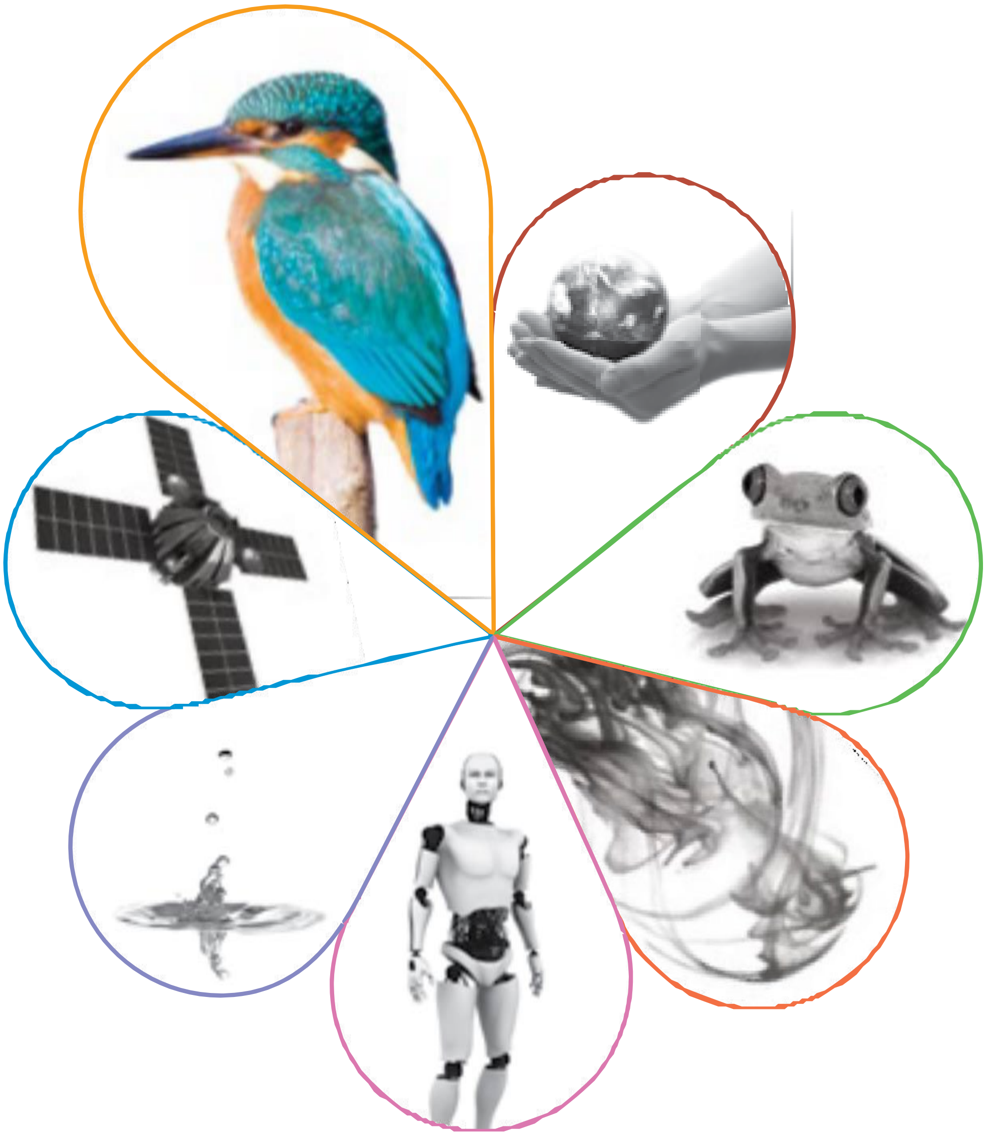
Entry Level Certificate Science

(5960)

Teaching guide

Version1.1 October 2016



Contents

Introduction

We have produced this guide to support the teaching and learning of Entry Level science. It should be read in conjunction with the specification and the scheme of work.

Our aim has been to give some background information on the new ELC course and to illustrate the specification content. Any words, ideas, concepts or facts in this guide that are not contained in the published specification will not be required in the examination.

The development of practical skills is key to a student's understanding of science. The investigative skills students should develop through doing the Teacher Devised Assignments (TDAs) are outlined on pages 45–47 of the specification. Any suitable practical can be used to develop these five skills areas, and we have suggested possible TDA activities throughout the specification.

Students benefit from lots of opportunities to master the individual skills before embarking on the full investigation covering all five skills areas that is required for the final assessment. In this guide we suggest practical activities that teachers could use to help students develop particular skills. These are suggestions only, and teachers may prefer to use others that are appropriate for their own students. Many of the suggestions in this guide tie in with the required practical activities for our two GCSE Combined Science specifications.

To support the use of correct scientific language we have given simple definitions for key words. To ensure consistency, wherever possible we have used the same definitions as in our Key Stage 3 syllabus.

Extra resources to support planning, teaching and the assessment of the ELC course are available on our website.

These include:

- co-teaching documents: ELC and both combined science specifications
- medium term scheme of work
- possible writing frames for students to record information for a TDA
- selection of worksheets to support teaching and learning
- sample externally set assignments (ESA)
- PowerPoint presentation of our Introduction to ELC (5960) course
- *Steps to success in science* – Literacy resources, working scientifically, revision materials and exam techniques

Other useful websites are listed at the end of the guide.

How to use this guide

Outcome

- Each outcome is taken from the specification.
- These are the facts that students need to know and understand.

Supporting information

- To provide teachers with more background to the subject, extra information is included here.
- Might include diagrams, block diagrams, charts, maps or other types of illustrative materials.
- These facts are not always required by the students.

Practical opportunity to develop skills

- A suggestion of which skill or set of skills could be introduced or developed during a practical activity.
- The detail of the practical can be found in the medium term scheme of work.

Key words

- These comprise all the specialist scientific terms contained in the component. The definition is the meaning which will be attached to them for the purpose of the examination.
- 'Key words' will be the only scientific words of which students will need to know the meaning. Other scientific words are used in the specification, but students will not be required to provide a definition of those for the examination.
- What has been provided is a simple definition appropriate for the level of demand of the Entry Level.

Component 1: Biology – The human body

3.1.1 What is the body made of?

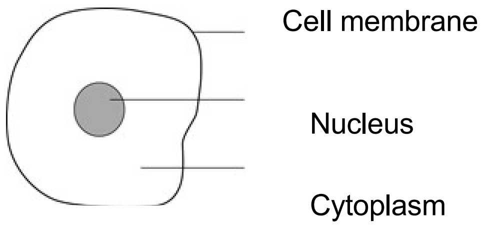
Outcome 1

- Cells are the basic building blocks of all living organisms.
- Most human cells are like most other animal cells and have the following parts:
  - nucleus – controls the activities of the cells and contains the genetic material
  - cytoplasm – where most chemical reactions take place
  - cell membrane – controls the passage of substances in and out of cells.
- Cells may be specialised to carry out a particular function, eg sperm cells, nerve cells and muscle cells.
- Students should be able, when provided with appropriate information, to explain how the structure of different types of cell relates to their function.

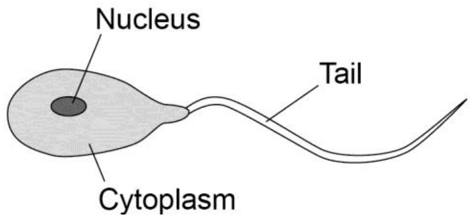
Supporting information

- Cells are the smallest units or 'building blocks' of animals and plants.
- Most animals and plants are made up of millions of different cells.
- Cells specialise in order to carry out different functions.
- Cells are different shapes and sizes according to their function.
- Tissue and organs are made of cells.
- Details of sub-cellular structures are not needed.

A typical animal cell



A sperm cell, which has a long tail for swimming



Practical opportunity to develop skills

Skill area B: Working safely and making measurements or observations.

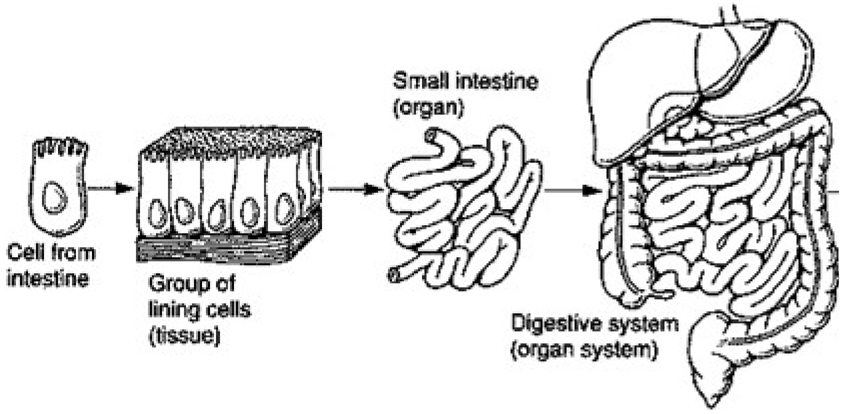
- Use a bio viewer or microscopes to look at specimens. For example, a newspaper, human hair, prepared slides, make a slide of an onion cell.
  [this practical links to a required practical activity in the Combined specification]

Key words

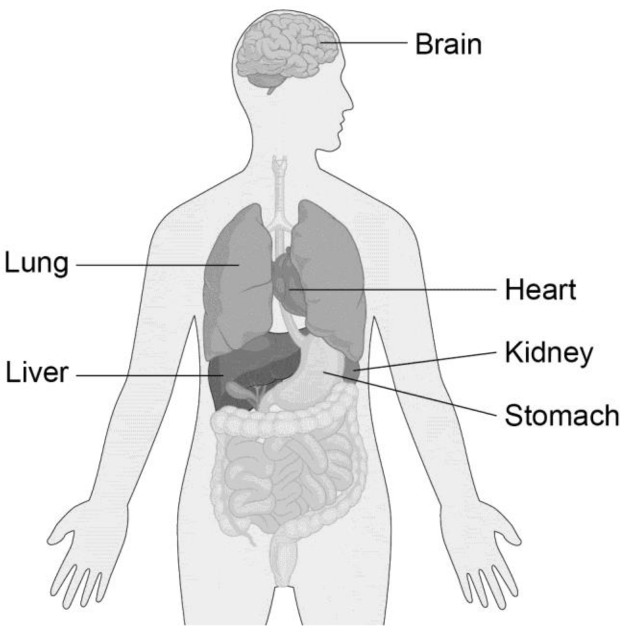
Cell	the unit of a living organism, contains parts to carry out life processes
Cell membrane	surrounds the cell and controls movement of substances in and out
Cytoplasm	jelly-like substance where most chemical processes happen
Genetic	genetic material controls inherited characteristics such as eye colour
Nucleus	contains genetic material (DNA), which controls the cell's activities

Outcome 2

- A tissue is a group of cells with a similar structure and function.
- Students should develop some understanding of size and scale in relation to cells, tissues, organs and systems.



- Organs are aggregations of tissues performing similar functions.
- Organs are organised into organ systems which work together.
- Students should be able to identify the position of the major organs in the human body such as the brain, heart, liver, lungs, kidneys and reproductive organs.



- Students should be able to identify the function of the main organ systems.
- The human circulatory system consists of the heart, which pumps blood around the body (in a dual circulatory system) and blood, which transports oxygen, proteins and other chemical substances around the body.
- The blood contains both red and white blood cells.
- Students should be able to recognise the different types of blood cell from a photograph or diagram.

Supporting information

- A collection of identical cells is called a tissue, and an organ is made up from different tissues.
- Several organs may work together as part of a system, eg the blood circulatory system.
- The main organ systems and their functions:

  Brain – Part of the nervous system that processes information

  Lungs – Organs of the body that exchange gases; when we breathe air into our lungs, oxygen from the air is absorbed into our blood. Carbon dioxide is also released from the blood back into the lungs then it is breathed out.

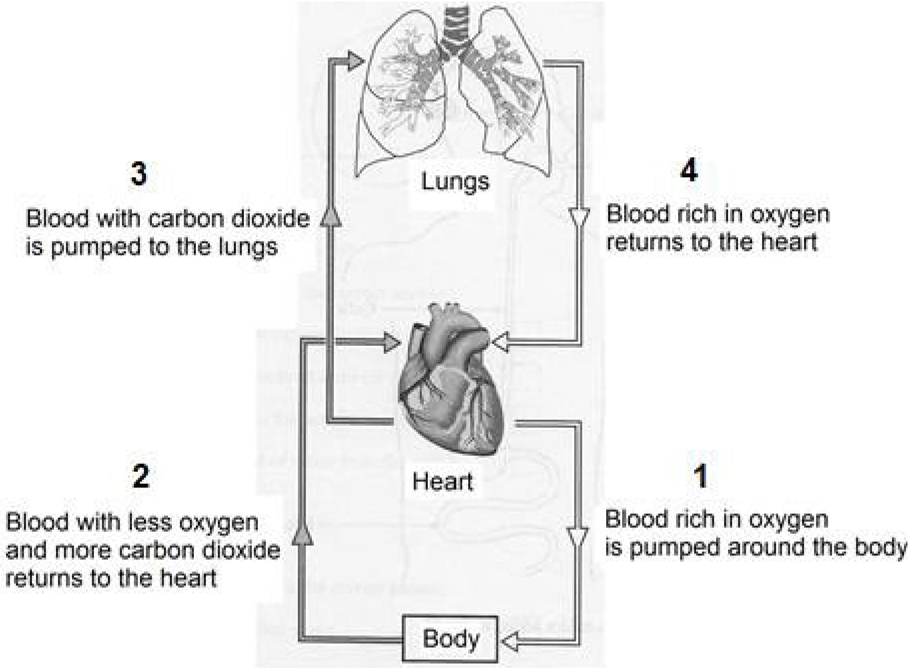
  Heart – The organ that pumps blood around the body

  Liver – Removes toxins, can store energy from food and produces bile

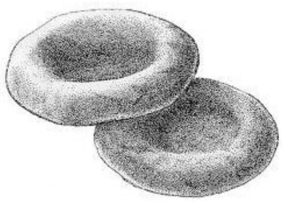
  Kidneys – Filters the blood and produces urine

  Stomach – Muscular bag that breaks down the food; acidic conditions.

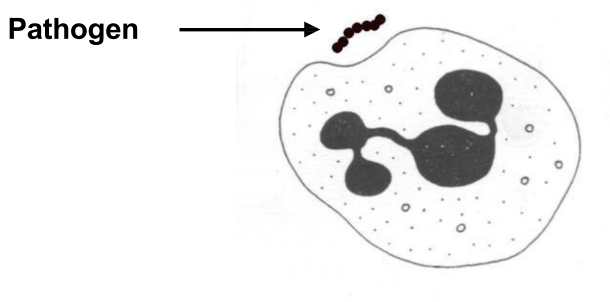
- The diagram shows a simplified version of the dual circulatory blood system.



- Red blood cells are shaped like a doughnut and have no nucleus to maximise their size so they can absorb lots of oxygen.



- The diagram shows a white blood cell about to ‘eat’ or ingest a pathogen.

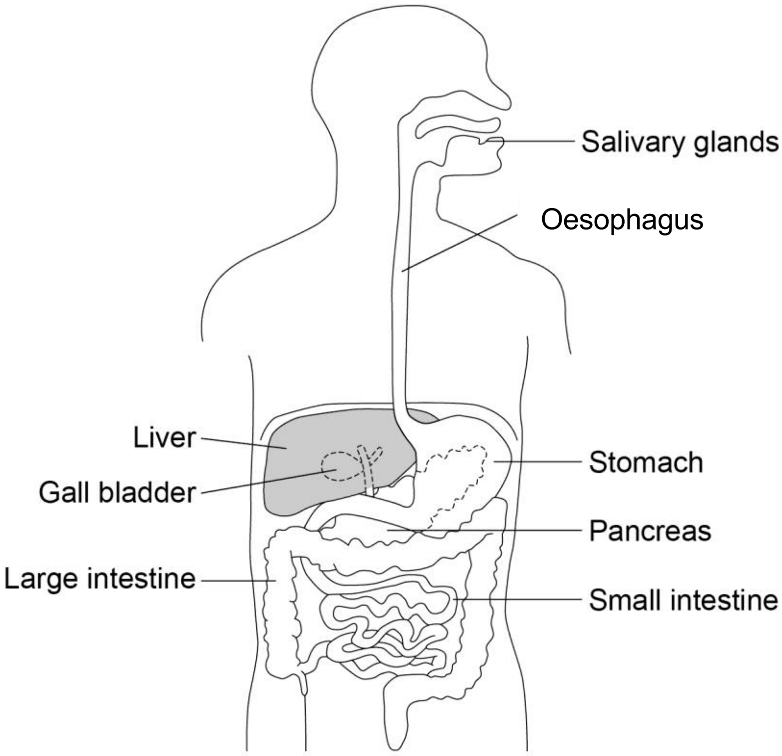


Key words

Blood	a fluid that our heart pumps around our whole body
Brain	a large organ inside the skull; it receives and processes information from body sensors and uses this information to make decisions
Carbon dioxide	a waste gas produced as a result of respiration
Heart	a large organ in the chest that pumps blood around the body
Kidneys	a pair of organs in the body that are responsible for removing some of the liquid waste products
Liver	a large organ in the abdomen; it does many things, including cleaning the blood of toxins
Organ	group of different tissues working together to carry out a job
Oxygen	a gas found in the air that we use in respiration
Red blood cells	carry oxygen around to all parts of the body
Reproductive organs	the testes in males and the ovaries in females
Tissue	group of cells of one type
White blood cells	help us to fight diseases

Outcome 3

- The human digestive system contains a variety of organs:
  - salivary glands
  - stomach
  - liver
  - gall bladder
  - pancreas
  - small intestine
  - large intestine.
- Students should be able to identify the position of these organs on a diagram of the digestive system.



- Enzymes are used to convert food into soluble substances that can be absorbed into the bloodstream.

Supporting information

- The digestive system consists of the mouth, the oesophagus, the stomach and the intestines.
- Food travels along the digestive system, in the order: ‘mouth’, ‘oesophagus’, ‘stomach’, ‘small and large intestines’.
- The mouth is where food is taken in and digestion starts.
- The oesophagus is a tube that carries food from the mouth to the stomach.
- The stomach is where digestion continues.
- The small intestine is where useful products are absorbed into the blood.
- Enzymes are biological catalysts that speed up the process of chemical digestion. They are not changed during the chemical process. Enzymes are sensitive to pH (acidity or alkalinity) and temperature. They work best at body temperature, 37ºC. There are different enzymes for different food groups. Details of specific enzymes and their reactions are not required.

Practical opportunity to develop skills

Skill area A: Experimental design

- Investigate the rate of enzyme action of amylase on starch.
  Using iodine as an indicator to show the time it takes for amylase to break down starch solution.
  [This practical links to a required practical activity in the combined specification]

Key words

Absorbed	‘taken in’; useful products from digestion are absorbed through the wall of the intestine into the blood
Digestion	the process of breaking down food into simple substances that can be absorbed into the blood
Enzymes	substances that speed up the chemical reactions of digestion
Gall bladder	a storage organ that helps in the digestion of fat by storing bile
Gullet	a tube connecting the mouth to the stomach
Small intestine	upper part of the intestine where digestion is completed and nutrients are absorbed by the blood
Large intestine	lower part of the intestine where water is absorbed and where faeces are formed
Liver	removes toxins, can store energy from food and produces bile
Pancreas	a large gland behind the stomach; it releases digestive enzymes into the small intestine and releases hormones into the bloodstream
Saliva	a watery liquid produced in the mouth; it lubricates the food, making it easier to swallow, and starts the process of digestion
Salivary glands	produce saliva in your mouth
Stomach	a sac where food is mixed with acidic juices to start the digestion of protein and kill microorganisms

3.1.2 How the body works

Outcome 4

- Respiration releases the energy needed for living processes and is represented by the equation:

  Glucose + oxygen → carbon dioxide + water (+ energy)

- Students should know that glucose is derived from the diet and that carbon dioxide and oxygen gases are exchanged through the lungs.
- Lifestyle can have an effect on people's health eg the factors of diet and exercise are linked to obesity; smoking to cancer; and alcohol to liver and brain function.
- A healthy diet contains the right balance of the different foods you need and the right amount of energy.
- People who exercise regularly are usually fitter than people who take little exercise.

