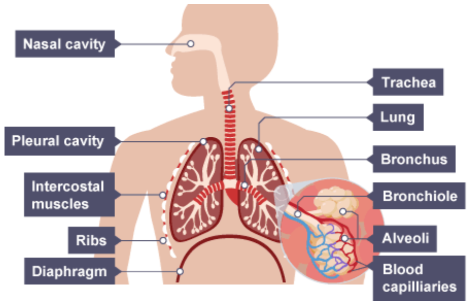
Metal extraction summary



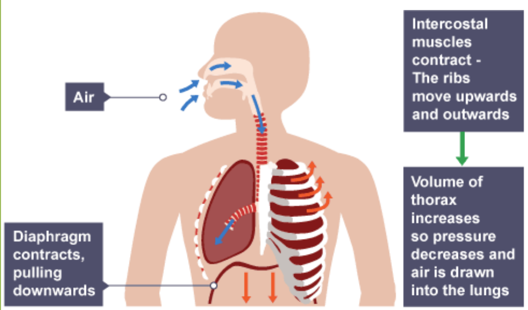
Year 9 Biology Knowledge Organiser – Pg 13
Topic 7: Organ Systems

Structure of the respiratory system

Air enters the body through the nasal cavity. It travels down the trachea, then one of two bronchi, one of many bronchioles and ends up in the alveoli. There, oxygen diffuses into the blood stream. Carbon dioxide diffuses in the opposite direction, then follows the reverse of the above journey, to leave the body.



Ventilation



Don't confuse respiration with ventilation. Respiration is a chemical reaction which happens in the body's cells and transfers energy.
Ventilation is the process of bringing gas in to and expelling gas from the body.
The diagram shows what happens when we breathe in. Breathing out is the exact opposite.

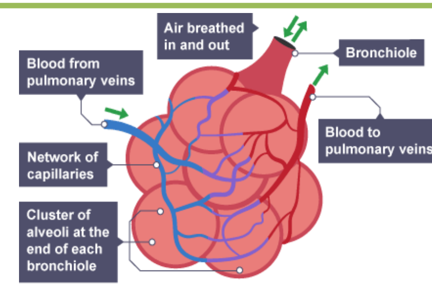
Respiratory diseases

Asthma is a disease where airways become inflamed. The muscles around the bronchioles contract, constricting the airways and making breathing difficult. Asthma is non-communicable but can be triggered by environmental factors such as infections, allergies and exercise. Asthma is treated using steroids.
Cystic fibrosis is a homozygous recessive disorder where mucus builds up in the bronchioles, reducing lung capacity. Lung capacity can be measured using a spirometer.
$Lung\ capacity = vital\ capacity + residual\ volume$

Key Terms	Definition
respiratory system	The organ system responsible for exchanging gases with the environment.
alveoli	Balloon-like structures which are responsible for exchanging oxygen and carbon dioxide between the blood and the lung cavity.
respiration	A chemical reaction which transfers energy for the body: oxygen + glucose → carbon dioxide + water (+ energy).
ventilation	Breathing: bringing in and expelling gases from the body.
capillary	The smallest type of blood vessel.
vital capacity	The volume of air you can breathe out after breathing in as much as you can.
residual volume	Volume of air left in the lungs after breathing out as much as you can.
tidal volume	Volume of air in a normal breath (in or out).

Gas exchange and alveoli

The lungs are a site of gas exchange. Oxygen for respiration diffuses into the bloodstream and waste carbon dioxide diffuses out of the blood into the alveoli, from where it is expelled in ventilation.



Alveoli are adapted by:
1. High surface area thanks to their balloon-like shape
2. Many capillaries give a good blood supply for gas exchange
3. Walls only one cell thick
4. Moist walls pick up gases (gases dissolve in water)

Recreational drugs and gas exchange

Smoking can affect the gas exchange system in the following ways:
1. Destroying cilia in the airways so they are less able to sweep mucus containing pathogens out of the lungs, leading to a smoker's cough
2. Irritating the bronchi, causing bronchitis
3. Destroying alveoli, reducing the surface area for gas exchange and causing emphysema
4. Cigarette smoke contains carbon monoxide (CO) which binds to red blood cells, so they can carry less oxygen to cells and the heart has to work harder
5. Increasing the risk of lung, throat, mouth and oesophagus cancers

