Section 2

Booster lessons

Lesson 1 The characteristics of animals

Objectives

Recall, explain and exemplify the characteristics of life ('MRS GREN')

Recall the major organ systems of the human body; show how they are interdependent and relate to the characteristics of life

Vocabulary

organ, characteristic, system, circulatory, respiration, excretion, reproduction, nutrition, sensitivity, movement, growth, skeletal, muscle, concept, nervous (plus vocabulary related to systems)

Resources

Handouts of S1.1 (one between two pupils)

Handouts of S1.2 and S1.3 (cut out beforehand; one set per group of three)

Handouts of S1.4, S1.5 and S1.6 (one each)

Handouts of S1.7 (cut out beforehand; one set per group of three)

By the end of the lesson

pupils should be able to:

- describe the characteristics of animals
- describe the main human organ systems and what they do
- begin to explain how the organ systems work together
- explain that many animals have similar organ systems

Possible follow-up activities or homework

Produce a concept map for 'The characteristics of life' or 'The major organ systems'.

In groups of three, produce three new taboo cards and try them out on one another.

Try to provide an answer to all of the questions on **handout S1.4**.

Starter 15 minutes

Introduce the lesson objectives. Do a quick question-and-answer session on 'What are the characteristics of life?' or straight away re-introduce 'MRS GREN' and start from there.

The activity 'Statements into explanations' is to determine levels of prior knowledge and understanding of the seven characteristics and to allow pupils thinking time to attach characteristics of life to explanations and outcomes. You may need to recap the meaning of 'organ'. Give out **handout S1.1** to pairs of pupils. Ask pupils to match each characteristic with its best description. When pupils have done this, ask them to consider the explanations for why each characteristic is vital to life and any possible consequences with system failure.

During the activity listen to the pairs to determine any misconceptions. After 10 minutes go from pairs to fours for groups to compare their answers. Go through the correct answers but allow other thoughts from pupils.

Organ mysteries 15 minutes

This activity helps classification skills. Pupils explore the major organ systems of the body which sustain the 'characteristics of life'. Give out the 'Organ mysteries' cards (**handouts S1.2–S1.3**) and ask pupils to group the statements. For more details, see the notes below.

Circulate among groups, asking pupils why they put certain statements under headings. Some pupils will group according to their own method; again, ask pupils to explain their choices.

You will need to explain to pupils what some of the statements mean but try not to give away the answers. Some pupils will require more guidance than others at this stage. You may want pupils to glue their groups into exercise books or on to paper.

When pupils have grouped their statements, they can attempt the questions of their choice on **handout S1.4**.

Concept maps 15 minutes

Use the previous activity to draw links between the characteristics of life and the major organ systems. Ask pupils to look at the groups and headings from the last activity. Now create mini concept maps linking an organ or organ system to the characteristic of life. Give out the example starters on the resource 'Mini concept maps' (**handout S1.5**) and explain how they work. The idea is that pupils produce a 'connector' on the arrow which describes or explains the connection (see examples on the resource). Progress to more-detailed concept maps (**handout S1.6**) which use more key words but with fewer connecting words.

Plenary 15 minutes

Each group of three will need a set of taboo cards (**handout S1.7**). For details of how to play, see page 23 of section 1.

Teacher's notes: Organ mysteries (sheets S1.2 to S1.4)

Sheets S1.2 and S1.3 are cards with statements relating to the major organs and systems of the human body. The statements include the main organs of each system, facts about organs or systems, and consequences (what might happen if an organ or system fails in some way). The relevant organs, facts and consequences are printed alongside each of the major systems. The major systems are in bold to help pupils to use these as headings during the activity.

Decide how many of the statements you want to use with your groups. You may wish to remove the more complex statements for lower ability groups. Where possible, however, try to keep the challenge built in to the activity. You will also need to decide how best to trigger the activity, that is, what information you will give to pupils just before the activity.

You will need to print enough copies for groups of three pupils (or four if you wish to keep the same fours together after the introductory activity 'Statements into explanations'). You then need to guillotine the cards and completely mix them up. Place the statements into an envelope or paper-clip them together.

There are two ways you could set the task:

- Either ask pupils to group the statements if you feel that this is the only instruction they need. Most pupils will see the systems in bold and work from there. Note: there is no right or wrong way to group the statements. Allow pupils to make this decision but when the activity is underway ask them to describe why they have grouped the statements in such a way.
- Or give more detailed instruction about how you would like the statements to be grouped, for example, using the 'system' headings.