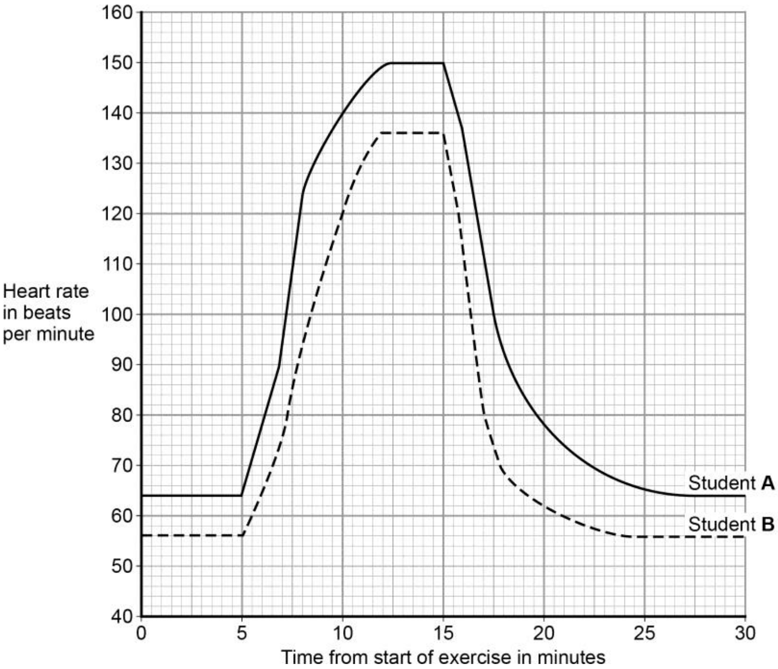
Supporting information

- Glucose used in respiration comes from our food.
- Gas exchange happens in the lungs.
- Details of aerobic/anaerobic respiration are not needed.
- Onset of Type 2 diabetes is associated with a person being overweight.
- Knowledge of deficiency diseases is not required.
- Knowledge of the effects of an unbalanced diet is limited to a person being underweight or overweight.
- Normal pulse rate varies greatly from one person to another.
- A measure of fitness is how quickly your pulse rate returns to what is normal for you, after you have exercised.
- The faster a person's pulse rate returns to normal after exercise, the fitter that person is.
- Fitness is very difficult to define. What 'being fit' is for a teenager will not be the same for a person in their nineties.
- Students should be familiar with how to measure a pulse rate, by detecting the pulse in the wrist or the neck. Don't use the thumb to take a pulse as it has a pulse itself and can be confusing. The easiest place to feel a pulse is often the neck.

Wrist pulse

Neck pulse

- Students should be familiar with graphs that show how exercise causes the pulse rate to change.
- Who is the fitter, Student **A** or Student **B**?



Practical opportunity to develop skills

Skill area C: Recording data
Skill area D: Presenting data

- Does exercise affect pulse rate?
  - Students take their resting pulse, then do some exercise and take their pulse again
  - Note and discuss any changes
  - Design a table to put your results in
  - Draw a bar chart to show different people's results.

Key words

Pulse	a rhythmical throbbing that can be felt in an artery; it is caused by the heart pumping blood through the artery
Pulse rate	the number of pulses that can be felt in a certain time
Respiration	how living things use oxygen to release energy from food

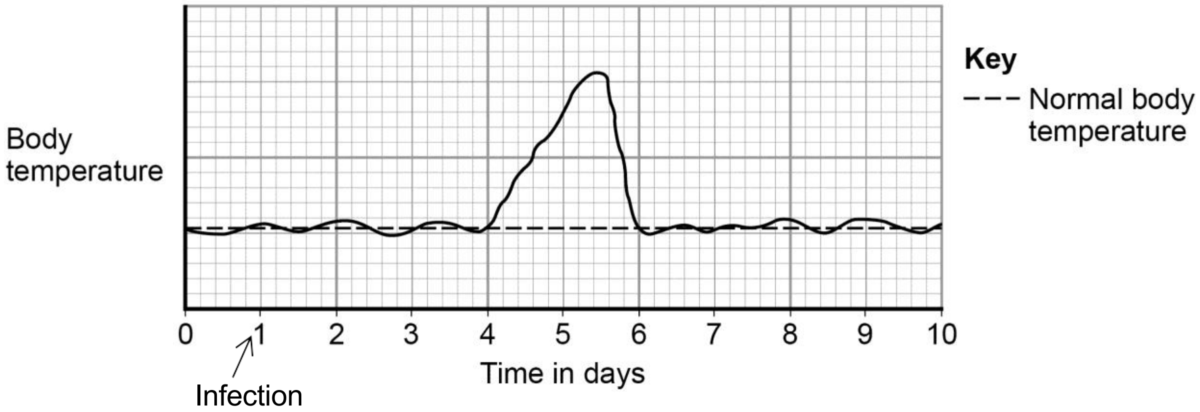
3.1.3 How the body fights disease

Outcome 5

- Infectious (communicable) diseases are caused by microorganisms called pathogens.
- These may reproduce rapidly inside the body and may produce poisons (toxins) that make us feel ill.
- Viruses damage the cells in which they reproduce.

Supporting information

- An infectious disease is any disease caused by a pathogen such as a virus, bacteria, parasite, or fungus.
- Types of pathogen are limited to bacteria and viruses.
- Bacteria and viruses are tiny microscopic organisms.
- They can both grow rapidly inside our bodies.
- Some bacteria are useful to us, but others can make us ill.
- It is not the bacteria themselves that cause the harm; it is the poisons that they produce as a waste product that cause the illness.
- Viruses cause harm.
- No recall of specific illnesses is required.
- One of the signs of an infection is an increase in body temperature.
- The diagram below shows the type of graph that students may be required to interpret regarding body temperature and infection.



Key words

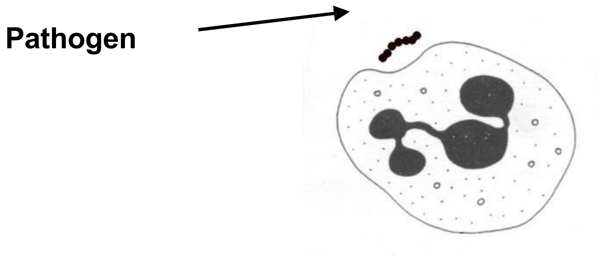
Bacteria	simple microscopic single-celled organisms; some are good for the body, others can cause illness and disease
Pathogen	a microorganism that causes disease
Toxin	a type of poison
Virus	the smallest type of microorganism; they can live inside body cells and cause disease

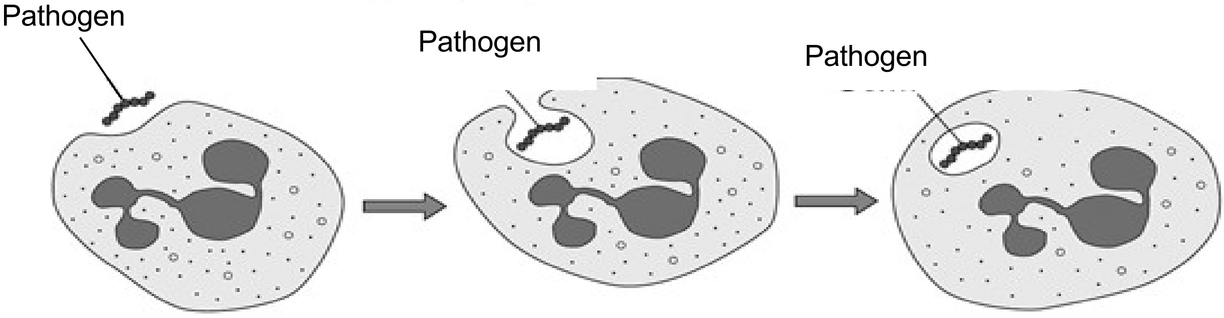
Outcome 6

- White blood cells help to defend against bacteria by ingesting them.
- Vaccination involves introducing small quantities of dead or inactive forms of a pathogen into the body to stimulate the white blood cells to produce antibodies so that if the same pathogen re-enters the body, antibodies can be produced rapidly.
- Students should be able to explain the use of vaccination in the prevention of disease.

Supporting information

- There are different types of blood cells: white blood cells and red blood cells.
- White cells in the blood help us to fight disease. They do this by ingesting bacteria and producing antibodies.
- White blood cells are part of the body’s natural defence mechanism.
- White blood cells can also help to fight illness by producing antibodies.
- The diagram shows a white blood cell about to ingest a pathogen and the stages of ingestion.





- Viral infections are hard to treat because viruses live inside the body's cells.

Key words

Antibody	a substance produced by the body to fight disease. Antibodies are proteins that are produced by the immune system
Ingest	consume
Vaccination	injection of a killed microbe in order to stimulate the immune system to protect us against the microbe, so preventing a disease
White blood cell	one of the different types of cell found in the blood; they help us to fight diseases

Outcome 7

- Medical drugs are developed and tested before being used to relieve illness or disease.
- Drugs change the chemical processes in people's bodies.
- People may become dependent or addicted to the drugs and suffer withdrawal symptoms without them.
- Antibiotics, including penicillin, are medicines that help to cure bacterial disease by killing infective bacteria inside the body, but cannot be used to kill viruses.

Supporting information

- Drugs are often used properly to cure an illness.
- Drugs can also be misused if they are taken for the wrong reasons.
- The names of any antibiotics other than penicillin are not required.

Practical opportunity to develop skills

Skill area B: Working safely and making measurements or observations.
Skill area E: Identifying patterns and relationships.

- Evaluate the effect of disinfectants and antibiotics on pre-inoculated agar in petri dishes.

Key words

Addictive	an addictive substance is one that your body becomes dependent on: once you start taking it, you want more and it is difficult to give up
Antibiotic	a drug that acts on bacteria
Drug	a substance not normally found in the body that is taken to bring about a particular effect
Penicillin	a type of antibiotic; it was one of the first ones to be produced

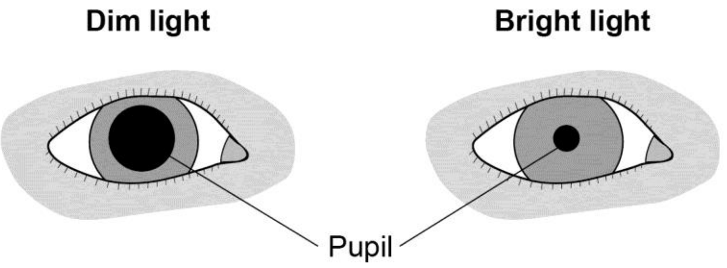
3.1.4 How the body is coordinated

Outcome 8

- The human body has automatic control systems, which may involve nervous responses or chemical responses coordinated by hormones.
- Reflex actions are automatic and rapid. Examples include the response of the pupil in the eyes to bright light, and the knee jerk reaction.

Supporting information

- Hormones are chemical substances that act as ‘messengers’ around the body.
- Hormones are released by glands in the body and travel round to another part, where they have an effect.
- The part of the body that produces hormones is called a gland.
- Different glands make different hormones.
- The part of the body that receives the hormone is called the target organ.
- A reflex action is one that happens automatically, and very quickly.
- We have no control over reflex actions.
- The brain is not involved in reflex actions.
- Knowledge of the reflex arc is not required.
- A good example of a reflex action is blinking when something is about to go in your eye.
- Another example is the pupil in the eye contracting suddenly when a bright light is switched on.



Practical opportunity to develop skills

Skill area E: Identifying patterns and relationships.

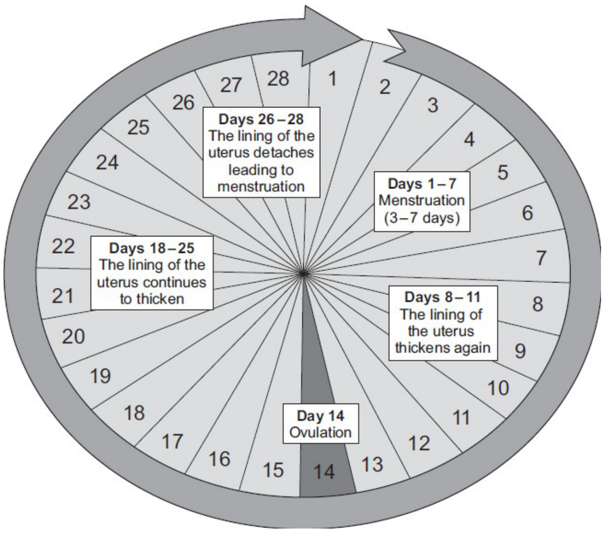
- What is the best way to find out who has the quickest reaction times in the group? Compare reaction times using the drop the ruler method. Compare this method with a computer generated test; which one is more accurate and why?
  [This practical links to a required practical activity in the combined specification]

Key words

Action	any response which our body carries out, such as kicking, walking or blinking
Automatic	means that a response happens without thinking about it; we cannot control automatic reactions
Coordinated	if processes are coordinated it means that they are working together for the same purpose
Glands	these are organs in the body that make hormones
Hormones	this is a chemical messenger that carries a signal from one cell (or group of cells) to another via the blood
Reflex action	a reflex is an automatic response of the body; it usually happens very quickly and it often helps to protect our body
Secreted	when hormones are released into the blood, they are said to be secreted
Target organ	this is an organ in the body that receives the hormone and produces a response

Outcome 9

- Hormones are secreted by glands and are transported to their target organs by the bloodstream.
- Several hormones are involved in the menstrual cycle of woman, including some that are involved in promoting the release of an egg.
- Knowledge of the names of specific hormones is not required.
- Students should be familiar with a diagram of the menstrual cycle.



Supporting information

- The release of eggs is controlled by hormones in a woman's body.
- Oestrogen and progestogen are two hormones involved in the menstrual cycle.
- An egg is released from the ovary; it travels down the fallopian tube where it can be fertilised by a sperm.
- If the egg is fertilised it embeds itself in the lining of the womb where it grows and develops.
- If the egg is not fertilised the lining of the womb breaks down. This is known as menstruation or a period.
- The menstrual cycle lasts approximately 28 days.
- An egg is released around day 14.

Key words

Egg	the female reproductive cell; when fertilised it can develop into an embryo
Glands	organs in the body that make hormones
Hormone	a chemical messenger that carries a signal from one cell (or group of cells) to another via the blood
Menstrual cycle	this is a recurring series of changes that occur in a woman’s body; these changes are brought about by hormones and are linked to reproduction
Secreted	when hormones are released into the blood they are said to be secreted

Outcome 10

- The uses of hormones in controlling fertility include:
  - giving oral contraceptives that contain hormones to inhibit eggs from maturing
  - giving ‘fertility drugs’ to stimulate eggs so that they mature
- Students should be able to evaluate the benefits of, and the problems that may arise from, the use of hormones to control fertility.

Supporting information

- Women have different levels of fertility.
- Fertility is affected by the presence of certain hormones in the blood.
- Fertility may be increased by the woman being given certain hormone treatments.
- Fertility may be reduced by the woman taking oral contraceptives containing another type of hormone.
- One of the effects of fertility treatment is that it may result in multiple births.
- Multiple conceptions can sometimes increase the risk of complications in pregnancy and childbirth, and may lead to premature or underweight babies.
- The names of the hormones involved and the mechanism by which they work are not required.

Key words

Contraceptive	a method designed to prevent the fertilisation of an egg
Fertility	the natural ability to produce another living being; if a woman is fertile it means that she has the ability to produce a baby
Inhibit	to prevent
Mature	to grow to full size
Oral	taken into the body through the mouth
Stimulate	to provide a signal that will produce a response; eggs will not grow to maturity until they receive a signal to do so

Component 2: Biology - Environment, evolution and inheritance

3.2.1 What are the feeding relationships between living organisms?

Outcome 1

- Radiation from the Sun is the source of energy for living organisms.
- Green plants and algae absorb a small amount of the light that reaches them and make glucose by photosynthesis. These organisms are called producers.
- Students should know the word equation for photosynthesis:

Carbon dioxide + water → glucose + oxygen

Supporting information

- Both light and water are needed for plants to grow.
- Chlorophyll is the green pigment in the leaves and is needed for photosynthesis to occur.
- Carbon dioxide is removed from the environment by green plants and algae for photosynthesis.
- Photosynthesis produces oxygen, which can be released into the atmosphere.
- The carbon from the carbon dioxide is used to make carbohydrates, fats and proteins, which make up the body of plants and algae.

Practical opportunity to develop skills

Skill area C: Recording data.
Skill area D: Presenting data.

- How do we know plants are photosynthesising?
  - Using pond weed, collect the gas given off from a newly exposed stem.
  - Does the intensity of light change how much gas is given off?
  - Construct a line graph to show how light intensity (distance of the lamp) affects oxygen production.
  [This practical links to a required practical activity in the combined specification]

Key words

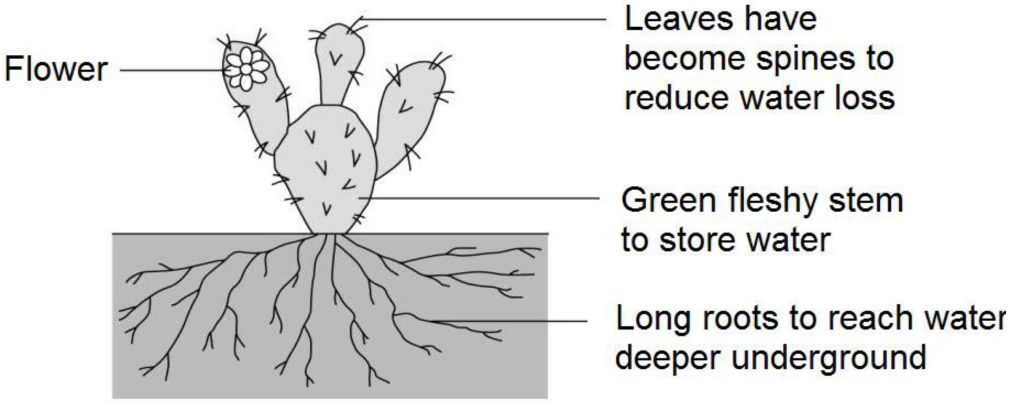
Algae	single-celled or multiple-celled organisms formerly classified as plants. Algae are found in fresh or salt water or moist ground. Algae have chlorophyll and other pigments but lack true stems, roots, and leaves
Carbon dioxide	a gas produced by burning fossil fuels and by respiration
Chlorophyll	green pigment in plants and algae, which absorbs light energy
Organism	a living animal or plant
Photosynthesis	a process where plants and algae turn carbon dioxide and water into glucose (food) and releases oxygen
Producer	green plant or algae that makes its own food using sunlight
Radiation	transfer of energy as a wave

Outcome 2

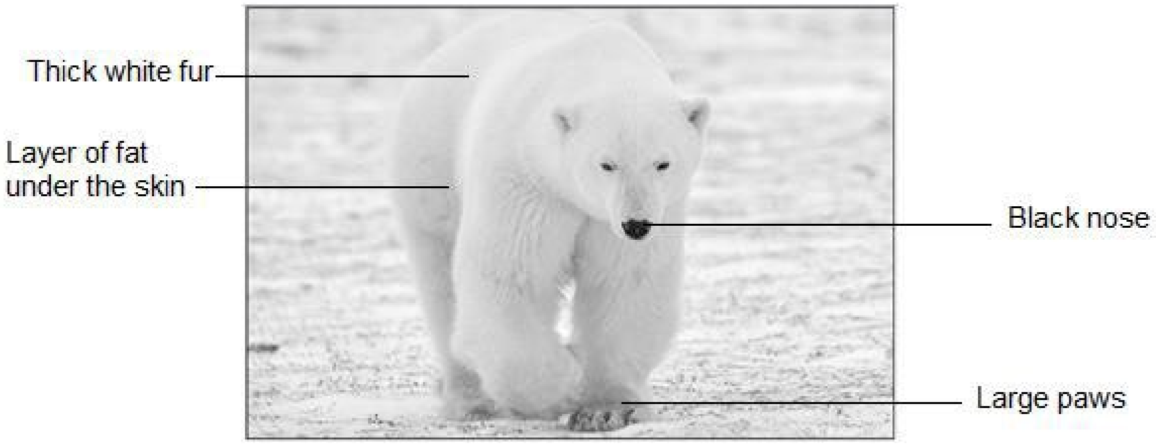
Animals and plants may be adapted for survival in the conditions where they normally live.

Supporting information

- The places where a plant or animal lives is called its habitat.
- Habitats can be very different eg in temperature, water supply and availability of food.
- In deserts there is very little water and there are extremes of temperature.
- Plants like cacti have adapted to desert conditions.



- Students should be able to explain how organisms are adapted to live in their natural environment given appropriate information in image or prose format.
- Examples may include polar bears in the Arctic, or cacti in deserts.



Practical opportunity to develop skills

Skill area D: Presenting data.

Why do polar bears have thick coats?
Insulating experiment using different ‘skins’ to measure heat lost from a beaker of water – fur (polar bear), wool (sheep), paper (skin).

Key words

Adapted	over millions of years, plants and animals have changed (or evolved). For example, polar bears that have thicker fur may be better able to survive. These animals will then reproduce and pass on their genes for thicker fur to their offspring. Over many millions of years, the average thickness of the polar bear’s fur will become thicker. We say that the animal has adapted to suit the conditions where it lives
Habitat	a place where something lives
Survival	the ability to stay alive

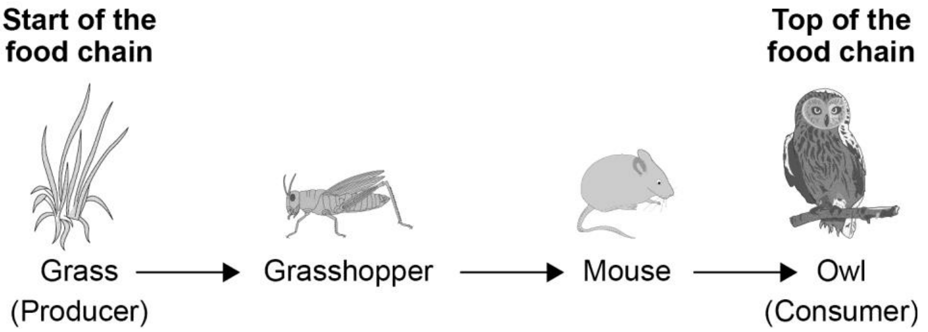
Outcome 3

- Feeding relationships within a community can be represented by a food chain.
- All food chains begin with a producer.
- A food web can be used to understand the interdependence of species within an ecosystem in terms of food resources.