Year 9 Biology Knowledge Organiser – Pg 14
Topic 7: Organ Systems

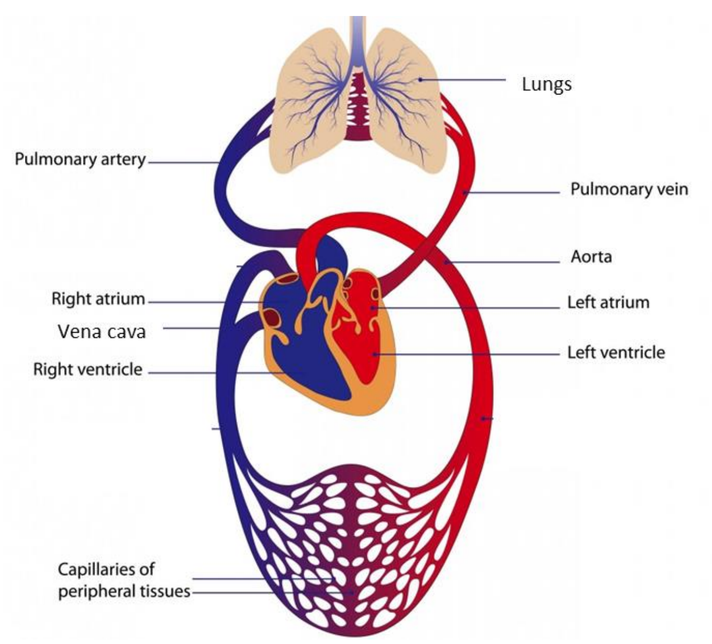
Key Terms	Definition
circulatory system	The organ system responsible for moving blood around the body.
artery	A blood vessel which carries blood away from the heart e.g. the aorta and the pulmonary artery.
vein	A blood vessel which carries blood towards the heart e.g. the vena cava and the pulmonary vein.
pulmonary	Relating to the lungs.
atrium	The upper two chambers of the heart are the right and left atria.
ventricle	The lower two chambers of the heart are the right and left ventricles.
capillary	The smallest type of blood vessel.
valve	A structure which allows blood to flow past it in only one direction.

Movement of blood and gases by the circulatory system

Blood flows around the body in the following stages:

Stage	Movement of blood	Movement of gases
1	Left ventricle pumps blood into aorta	
2	Aorta and smaller arteries deliver blood to body's cells	*Oxygen* diffuses into cells for respiration. Waste *carbon dioxide* diffuses out of cells to be expelled. Blood is deoxygenated.
3	Veins and vena cava deliver blood to right atrium	
4	Blood flows into right ventricle and right ventricle pumps blood into pulmonary artery	
5	Pulmonary artery delivers blood to lungs	*Carbon dioxide* diffuses out of bloodstream into alveoli for exhalation. *Oxygen* diffuses from alveoli into blood. Blood is oxygenated.
6	Pulmonary vein delivers blood to left atrium	
7	Blood flows into left ventricle	

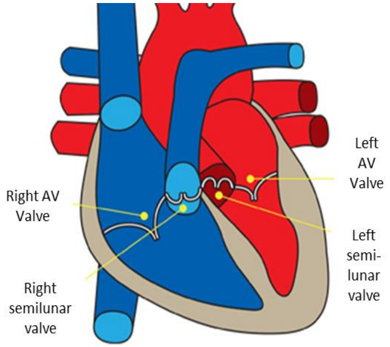
Structure of the circulatory system



Heart beats

The stages of a heartbeat are as follows:

1. Both atria contract at once, pushing blood through the atrioventricular (AV) valves into the ventricles.
2. The AV valves snap shut. This is the "lub" in the "lub-dub" sound of a heartbeat.
3. Both ventricles contract at once, pushing blood through the semilunar valves and out through the aorta (oxygenated blood) and pulmonary artery.
4. The semilunar valves snap shut. This is the "dub"



Year 9 Biology Knowledge Organiser – Pg 15
Topic 7: Organ Systems

Adaptations of the circulatory system

The human circulatory system is adapted for effective circulation as follows:

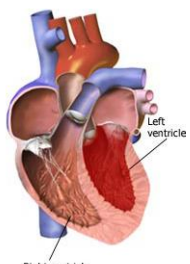
Valve opens fully, blood flows through

Valve closes tightly, blood cannot flow backwards

Valves
Valves are found in the heart and in veins. This is an important adaptation because valves prevent blood from flowing backwards.

Red blood cells
Red blood cells have a biconcave shape (like a squashed ball of blutac). This gives them a high surface area for maximum diffusion of oxygen and carbon dioxide in and out. They also have no nucleus, which increases their capacity for carrying these gases.

Muscular left ventricle wall
When the left ventricle pumps blood into the aorta, it must give the blood enough pressure to reach your extremities (e.g. your toes). It therefore has a muscular wall for a powerful contraction.



Double circulation
For every complete circuit around the body the blood passes through the heart twice – a double circulation. This means that oxygen is delivered to cells more efficiently.

Performance

Regular training has the following effects:

- Heart muscles are strengthened
- Cardiac output increases
- Resting heart rate is lower (fewer beats needed because heart muscles are stronger)
- Recovery (returning to resting heart rate) happens more quickly after exercise

Some athletes use performance-enhancing drugs – this is often called doping. Two methods of doping which affect the circulatory system are:

- Injections of erythropoietin (EPO) – a naturally-occurring hormone which stimulates the production of red blood cells by the bone marrow. More red blood cells means more oxygen can be delivered to cells for respiration, for energy release
- Blood transfusion – adding red blood cells (from yourself, frozen, or from someone else) to your blood. Again, this boosts the capacity of your blood to carry oxygen

Key Terms	Definition
coronary	Relating to the heart.
biconcave	A shape which goes **in** on both sides.
heart rate (*bpm*)	Number of heart beats per minute.
stroke volume (cm^3)	Volume of blood pumped from the heart with each beat.
cardiac output (cm^3)	Volume of blood pumped from the heart each minute.
blood clot	A clump of blood which can block a blood vessel.
congenital	Something you are born with.