Your main role during the activity is to listen to pupils talking about how and why they are putting various statements into groups. Listen out for misconceptions and draw on these later. Don't spend time explaining or correcting pupils' science at this stage.

When pupils have grouped the statements they can then have a go at the questions on handout S1.4. These are questions related to the grouping activity. You may in fact feel that pupils have got enough out of the grouping activity to move on to the next part of the lesson. The questions on S1.4 are designed to provoke discussion rather than a search for answers in the grouped statements. However, the grouping will help pupils to target which organ system is under consideration and perhaps trigger the start of the discussion.

Statements into explanations S1.1

Connect each characteristic of life (the words on the left) with the most appropriate description. Then link each description with the best explanation. For example: movement, description 6, explanation C.

Characteristic	Description	Explanation
Movement	**1** This is how our bodies increase in size. It is also related to how our systems increase in complexity.	**A** If this system did not operate correctly it would affect everything from our ability to move to our ability to detect hot surfaces and pain. This is because nerves carry information between the brain and other vital body parts and help us to respond for survival.
Respiration	**2** This is the system associated with making more of the same species. It includes sexual intercourse, the fertilisation of an egg by a sperm, and the production of human babies.	**B** This system is essential because the lack of materials for building, for energy, and for repairing damaged body tissues could seriously affect our chances of survival.
Sensitivity	**3** These are the processes of removing waste products from the body.	**C** This is a basic survival characteristic. Without this ability we would not be able to hunt for or collect food.
Growth	**4** This involves a reaction between oxygen (breathed in) and food to produce energy. The waste products carbon dioxide and water are breathed out.	**D** If waste products accumulate (gather or collect) in a human, these materials will poison us. It is essential that these waste products are removed from our bodies.
Reproduction	**5** This involves taking materials into the body to provide energy and nutrients.	**E** Without this characteristic of life we would not be able to mature into adults, and so we would not be able to produce more babies. Our development into adults is a key factor in ensuring our survival.
Excretion	**6** The antagonistic action of muscles pulling on our skeletal system results in this.	**F** Without the ability to produce babies, i.e. more humans, our chances of survival as a species would be nil.
Nutrition	**7** Stimuli such as taste, light, temperature changes and sound are related to this characteristic of life.	**G** Without this system we would not be able to convert our food into energy. For example, if heat energy is not produced in our bodies, then our body temperature would fall to dangerous (fatal) levels. This seriously affects the function of all major body organs.

Organ mysteries 1 S1.2

The nervous system	Main organs: eyes, nose, tongue, skin, ears, brain and spinal cord	This system works very closely with the hormonal system to monitor and control other systems.
This system controls your actions. It coordinates different parts of the body so that you can react to different situations.	Example: when you see a flash of bright light, your response is to blink.	One problem which can affect this system is called ‘motor neuron disease’. Nerve cells which carry signals to muscles do not work any more. This can lead to paralysis.
The skeletal system	Main tissues: cartilage and bone	You would find this material on the ends of some bones. It acts as a shock absorber and prevents bones in joints from rubbing together.
Without this system in humans the major organs such as the heart and lungs would be poorly protected.	This system provides support for the body. Its links to the muscular system mean that we are able to move around.	This system is where red and white blood cells are made.
The reproductive system	Main organs: ovaries and uterus (females); testes and penis (males)	Humans are examples of mammals. This means that sperm and egg (the male and female sex cells) join inside the body of the female.
Sperms are made inside the male sex organs called testes. Eggs are made inside the female sex organs, the ovaries.	Compared with animals like fish, human females normally only produce one egg at a time. Fish produce many more eggs at one go.	This system involves the making of new living things. Animals and plants reproduce to produce individuals of the same species.

Organ mysteries 2 S1.3

The respiratory system	Main organ: lungs, including trachea and bronchi (air passages)	This system controls the release of energy from food (glucose).
glucose + oxygen $\xrightarrow{\text{energy released}}$ carbon dioxide + water	The lungs are specialised organs. They contain many alveoli where oxygen passes into the blood and carbon dioxide passes out again.	Damaged or diseased lungs (e.g. emphysema) can mean that less exchange of gases can occur in the alveoli. This will make breathing much more difficult.
The circulatory system	Main organ: heart. Main vessels: arteries and veins.	This system transports oxygen from your lungs to your cells for respiration.
This system is involved in transporting food from your gut to your cells.	This system carries waste carbon dioxide back to your lungs and waste chemicals from your cells to your kidneys.	The main vessels in this system are the arteries and the veins. Arteries carry blood away from the heart. Veins carry blood back to the heart.
The digestive system	Main organs: the stomach and the small intestine (these are the main places where food is digested)	Food that we eat contains starch, proteins and fat. These molecules are too big to be absorbed by the body. This system breaks them down into smaller ones.
The larger molecules are broken down by specialised chemicals called enzymes. The smaller molecules produced can then be absorbed into the blood.	Once the smaller molecules enter the blood they have entered the circulatory or blood system. They are important for respiration, growth and repair.	