Supporting information

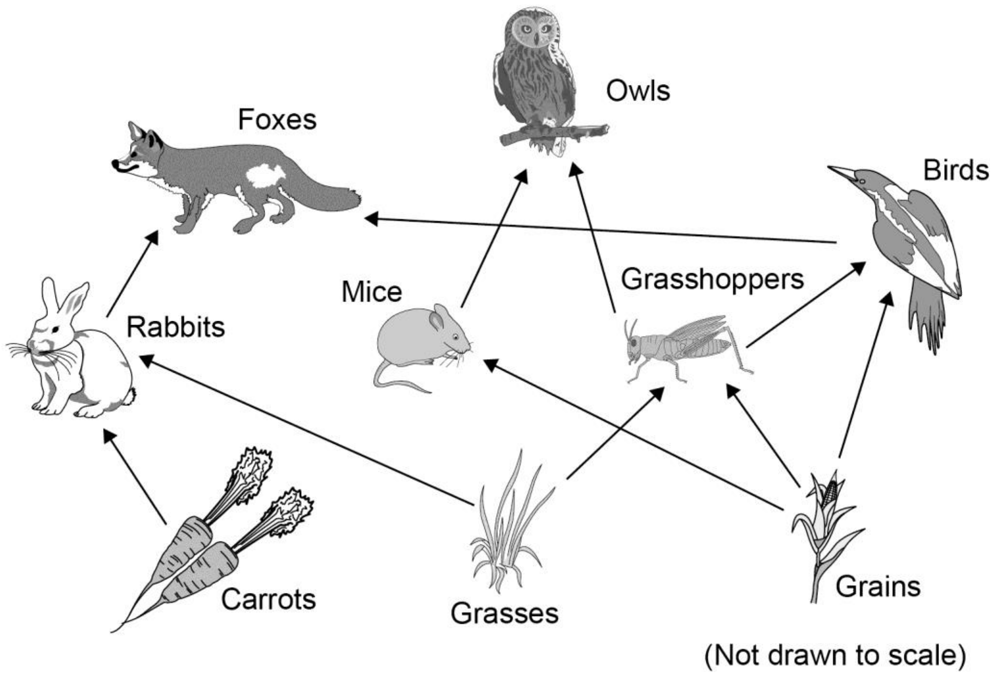
- Producers (green plants) are at the bottom of the food chain.
- Large predators are at the top of the food chain.
- Energy is transferred through the food chain, but there is energy lost at each stage.

A food chain



- Organisms that are part of a food web have a greater chance of survival, as if one food source is reduced they have others to fall back on.

A food web



Key words

Ecosystem	the living things in a given area and its habitat
Food chain	shows what eats what in a particular habitat; it shows the flow of energy from one organism to the next, starting with a producer, ending with a top predator
Food web	shows how food chains in an ecosystem are linked
Producer	plants or algae that makes its own food using sunlight
Consumer	feeds on another organism

Outcome 4

- All materials in the living world are recycled to provide the building blocks for future organisms.
- Decay of dead plants and animals by microorganisms returns carbon to the atmosphere as carbon dioxide, to be used by plants in photosynthesis.

Supporting information

- Living things use materials from the environment for growth and other processes.
- These materials are returned to the environment either in waste materials or when living things die and decay.
- Materials decay because they are broken down (digested) by microorganisms.
- Microorganisms are more active and digest materials faster in warm, moist, aerobic (oxygen rich) conditions.
- Carbon is one of the most important elements to be naturally recycled.
- The carbon cycle is the process whereby carbon moves from the atmosphere, through various animals and plant, then back into the atmosphere.
- Carbon dioxide is removed from the environment by green plants and algae for photosynthesis.
- Carbon dioxide is returned to the atmosphere by organisms respiring and by burning fossil fuels.
- In a stable community, the processes that remove materials are balanced by processes that return materials. The materials are constantly cycled.
- The names of particular microorganisms are **not** required.

Practical opportunity to develop skills

Skill area A: Experimental design.

- Who can make their grape disappear the fastest?
  Students are given 4 grapes in individual Petri dishes or bowls and access to sugar solution, warmth, cold and heat. They are given the challenge to work out how to make their grape last the longest.

Key words

Carbon cycle	how carbon is recycled so that it can be used again
Decay	how living things are broken down when the die
Environment	the surrounding where an organism lives
Microorganism	an organism that is too small to be seen with the naked eye, but can be seen under a microscope. Microorganisms include bacteria, viruses and some fungi. Many of these microorganisms are very useful to us because they break down waste products

3.2.2 What determines where particular species live?

Outcome 5

- Plants often compete with each other for light and space, and for water and nutrients from the soil.
- Animals often compete with each other for food, mates and territory.

Supporting Information

- Habitats have limited resources needed by plants and animals.
- Plants and animals compete with one another for water, food, space and mates in order to survive.
- Sometimes the competition is between individuals of the same species, sometimes it is between species.
- An example of competition between species is red squirrels and grey squirrels, where grey squirrels have driven out red squirrels from most habitats in the UK.
- Students will not be required to recall any specific examples of nutrients.

Practical opportunity to develop skills

Skill area C: Recording data

- Why are there more plants growing in one part of a field than others?

  Using a 'transect' (string line) – as you move along the 'transect', compare the growth of grass or a flower like daisies. If possible include an area shaded by a tree or bush and in an open area.
  [This practical links to a required practical activity in the combined specification]

Key words

Competition	when two or more living things struggle against each other to get the same resource
Nutrients	are substances that all living things need in order to survive; plants get their nutrients from the soil; animals get their nutrients from eating plants or other animals
Plants	living things that can produce their own food by photosynthesis
Territory	the area in which a plant or animal lives

Outcome

- Animals and plants are subjected to environmental changes. Such changes may be caused by non-living or living factors.

Supporting information

- Non-living factors of an ecosystem such as climate, temperature, water, and soil type, are abiotic factors.
- A change in the average temperature or rainfall is an example of a non-living factor (abiotic)
- Living factors of an ecosystem, such as plants and animals, are called biotic factors.
- An example of a living factor (biotic) is the introduction of a competitor or predator.
- Over a long period of time, conditions in an environment eg temperature and rainfall levels can change.
- Environmental change can be caused by flooding, pollution and erosion.
- If the change in conditions is extreme, and lasts for a long period of time, some species may not be able to survive.
- If the species dies out completely, it is said to be extinct.

Practical opportunity to develop skills

Skill area C: Recording data.

Even in a small garden or open space there are non-living factors students can measure and compare:

- is the temperature or the soil the same everywhere in the garden?
- is the light intensity the same?
- is there moisture in the soil?

Key words

Abiotic	non-living factor of an ecosystem
Biotic	living components that affect population size or the environment eg predators
Extinct	when no more individuals of a species remain
Environment	the surroundings within which an organism lives

Outcome

- Pollution of the environment can occur:
  - in water, from sewage, fertiliser or toxic chemicals
  - in air, from smoke and gases such as sulfur dioxide which contributes to acid rain
  - on land, from landfill and from toxic chemicals such as pesticides and herbicides, which may be washed from land into water.
- Students should recognise that rapid growth in human population means that more resources are used and more waste is produced.

Supporting information

- Humans can cause widespread changes in the environment.
- Rapid increase in the human population means that non-renewable resources are being used up more quickly.
- Humans reduce the amount of land available for other plants and animals eg by building, quarrying, farming and dumping waste.
- Humans pollute the environment eg water with sewage, air with smoke, and land with poisonous chemicals.
- Burning fossil fuels produce gases that cause global warming.
- Natural indicators can be used to show whether water or the air is polluted.
- A larger variety of animals are found in unpolluted water than in polluted water.

Practical opportunity to develop skills

Skill area C: Recording data.
Skill area D: Presenting data.
Skill area E: Identifying patterns and relationships.

Is there more air pollution near the road?

Collect leaves from near to and far from a busy road. Using a moist cotton wool swab, wipe the leaves and compare the differences in how dirty the cotton wool is.

Key words

Acid rain	when sulphur dioxide and other gases such as oxides of nitrogen dissolve in rain water an acidic solution known as 'acid rain' is formed
Deforestation	the cutting down and removal of forests
Environment	the surrounding air, water and soil where an organism lives
Herbicide	a weed killer, used to kill unwanted plants
Landfill sites	these are sites where waste material can be buried in the ground; they are often used to dispose of household rubbish
Pesticide	a toxic substance used to kill living things such as insects
Pollution	contamination that can harm living organisms
Sewage	waste material such as urine and faeces that is taken away from homes through pipes and treated to make it harmless
Toxic	poisonous

3.2.3 How life has developed on Earth

Outcome 8

- Darwin's theory of evolution states that all species of living things have evolved from simple life forms that first developed more than three billion years ago.
- In natural selection, individuals with characteristics most suited to their environment are most likely to survive to breed successfully.
- Artificial selection (selective breeding) is the process by which humans breed plants and animals for particular genetic traits.

Supporting information

- The very first life forms on Earth were very simple organisms, often consisting of a single cell.
- Very simple organisms have evolved or changed into more complex plants and animals.
- Over millions of years, the appearance of most plants and animals has changed very slowly.
- We can see evidence of this change by studying fossils. These are the remains of plants or animals that lived millions of years ago. Often these plants and animals have become extinct, and no more of those species are still alive today.
- Evidence to support the theory of evolution is limited to fossil evidence and the similarity of characteristics between species.
- An example of natural selection is the distribution of the peppered moth.

- Particularly useful traits that are bred into plants are resistance to disease and certain coloured fruits.

- Particularly useful traits that are bred into animals include high milk yield, lean meat and multiple births.
- Examples of artificial selection include disease resistance in food crops, domestic dogs with a gentle nature and plants with large flowers.
- It is very difficult to give a precise definition of the word 'species' at this level.

Key words

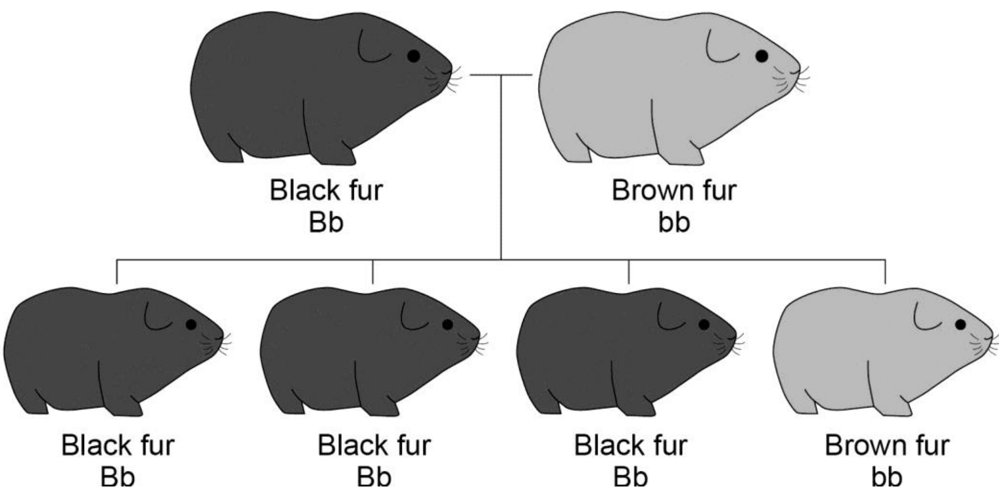
Evolution	theory that the animal and plant species living today descended from species that existed in the past
Extinct	when no more individuals of a species remain
Fossils	the preserved remains or traces of animals, plants and other organisms from the past
Selective breeding	breeding plants and animals for particular desirable genetic traits
Theory	a well-substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment

Outcome 9

- There are two types of reproduction:
  - sexual reproduction, which involves the joining of male and female sex cells; there is a mixing of genetic information, which leads to variety in the offspring
  - asexual reproduction, where only one individual is needed as a parent. There is no mixing of genetic information, which leads to identical offspring (clones).

Supporting information

- In animals, genes are passed on to the offspring through the male sperm and the female egg.
- In plants, genes are passed on through the male pollen and the female ovule (egg).
- In sexual reproduction, the offspring will receive genes from both parents.
- As each parent has a different mixture of genes, offspring born to the same parents will be different from each other.
- Physical differences are called characteristics.
- Some living things can produce offspring from a single parent. This is called asexual reproduction.
- Because all the genes in the offspring have come from a single parent, the offspring will be identical to that parent.
- Examples of asexual reproduction are:
  - cuttings taken from plants
  - yeast cells dividing to make new cells.
- Gardeners can often grow new plants more quickly by taking cuttings than they can by planting seeds.
- The term 'gamete' is not required.
- An example of sexual reproduction leading to variety is shown in the diagram below.



Key words

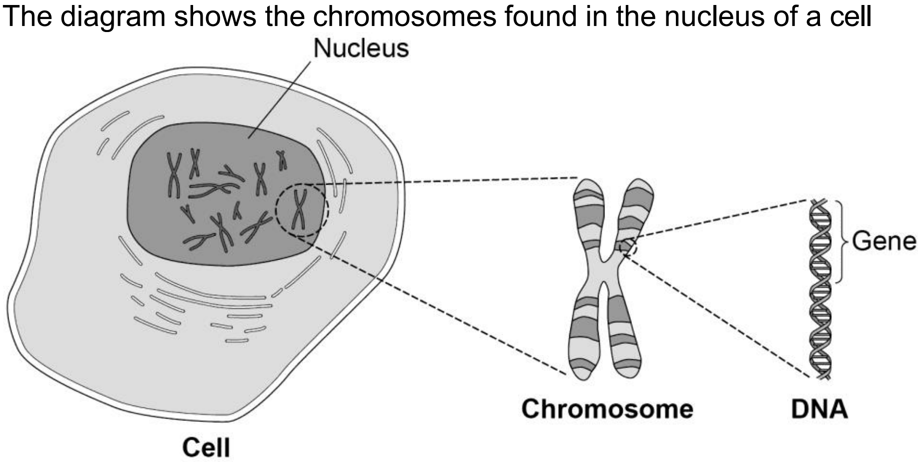
Asexual reproduction	a way of reproducing new identical offspring from only one parent
Characteristics	features that distinguish one person from another, eg shape of nose or colour of eyes
Clone	an organism that is genetically identical to another organism
Cutting	a piece of a plant (often a leaf) that is cut off; it can then be planted in soil in an attempt to grow a new plant
Gene	a section of DNA that determines an inherited characteristic; genes are held on the chromosome
Offspring	the young animals or plants that are produced by the parent(s) as a result of reproduction
Sexual reproduction	a process by which a new individual animal or plant can be made; it involves two parents, one male and one female
Variety	individual animals and plants that are not identical to each other, but which have slight differences

Outcome 10

- The genetic material in the nucleus of a cell is made of a chemical called DNA, which is contained in structures called chromosomes.
- Chromosomes carry genes that control the characteristics of the body.
- Humans have 23 pairs of chromosomes. Only one pair carries the genes that determine sex: females have the same sex chromosomes (XX); in males the chromosomes are different (XY).
- In genetic engineering, genes from chromosomes of humans and other organisms can be ‘cut out’ and transferred to the cells of other organisms.
- Students should know that a cell consists of a nucleus that controls the actions of the cell and cytoplasm.
- Students should be aware of the potential benefits and risks of genetic engineering.

Supporting information

- Chromosomes are made up of genes, which are made from DNA.
- Chromosomes are found in the nucleus of a cell.
- Genes carry the information for making new individuals.
- Different genes control the development of different characteristics.
- Most genes have more than one form. For example, the gene for eye colour may produce blue or brown eyes.
- Some characteristics are controlled by more than one gene.
- Genetic engineering identifies useful or desirable characteristics. Scientists then isolate the gene responsible for that characteristic. Enzymes are used to cut out the desired gene, which is then inserted into a bacterium plasmid. The bacteria then reproduce rapidly, creating lots of bacteria with the new desirable characteristic.
- The benefits of genetic engineering include uses in medicine such as making insulin and in agriculture to produce crops that are pest resistant (GM crops).
- Some people believe the process of genetic engineering is unethical and dangerous as we are changing the genetic structure of organisms.
- Diagrams of genetic crosses will not be required.
- No knowledge of the structure or function of DNA is required.
- The diagram shows the chromosomes found in the nucleus of a cell



Key words

Characteristics	features that distinguish one person from another, eg shape of nose or colour of eyes
Chromosomes	thread-like structures containing tightly coiled DNA
DNA	material found in the nucleus of cells that contains genetic information
Gene	a section of DNA that determines an inherited characteristic
Genetic engineering	transplanting genes for a desired characteristic into a different organism
Plasmid	the small circular genetic material present in bacterial cells and used in genetic engineering or genetic modification

Component 3: Chemistry – Elements, mixtures and compounds

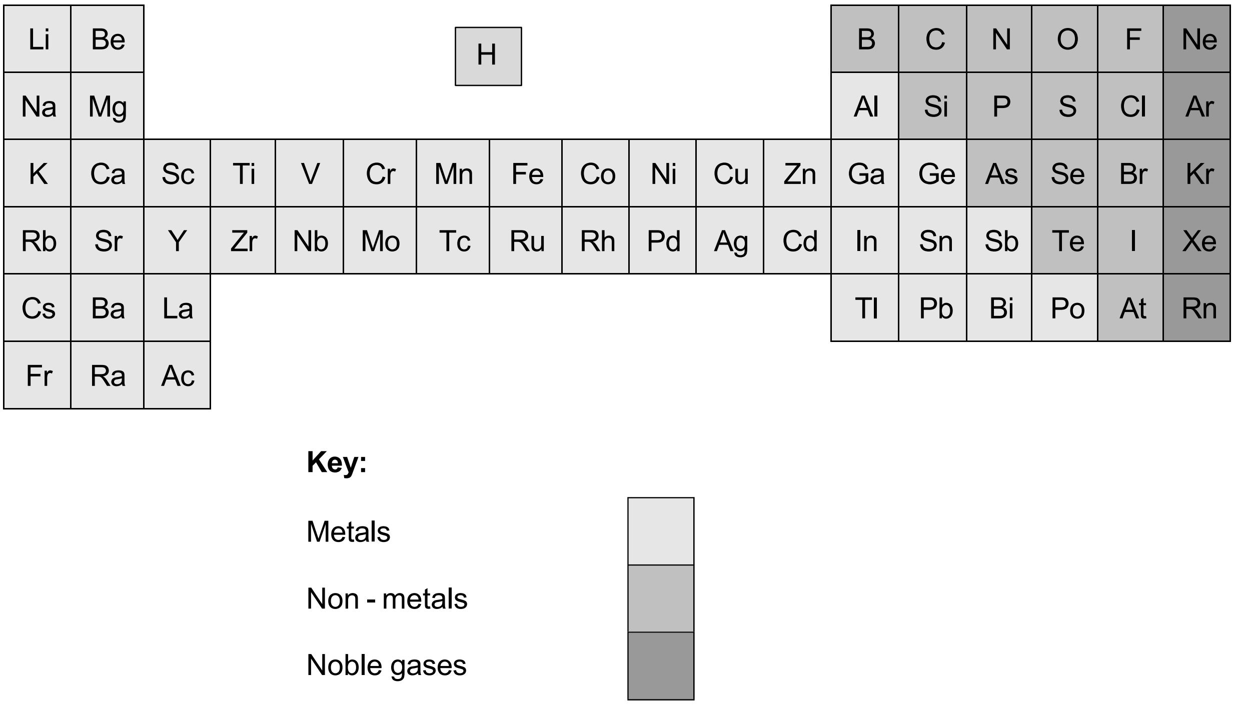
3.3.1 Atoms, elements and compounds

Outcome 1

- All substances are made of atoms.
- An atom is the smallest part of an element that can exist.
- A substance that is made of only one sort of atom is called an element.
- There are about 100 different elements.
- Elements are shown in the periodic table.
  - metals are towards the left and the bottom of the periodic table.
  - non-metals are towards the right and the top of the periodic table.
- Elements in the same group of the periodic table have similar chemical properties.
- Students should know that most of the elements are metals.

Supporting information

- Atoms are the ‘building blocks’ of all materials.
- More than half the known elements are metals.
- Metals can be recognised by their physical properties. These include: the ability to conduct heat and electricity, a high melting point, high mechanical strength and shiny appearance.
- Some elements are non-metals.
- Non-metals can be recognised by their properties. These include: the ability to resist the flow of heat and electricity through them, and a low melting point.
- Knowledge of groups in the periodic table is limited to Group 1 as reactive metals and Group 7 as reactive non-metals.
- It is sometimes difficult to distinguish between metals and non-metals. Some elements, such as silicon, have some properties of metals and some of non-metals. A judgement must be made after considering many different properties of the material. Even then, it may be difficult.
- Although students do not need to know the positions of elements within the periodic table, they may benefit from seeing the general layout of one.
- A copy of the periodic table can be found at the end of this document.



Key words

Atom	the smallest particle of an element that can exist
Boiling point	the temperature at which a substance changes from being a liquid to being a gas
Conduct	means ‘to allow to pass through’. Metals let both electricity and heat flow through them easily
Elements	what all substances are made up of, and which contain only one type of atom
Melting point	the temperature at which a substance changes from being a solid to being a liquid
Metals	shiny, good conductors of electricity and heat, malleable and ductile, and usually solid at room temperature
Non-metals	dull, poor conductors of electricity and heat, brittle and usually solid or gaseous at room temperature
Periodic table	shows all the elements arranged in rows and columns
Strength	materials with a high mechanical strength are able to withstand large forces without breaking

Outcome 2

- When elements react, their atoms join with other atoms to form compounds.
- Some compounds are made from metals combined with non-metals, for example sodium chloride and magnesium oxide.
- Some compounds are made from only non-metals, for example carbon dioxide.
- Chemical reactions can be represented by word equations.
- Students should be able to recognise simple compounds from their names eg sodium chloride, magnesium oxide, carbon dioxide.
- Students should be able to write word equations for reactions of metals and non-metals, reactions of non-metals to produce oxides, and the other chemical reactions in this specification.