Equation	Meanings of terms in equation and units
$CO = HR \times SV$	*CO = cardiac output, cm^3* *HR = heart rate, beats per minute, bpm* *SV = stroke volume, cm^3*

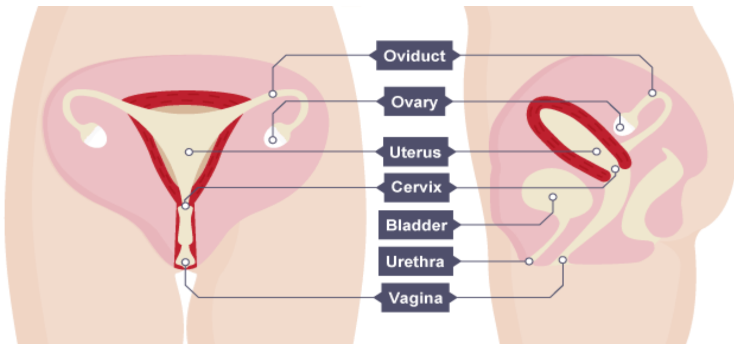
Diseases of the circulatory system

Lifestyle-based diseases
Coronary heart disease (CHD) describes when fat builds up in the arteries which deliver blood to the heart. If a blood clot forms on the fatty deposit, it can block the artery, stopping blood flow to the heart muscles and causing a myocardial infarction (heart attack). You are more at risk of CHD if you smoke, have high blood pressure and eat a lot of salt and/or saturated fats.

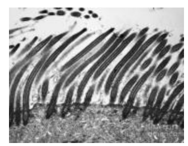
Congenital heart diseases
A "hole in the heart" refers to a hole in the wall (septum) which separates the two atria (an atrial septal defect, ASD) or the two ventricles (a ventricular septal defect, VSD) of the heart. This allows oxygenated and deoxygenated blood to mix, causing problems with blood pressure and circulation of oxygen in the body. The hole can be closed by surgery. 8 out of 1,000 babies are born with a heart or blood vessel problem. Of these, 4 will have a VSD. This makes it the most common congenital heart problem.

Year 9 Biology Knowledge Organiser – Pg 16
Topic 7: Organ Systems

Structure and adaptations of the female reproductive system



Cilia

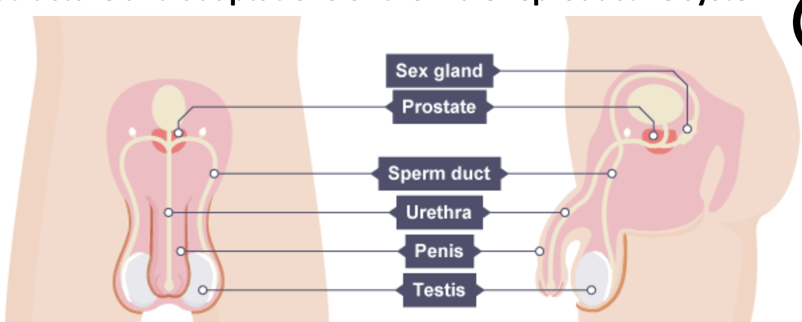


Adaptations in the female reproductive system

- The lining of the oviduct is ciliated (covered in cilia – hair-like structures) to sweep the ovum along the oviduct into the uterus.
- The menstrual cycle: the uterus lining builds up once every 28 days, in preparation to receive a fertilised ovum. If one does not arrive, the lining is shed and lost through the vagina (menstruation).

Key Terms		Definition
oviduct	♀	Where ova move along into the uterus. Site of fertilisation.
ovary	♀	Where ova (eggs) form and mature.
uterus	♀	Where a fertilised egg develops into a foetus during gestation.
cervix	♀	A ring of muscle which keeps the developing foetus in place.
vagina	♀	A muscular tube which the penis enters during sexual intercourse.
sex gland	♂	Produce fluids which contain nutrition for the sperm on their journey.
sperm duct	♂	Sperm travel through the sperm duct to the urethra. On the way, they mix with fluids from the sex glands to form semen.
penis	♂	Enters the vagina during sexual intercourse.
testes	♂	There are two testes. They produce sperm and testosterone (a hormone).
urethra	♂ + ♀	Passes urine out of the body from the bladder. In males, semen also leaves the body through the urethra.
bladder	♂ + ♀	Where urine is stored before it leaves the body via the urethra.

Structure and adaptations of the male reproductive system



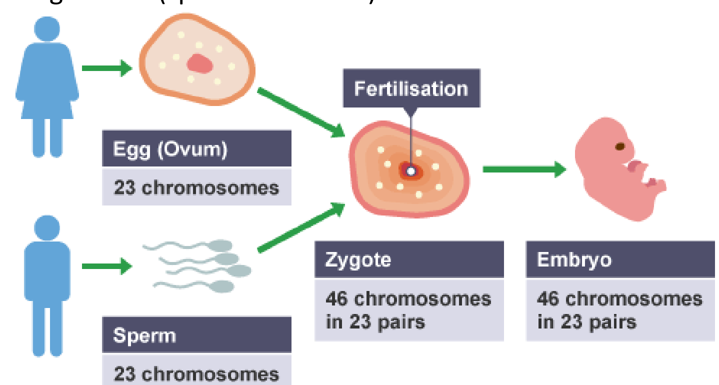
Sperm cell

Adaptations in the male reproductive system

- Sperm cells have a flagellum (tail) for swimming long distances. Mitochondria are organised in a spiral arrangement around the top of the tail to transfer energy in respiration, for swimming.