Organ mysteries: questions S1.4

Use your grouped statements to help you to think about these.

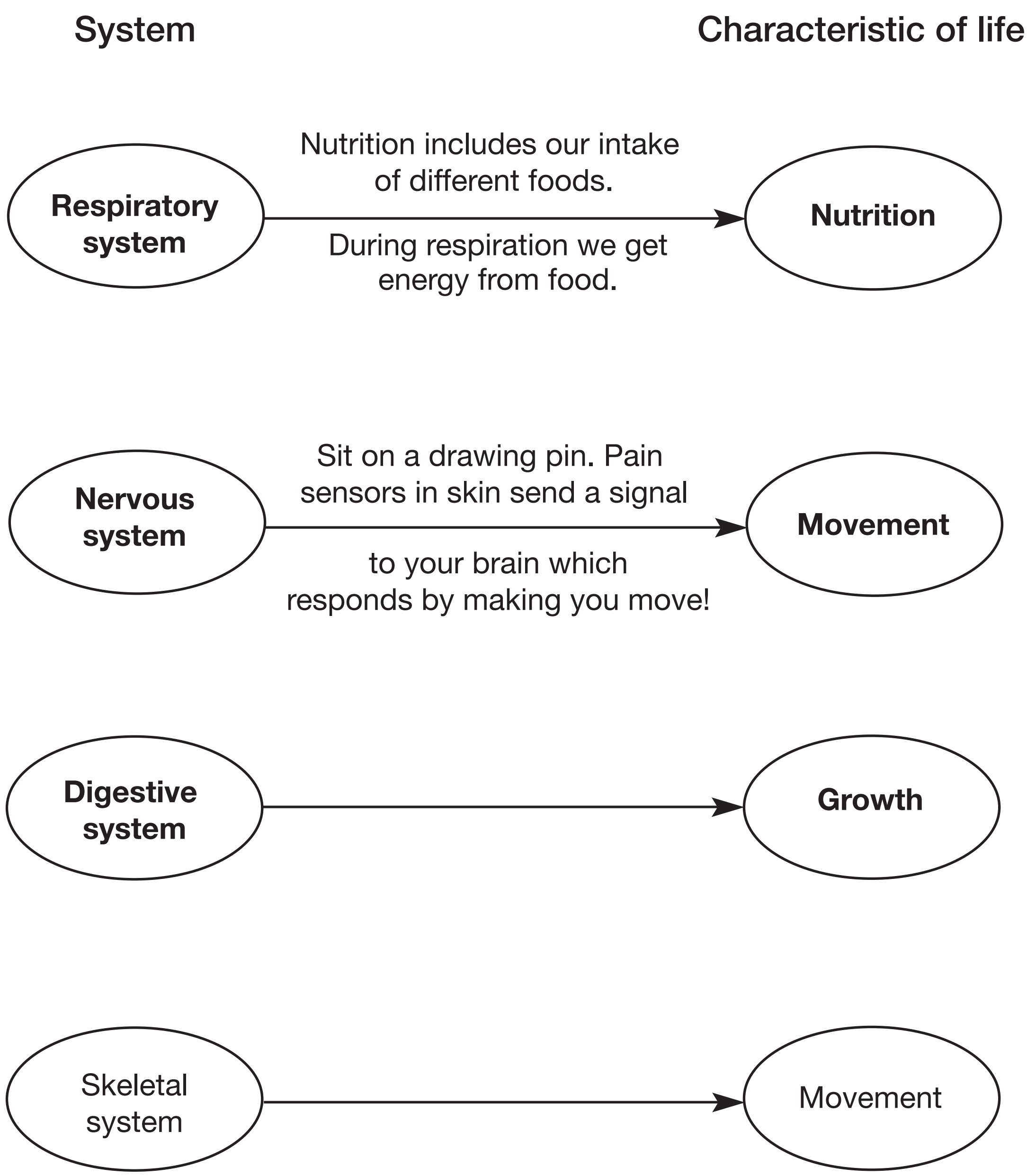
- Two pupils were arguing:

  'I think that fish produce millions of eggs at one go because the male fish produce billions of sperm – so they have to produce many more eggs.'