Supporting information

- When a chemical reaction takes place, elements combine together.
- Chemical equations can be written in words and/or symbols to represent reactions.
- Word equations are a way of showing what happens in a chemical reaction:
  - reactants go on the left-hand side of the equation
  - products go on the right-hand side of the equation.
- The easiest reactions to make happen are those where a metal combines with a non-metal.
- Knowledge of chemical symbols or formulae is not required.
- A typical chemical reaction between two different elements to form a compound is:

$$\text{Sodium} + \text{chlorine} \rightarrow \text{sodium chloride}$$

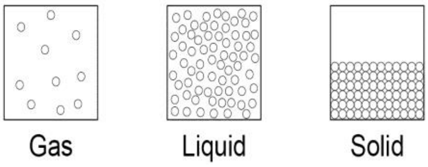
Key words

Compound	two or more elements chemically joined together
Equation	a way of writing down what happens in a chemical reaction; instead of putting an 'equals' sign in the middle, an arrow pointing to the right is used
Products	substances formed in a chemical reaction, shown after the reaction arrow in an equation
React	chemical reactions occur when substances change to produce new substances
Reaction	a change in which a new substance is formed
Reactants	substances that react together, shown before the arrow in an equation
Word equation	a chemical word equation shows on the left-hand side those chemicals that reacted together (the reactants) and on the right-hand side the new chemicals that were made in the reaction (the products)

3.3.2 How structure affects properties

Outcome 3

- The three states of matter are solid, liquid and gas.
- Melting and freezing take place at the melting point, boiling and condensing take place at the boiling point.
- The three states of matter can be represented by a simple model. In this model, particles are represented by small solid spheres.



- When a solid melts to become a liquid, the particles are able to move about but stay close together.
- When a liquid boils and becomes a gas, the particles separate and move about rapidly.
- Substances with high melting points have strong forces that hold their particles together.

Supporting information

- Solids have a fixed volume and a fixed shape.
- Liquids have a fixed volume but no fixed shape.
- Gases have neither a fixed volume nor a fixed shape. They expand to take up as much space as there is available.
- If you give enough thermal energy (heat) to a solid, it will eventually melt, changing state to become a liquid.
- If you give enough thermal energy to a liquid, it will eventually evaporate, changing state to become a gas.

Key words

Gas — a material in which the particles are spread out from each other

Kinetic theory — a theory that says that all material is made up of tiny particles. These particles move:

- in solids, the particles vibrate but do not change place
- in liquids, the particles move with more energy and can change places
- in gases, the particles move at high speed.

Liquid — a material in which the particles are closely packed but not in any definite or fixed pattern

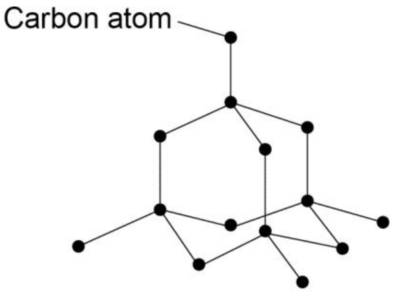
Solid — a material in which the particles are closely packed and usually in a regular pattern

Outcome 4

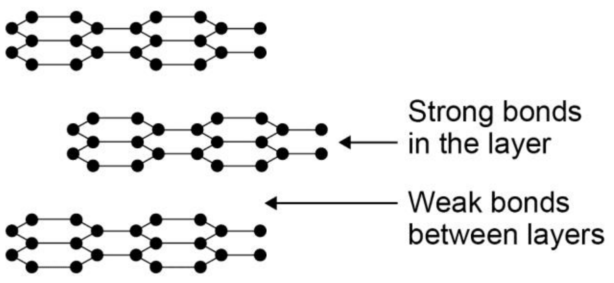
- Diamond and graphite are forms of the element carbon with different properties because of their different structures.
- Diamond is hard because the carbon atoms are joined together in a giant three-dimensional structure.
- Graphite is slippery because the carbon atoms are joined together in layers that can slide over each other.

Supporting information

- Carbon exists in several different forms.
- Soot is a black powder formed when substances like coal are burned without sufficient oxygen.
- Graphite is soft and slippery.
- Diamond is very hard. It is used for jewellery and for cutting tools such as diamond-tipped drill bits.
- Students should be able to recognise diamond and graphite from diagrams of their structures.



Diamond



Graphite

Key words

Carbon	non-metallic element that can exist in different forms, eg soot, graphite or diamond

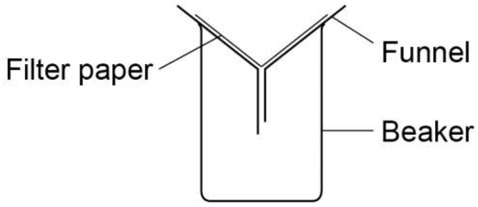
3.3.3 Separating mixtures

Outcome 5

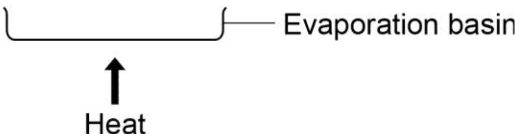
- A mixture contains two or more substances not chemically combined together.
- Mixtures can be separated by processes such as filtration, distillation, crystallisation and chromatography.

Supporting information

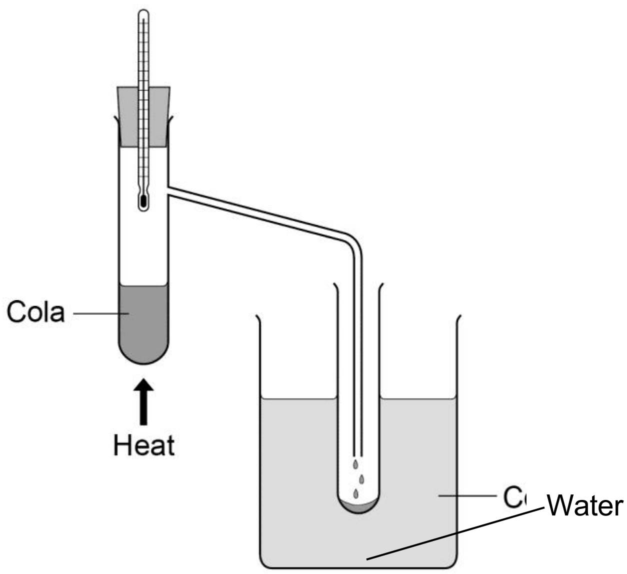
- Mixtures may be solids, liquids or gases.
- Mixtures can be separated by simple physical processes.
- Different separation methods are needed for different types of mixtures, depending on the physical properties of the materials making up the mixture, for example:
  - sand and salt can be separated by dissolving the salt in water and then filtering the sand
  - a sugar solution can be separated into water and sugar by allowing the water to evaporate, leaving behind sugar crystals
  - different coloured inks or food colourings can be separated using chromatography.
- Students should be able to select methods from those given to separate simple mixtures.
- Diagrams of separation techniques:



Filtration



Evaporation



Simple distillation

Practical opportunity to develop skills

Skill area A: Experimental design.

- How can you separate out the hidden gems in the mystery solution?
- Can you clean the water so that you can survive on the desert island?
- Students are given a mystery mixture and access to the basic equipment needed to separate solutions. They are asked to plan how they would separate out one component of the mixture.
  [This practical links to a required practical activity in the combined specification]

Key words

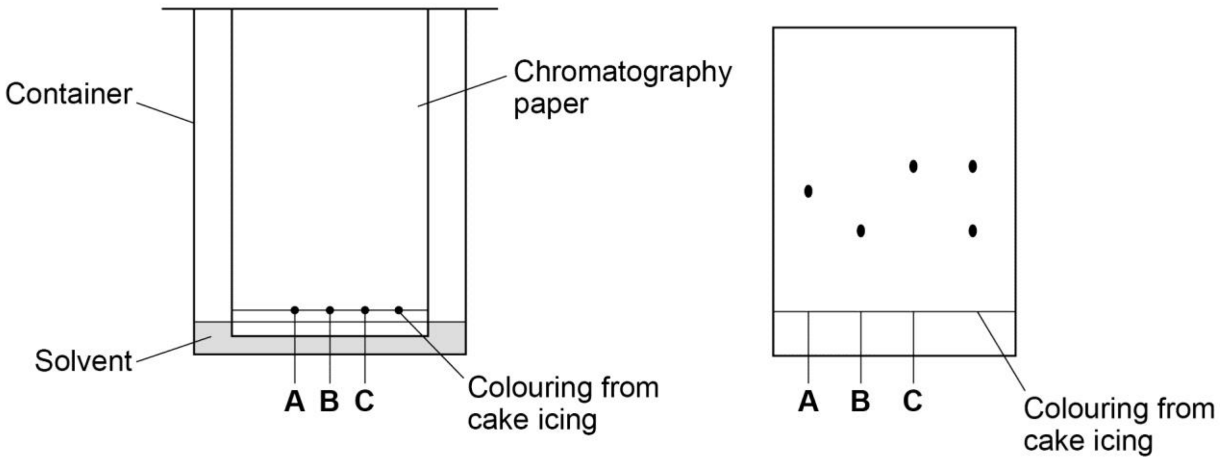
Chromatography	a process used to separate different soluble substances
Crystallisation	a method of separating a solid that has dissolved in a liquid and made a solution. The excess water is evaporated and then the concentrated solution cools and crystals will start to grow.
Distillation	a method to separate different liquids in a mixture which have different boiling points by boiling and condensing the liquids.
Filtration	separating an undissolved solid in a solution using a filter to produce a filtrate (solid) and residue (liquid).
Mixture	two or more elements or compounds mixed together but not chemically bonded.

Outcome 6

- Paper chromatography can be used to separate mixtures and can give information to help identify substances.
- In paper chromatography a solvent moves through the paper carrying different compounds different distances.

Supporting information

- Paper chromatography can be used to separate a mixture of liquids such as coloured inks or food dyes.
- A spot of the mixture is placed near the bottom of a piece of filter paper.
- The paper is then suspended so that the bottom of the paper is just in the solvent, with the spot of mixture just above the solvent level.
- As the solvent soaks up the paper, it carries the mixtures with it.
- Different colours in the mixture move up at different rates and so become separated.
- The diagram shows an example of paper chromatography.



B and C are found in the cake icing

Key words

Chromatography	a process used to separate different soluble substances
Solvent	a substance that dissolves another substance

3.3.4 Metals and alloys

Outcome 7

- Unreactive metals, such as gold, are found in the Earth as the metal itself, but most metals are found as compounds that require chemical reactions to extract the metal.
- Metals less reactive than carbon can be produced by heating the metal compounds in the ore with carbon.
- Ores contain enough metal to make it economic to extract the metal.
- Large amounts of rock need to be quarried or mined to get metal ores.
- We should recycle metals to save resources and limit environmental impacts.
- Students should be able to describe the social, economic and environmental impacts of mining ores and recycling metals.

Supporting information

- The ore bauxite contains aluminium oxide.
- Copper is a good electrical conductor. This means that it allows an electrical current to pass easily through it.
- Copper is quite soft. This means that wires and cables made from copper can easily be bent to turn round corners.
- Aluminium is often used to make the bodies of aircraft. Using aluminium means that the aircraft has a light weight.
- Aluminium is often used to make window frames for buildings. Aluminium is useful for this because it does not corrode easily.
- Students should be familiar with some common uses of aluminium and copper.
- Metals are finite resources. It is costly to mine the ore and then extract the metal from it so metals should be recycled wherever possible.

Key words

Unreactive	does not chemically react with anything including air and water
Ore	a rock with enough metal in it to make it worth extracting
Recycle	reuse materials

Outcome

- Metals have giant structures of atoms with strong bonds between the atoms and so most metals have high melting points.
- Metals are good conductors of electricity and thermal energy.
- Copper has properties that make it useful for electrical wiring and plumbing.
- Aluminium is a useful metal because of its low density and resistance to corrosion.

Supporting information

- Copper can be made into alloys such as brass and bronze, which are often used for items such as water taps and ornaments. Pure copper is a good electrical conductor, and so is often used for electrical wiring.
- Aluminium is used to make cooking foil, kitchen utensils and for the bodies of cars and aeroplanes.
- Knowledge of the properties of copper is limited to its ability to conduct electricity easily and the ease with which it can be worked.
- The names of ores are not required, nor any knowledge of the extraction process of aluminium.

Practical opportunity to develop skills

Skill area D: Presenting data.

- Which metal would you choose to make a saucepan out of?
  - use some teacher-generated data on how quickly different metal rods transfer heat along them. Students present the information and write a conclusion using the data to help explain their findings.

Key words

Alloy	a mixture of substances, at least one of which is a metal
Aluminium	a silvery white metallic element not found in its natural state but which has to be extracted from a compound in its ore
Copper	a reddish-brown metallic element that is an excellent conductor of heat and electricity
Corrosion	air and water break the metal down
Low density	low mass per unit volume

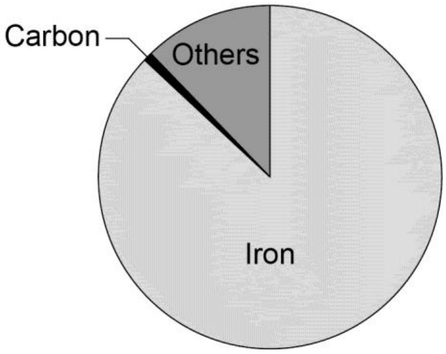
Outcome

- Most metals in everyday use are alloys.
- Pure iron, gold and aluminium are too soft for many uses and so are mixed with small amounts of other elements to make alloys, which are harder for everyday use.
- Most iron is converted into steels.
- Steels are alloys since they are mixtures of iron with carbon and other metals.

Supporting information

- Alloys often have different properties from the metals that they contain.
- Pure iron is not often used to manufacture items as it is brittle and rusts easily.
- Mixing iron with another substance makes an alloy.
- Mixing other chemical materials with iron makes substances called steels.
- Different steels can be made to have different properties, depending on what is mixed with the iron. For example, stainless steel is good at resisting corrosion; other types of steel may be particularly strong.
- Steel is often used as the framework for large buildings, for making pipes and for making sharp cutting tools.
- Knowledge of the composition of specific alloys is not required.
- Students should be able to interpret pie charts. Using pie charts to show the composition of some alloys may be a good way of introducing them.

Composition of steel



Practical opportunity to develop skills

Skill area D: Presenting data.

How is data presented by scientists and what's the best way to present data?

Using some simple lists of data, discuss which method – bar chart, pie chart or line graph is the best method to use to display the data.

(Resources in steps to success on data analysis will be particularly helpful here)

Key words

Alloy	a mixture of substances, at least one of which is a metal
Carbon	a non-metallic element that can exist in different forms, eg soot, graphite or diamond
Iron	a metallic element not found in its natural state but which has to be extracted from a compound in its ore
Mixture	two or more elements or compounds mixed together but not chemically bonded
Steels	are alloys that always contain iron and carbon and sometimes other metals as well

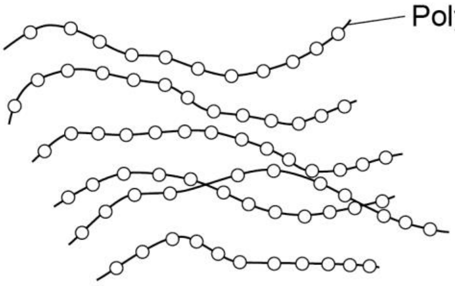
3.3.5 Polymers

Outcome 10

- Polymers such as poly (ethene), poly (propene), polystyrene and PVC are made from small compounds called monomers that join together to form very long chains.
- Polymers are waterproof, resistant to chemicals, and can be moulded, so they have many useful applications as packaging materials, pipes and containers.
- Many polymers are not biodegradable, so they are not broken down by microbes. This can lead to problems with waste disposal.

Supporting information

- Crude oil is used as a raw material to make polythene.
- Polymers are made up of repeating units (compounds) call monomers.
- The small units are joined chemically together in long chains.
- The analogy of a string of beads is often used to explain these chains of monomers.
- Polythene has many properties that make it useful.
- Heat makes polythene soften. This is useful because it means that polythene can be moulded or rolled into sheets.
- Polythene is waterproof and is not affected by most chemicals such as acids and alkalis.
- The correct chemical name for polythene is poly (ethene). However, it is often called simply polythene and students may use this simpler term.
- Polythene is used to make many household items.
- Polythene is often used for wrapping and packaging, especially of food products. It is also used for containers that need to be resistant to chemicals, and to make a range of household items, such as buckets and washing-up bowls.
- Although polymers are very useful, there are problems about how we get rid of them.
- Most polymers will not rot naturally when they are thrown away.
- This causes a problem because they can cause litter and can cause landfill sites to become full quickly.
- Students should appreciate the problems caused by plastics in litter and that recycling plastics is difficult because of the many different types of plastic.
- Knowledge of plastic waste disposal is limited to landfill sites, incineration, and recycling.
- Items such as polythene bags can be a danger to wildlife.
- Common names of these polymers will be accepted.
- Knowledge of the names of other polymers is not required.
- The chemical structure of the hydrocarbon is not needed.



Poly(ethene)

Key words

Biodegradable	a 'biodegradable' product breaks down, safely and relatively quickly, by biological means, into its raw materials
Incineration	a process of burning rubbish. It can be useful for getting rid of waste material, but it can often produce toxic gases or greenhouse gases
Landfill sites	sites where waste material can be buried in the ground; they are often used to dispose of household rubbish
Microorganism	this is a microscopic organism that is too small to be seen with the naked eye, but can be seen under a microscope. Microbes include bacteria, viruses and some fungi. Many microbes are very useful to us because they break down waste products
Moulded	a material that can be squeezed into different shapes
Polythene	a common plastic which softens on heating and is unaffected by most chemicals
Recycling	processing a material so that it can be used again

Component 4: Chemistry – Chemistry in our world

3.4.1 Reactions of acids

Outcome 1

- Acids react with some metals to produce salts and hydrogen.
- Hydrochloric acid produces chlorides and sulfuric acid produces sulfates.
- The test for hydrogen uses a burning splint held at the open end of a test tube of the gas.
- Hydrogen burns rapidly with a pop sound.
- Students should be able to complete word equations for these reactions, given the names of the reactants.

Supporting information

- Many metals will react with acids to produce hydrogen.

Metal + acid → salt + hydrogen

- Knowledge of reactions is limited to those of magnesium, zinc and iron with hydrochloric and sulfuric acids.
- Examples of the word equations.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

zinc + sulfuric acid → zinc sulphate + hydrogen

- Some metals, such as gold, do not react with acids such as hydrochloric or sulfuric acid.

Key words

Acid	a substance that will turn litmus red, neutralise alkalis, and dissolve some metals
Hydrochloric acid	an acid which, when reacted with metals, produces salts called chlorides, eg sodium chloride and magnesium chloride
Hydrogen	a highly flammable gas
Reaction	a change in which a new substance is formed
Salts	substances produced when a metal and an acid react; common table salt is sodium chloride
Sulfuric acid	an acid which, when reacted with metals, produces salts called sulfates, eg copper sulfate and iron sulfate

Outcome 2

- Acids are neutralised by alkalis (eg sodium hydroxide) and bases (eg insoluble metal oxides) to produce salts and water.
- Acids are neutralised by carbonates to produce salts, water and carbon dioxide.
- Carbon dioxide turns limewater milky.
- Salt solutions can be crystallised to produce solid salts.
- Students should be able to complete simple word equations, given the names of the reactants, for example:

  Magnesium oxide + sulfuric acid → magnesium sulfate + hydrogen

Supporting information

- A base is anything that neutralises an acid. A base that dissolves in water is called an alkali (students are familiar with the term alkali, so can find it difficult to understand when the word base is introduced).
- A neutralisation reaction occurs when an acid reacts with a base to form a salt plus water.

  acid + alkali → salt + water
  acid + base → salt + water

  An example is:

  hydrochloric acid + copper oxide → copper chloride + water
  (acid) (base) (salt)

- Indicators such as litmus paper or universal indicator are used to show if a solution is acid, alkali or neutral.
- Household chemicals may be used to illustrate these reactions.
- Similar reactions can be done using acid and carbonates; when carbonates are used carbon dioxide is also released during the reaction. An example is:

  sodium carbonate + hydrochloric acid → sodium chloride + carbon dioxide + water

- When neutralisation reactions are done in the lab, the gas can be collected and tested to identify the gas released.
- The salt in the solution formed during the reaction will need to be crystallised by evaporation to extract the solid salt.