Fertilisation

During sexual intercourse, semen leaves the man's penis and enters the woman's vagina. Sperm cells swim to the oviduct where they may meet an ovum. One sperm cell will break through the membrane of the ovum and the nuclei of the gametes (sperm and ovum) will fuse.

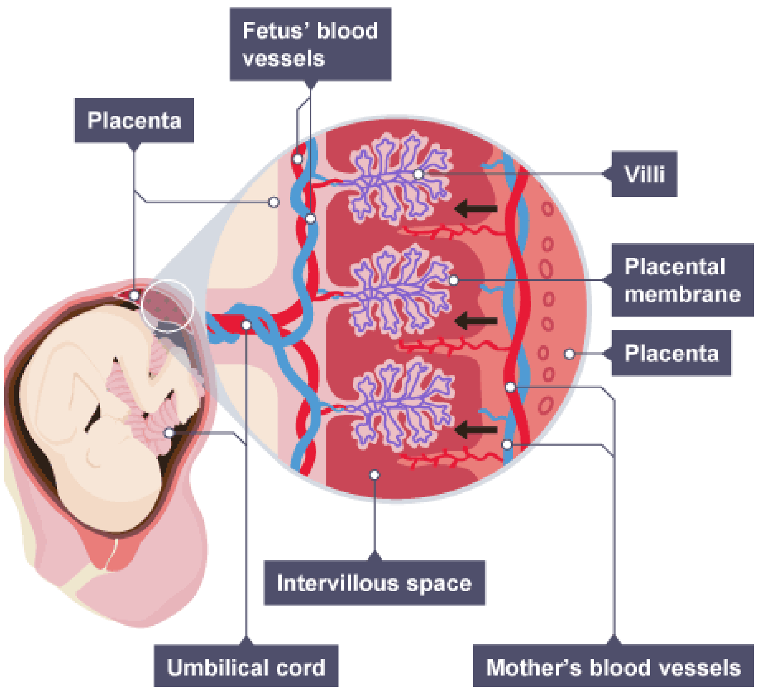


Year 9 Biology Knowledge Organiser – Pg 17
Topic 7: Organ Systems

Gestation

Gestation describes the development of a foetus in the womb. In order to grow the foetus needs to get nutrients and oxygen. Since they can't eat or breathe, they get this from the mother's blood. Nutrients and oxygen diffuse from the mother's blood into the baby's blood vessels in the placenta, and through the umbilical cord.

The umbilical cord also carries away waste (e.g. CO_2) which also gets transferred in the placenta. It diffuses from the foetal blood vessels into the mother's blood.



Key Terms	Definition
zygote	The fertilised ovum – 46 chromosomes in 23 pairs.
embryo	A ball of cells which have formed by the zygote replicating.
foetus	After 8 weeks the baby is classed as a foetus.
placenta	An organ which develops during pregnancy, and supplies the developing foetus with oxygen and nutrients, while also removing waste.
umbilical cord	A tube which connects the baby to the placenta.
amniotic sac	A membrane-bound "balloon" which contains amniotic fluid and cushions the baby during gestation. When we say "waters break" this refers to the amniotic sac bursting.
amniotic fluid	A clear liquid which fills the amniotic sac and provides the cushioning.

Recreational drugs and gestation

The mother's behaviour during gestation can affect the development of the unborn baby because of the transfer of substances across the placenta.

Smoking or being exposed to cigarette smoke (passive smoking) during gestation can:
- Reduce the volume of oxygen which reaches the baby's cells, affecting their ability to transfer energy in respiration. This is because of nicotine and carbon monoxide in the cigarette smoke. Nicotine narrows blood vessels and carbon monoxide inhibits red blood cells from carrying oxygen
- Smoking increases the risk of premature (early) birth, stillbirth (death of the foetus), cot death (death of the new-born) and low birth weight caused by growth impairment
- Children whose mothers smoked during gestation are more likely to experience learning disorders, behavioural problems, low IQ and asthma.

Drinking alcohol during gestation can lead to foetal alcohol syndrome (FAS).
Symptoms of FAS:
- Physical defects e.g. small head size, low birth weight
- Cerebral palsy (movement and coordination problems)
- Behavioural differences including autistic traits and attention-deficit hyperactivity disorder (ADHD)
- Problems with organs including the liver, kidneys, and heart
- Learning difficulties