  'No! I think it's because more fish need to be produced – this helps their species to survive.
- Why does the circulatory system need both types of blood vessel – arteries and veins – to carry blood away from the heart and then back to it? Why are they not the same type of blood vessel?
- Why can smoking affect how well you are able to breathe?
- Why do boys between the ages of 11 and 16 start to produce the hormone testosterone in their testes? Why do girls between the ages of 10 and 15 begin to produce the hormones progesterone and oestrogen in their ovaries?
- Why do we need special chemicals to deal with proteins in our food so we can use them to build our bodies?
- What would happen if we didn't have a skeleton? How might this affect our daily lives? Would we be able to survive?

Mini concept maps

Complete these mini concept maps by writing on the arrows. The first two have been done for you.

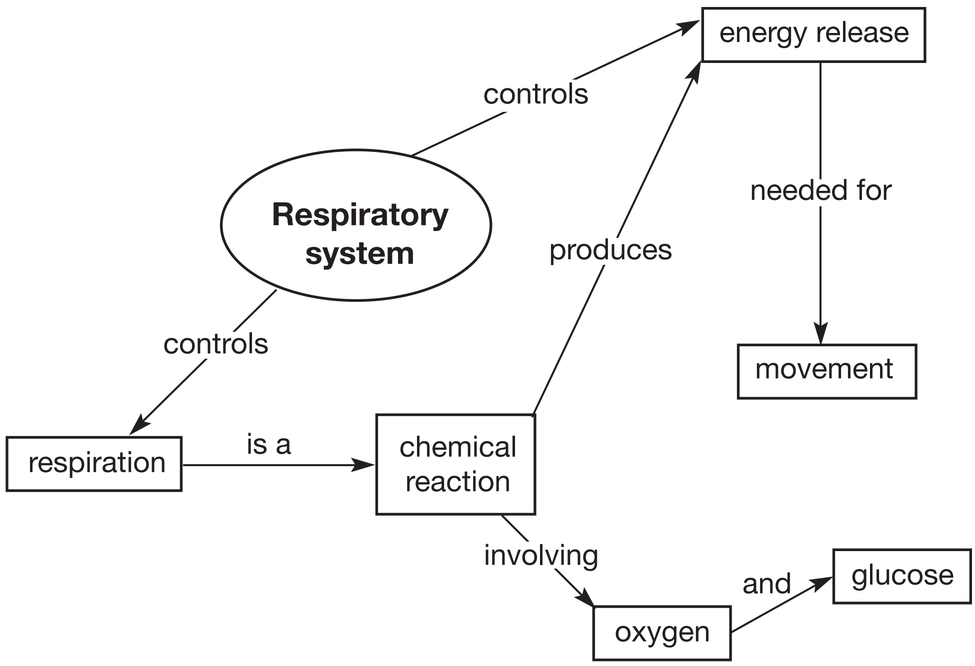


Concept maps S1.6

You can draw concept maps to show connections between organs and systems. Here is an example.

Main theme: respiratory system

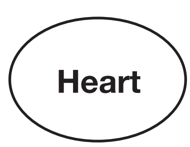
Connect with: energy release, respiration, chemical reaction, movement, glucose, oxygen



Draw a concept map using the following words. Try to add other connections and words if you can.

Main theme: heart

Connect with: blood, pump, vessel, muscle, circulatory system, skeletal system, movement, arteries, veins, oxygen, carbon dioxide



Taboo

S1.7

heart taboo words: blood, pump	**lungs** taboo words: air, respiration (or respiratory), oxygen, gases	**blood** taboo words:	**skeleton** taboo words: bones, support, hold, protect (or protection), organs
skeletal system taboo words: bones, support, protection	**circulatory system** taboo words: blood, heart	**enzyme** taboo words: chemical, digestion, food	**brain** taboo words: control, important, organ
artery taboo words: blood, away from, back to, heart	**vein** taboo words:	**small intestine** taboo words: digestion (or digestive system), food	**blood vessel** taboo words: carry, red, white, circulatory system
stomach taboo words:	**cartilage** taboo words: bone, friction, between, joint	**carbon dioxide** taboo words: breathe, respiration, waste product	**energy** taboo words: oxygen, food, movement (or move), heat, kinetic, potential