Key words

Acid	a substance that will turn litmus red, neutralise alkalis, and dissolve some metals
Alkali	a soluble base. A substance that will turn litmus blue, neutralise acids, and dissolve some metals
Base	a solid substance that neutralises an acid; bases that dissolve in water are called alkalis
Carbon dioxide	a gas that turns limewater cloudy
Carbonate	a compound of carbon and oxygen that reacts with acids to release carbon dioxide
Crystallised	a solid that was dissolved in a solution has formed crystals
Limewater	goes cloudy if carbon dioxide is bubbled through it
Neutralise	to make the solution neither acid nor alkaline

3.4.2 Energy and rate of reaction

Outcome 3

- Some reactions transfer energy to the surroundings so the temperature increases. Such reactions include combustion, oxidation and neutralisation.
- Other reactions take in energy from the surroundings, so the temperature decreases. These reactions include dissolving ammonium chloride in water and reacting citric acid with sodium hydrogencarbonate.

Supporting information

- Whenever a chemical reaction happens, there is an energy change.
- Some of these energy changes are very small, and difficult to detect.
- Some of these energy changes are very large, and this makes them useful.
- Students are not required to know the term 'exothermic'.
- Students are not required to know the term 'endothermic'.

Key words

Combustion	burning, in which a fuel combines with oxygen to release energy
Neutralisation	adding just the right amount of acid to an alkali so that the end product is neither acid nor alkaline
Oxidation	reaction in which a substance combines with oxygen

Practical opportunity to develop skills

Skill area D: Presenting data.

- Which reaction transfers most heat energy?

  If chemicals are available, students can carry out simple chemical reactions, measuring the start and finish temperatures. Students can also simply feel the outside of the tube (with care) to see if it has warmed up.

  If not available, provide students with some appropriate data and ask them to present the data and make a conclusion using the evidence they have collected.

Outcome 4

- The rate of a chemical reaction may be increased by increasing the temperature, increasing the concentration of reactants, increasing the surface area of solid reactants or by adding a suitable catalyst.

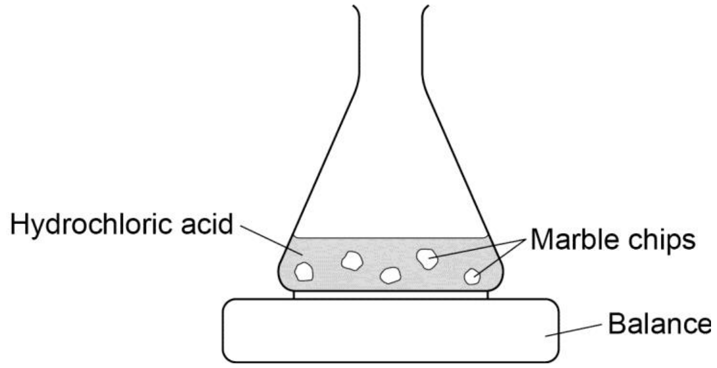
Supporting information

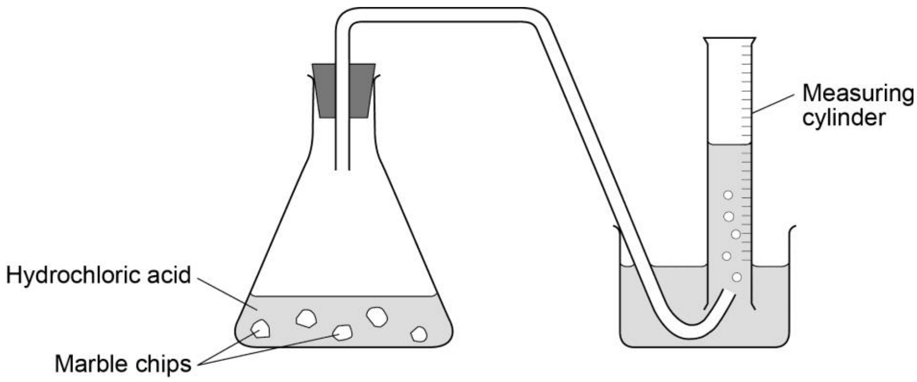
- The rate of a chemical reaction is how quickly the reaction takes place. This can be measured by:
  - timing how long the reaction takes to stop
  - timing how long it takes to collect a stated volume of gas
  - timing how long a colour change takes
  - timing a change in mass from the start to the finish of the reaction.

- Some reactions, such as explosions, are very fast.
- Some reactions, such as rusting, are very slow.
- Students do not need to calculate rates of reactions, but should be able to compare relative rates by measuring the time for a reactant to be used up, the volume of a gas produced in a given time, the time for a solution to become opaque or coloured.

There are different ways of measuring how fast a reaction is:

1. Change in mass as a gas is released.
   The faster the mass decreases, the faster the reaction.





2. Change in the volume of gas collected.
   The more gas collected over a given time period, the faster the reaction.

3. Production of a precipitate.

The quicker it takes for a precipitate to form, the faster the reaction.

If using sodium thiosulfate solution and adding different concentrations of acid, students can time how long it takes for the cross to disappear.

Practical opportunity to develop skills

All skill areas can be covered in this practical.

- Investigating any of the variables that affect a rate of reaction would be appropriate for assessing all skill areas.

  If you don't have access to standard chemicals, students could investigate how the surface area of a mint affects the rate at which it reacts with cola. [This practical links to a required practical activity in the combined specification]

Key words

Catalyst	substances that speed up chemical reactions but are unchanged at the end
Explosion	in the reaction, large amounts of gases are produced and these expand very rapidly, blowing everything outward; explosions happen instantaneously
Rusting	Iron chemically combines with oxygen from the air to form a new substance called rust. Rusting happens very slowly and may take years to complete

3.4.3 Earth's atmosphere

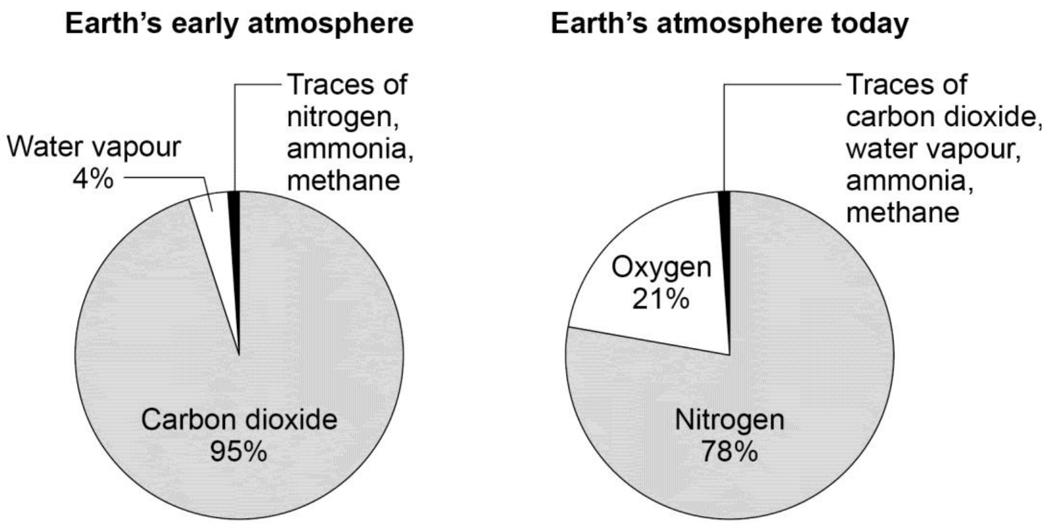
Outcome 5

- During the first billion years of the Earth's existence, there was intense volcanic activity. This released the gases that formed the early atmosphere and the water vapour that condensed to form the oceans.
- The early atmosphere was mainly carbon dioxide with little or no oxygen.
- From about three billion years ago, algae and plants developed and produced the oxygen that is now in the atmosphere, by a process called photosynthesis.
- Photosynthesis can be represented by the word equation:

  Carbon dioxide + water → glucose + oxygen

Supporting information

- The atmosphere contains a mixture of gases.
- When the Earth was first formed, these gases were mainly carbon dioxide and water vapour.
- Oxygen was released into the atmosphere once green plants evolved and photosynthesised.
- The present-day atmosphere contains oxygen, which we need for respiration.
- The largest component of the present-day atmosphere is the gas nitrogen.



Practical opportunity to develop skills

Skill area A: Experimental design.

- How could you show that plants release oxygen?
  Using Elodea or Cabomba in water, try to collect the bubbles and see if it will relight a glowing splint.

Key words

Atmosphere	a layer of gases surrounding the surface of the Earth
Billion	a billion is a thousand million (1,000,000,000)
Photosynthesis	a process where plants and algae turn carbon dioxide and water into glucose and release oxygen

Outcome 6

- Carbon dioxide was removed from the early atmosphere by dissolving in the oceans and by photosynthesis.
- Most of the carbon from the carbon dioxide gradually became locked up in rocks as carbonates and fossil fuels.
- The Earth's atmosphere is now about four-fifths (80%) nitrogen and about one-fifth (20%) oxygen, with small amounts of other gases, including carbon dioxide, water vapour and argon, (which is a noble gas).

Supporting information

- Plants and algae produced the oxygen that is now in the atmosphere, by a process called photosynthesis.
- Without green plants, we could not live.
- By a process called photosynthesis, plants put back into the atmosphere oxygen that we have used up in respiration.
- The atmosphere has changed since it was first formed millions of years ago.
- Nowadays there is a lot less carbon dioxide in the atmosphere.
- Chemical reactions have taken place, which have turned some of the carbon dioxide into rocks called carbonates.
- Carbon dioxide has also been used by plants for photosynthesis. When these plants have died, they have formed fossil fuels. This means that the carbon dioxide has not been released from them yet.

Key words

Carbonates	chemical compounds; they are formed when carbon dioxide reacts with an acid
Fossil fuels	remains of dead organisms that have been compressed and formed coal, oil and natural gas; these are burnt as fuels, releasing carbon dioxide
Photosynthesis	a process where plants and algae turn carbon dioxide and water into glucose and release oxygen

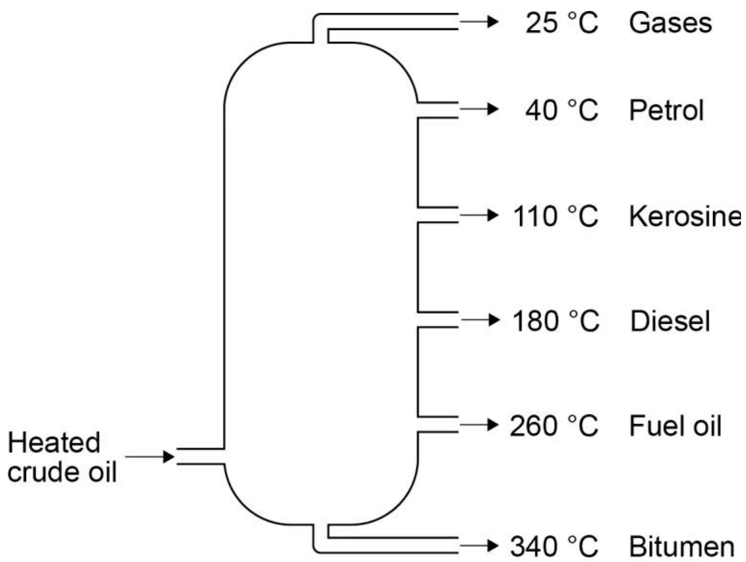
3.4.4 Fuels and human impacts on the atmosphere

Outcome 7

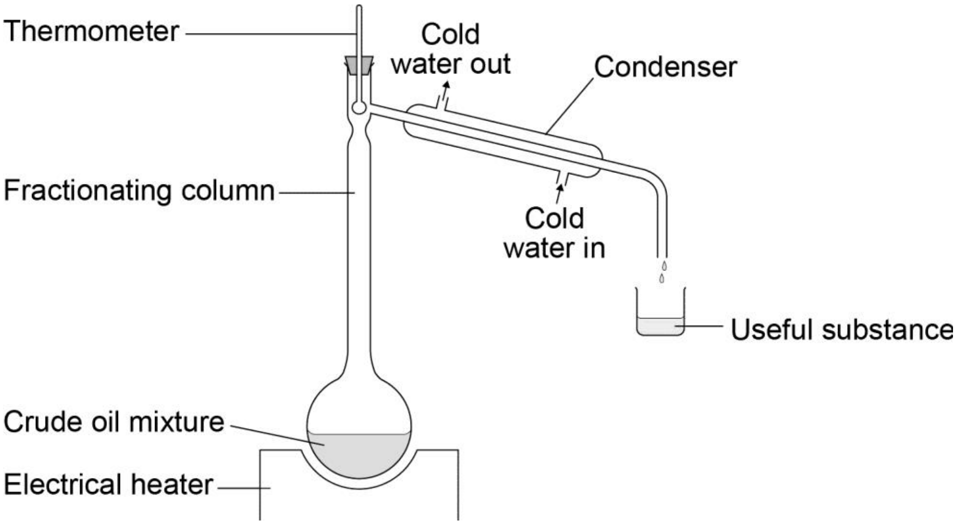
- Crude oil is a mixture of a very large number of compounds.
- Crude oil is found in deposits underground, eg the oil fields under the North Sea.
- Crude oil may be separated into fractions by fractional distillation. This process, which takes place in a refinery, can be used to produce a range of useful fuels and oils, including petrol and diesel.

Supporting information

- Crude oil is formed from tiny sea creatures which have been buried and altered.
- Crude oil is a fossil fuel.
- The compounds in crude oil can be separated into useful products.
- This separation into useful products is done in an oil refinery.
- Each of the compounds (fractions) has a different boiling point, which allows them to be separated by heating them in a fractional distillation column.
- Petroleum gas (LPG), petrol, kerosene, diesel oil, lubricating oil and bitumen are some of the fractions that can be obtained from crude oil.
- Students will not be required to recall the name of any other fractions.
- A diagram of a fractional distillation column may also be useful (see below).



Fractional distillation



Fractions boil off at different temperatures

Key words

Compound	two or more elements chemically joined together
Crude oil	a natural liquid product used as a raw material by oil refineries
Distillation	separating substances by boiling and condensing liquids
Fuel	material that is burned to release its energy
Fraction	one of the parts that can be separated from crude oil
Fractional distillation	the process of distilling crude oil in order to obtain useful products
Mixture	two or more elements or compounds mixed together but not chemically bonded
Oil refinery	a processing plant where crude oil is separated out into useful products
Oilfield	a place where there is enough oil to be found underground to make it worth extracting

Outcome 8

- When fuels burn completely, the gases released into the atmosphere include carbon dioxide, water (vapour), and oxides of nitrogen. Sulfur dioxide is also released if the fuel contains sulfur.
- When fuels burn in a limited supply of air, carbon monoxide is produced. Solid particles (soot) may also be produced.
- Oxides of nitrogen and sulfur dioxide cause acid rain and problems for human health.
- Carbon monoxide is a colourless, odourless, poisonous gas that can cause death.
- Solid particles can cause global dimming and problems for human health.
- Students may be required to describe the impact on the environment of burning fossil fuels.

Supporting information

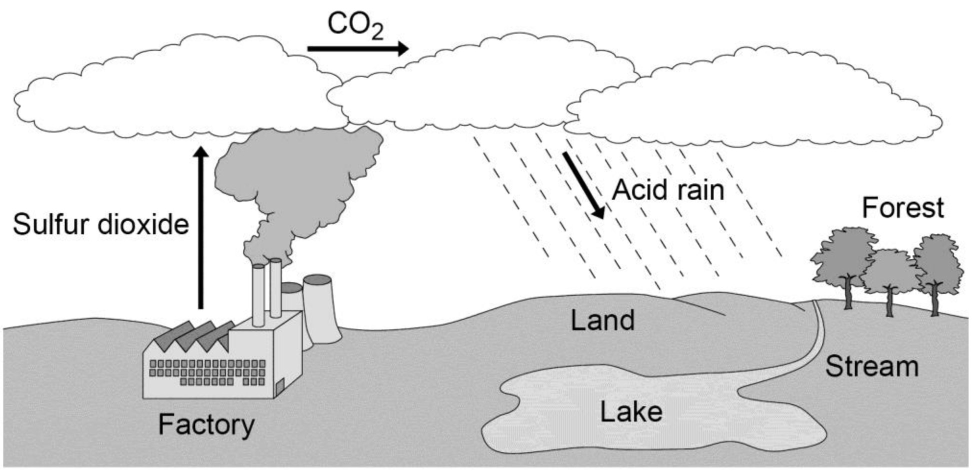
- When natural gas burns in a limited supply of air, carbon monoxide is produced and there is less carbon dioxide and energy released.
- Carbon monoxide is an invisible, poisonous gas.
- Carbon monoxide can be produced when fossil fuels such as coal, gas and oil are burned in rooms where there is not enough ventilation.
- Carbon monoxide is also produced by car engines and smoking tobacco.
- Burning a fossil fuel releases carbon dioxide and water vapour into the atmosphere.
- Carbon dioxide and water vapour are both 'greenhouse gases'.
- Greenhouse gases can lead to global warming, where the average temperature of the Earth's atmosphere becomes greater.
- Global warming can lead to climate changes.
- Climate changes caused by global warming can involve the increased risk of flooding in certain parts of the world. In other parts of the world it may lead to droughts.
- Global warming may lead to the melting of ice in the polar regions, and so to increased sea levels.
- Global warming could have a severe effect on the habitats of wild animals and plants, leading to the extinction of some species.
- Burning a fuel in a limited supply of air is sometimes referred to as incomplete combustion.

Incomplete combustion

fuel + limited oxygen → carbon monoxide + water (+ less energy)

- Students should be aware of the dangers of using gas fires in a poorly ventilated room.
- Students may be familiar with carbon monoxide detectors.

Formation of acid rain



Practical opportunity to develop skills

Skill area E: Identifying patterns and relationships.

- Does acid rain affect the growth of plants?
  Grow cress using dishes of cress seed, watered with different strengths of acid.
  Compare the results and suggest improvements to the method.

Key words

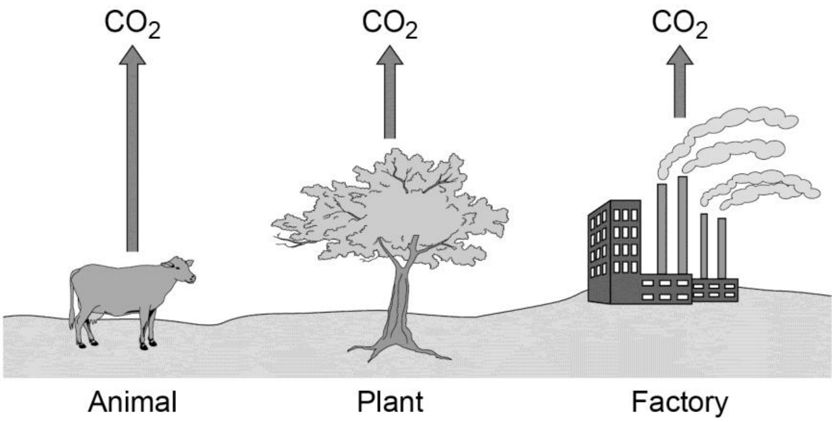
Burning	is sometimes called combustion; it is a chemical reaction in which a fuel combines with oxygen to release heat energy
Carbon monoxide	a poisonous gas produced when fuels burn in a limited supply of oxygen
Fossil fuels	remains of dead organisms compacted over millions of years that are burned as fuels, releasing carbon dioxide
Global warming	the gradual increase in surface temperature of the Earth
Greenhouse gases	they reduce the amount of energy lost from the Earth through radiation and therefore cause the temperature of the atmosphere to increase
Soot	a form of carbon, usually a black powder

Outcome 9

- Some human activities increase the amounts of greenhouse gases in the atmosphere, such as carbon dioxide from burning fossil fuels and methane from landfill and cattle farming.
- Increased levels of greenhouse gases in the atmosphere cause the temperature to increase. Many scientists believe that this will result in global climate change.

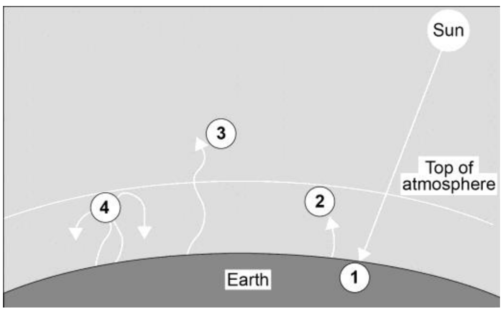
Supporting information

- Increasing amounts of carbon dioxide are being released into the atmosphere because of human activity. As the world population and industrialisation increases, this is becoming a global concern.
- How carbon dioxide is released into the atmosphere:



  - carbon dioxide, like any other greenhouse gas, reduces heat transfer away from the earth
  - greenhouse gases act as a 'blanket' around the earth keeping heat in.
- There is some scientific evidence to back this up but not all scientists agree with the evidence.
- Carbon dioxide is an important greenhouse gas others are water vapour, methane, nitrous oxide and ozone.