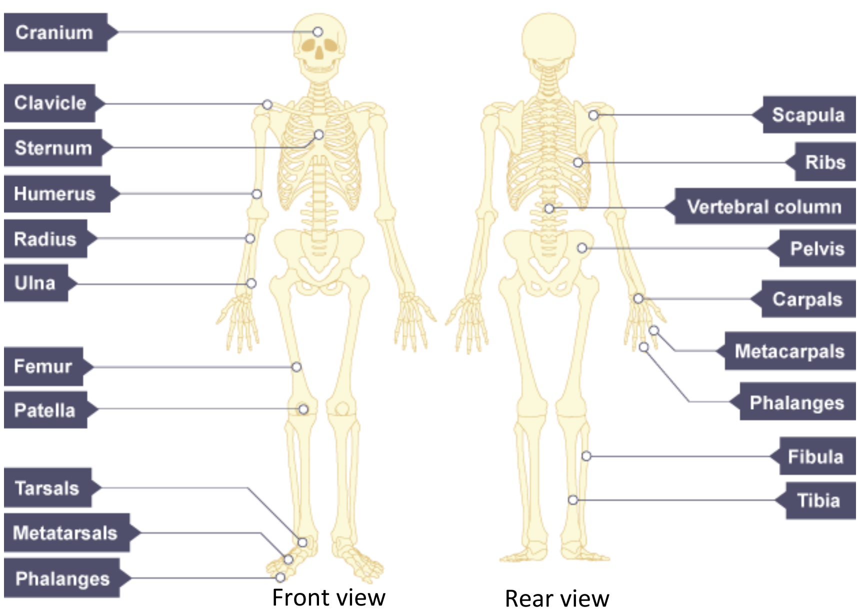
Neonatal abstinence syndrome occurs when a mother has taken a drug which causes dependency, during gestation. An example is the illegal, opioid drug heroin. The baby is born with a dependency on the drug and goes through withdrawal much like an adult would. These include cramps, muscle spasms, chills and increased heart rate and blood pressure.

Year 9 Biology Knowledge Organiser – Pg 18
Topic 7: Organ Systems

Structure and function of the skeletal system

The diagram below shows the skeletal system. The main functions of the skeletal system are movement, support, protection, and making blood cells. 206 bones make it up. Bones are attached to each other by ligaments.

- The vertebral column (spine) is made up of individual vertebrae, with the smallest at the top. The column encloses and protects the spinal cord. The spine supports the upper body and allows us to stand upright.
- The ribcage protects the heart and lungs. The ribs also move in and out to change the volume of the chest cavity, for ventilation. Each pair of ribs is connected to one of 12 vertebra, so there are 24 ribs in total.
- The top of the ribcage is also connected to the sternum at the front
- The cranium houses and protects the brain.



Key Terms	Definition
skeletal system	The system responsible for support, movement, protection of organs, and making blood cells.
specialised	Adapted for a specific function.
calcium	A mineral which promotes healthy and strong bones and teeth.
vitamin D	A vitamin which helps the body absorb calcium.
broken/fractured bone	Damage to a bone, caused by a force. These terms are interchangeable.
ligament	A band of tough, flexible connective tissue between bones.
torn ligament	If over-stretched, a ligament can snap

Bone disease

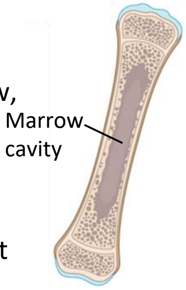
Rickets can be caused by a deficiency of calcium or vitamin D. Rickets causes bone pain, and soft bones which can deform.

Osteoporosis is a condition in which someone loses bone density, making their bones fragile so they are more likely to break bones.

X-ray showing the legs of a child with rickets

Making blood cells

Long bones in the body are hollow – in the middle of the bone is a marrow cavity. The cavity contains bone marrow, from which blood is produced.



Bone marrow produces:

1. Red blood cells (which transport O_2 and CO_2)
2. White blood cells (some of which fight disease)
3. Platelets (which cause blood clotting e.g. when we cut ourselves)

Cells in bone marrow haven't specialised yet. This makes them stem cells. Stem cells are useful in medicine because they have the potential to develop into many types of specialised cell. This means they can be used to treat conditions where cells have stopped performing their usual function.

Year 9 Biology Knowledge Organiser – Pg 19
Topic 7: Organ Systems

Key Terms	Definition
muscle	A collection of tissues which can contract and relax, causing other body parts (including bones) to move.
contraction	Shortening/tightening.
relaxation	Lengthening/loosening.
tendon	A strong, flexible tissue attaching a muscle to a bone.
tennis elbow	A common injury in tennis players caused by damage to the tendon between the lower arm muscle and the humerus bone.
antagonistic muscles	Pairs of muscles where when one contracts the other relaxes.

Structure and function of the muscular system

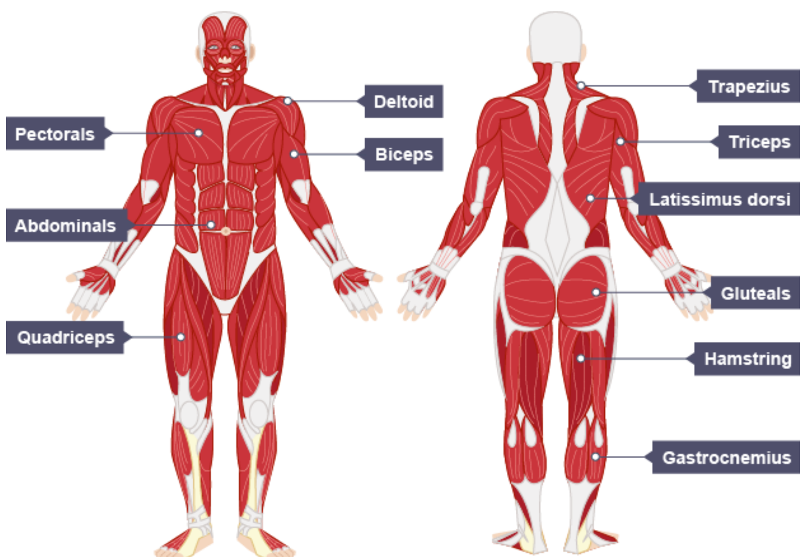
Working alongside the skeletal system is the muscular system. This working together is called biomechanics. The diagram below shows the muscular system. This system allows us to move by muscles contracting and relaxing.