Lesson 2 Plant structure and function

Objectives

Recall and review plant structures

Relate these structures to understanding of life processes

Group features of plants according to different criteria

Vocabulary

root, stem, leaf, flower, petals, stamen, carpel, seed, ovary

Resources

Drawing paper

Handout of S2.1 (copy onto card and cut up beforehand; one set per group of four)

Selection of familiar Key Stage 3 textbooks

Dictionaries

By the end of the lesson pupils should be able to:

- apply ideas of processes to plant organs
- compare and contrast plant organs and functions
- identify existing knowledge and misconceptions
- explore ideas, etc. collaboratively
- justify choices and hypothesise

Homework

Ask the pupils to produce a plant diagram with labels showing plant organs and relevant life processes.

Alternatively you could ask them to produce a concept map using the words generated during the lesson.

Starter 10–15 minutes

Introduce the lesson objectives but do not at this stage identify a list of key words.

This activity is used to help pupils recall work done in Key Stage 2. Ask the pupils to work in pairs, to do a quick drawing of a plant and to label the organs on the plant. They should then compare drawings with another pair and modify them if necessary.

Take feedback from the groups of four to identify the main plant organs but in addition ask the spokesperson for each group to say briefly what each organ does.

At this stage pupils' drawings should include (as a minimum): root, stem, leaf, flower, petals. They may also include: root hairs, shoot, stigma, style, filament, anther, carpel, seed, ovary, nectary, fruit, bud, and (if they consider trees) trunk and branches. It might be useful to build this word list on the board or an OHT as pupils give feedback.

Main activity 20 minutes

This activity develops from the first and involves setting up a situation which will generate cognitive conflict. The task involves pupils sorting cards with plant-related words into categories of their own choosing. The cards include the words listed on the left but also others, some of which are not parts of plants but life processes and others the pupils may well not remember. They will therefore have to discuss what they think these words mean and may have to look them up in a dictionary or science textbook. Both should be available.

Issue a set of the word cards (**handout S2.1**) to each group of four and tell them to sort cards into groups. There is no correct way to do this so pupils can choose their own groupings. However, they must be able to justify their reasons for choosing their groups and explain, if challenged, why individual words should go into a particular group.

During the activity move around the groups, scanning responses and mediating as appropriate. Use your judgement about explaining the meaning of words but if at all possible get the pupils to research those that they do not know.

Plenary 20 minutes

Explain that a spokesperson from each group has to tell the rest of the class about one of their groups of words and why the grouping was chosen. Allow a maximum of 2 minutes with a couple of minutes for questions. It is important that the justification is made clear. Other pupils in the class (or the teacher) can ask questions to seek further explanations but cannot challenge the grouping unless there are inconsistencies. Ask each group in turn to give feedback. Once all groups have had a turn you can begin again.

There are likely to be more groups of words than time to allow each to be fed back so you may have to choose 'particularly interesting examples you noticed as you went around the class'. Whenever misconceptions or errors in knowledge emerge, make a note on the board or OHT and explore them with the class as a whole.

Plant word cards

chlorophyll	phloem	palisade mesophyll	fertilisation
chloroplasts	xylem	osmosis	shoot
roots	branches	fruit	pollen
stem	cuticle	carpel	carbon dioxide
leaf	epidermis	water	oxygen
flower	stomata	transpiration	sun
bud	petals	starch	nitrates
nutrients	sepal	ovary	adventitious
root hair	stamen	ovule	

Lesson 3 Human growth and reproduction

Objectives

Review knowledge and understanding of growth and reproduction in a plant

Explain human growth and reproduction, including the role of the placenta in supporting the growth of the embryo

Identify similarities and differences in growth and reproduction of humans and plants

Work collaboratively

Vocabulary

male, female, sperm, egg, mature, adolescence, fallopian tubes, baby, seed, male nucleus, pollen tube, style, ovary, ovule, female nucleus, fertilised cell, fertilisation, amniotic fluid, umbilical cord, placenta, uterus, menstrual cycle

Resources

OHT or poster of S3.1 (word list)

Handouts of S3.2 (copy onto card and cut up beforehand; one set per pair)

By the end of the lesson pupils should be able to:

- describe human reproduction and growth and explain key words
- process verbal and visual information
- create and use own symbolic representation

Homework

Compare and contrast the life cycle of a different animal or plant with that of the plant in the lesson.