Simplified diagram of the greenhouse effect:



1 = heat from the sun

2 = heat reflects off the earth and out towards the atmosphere

3 = heat transferred through the atmosphere and escapes

4 = heat which was lost is now reflected back towards the earth, causing the Earth's temperature to rise

Key words

Carbon dioxide	a gas produced by burning fossil fuels and by respiration
Greenhouse gas	any gas in the atmosphere that reduces heat transfer away from the earth

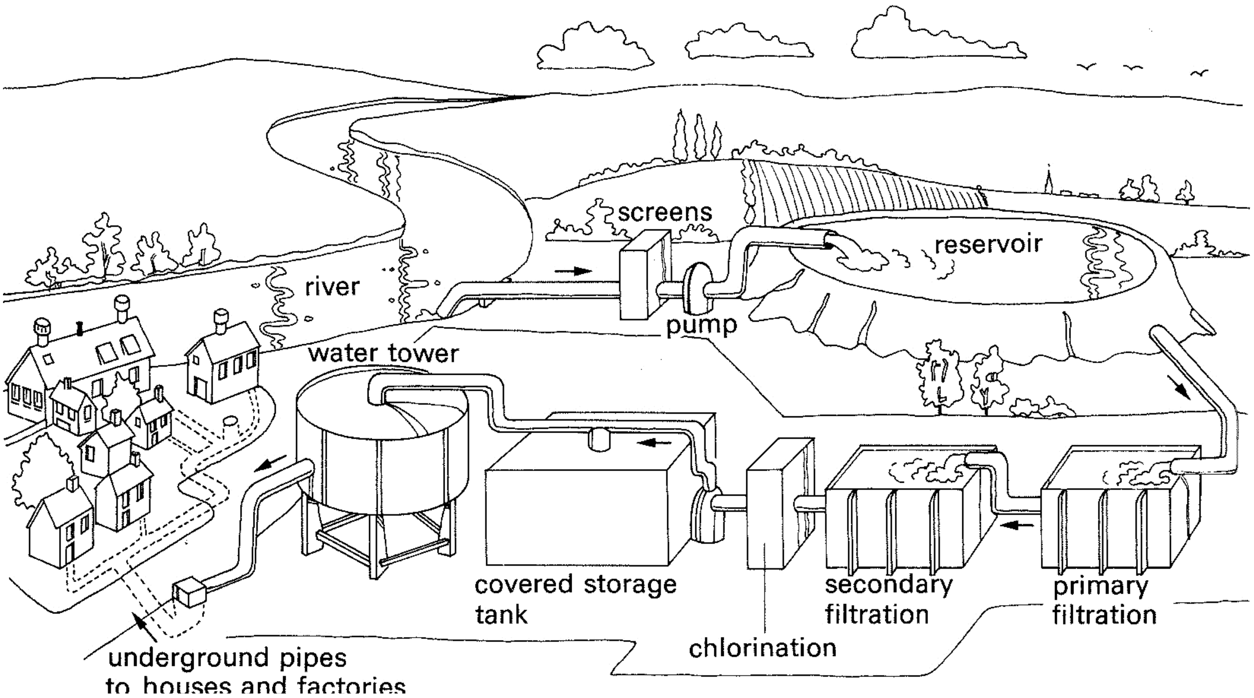
3.4.5 Water for drinking

Outcome 10

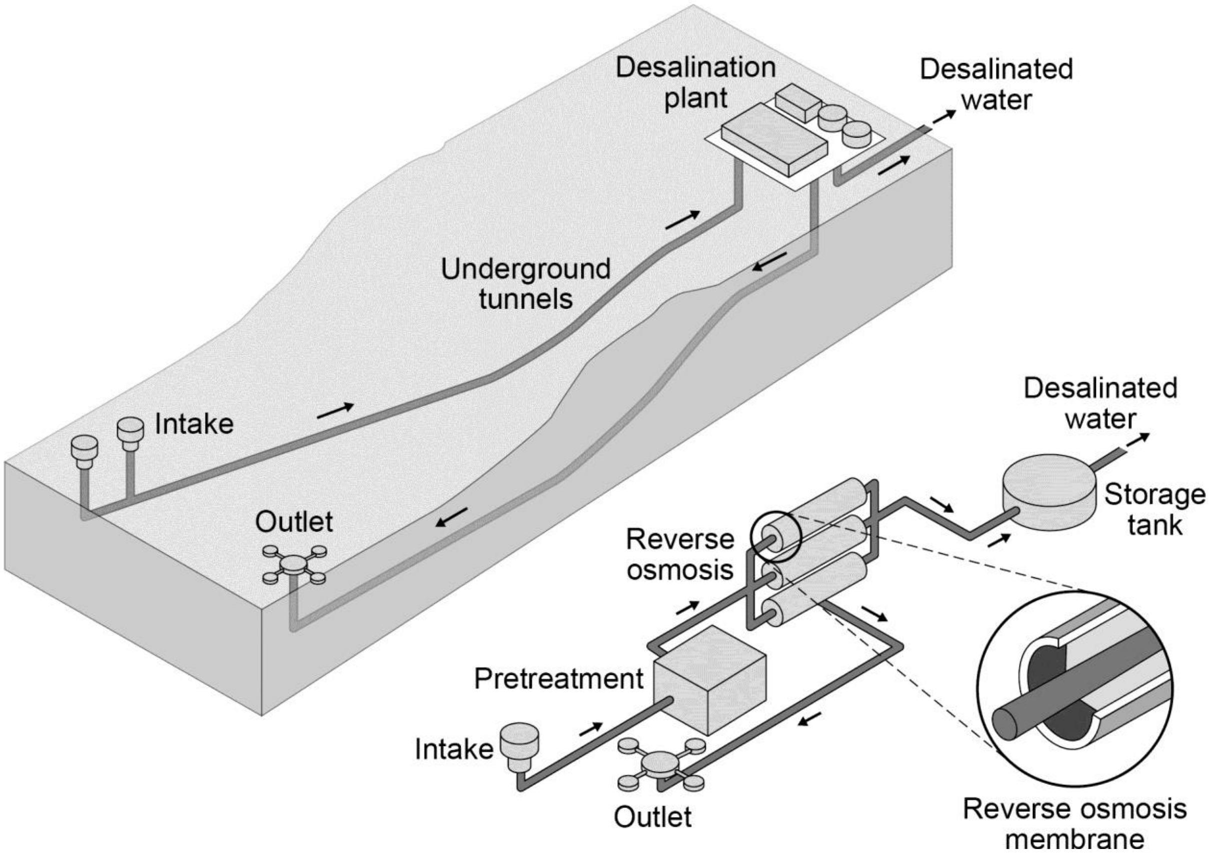
- Water that is safe to drink has small amounts of dissolved substances and low levels of microbes.
- Most drinking water is produced by choosing a suitable source of fresh water, filtering to remove solids and sterilising to kill microbes.
- If supplies of fresh water are limited, salty water can be distilled to produce fresh water. This requires a large energy input.

Supporting information

- Water from a river or reservoir goes through several stages of purification to make drinking water. These include:
  - screening, where the water passes through a grid to remove large objects such as branches
  - coarse filtering, usually through beds of stone and grit
  - fine filtering, often through sand
  - sterilising with, eg chlorine to kill bacteria.
- The diagram shows a typical system for producing clean drinking water.



- Distillation of salt water is used in some countries where fresh water is in short supply.



Key words

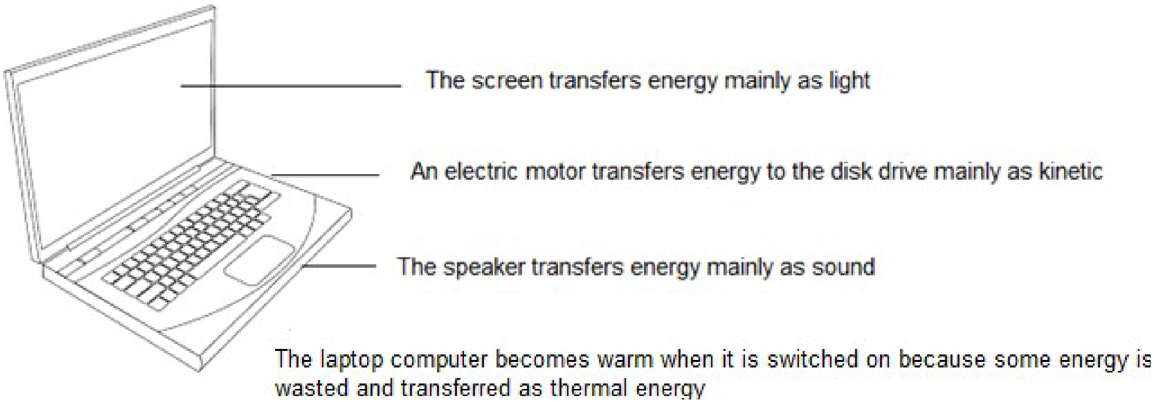
Distillation	separating substances by boiling and condensing liquids
Filtering	when water is filtered, it is strained through a sieve or mesh to remove solid particles; very small particles may be removed by filtering the water through sand
Microbes	are microscopic organisms that are too small to be seen with the naked eye, but can be seen under a microscope; microbes include bacteria, viruses and some fungi. Many microbes are very useful to us because they break down waste products
Sterilising	means removing or killing bacteria and other microbes

Component 5: Physics – Energy, forces and the structure of matter

3.5.1 Energy, energy transfers and energy resources

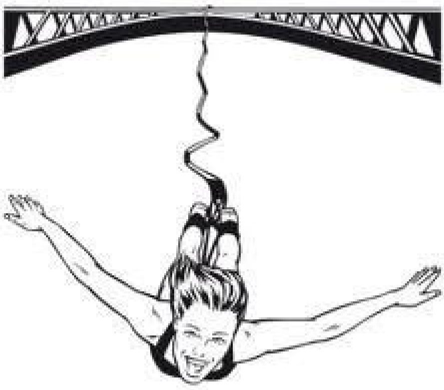
Outcome 1

- Describe, for common situations, the changes involved in the way energy is stored when a system changes.
- Students may be required to describe the intended energy transfers and the main energy wastages that occur in a range of devices. An example is shown below.



Supporting information

- Energy may be stored in different forms.
- When energy is transferred, the total is conserved, but some energy is dissipated, reducing the useful energy.
- Examples of energy stores include:
  - chemical
  - elastic potential
  - gravitational potential
  - kinetic
  - thermal
  - magnetic
  - nuclear
  - electrostatic.
- Examples of energy transfers include:
  - a light being switched on
  - a moving object hitting an obstacle
  - a vehicle slowing down
  - bringing water to the boil in an electric kettle.



- When the bungee jumper is on the bridge, she is high up and so has a lot of gravitational potential energy.
- As she falls, this energy is transferred to kinetic (movement) energy.
- When the bungee cord is fully stretched, the energy has been transferred to elastic (strain) energy.

Key words

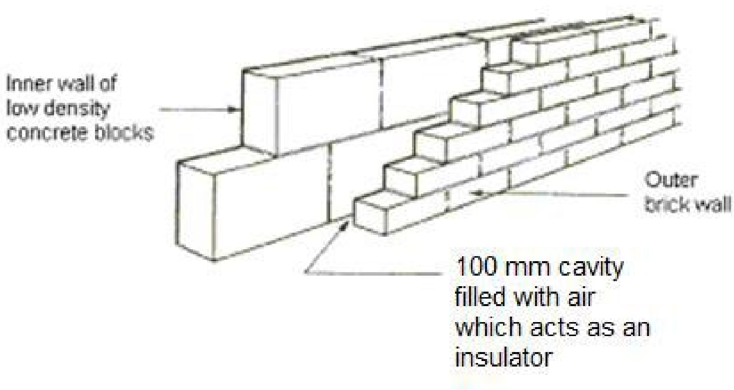
Chemical energy	emptied during chemical reactions when energy is transferred to the surroundings
Elastic potential energy	filled when a material is stretched or compressed
Energy	energy is what allows us to do work, eg when moving things
Energy resource	something with stored energy that can be released in a useful way
Energy store	there are many different types of energy store, including chemical, elastic, gravitational potential, kinetic and thermal
Kinetic energy store	filled when an object moves
Thermal energy store	filled when an object is warmed up
Gravitational potential store	filled when an object is raised

Outcome 2

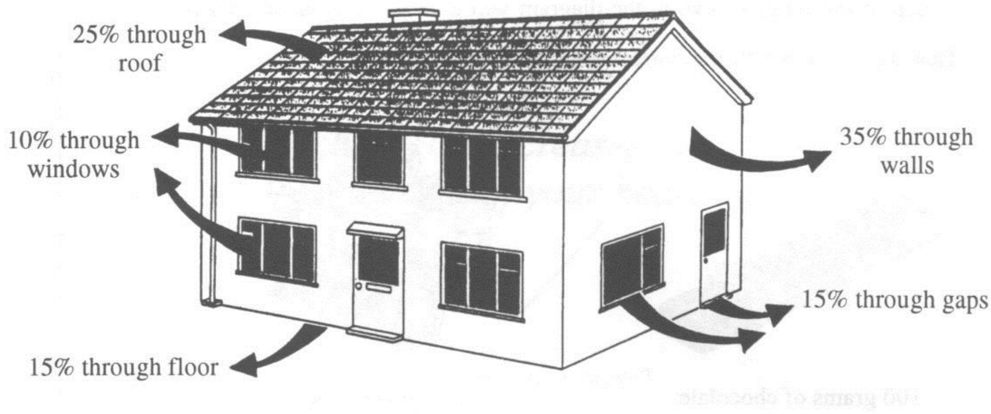
- Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
- The idea of efficiency. Whenever there are energy transfers in a system, only part of the energy is usefully transferred. The rest of the energy is dissipated so that it is stored in less useful ways. This energy is often described as being 'wasted'.
- Unwanted energy transfers can be reduced in a number of ways eg through lubrication and the use of thermal insulation.
- How the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls.
- The higher the thermal conductivity of a material, the higher the rate of energy transfer by conduction across the material.

Supporting information

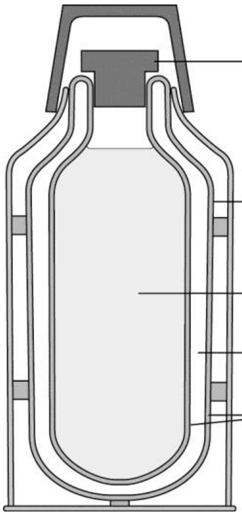
- Infrared (thermal) radiation is the transfer of energy by electromagnetic waves, and no particles are involved in the transfer.
- No definition of the term electromagnetic wave will be required.
- The rate at which a surface emits or absorbs thermal radiation depends upon:
  - the type of surface
  - the colour of the surface.
- Dull, black surfaces are good at transferring thermal radiation. This is why car radiators are painted dull black – it allows them to lose heat quickly.
- Shiny surfaces are poor at transferring thermal radiation. This is why athletes who have just finished a marathon are often given a shiny silver cloak to wrap around them – it prevents them from losing thermal energy too quickly.
- Thermal energy can be moved from one place to another. Normally it will go from a hot object to a colder object.
- Conduction is the way in which thermal energy can travel through solids. Metals are good conductors of heat and non-metals are good insulators of heat.
- No definition of thermal conductivity will be required.
- In the UK, it is important to reduce the thermal energy that is lost from our homes, eg by insulating our homes.
- Methods of insulating the home include:
  - for windows: double glazing or the use of blinds or curtains
  - for walls: cavity wall insulation, thermal (plasterboard) lining or rendering
  - for floors: carpet and/or underlay or laying wood on top of concrete
  - for roofs: the use of fibreglass insulation
  - for chimneys: the use of a cowl
  - for gaps around doors and windows: the use of draught excluders or sealing mastic
  - for the whole house: turning down the thermostat on the central heating or the use of individual thermostatic radiator valves
  - fibreglass or foam cavity wall insulation reduces energy lost through the walls.
- Cavity walls are one method of building house walls. Two walls are built, with a small gap or cavity in-between. This gap is often filled with special foam or fibreglass in order to reduce energy losses.



- The diagram below shows some of the main ways in which energy is lost from a house. Students would not be expected to recall such numerical information in an examination. However, they may be provided with the information and asked to interpret or process it.



- Calculations of efficiency will not be required.
- Examples of the application of the idea of efficiency could include domestic appliances, light bulbs and vehicles.
- Students should know that radiation is the method by which thermal energy travels from the Sun to the Earth. Other examples of thermal radiation include electric radiant heaters and fires.
- A Thermos flask is a good way in which to illustrate how knowledge of the different types of surface can be used to control thermal energy flow.



Practical opportunity to develop skills

All skill areas can be covered in this practical as a TDA
(Writing frame available)

- Investigative activity: which material will keep my cup of tea hot the longest?
- Using a selection of material coverings, a cup of hot chocolate or tea find out which one keeps it hot the longest

Key words

Absorber	an object that is taking in energy
Conductivity	how good a material is at conducting thermal energy
Dissipated	become spread out wastefully
Efficiency	a measure of how much of the input energy is changed into a useful form at the output
Emitter	an object that is giving out energy
Insulation	a material that is not good at allowing thermal energy to be conducted through it
Lubrication	a method of reducing friction eg by oiling
Matt	dull, not shiny
Radiation	transfer of thermal energy as a wave
Shiny	polished, with a reflective surface
Thermostat	a device that controls the temperature in a room

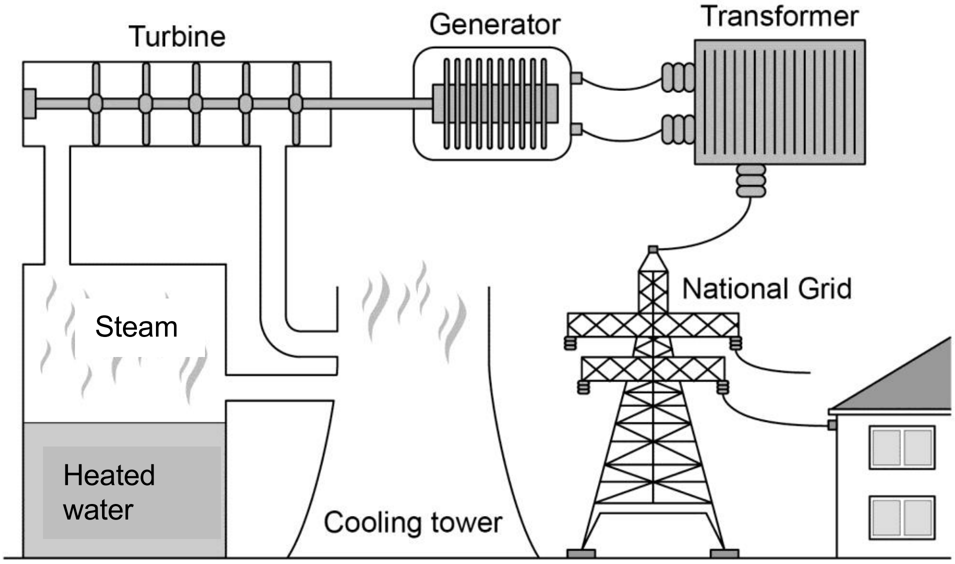
Outcome 3

- Describe the main energy resources available for use on Earth. These include fossil fuels (coal, oil and gas), nuclear fuel, bio-fuel, wind, hydro-electricity, geothermal, the tides, the Sun, water waves.
- Distinguish between energy resources that are renewable and energy resources that are non-renewable.

Supporting information

- Coal, oil and gas are called fossil fuels. This because they were formed millions of years ago from living material.
- Some materials are naturally radioactive. These emit high-energy radiation. Uranium and plutonium are examples of materials that are naturally radioactive. They are used in nuclear reactors.
- Biofuels include materials such as straw, or ethanol produce from sugar cane.
- The wind, making air flow past the turbine blades of a windmill causes them to turn.
- Water falling from a height can be made to turn the turbine blades in a hydroelectric scheme.
- Deep down below the surface, the Earth is very hot. We can use this energy to heat water to make steam for the turbines. This is called geothermal energy.
- Water rising and falling with the tide can also be used to turn turbine blades.
- It is the visible light part of the Sun's radiation that operates a solar cell. Solar cells are only capable of generating small amounts of electrical energy. Solar cells are most useful in remote areas where there is no mains supply of electricity.
- Water waves at sea can be used to turn turbines.
- Renewable energy sources include:
  - biofuels, that can be burned to heat water
  - water and wind that can be used to drive turbines directly
  - solar cells that can be used to produce electricity directly from the Sun's radiation
  - geothermal energy. In some volcanic areas, hot water and steam rise to the surface. The steam can be used to drive turbines.
- Descriptions of how electricity is generated in a power station are not required other than the idea that a turbine is used to turn a generator.
- Students may be required to interpret a flow diagram, ie water is heated in a boiler to produce steam, steam at high pressure forces the blades of a turbine to rotate and this then rotates the moving part of a generator.

Diagram of a typical power station



Key words

Fossil fuels	remains of dead organisms that are burned as fuels, releasing carbon dioxide
Generator	a mechanical device that transfers kinetic energy (energy of movement) to produce electricity
Geothermal energy	energy that is provided by hot rocks beneath the surface of the ground
Hydroelectric	a way of producing electricity by allowing water from a high reservoir to run downhill and drive a turbine linked to a generator
Nuclear reactor	part of a power station that uses radioactive materials as the energy source
Power station	a place in which an energy resource is used to produce electricity, usually for the mains electricity supply
Radioactive	describes a material that can emit very high energy radiation
Renewable	an energy resource that can be replaced and will not run out; examples are solar, wind, waves, geothermal and biomass
Solar cell	a device that can use energy carried by light to produce electricity
Turbine	a system of blades on an axle (like a propeller) that can be made to turn by air, steam or water being made to flow onto them

3.5.2 Forces and work

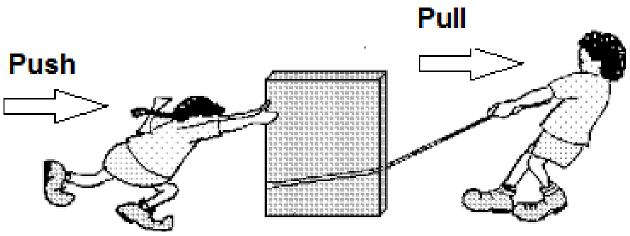
Outcome 4

- A force is a push or a pull that acts on an object due to the interaction with another object.
- All forces between objects are either:
  - contact forces – the objects are physically touching
  - non-contact forces – the objects are physically separated.