Adaptations of muscle cells

- Muscles require a lot of energy to contract, so muscle cells have a high concentration of mitochondria for respiration, which transfers energy
- Muscle cells contain protein fibres which can contract and relax, making the whole cell shorter and longer

Tendons

Muscles are attached to bones by tendons. Over-stretching a tendon can cause it to snap. Tendons will heal themselves but become shorter in the process because the two severed ends overlap to heal, reducing flexibility. An example of a tendon which is commonly injured is the Achilles tendon (which connects the gastrocnemius muscle to the heel bone). As the body tries to heal a tendon, it will swell and become painful. This is called tendonitis.



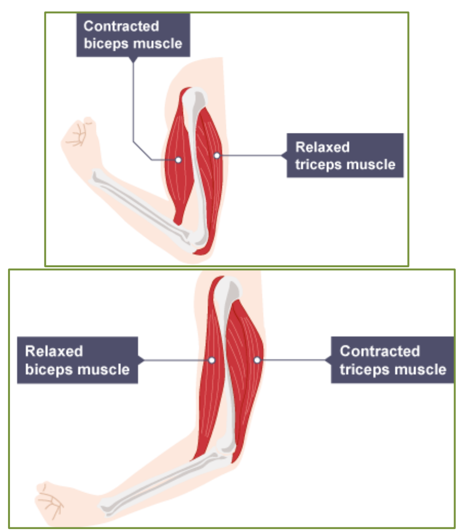
Antagonistic muscle pairings

In order to move bones in two directions (e.g. bending then stretching your arm), muscles are paired antagonistically (one moves the bone in one direction, the other in the opposite direction).

Examples of antagonistic muscle pairings are:

- Biceps and triceps in the upper arm – control forearm movement
- Quadriceps and hamstring in the upper leg – control lower leg movement

How it works – biceps and triceps example



1. To raise the forearm, the biceps contracts and the triceps relaxes.

This brings the forearm towards the upper arm because the biceps are shorter and the triceps are longer

2. To lower the forearm again, the triceps contracts and the biceps relaxes.

This brings the forearm away from the upper arm because the triceps are shorter and the biceps are longer

Muscles exert a force on bones to move them. The longer the bone and the stronger the muscle, the greater the force, due to moments.

Year 9 Knowledge Organiser – Pg 20
Topic 8: Rates of Reaction

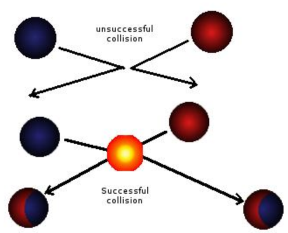
Chemical Reactions - Collision theory

- A chemical reaction happens when particles collide with at least the activation energy.
- The activation energy is the minimum amount of energy for a reaction to happen, this different for each chemical reaction.

The rate of a reaction depends on two things:

· the frequency of collisions between particles. The more often particles collide, the more likely they are to react.

· the energy with which particles collide. If particles collide with less energy than the activation energy, they will not react.



Rate of Reaction

- The rate of reaction is the speed at which a chemical reaction is happening. This can vary hugely from reaction to reaction.
- The rate of reaction can be calculated either by measuring the quantity of reactant used or the amount of product made in a certain length of time.

Factors which affect Rate of Reaction

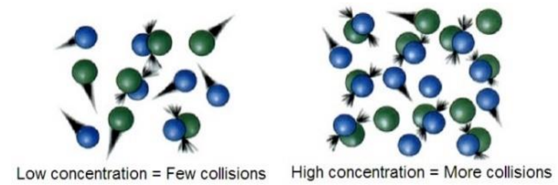
Being able to slow down and speed up chemical reactions is important in everyday life and in industry. We can change the rate of a reaction by:

· Changing temperature
· Changing the concentration of a solution
· Changing the surface area of a solid
· Adding a catalyst

Key Terms	Definitions
rate of reaction	The rate at which reactants are being turned into products
reactant	What is used in a chemical reaction
product	What is made in a chemical reaction
collision frequency	The number of collisions per second
activation energy	The minimum energy required for a successful collision between reactants

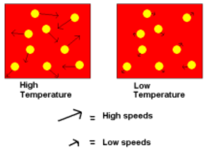
Collision Theory - Concentration

- If the concentration of a solution is increased then there are more particles in a given volume.
- This means collisions are more frequent and the chemical reaction is faster.



Collision Theory - Temperature

- When you increase the temperature of something the particles will move around faster.
- This increases the frequency of the collisions.
- As well as that, as the particles are moving faster the particles collide with more energy making it more likely that collisions will have more energy than the activation energy.