Starter 5 minutes

This activity is used to review work done in Key Stage 2 and to ensure that pupils understand the idea of a life cycle.

Ask pupils to work in pairs to produce a simple sketch of the life cycle of a flowering plant. Allow only a couple of minutes before asking the pairs to work in groups of four to compare what they have done. Ask them to agree among themselves a simple sketch.

Take brief feedback from the whole class. Where necessary clarify words and ideas, making a note on the board or OHT of any which seem particularly difficult.

Main activity 30 minutes

Tell pupils that in this activity they will need to use symbols or single words as a shorthand instead of pictures because they will not have time to write much. Pupils can use letters such as ‘B’ for ‘baby’, ‘S’ for ‘sperm’ etc. or could use full words.

First, ask pupils to listen as you read out the texts on human reproduction and growth (see the script below). Next, invite them to draw their own visualisation of reproduction and growth in humans using symbols and single words as you read the text again. They should then work in groups (of four, say) to agree a brief model or view of the aspects of human reproduction and growth that were described and to add any extra words to fill in details of events before the baby’s first photo and between that and black Monday.

Give out sets of the human reproduction and growth cards (**handout S3.2**), one per pair. Ask the pupils to sort cards in any way they want in order to sequence the pictures. They should then compare their sequence with that of another pair and produce a sequence which all four pupils agree on.

Then ask the groups to select one or two pictures that represent a ‘stage’ in the human life cycle. Ensure at least one group chooses pictures that require some explanation of the role of the placenta. Ask them to use their memories, their own notes or textbooks to prepare a short presentation on what is happening in the pictures. These presentations will form the plenary.

Plenary 25 minutes

Organise feedback from groups one at a time. A spokesperson should explain to the class the ‘stage’ of human growth and reproduction they have chosen and as much as they can of what is taking place. Once the explanation is complete, other pupils can ask questions. Be prepared to ask your own open questions of both the spokesperson and others in the class. Summarise the main points on the board or OHT.

Common misconceptions include the failure to recognise the importance of the nucleus in sperm and eggs (and also pollen in plants).

During the final five or so minutes, ask pupils to describe similarities between human growth and reproduction and the life cycle of a plant

Teacher's script

Baby's first photo

Mark and I waited anxiously for the nurse to see us. I was in week 20 of pregnancy and we had arrived early for our appointment to have an ultra-sound scan of the baby. I could feel a 'fluttering' in my tummy as the baby moved. Perhaps it was nervous too.

The nurse arrived and placed gel on my tummy. It was very cold! The gel helps to make a connection between the scanner and my skin. Instantly we could see the baby on the large monitor. It looked as if it was in a snowstorm. The nurse said that the baby was a healthy 25 cm from head to toe. She pointed out its arms and legs and we could see its little heart beating.

We were also shown the umbilical cord and the placenta. She explained how the baby receives its food supply through the placenta and the umbilical cord.

Mark and I couldn't take our eyes off the screen. The baby was moving around a lot in the amniotic fluid that helps to protect it in the womb. The nurse told us that the baby looked fine and healthy. She printed off a photograph for us to keep. It was a very special time and the photograph is now in pride of place over the front room mantlepiece.

Black Monday

The weekend got worse and worse. The small pimples that started on Saturday morning have turned into real spots. Every time I looked, another had appeared. My skin's gone all greasy, with lumps around my nose. I feel awful. My big brother John is no help – he just laughs and says: 'Been there, done that. You'll get over it. It's just acne.'

JUST! That's no joke when my face is covered in molehills. John said they'd go by Monday. Well, here I am, looking at myself. They're worse. I tried squeezing them and although I got something out, it's made them flare up. My face looks like the surface on Mars! Some seem to have black heads, others have white heads. It's going to be a black day in my life at school today. I just know it.