Supporting information

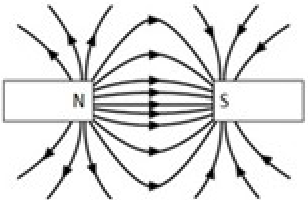
- Examples of contact forces include friction, air resistance, tension and normal contact force.
- Examples of non-contact forces are gravitational force, electrostatic force and magnetic force.
- Here are some examples of forces.

Contact forces



Friction

Non-contact force



Key words

Air resistance	when an object moves through the air, there is friction between the object and the air, this can make a moving object slow down; streamlining helps to reduce air resistance
Electrostatic force	non-contact force between two charged objects
Force	a push or a pull; it is measured in units called Newtons
Friction	force opposing motion, caused by the interaction of surfaces moving over one another; it is called ‘drag’ if one surface is a fluid
Gravitational force	the force caused by the pull of the Earth
Magnetic force	non-contact force from a magnet on a magnetic material

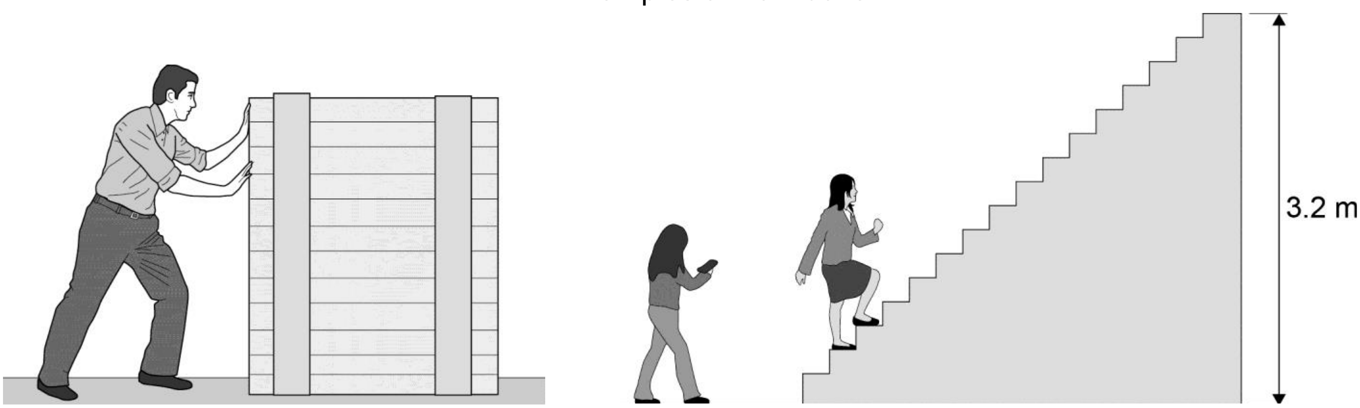
Outcome 5

- When a force causes an object to move through a distance, work is done on the object.
- Work done against the frictional forces acting on an object causes a rise in the temperature of the object.

Supporting information

- The bigger the force or the bigger the distance, the more work is done.
- Sometimes the temperature rise caused by friction can be useful, eg when striking a match.
- Sometimes the temperature rise caused by friction is not useful, eg the brakes on a car. In this case the brakes have to be designed to dissipate the energy.
- Calculations involving work are **not** required.

Examples of work done



Key words

Work	the transfer of energy when a force moves an object, measured in joules

3.5.3 Speed and stopping distances

Outcome 6

- Speed is calculated from the distance travelled in a certain time.
- Units of speed include metres per second, kilometres per hour and miles per hour.
- Simple calculations of average speed using the equation: speed = distance/time will be required.

Supporting information

- Speed is a measure of how quickly an object is moving.
- The faster you are travelling, the more ground you will cover in any given time.
- Students will not be required to rearrange the equation: speed = distance/time

Practical opportunity to develop skills

Skill area C: Recording data.
Skill area D: presenting data.
Skill area E: identifying patterns and relationships.

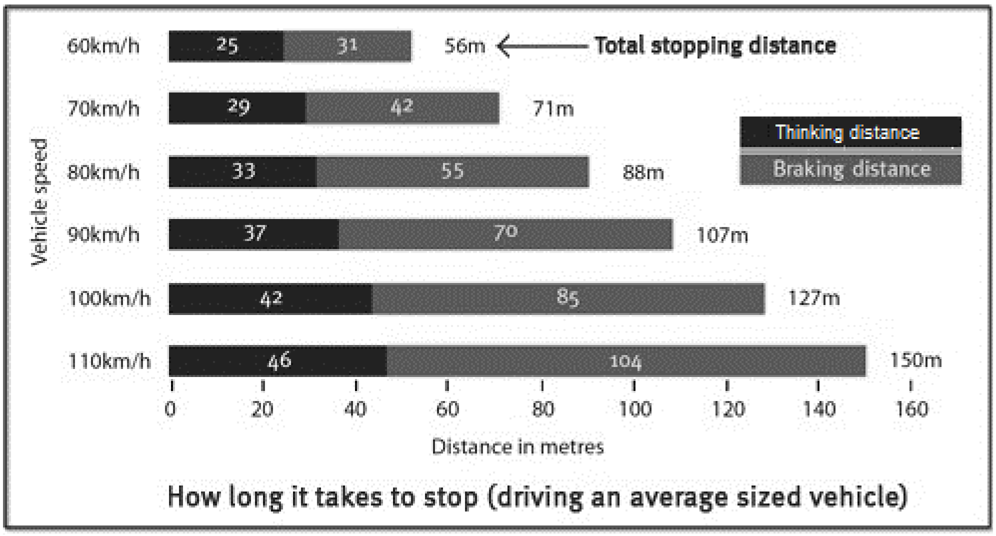
- Who is the fastest in your group?
  Measure out a set distance and then time how long it takes each student to cover the distance. Record the times, repeating the timings if possible. Present and analyse the data, evaluate the investigation.

Outcome

- The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance).
- For a given braking force, the greater the speed of the vehicle, the greater the stopping distance.

Supporting information

- Thinking distance may be affected by things such as tiredness and drugs.
- Braking distance may be affected by quality of tyres and brakes as well as the conditions of the road. Increased if wet or icy.
- Students may find it helpful to refer to the Highway Code:



Key words

Braking distance	the distance travelled between the time at which the brakes are first applied and the time when the vehicle comes to a stop
Braking force	the force that the driver applies to the brakes
Stopping distance	the total distance travelled between the driver first noticing the need to stop and the vehicle finally coming to a stop
Thinking distance	the distance travelled between the driver first noticing the need to stop and the driver applying the brakes

Outcome

- Reaction times vary from person to person. Typical values range from 0.2 s to 0.9 s.
- Knowledge and understanding of methods used to measure human reaction times.
- Knowledge of how a driver's reaction time can be affected by tiredness, drugs and alcohol.
- Distractions may also affect a driver's ability to react.

Supporting information

- Reaction times vary from person to person.
- Reaction times may be slowed by distractions, ill health, tiredness, or certain drugs.
- Students should be able to interpret and evaluate measurements from simple methods to measure the different reaction times of students.
- There are many ways of testing human reaction times, including the use of computer programs.
- One classic way is to find out how quickly you can catch a ruler that has just been dropped.

- Students should be able to evaluate the effect of various factors on thinking distance and apply it to driving a car.

Practical opportunity to develop skills

Skill area C: Recording data.
Skill area D: presenting data.
Skill area E: identifying patterns and relationships.

- What is the best way to find out who has the quickest reaction times in the group? Compare reaction times using drop the ruler method. Compare this method with a computer generated test: which one is more accurate, and why?
  [Link to combined required practical activity]

Key words

Reaction	a response made by the body to a stimulus
Reaction time	the time between the body detecting a stimulus and producing a response

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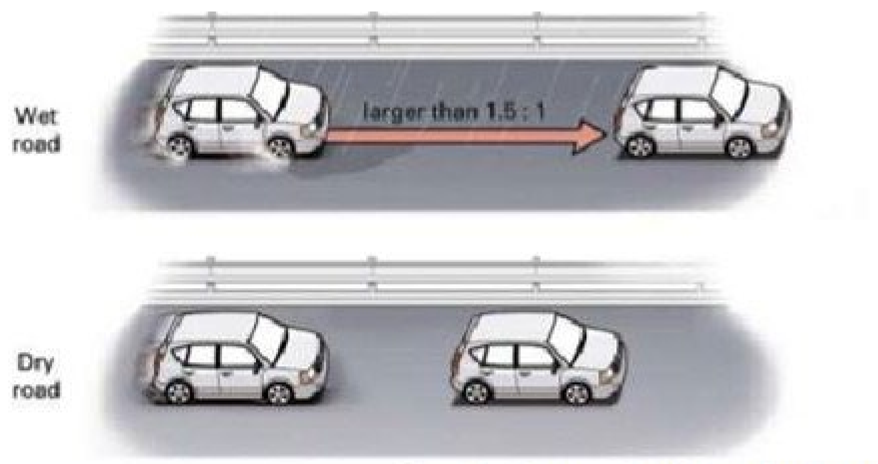
Outcome 9

- The braking distance of a vehicle can be affected by adverse road and weather conditions, and poor condition of the vehicle.
- Students should be able to analyse a given situation to identify how braking could be affected.

Supporting information

- Adverse road conditions include wet or icy conditions.
- Water and ice on the road will reduce the friction between the tyres and the road, and so will increase the braking distance.



Stopping distance is 1.5 times further on wet roads

- Tyres need to have a minimum tread depth to grip the road properly.
- The grooves in the tyre's surface are designed to get rid of water between the tyre and the road.
- Poor condition of the vehicle is limited to the vehicle's brakes or tyres.

Key words

Tread	the tread on the surface of a tyre is the pattern of grooves that are cut into it; these grooves are designed to get rid of water from between the tyre and the road

3.5.4 Atoms and nuclear radiation

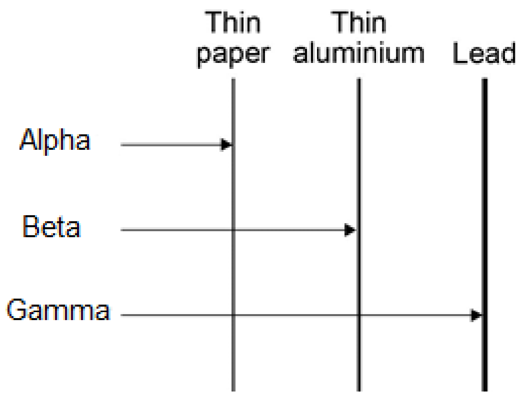
Outcome 10

- Some atomic nuclei are unstable. The nucleus gives out ionising radiation. This is a random process called radioactive decay.
- The nuclear radiation emitted may be:
  - alpha particles
  - beta particles
  - gamma rays.
- Properties of alpha particles, beta particles and gamma rays limited to their penetration through materials and their range in air.
- Students will be expected to know some of the uses and dangers of the three types of radiation.

Supporting information

- The nuclei of some atoms are unstable which means they will spontaneously break down, giving out alpha, beta or gamma radiation.
- Alpha particles are the least penetrating (only a few centimetres of air) but can damage body cells.
- Beta particles can penetrate thin sheets of aluminium.
- Gamma rays are the most penetrating and need several cm of lead to absorb them.

Penetration of alpha, beta and gamma radiation



Uses and dangers of the three types of radiation

Type	Uses	Dangers
Alpha	Smoke detectors	Not as dangerous because they are unlikely to reach living cells
Beta	Tracers for medical imaging Treat some cancers	dangerous sources because they can penetrate the skin and damage the cells inside
Gamma	Tracers for medical imaging Kill cancer cells Sterilize medical equipment	dangerous sources because they can penetrate the skin and damage the cells inside Cancer and radiation sickness

Key words

Alpha particle	a particle given out from the nucleus of a radioactive atom
Beta particle	another type of particle given out by a radioactive atom
Emit	to give out
Gamma ray	a type of wave that carries a large amount of energy, given out by radioactive atoms
Ionising radiation	radiation that can cause damage to living cells
Nucleus	the centre part of an atom, which contains protons and neutrons
Penetration	the ability of radiation to travel through different substances
Radioactivity	some atoms are unstable and will break down, giving out alpha, beta or gamma radiation
Range	how far radiation can travel before losing all of its energy

Component 6: Physics – Electricity, magnetism and waves

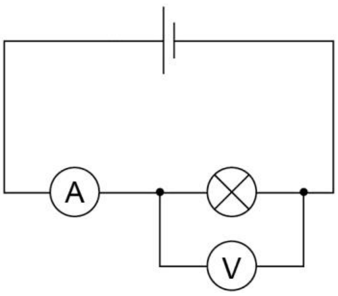
3.6.1 Electrical current

Outcome 1

- Electric current is a flow of electrical charge.
- The size of the electric current is the rate of flow of electrical charge.
- The current through a component depends on both the resistance of the component and the voltage across the component.
- The greater the resistance of the component the smaller the current for a given voltage across the component.
- The resistance of a component is a measure of how difficult it is for an electric current to pass through it.

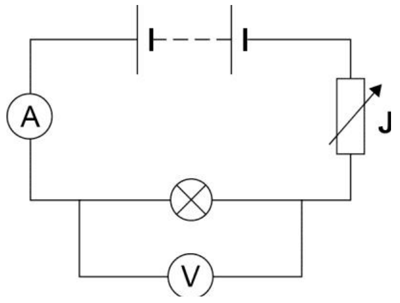
Supporting information

- Electrical charge is carried by particles called electrons. In certain materials such as metals, these electrons can move freely and form an electric current.
- Electrical current is measured in amps using an ammeter.
- Voltage is measured in volts using a voltmeter.
- An ammeter is connected in series; a voltmeter is connected in parallel across the component.



- The term 'potential difference' will not be used.
- Calculations of resistance will not be required, nor will the units of resistance.

- A variable resistor in a circuit can be used to show the effect on the brightness of a bulb of a changing resistance.



Practical opportunity to develop skills

Skill area B: Working safely and making measurements.

- Which component has the greatest resistance to the flow of electrical current?
  Using a selection of buzzers, motors and lights, and keeping the voltage constant, use the reading from the ammeter to find out which component offers the most resistance (smallest ammeter reading).
  [This practical links to a required practical activity in the combined specification]

Key words

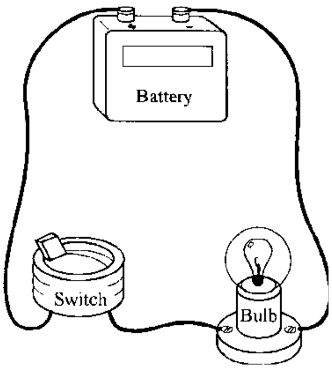
Component	part of an electrical circuit, eg a bulb or battery
Current	flow of electric charge, measured in amperes (A)
Resistance	a property of a component, making it difficult for charge to pass through it; it is measured in ohms (Ω)
Voltage	a measure of the size of the ‘push’ that is given to the electrons that form the current; the bigger the voltage, the bigger the current for any given resistance

Outcome 2

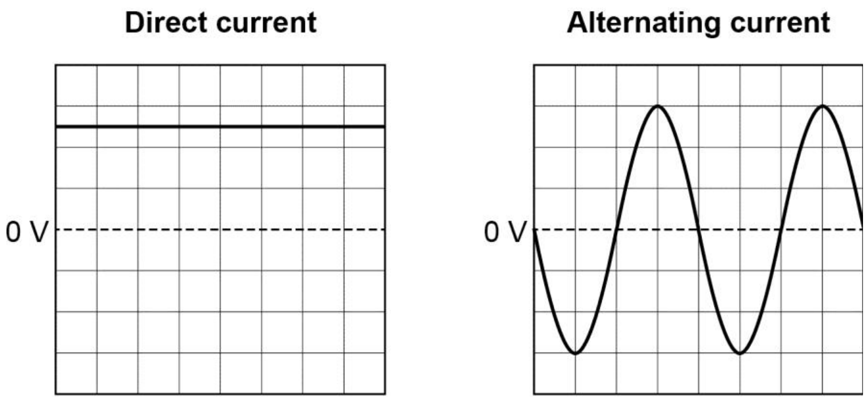
- A complete circuit is necessary for a current to flow.
- Cells and batteries supply current that always passes in the same direction. This is called direct current (dc).
- An alternating current (ac) is one that changes direction.
- Mains electricity is an ‘ac’ supply. In the UK it has a frequency of 50 Hz and is 230 V.

Supporting information

- Diagrams of electrical circuits will be shown in a similar way to the one below.



- The use of conventional circuit diagram symbols will not be required.
- No distinction between series and parallel circuits needs to be made.
- Current can flow in two different ways, either in one direction only or repeatedly reversing its direction.
- The battery in a torch makes the current go around the circuit in one direction only.
- Mains electricity we use in the home uses alternating current.
- An alternating current flows one way then the opposite way in cycles.
- A simple wave pattern from an oscilloscope can be useful to illustrate the difference between ac and dc.



Key words

Alternating current	continually changes direction very rapidly, flowing first one way and then the other
Direct current	always flows in the same direction
Battery	a number of cells joined together
Cell	a cell pushes the electric current from the positive terminal round to the negative one

3.6.2 Domestic electricity

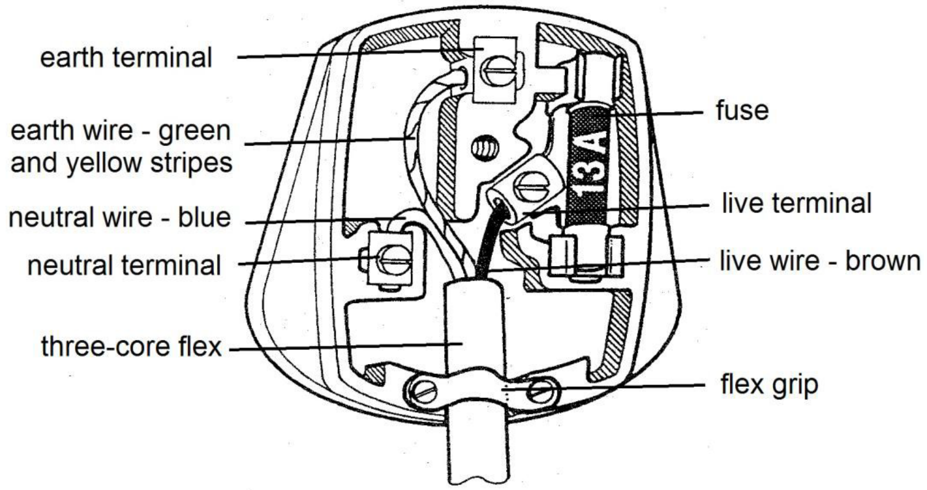
Outcome 3

- Most electrical appliances are connected to the mains using a three-core flex.
- The insulation covering each wire in the flex is colour-coded for easy identification:
  - live wire – brown
  - neutral wire – blue
  - earth wire – green and yellow stripes.
- The earth wire is a safety wire to stop the appliance becoming live.
- The fuse contains a thin piece of wire, which melts if the current becomes too large, thereby cutting off the supply.
- Students should be able to select the correct fuse from a list when given the current rating of an appliance.
- Some appliances do not have an earth wire because they are double insulated.

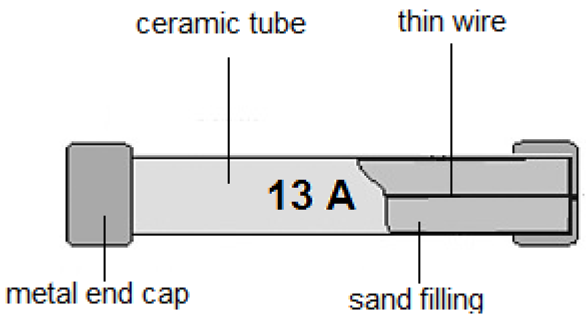
Supporting information

- The earth wire is connected to some metallic part of the appliance. If the live wire becomes loose and touches this metal part, a large current will flow through the earth wire and cause the fuse to 'blow'.
- Double insulated appliances have a plastic case rather than metal, and do not need an earth wire connection.
- A normal domestic plug commonly contains a 13 amp plug.
- Fuses for a standard 3-pin plug are called cartridge fuses. They are commonly available in ratings of 3 amps, 5 amps and 13 amps.
- The correct fuse to choose is the one with a current rating nearest to, but above, the current taken by the appliance.