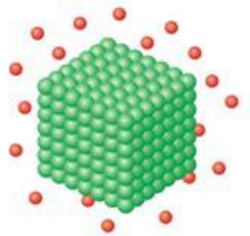


Year 9 Knowledge Organiser – Pg 21
Topic 8: Rates of Reaction

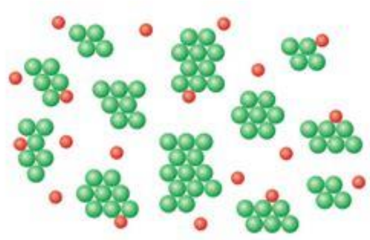
Key Terms	Definitions
catalyst	A substance which speeds up a chemical reaction, without being used up in the reaction
reaction profile	A graph which show the energies of the reactants and products at different stages of the chemical reaction
concentration	The number of particles in a given volume

Collision Theory - Surface Area

- When you increase the surface area of a solid (you cannot increase the surface area of a liquid or gas) you increase the number of particles that are available for collision.
- The frequency of collisions therefore increases and so does the rate of reaction.
- An easy way to increase the surface area of a solid is to crush the solid into a powder.



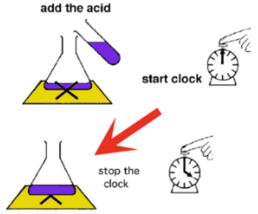
Small surface area.
Slower reaction



Large surface area.
Faster reaction

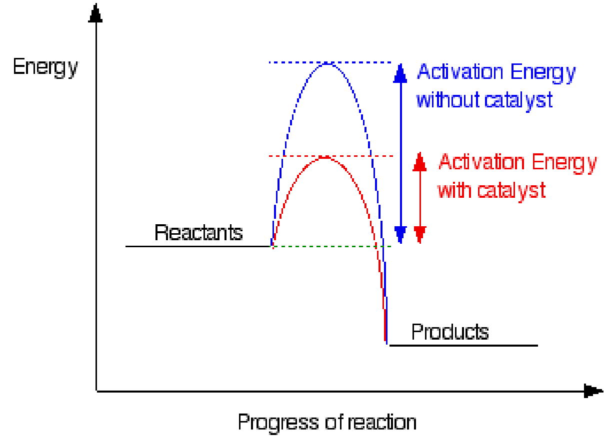
Measuring Rate of Reaction

- There are several experiments that can be used to measure the rate of a chemical reaction.
- One is using sodium thiosulphate and hydrochloric acid.
- This produces a solid, which makes the solution go cloudy. To measure the rate of reaction you can time how long it takes for an X to disappear under a conical flask.



Collision Theory Catalysts

- A catalyst is a substance which speeds up a chemical reaction without being used up.
- It speeds up a reaction because it lowers the activation energy, this means that there are more successful collisions and a faster reaction.
- The effect of a catalyst is shown on the reaction profile below:



- Catalyst are specific to a particular reaction.
- Catalysts are not included in a chemical equation as they are not used up in a chemical reaction.
- Catalysts are used in the exhausts of car to break down harmful gases into less harmful gases. This part of the exhaust is called the catalytic convertor.

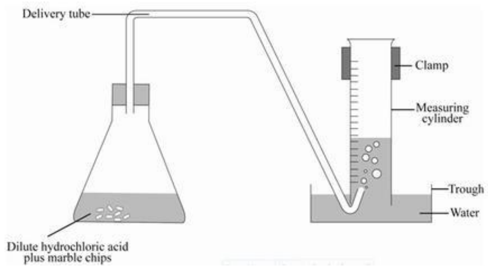
Year 9 Knowledge Organiser – Pg 22
Topic 8: Rates of Reaction

Key Terms	Definitions
gradient	The measurement of how steep a line is on a graph

Equation	Meanings of terms in equation
Rate of Reaction= $\frac{Reactant\ used}{time}$	*Reactant used can either be measured in grams or cm^3*
Rate of Reaction= $\frac{Product\ \ Made}{time}$	*Reactant used can either be measured in grams or cm^3*

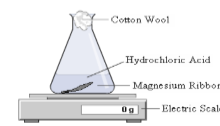
Measuring Rate of Reaction

- Another reaction that could be investigated is is using marble chips and hydrochloric acid.
- This produces carbon dioxide gas, which can be collected. We can time how much gas we make every 10 seconds. This allows us to plot a graph and calculate rate



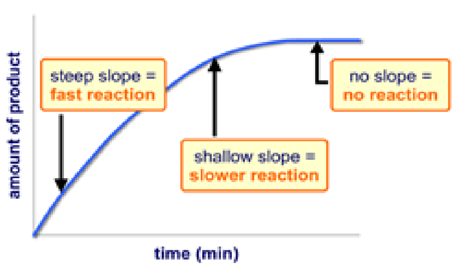
Measuring rate of reaction

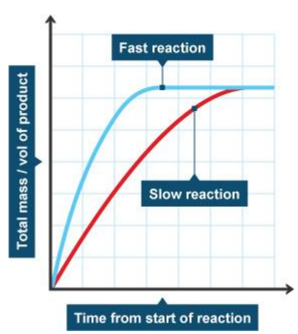
- Another way of measuring the rate of the marble chips and acids is by measuring the mass lost as a gas to the surroundings.
- If the reaction vessel is placed on a top pan balance the mass can be measured every 10 seconds to determine the rate of reaction



Interpreting Rate of Reaction Graphs

- The results from rate of reaction experiments can be plotted on a line graph.
- For example how much gas is made against time. Different lines can be plotted for different conditions, the steeper the gradient, the faster the reaction.
- The graphs flatten off (plateau) at the same point as the same amount of reactant is being used.