adolescence

amniotic fluid

egg

embryo

fallopian tubes

female nucleus

fertilised cell

male nucleus

mature

menstrual cycle

ovary

ovule

placenta

pollen grains

pollen tube

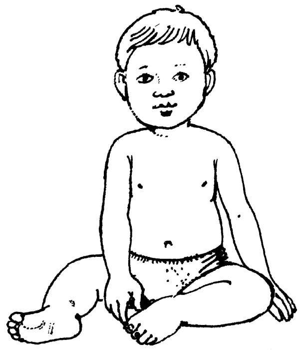
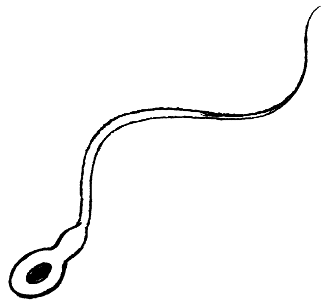
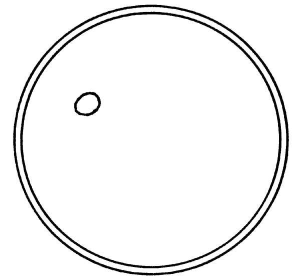
seed

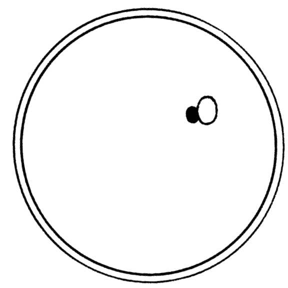
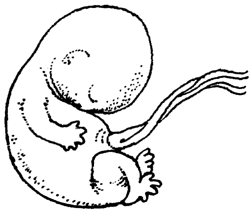
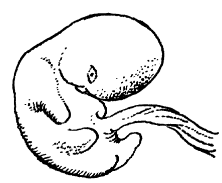
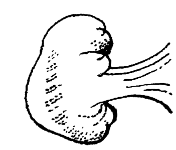
sperm

umbilical cord

uterus

Human growth and reproduction S3.2


Lesson 4

Feeding relationships between organisms

Objectives

Review food chains and webs

Describe and explain processes within a food web including energy transfer

Use models to explain phenomena

Generate and develop ideas, and hypothesise

Vocabulary

model, analogy, food web, food chain, chain, links, habitats, energy, energy transfer, producer, consumer

Resources

OHT or poster of S4.1

Food chain/web cards and arrows (see below for details)

Sticky tape

Hole punch

By the end of the lesson pupils should be able to:

- describe and explain the process of energy transfer in a food web
- recognise and construct a model to illustrate feeding relationships
- build a three-dimensional model

Homework

Pupils could make a two-dimensional drawing of their model and show the flow of energy through the web.

Starter — 10 minutes

In this activity pupils review previous knowledge and understanding. The strategy of focused free writing is not commonly used in science lessons and you may need to reassure pupils about it. They should write for one minute on ‘chains’, without stopping or worrying about spellings etc. Tell them to write whatever comes into their mind.

Take some feedback from pupils so that all can appreciate the diversity of ideas, none of which is wrong. Allow only a couple of minutes for this.

Now invite pupils to write for two minutes on ‘chains in living things (biology)’.

Ask pupils to work in groups of four, to compare ideas and write an agreed description or idea on biological chains. While they are doing this you can scan ideas and mediate if necessary. Allow about four minutes for this.

Finally, for two minutes, the groups report back to the class; clarify ideas of chains and links.

Main activity — 25 minutes

In this activity pupils use picture cards and arrows to build up food chains and then produce a three-dimensional food web; this will help them recognise the nature of food webs and the links between organisms. Explain to pupils that they are using and making a model of what happens.

Tell pupils to work in groups of four. They should use a selection of picture cards and arrows to construct a food chain linking four organisms. Point out that the base of the arrow identifies the organism which is eaten by the one attached to the arrowhead (see the notes below).

Now explore what happens in a food chain in terms of energy transfer. Question pupils on:

- Is all the available energy transferred from organism to organism?
- Why do we rarely find food chains with more than four organisms? (energy loss)

Ask each group to construct four food chains in all.

Now ask them to link the four food chains, using more links if necessary, to produce a three-dimensional model of a food web. Pupils may need some way of hanging the model in order to see it more easily.

Plenary — 25 minutes

Ask groups to report back to the whole class on their food web, explaining any links which they found interesting or unusual. They should include the idea of energy transfer in their explanations. The class can ask questions and you should also ask open questions to clarify points and to summarise.

Discuss what the arrows represent.

If there is time invite pupils to challenge each other to hypothesise what would happen if an organism was removed from the web.

Food chain cards

You will need to prepare a number of cards each with a picture of an animal or plant and a few with a picture of the sun. The number of cards depends on the size of the group but each group of four needs at least 16 cards to produce four food chains. Each group does not need to have a different set of cards, but the greater the variety the greater the range of food chains and then webs possible. Try to find organisms from a range of habitats. Within any department there will be several photocopiable resources or magazines with appropriate pictures you can draw upon.