A typical 13 amp plug



A cutaway diagram of a cartridge fuse



Key words

Appliance	a piece of electrical equipment designed for a specific task, eg a radio
Earth wire	a wire connecting the metal case of an appliance to the ground
Flex	a flexible electric wire
Fuse	a thin piece of wire designed to melt if the current becomes too large
Insulation	plastic covering for an electrical wire that does not conduct electricity
Live wire	a wire that carries the current from the electricity generator to the appliance
Neutral wire	a wire that returns the current from the appliance to the electricity generator

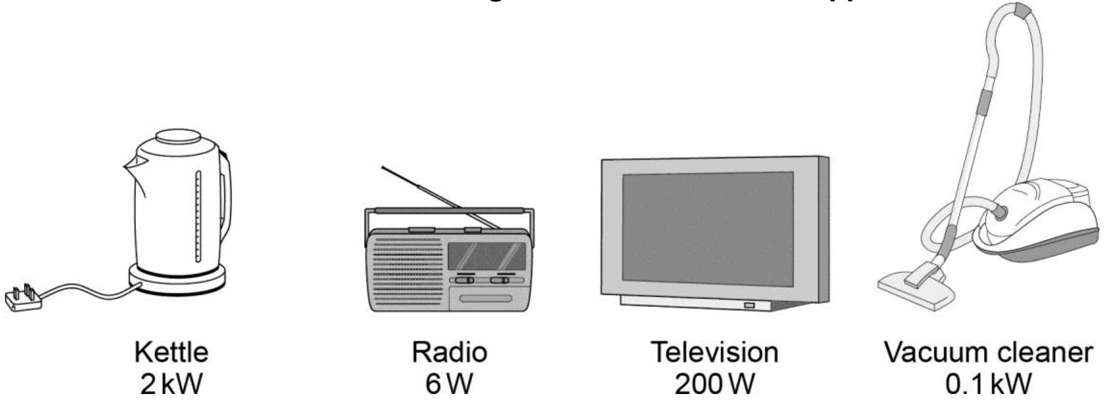
Outcome 4

- Everyday electrical appliances are designed to bring about energy transfers.
- The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power of the appliance.

Supporting information

- Electrical devices transfer energy from one energy store to another.
- Kettles, fires, toasters and immersion heaters are all examples of electrical heating devices.
- The amount of energy transferred can be calculated by multiplying the power of the appliance by the time it is on for.
- Students may be required to use the equation energy (kWh) = power (kW) × time.
- The longer the time the appliance is switched on for, the more energy will be transferred.
- The larger the power of the appliance, the more energy will be transferred.
- Power is measured in watts (W) or kilowatts (kW).
- A watt is a very small unit of power so power is often measured in kilowatts.
- One kilowatt equals one thousand watts.
- No calculations of power will be required.

Power ratings of various domestic appliances



Practical opportunity to develop skills

All skill areas can be covered in this practical as a TDA (writing frame available).

- Investigative activity: Which is the best electric kettle?

  Using a couple of kettles with the power rating visible, heat a set volume of water and record the time taken to boil the kettle. Calculate the amount of energy transferred by multiplying the power of the kettle by the time it takes to boil.

Key words

Power – how quickly energy is transferred by a device

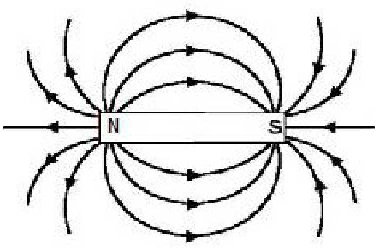
3.6.3 Magnetism and electromagnetism

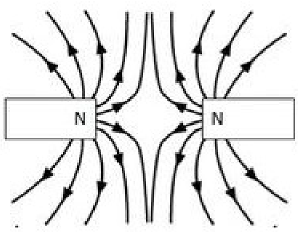
Outcome 5

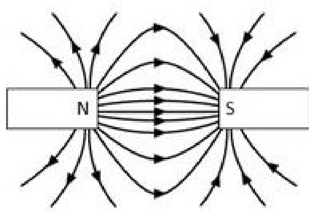
- The poles of a magnet are the places where the magnetic forces are strongest.
- When two magnets are brought close together they exert a force on each other.
- Two like poles repel each other.
- Two unlike poles attract each other.
- Attraction and repulsion between two magnetic poles are examples of noncontact force.

Supporting information

- Bar magnets have two poles, called north and south.
- Only a few metals are attracted to magnets; these include iron or alloys of iron, eg steel.
- A magnetic field is a region in which a compass needle is affected.
- The Earth has a magnetic field.
- The shape of a magnetic field around a bar magnet can be seen by laying a piece of paper on top of the magnet and sprinkling iron filings on the paper.
- A compass needle is a tiny bar magnet that lines itself up with the Earth's magnetic field.
- Students should be familiar with the shapes of the magnetic fields shown below.







Key words

Attraction	a pulling force
Poles	the ends of a magnetic field, called north-seeking (N) and south-seeking poles (S)
Repulsion	a pushing force

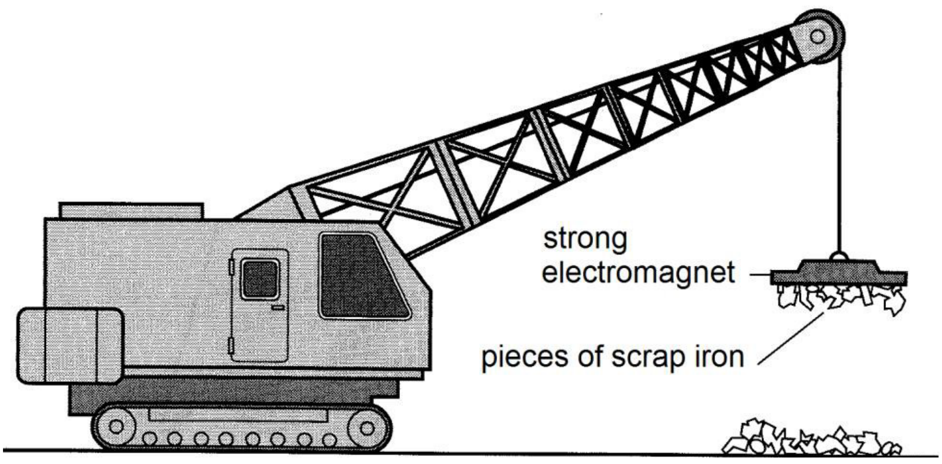
Outcome 6

- When a current flows through a conducting wire, a magnetic field is produced around the wire.
- The strength of the magnetic field depends on the current through the wire and the distance from the wire.
- Shaping a wire to form a solenoid increases the strength of the magnetic field created by a current through the wire.
- Adding an iron core increases the magnetic field strength of a solenoid.
- An electromagnet is a solenoid with an iron core.
- Students should be familiar with common uses of electromagnets, eg in scrapyard cranes and relays.

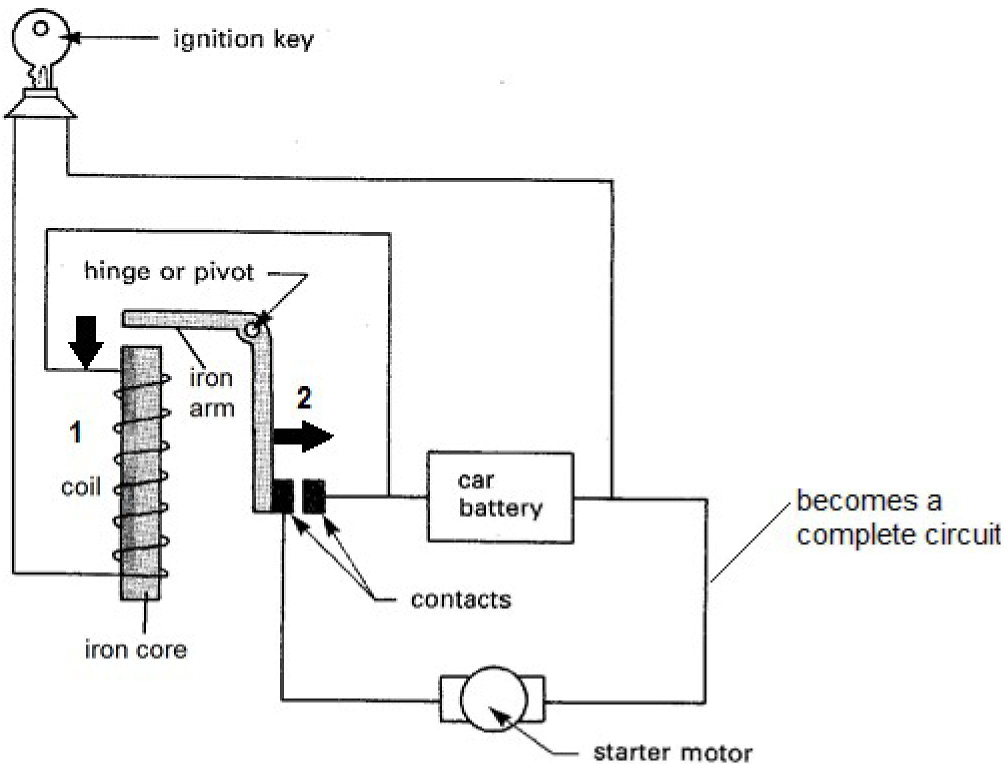
Supporting information

- A solenoid is a coil of insulated wire. This increases the strength of the magnetic field created when a current is passed through it.
- An iron core is added to further increase the strength of the magnetic field.
- Electromagnets can be extremely useful because by switching the current on and off the magnetism can be switched on and off.
- This can be useful in cranes in scrapyards so that when the current is switched off, the scrap iron will drop to the place where it is needed.

A scrapyard crane



A relay switch



- When the ignition key is turned:
  - a small current flows through the coil
  - this makes the iron core become a magnet
  - the iron core attracts the iron arm
  - this closes the contacts – creating a complete circuit
  - a much larger current flows through the starter motor.
- Other common uses of electromagnets are in an electric bell and a circuit breaker.

Practical opportunity to develop skills

All skill areas can be covered in this practical as a TDA

- How can you make the strongest electromagnet?

  Using insulating wire, an iron nail, batteries or power pack and paper clips, students make a simple electromagnet choosing a variable to change. Record results and present the data in a graph making a simple conclusion.

Key words

Current	flow of electric charge, measured in amperes (A)
Magnetic field	the space around a magnet in which a magnetic force exists
Solenoid	wire wound into a tight coil, part of an electromagnet
Electromagnet	a non-permanent magnet turned on and off by controlling the current through it
Relay	an electromagnet used to switch on or off another electrical circuit

3.6.4 Different types of waves

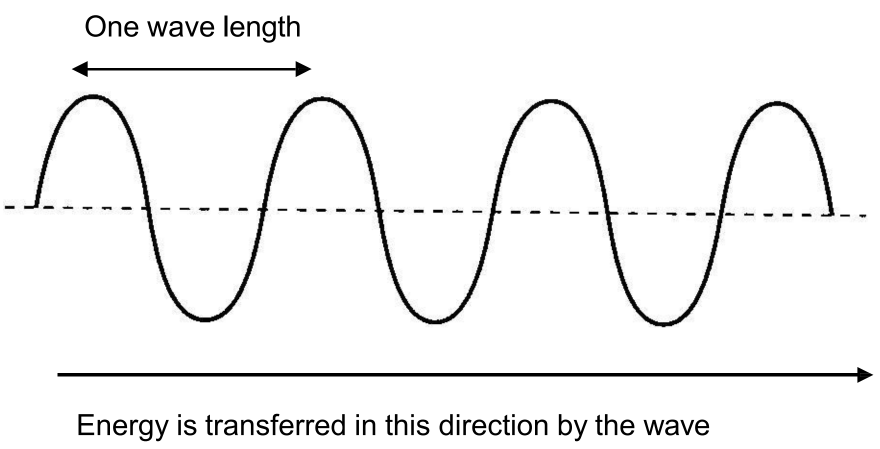
Outcome 7

- Waves may be either transverse or longitudinal.
- In a transverse wave, the oscillations are perpendicular to the direction of energy transfer.
- The ripples on a water surface are an example of a transverse wave.
- In a longitudinal wave, the oscillations are parallel to the direction of energy transfer.
- Longitudinal waves show areas of compression and rarefaction.
- Sound waves travelling through air are longitudinal.

Supporting information

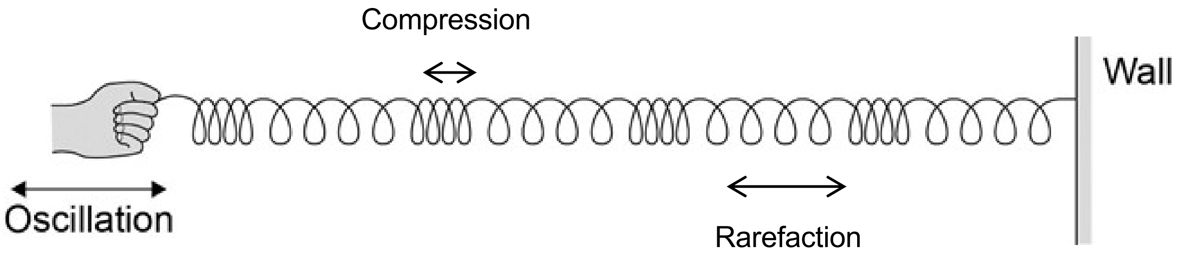
- Waves can transfer energy from one place to another.
- The material or medium carrying the wave does not travel from one place to another, but merely vibrates.
- Waves made by shaking one end of a rope are transverse waves.

A typical transverse wave



- A longitudinal wave can be made by pushing one end of a slinky spring.

A typical longitudinal wave



- Sound waves are longitudinal waves. They can travel through solids, liquids and gases. Sound waves cannot travel through a vacuum.
- Students should be able to identify whether a wave is longitudinal or transverse from a given diagram.

Key words

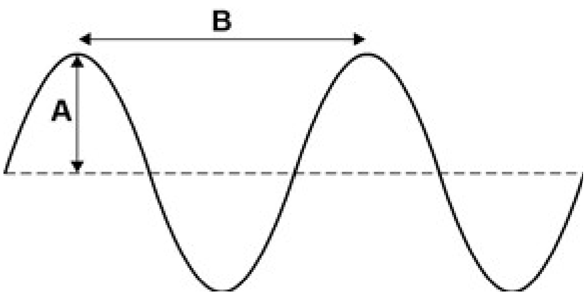
Compression	force squashing or pushing together
Longitudinal	where the direction of vibration is the same as that of the wave
Oscillation	a type of vibration, backwards and forwards or up and down
Perpendicular	at right angles to
Rarefaction	stretched apart
Transverse	where the direction of vibration is perpendicular to that of the wave

Outcome 8

- Waves are described by their amplitude, wavelength and frequency.
- The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.
- The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.
- Students may be required to use the equation: wave speed (m/s) = frequency (Hz) × wavelength (m).
- The frequency of a wave is the number of waves passing a point each second.

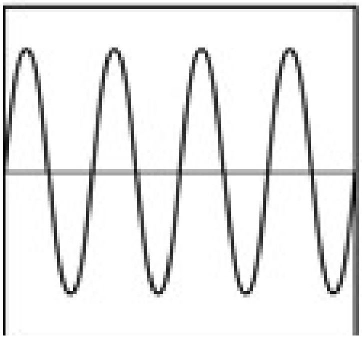
Supporting information

- A wave made by shaking one end of a rope up and down



A = amplitude
B = wavelength

- A high frequency wave



Key words

Amplitude	the maximum amount of vibration, measured from the middle position of the wave, in metres
Frequency	the number of waves produced in one second, in hertz
Wavelength	distance between two corresponding points on a wave, in metres

3.6.5 Electromagnetic waves

Outcome 9

- Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.
- Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.
- The waves that form the electromagnetic spectrum are grouped in terms of their wavelength and their frequency.
- Going from long to short wavelength (or from low to high frequency) the groups are:
  - radio
  - microwave
  - infrared
  - visible light (red to violet)
  - ultraviolet
  - X-rays
  - gamma rays.
- Ultraviolet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose.

Supporting information

- There is a whole family of waves called the electromagnetic spectrum. It contains gamma rays, X-rays, ultraviolet rays, visible light, infrared rays, microwaves and radio waves.
- The speed of electromagnetic waves is reduced if they travel through a material.
- The electromagnetic spectrum is continuous but the waves within it can be grouped into types of increasing wavelength and decreasing frequency.
- No quantitative values of frequency or wavelength will be required.
- All electromagnetic waves travel in straight lines in a vacuum.
- All electromagnetic waves travel at the same speed in a vacuum.

The electromagnetic spectrum

← Increasing frequency

Gamma rays	**X-rays**	**Ultraviolet waves**	**Visible light**	**Infrared waves**	**Micro waves**	**Radio waves**

Increasing wavelength →

- No knowledge of the speed of electromagnetic waves is required.
- No knowledge of the wavelength or frequency of any of these waves is required.

Key words

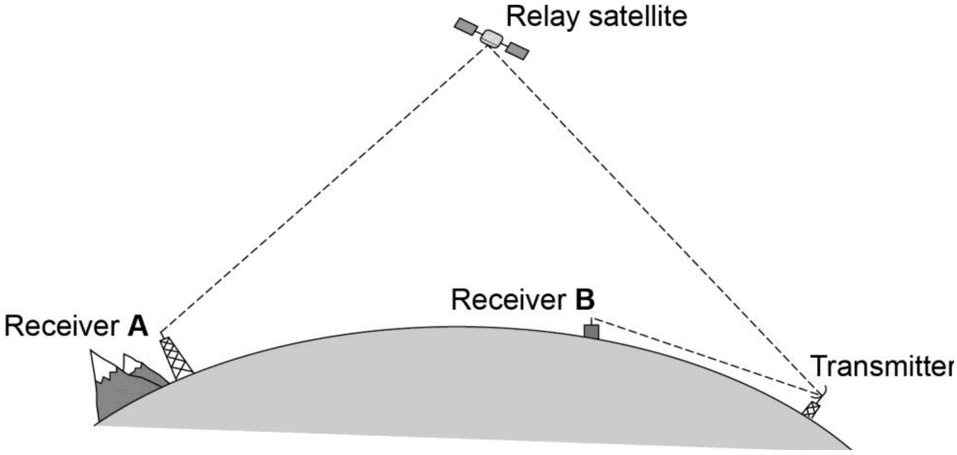
Electromagnetic waves	a group of waves that possess many similar properties They are all capable of carrying energy
Gamma rays	extremely short wavelength and very penetrating waves; they can be produced during some types of radioactive decay
Infrared	the energy of these waves is often used for heating
Microwave	some types of microwave are used in microwave cookers, others are used for communication, eg mobile phones or radar
Radio	a means of communicating sound messages by converting them first into electromagnetic waves
Spectrum	the whole band of electromagnetic waves
Ultraviolet	waves with frequencies higher than light, which human eyes cannot detect
Vacuum	a space with no particles of matter in it
Visible light	the waves that we can detect with our eyes
X-rays	very short wavelength waves that can pass through many substances that visible light cannot

Outcome 10

- Electromagnetic waves have many practical applications, such as:
  - radio waves – television and radio (including Bluetooth)
  - microwaves – satellite communications, cooking food
  - infrared – electrical heaters, cooking food, infrared cameras
  - visible light – fibre optic communications
  - ultraviolet – energy efficient lamps, sun tanning
  - X-rays – medical imaging and treatments
  - gamma rays – for sterilizing.
- Students should be able to give brief explanations of why each type of electromagnetic wave is suitable for the practical application.

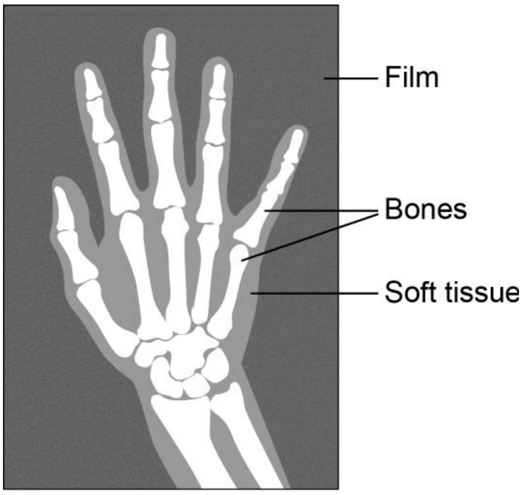
Supporting information

- Radio waves are used to transmit signals for radio, television, radar and telecommunications.
- Because the surface of the Earth is curved and radio signals travel in straight lines, a satellite has to be used to transmit the signal over very long distances.



- Microwaves can pass through the Earth's atmosphere and are used to send information to and from satellites and within mobile phone networks.
- Some microwaves are used for heating water, such as in a microwave oven.
- Infrared and visible light can be used to send signals along optical fibres and so travel in curved paths.
- Ultraviolet radiation may be used to detect forged banknotes.

- X-rays can pass through soft body tissue, but not bone. They can be used to produce a photograph of a broken bone.



- Gamma rays have an extremely short wavelength and carry a lot of energy. They can be used to preserve food such as strawberries by killing bacteria.
- Although all of the different types of electromagnetic wave can be useful to us, there are dangers if we expose ourselves to too much of them.

Key words

Optical fibre	a very thin strand of glass, visible light and infrared waves can be sent along this fibre; the fibre acts rather like a pipe, carrying the waves inside
Radar	a method used to detect aircraft and ships by reflecting electromagnetic waves from them
Reflection	a change of direction of a wave when it meets a surface
Satellite	a man-made object that can orbit the Earth

Useful websites and science organisations

1. Association For Science Educatation : ase.org.uk/resources/

The main resource site is schoolscience.co.uk . There is extensive health and safety guidance to help teachers to ensure safety is not a barrier to doing practical work.
The ASE have a guide to Special Educational Needs and Disabilities (SEND) which has Information and practical ideas for science teachers ase.org.uk/resources/send/

2. STEM Learning: stem.org.uk/

3. Teachit: teachitscience.co.uk/home

Science teaching resources for KS3 – 4 written by teachers *for* teachers.

Get help and support

Visit our website for information, guidance, support and resources at aqa.org.uk/5960

You can talk directly to the ELC Science team

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