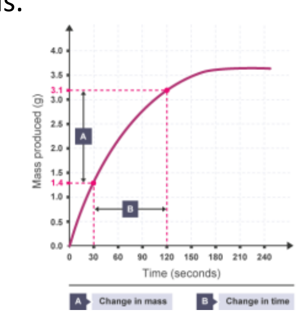




Calculating the Mean Rate of Reaction

To calculate the mean rate of reaction from a graph you need to pick two y values on the graph and two x values, subtract the largest from the smallest and the divide the value on the y axis by the value on the x axis.

$$rate = \frac{change\ in\ y}{change\ in\ x}$$



Year 9 Physics Knowledge Organiser – Pg 23
Topic 9: Forces in Action

Newton's First Law tells us that a stationary object stays stationary unless a resultant force acts on it. It also says that a moving object keeps moving at a constant speed unless a resultant force acts on it.

Newton's Second Law tells us that a resultant force acting on an object causes acceleration, depending on the size of the resultant force and the mass of the object. This formula shows the link:

$$F_R = m \times a$$

Where F_R is the resultant force measured in newtons,
m is the mass of the object measured in kilograms,
a is the acceleration of the object measured in metres per second per second (m/s/s).

Newton's Third Law tells us that forces are always caused by an interaction between two objects. The force that one object exerts on the other object is ALWAYS equal in size and opposite in direction to the force exerted by the second object on the first object. For example, Earth's gravitational pull on you is EXACTLY equal to your gravitational pull on the Earth.

Key terms	Definitions
force	An interaction between two objects that pulls the objects together or pushes them apart.
newton	The unit for force (N)
resultant force	The single force acting on an object resulting from all the separate forces acting on it. In other words, the resultant force is the single overall force.
deformation	Changing the shape of a material/object by applying forces.
extension	The measure of how much an elastic object has been stretched.
compression	The measure of how much an elastic object has been squashed.
elastic	Describes materials that can be extended or compressed by forces, and return to their original shape when the forces are removed.
inelastic	Describes materials that don't go back to their original shape after they've been deformed.
direct proportion	Describes a mathematical relationship between variables where: when the independent variable doubles, the dependent variable doubles too.
elastic potential energy	The store of energy in extended/compressed elastic objects.

Hooke's Law

- Hooke's law applies to all elastic materials/objects.
- Hooke's law says: the extension/compression of an elastic object is directly proportional to the force applied.
- When an elastic object is extended/compressed, it stores elastic potential energy.
- If too much force is applied to the elastic object, it reaches its elastic limit. After this elastic limit, the object no longer returns to its original shape once the force is removed.

Work done by a force

- Applying a force to get an object to move is one way to transfer energy between stores. Transferring energy is also known as 'doing work'.
- To calculate work done:

$$work\ done (J) = force (N) \times distance\ moved\ in\ the\ direction\ of\ the\ force\ (m)$$

- Work is done (energy is transferred) when elastic objects are extended/compressed.
- The amount of work done = the amount of elastic potential energy stored in the elastic object.

Year 9 Physics Knowledge Organiser – Pg 24
Topic 9: Forces in Action

Levers

Levers involve turning, or rotation. Levers allow forces applied to be multiplied.

- Levers have a pivot: a fixed centre of rotation
- The force applied to a lever is called the effort
- The output force of the lever is called the load (because levers can be used to lift large masses – loads!).
- Both the effort and load are forces that have a turning effect, meaning they make the lever rotate.
- The size of the forces' turning effects is called the moment of the force.
- The moment of a force can be increased by:
  1. Increasing the size of the force
  2. Increasing the perpendicular distance from the pivot

Equilibrium in lever systems

- When a lever is at equilibrium, it is NOT rotating.
- Equilibrium happens when:
  the clockwise moments = the anticlockwise moments
- The forces in each direction are not necessarily equal, but the *moments* of the forces in each direction are equal at equilibrium.
- Where there are multiple forces in one direction (clockwise or anticlockwise), the TOTAL moment in one direction is found by adding up the moments of each force in a particular direction.

Key terms	Definitions
lever	A simple machine that multiplies applied forces (efforts) through rotation around a pivot.
rotation	Turning, with a fixed centre of rotation. Rotation can be clockwise or anticlockwise – see diagram.
turning effect	The rotation of a lever caused by a force (effort OR load force).
moment	Another, more formal, name for 'turning effect of a force'. *See equation*.
perpendicular	At right angles to.
equilibrium	Describes a lever that is NOT rotating because the clockwise and anticlockwise moments are equal.

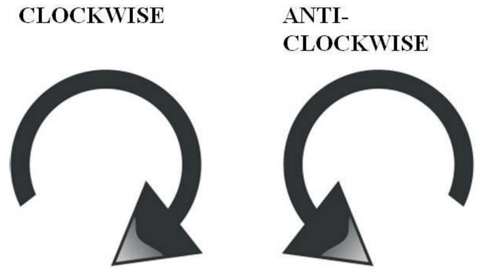
Equation to calculate the moment of a force

$$moment = force \times perpendicular\ distance\ from\ pivot$$

Forces are usually measured in newtons (N)

Distances are usually measured in metres (m)

Moments are measured in a compound measure using the units for force and distance, usually newtonmetres, Nm.



Ways to describe the direction of moments of a force.