Photocopy or glue the pictures onto different coloured cards, for example, plants – green, animals – red, sun – yellow.

There are various ways of constructing the arrows. Simple card strips with an arrow drawn or printed on them can be taped between organisms. Alternatively arrows can be made of pipe cleaners or bendy straws. In either case bend one end to form a hook; this represents the arrowhead and can be hooked into a hole in the picture card. The other end can be taped or held with Blu-Tack on the food. This method allows pupils to vary their food chains/webs and requires them to have access to a hole punch to make suitable holes in the picture cards.

analogy

chain

consumer

energy

energy transfer

food chain

food web

habitats

links

model

producer

Lesson 5 Physical changes

Objectives

Explain that a mixture contains particles from at least two different substances

Recognise that the process of dissolving produces a mixture

Use appropriate scientific terminology

Describe the physical processes involved in chromatography and distillation

Use particle model ideas to describe how the components in a mixture are separated

Vocabulary

filtration, simple distillation, chromatography, evaporation, crystallisation, mixture, physical change

Resources

OHT or poster of S5.1

Handouts of S5.2–S5.4 (see notes below)

Handout of S5.5

Apparatus

Distillation: round bottomed flask, ink, Liebig condenser etc.

Evaporation: evaporating dish, water bath

Chromatography: sticks of white chalk to stand in petri dish of dyes

Samples of mixtures: ink; ethanol and water; salt and water; chalk and dye mixture

By the end of the lesson pupils should be able to:

- describe the most appropriate method to use to separate a given mixture
- use particle ideas to describe how simple separation techniques work
- give at least one example of an everyday application of separating mixtures

Homework

Draw a concept map using the words on **handout S5.5**.

Warm-up 15–20 minutes

Introduce the lesson objectives and what pupils should learn by the end of the lesson. Using an OHT or poster of **S5.1** identify the key words and refer to these throughout.

Demonstrate the following separating techniques:

- Simple distillation – separate ink from water, ethanol from water, or pure water from sea water using a Liebig condenser (examples: getting alcohol from a brewing mixture, desalination)
- Chromatography – place a stick of white chalk into a Petri dish containing a mixture of dyes (example: testing urine in hospital)
- Evaporation – use salt solution in an evaporating dish (example: getting salt from sea water). Show how the rate of evaporation can lead to crystal formation by using a water bath to produce slow evaporation and hence crystallisation.

Involve the class by inviting pupils to help carry out each activity and through asking others to record class comments and observations on the board/OHT. Pupils could also summarise points on **handout S5.2** (see notes below).

Reinforcement activity 10 minutes

The above processes can continue as pupils consolidate ideas by completing **handout S5.3** (see notes below). As they do this, check that they are confident with filtration from Key Stage 2.

Understanding particles 20 minutes

Ask pupils now to consider for a given example what was happening in terms of particles. Use pupils to model the particle behaviour. Divide pupils into groups and ask each group to model a particular process. Provide pupils with labels to indicate what type of particle they represent, e.g. water, salt or sand. The group mime their process and the other pupils have to agree a commentary that goes with the mime to reflect accurately the various stages in the separating out. This can be in the form of simple sentences that you can support with prompts or it can be structured as a cartoon sequence showing changes in particle behaviour.

Where appropriate discuss the energy transfers made to and from the particles and the effect of this transfer on particle movement.

Plenary 10 minutes

Distribute **handout S5.4**. Pupils work in pairs to write a suitable question to an answer they have been provided with. The number of answers given to each pair and the type of question required can vary. Start with the single-word answers to encourage pupils to structure ‘recall questions’ first. Then introduce simple phrases to encourage pupils to structure ‘description questions’. Finally introduce phrases to encourage pupils to structure ‘explain questions’.

Use diagrams and sketches of graphs, and remember to use questions that probe Sc1 skills in addition to key ideas and content.

Notes on the handouts

Handout S5.2

This can be used 'as is', or with the labels on the diagrams blanked out. It can be used in various ways according to the ability of the group, such as:

- pupils label the apparatus in each technique;
- pupils record the name of the technique;
- pupils state what types of mixtures can be separated (e.g. insoluble solid+liquid for simple distillation);
- pupils give examples of everyday applications of these techniques.

Handout S5.3

For a more challenging activity, blank out the word-search solutions in the top right box.

chromatography

crystallisation

evaporation

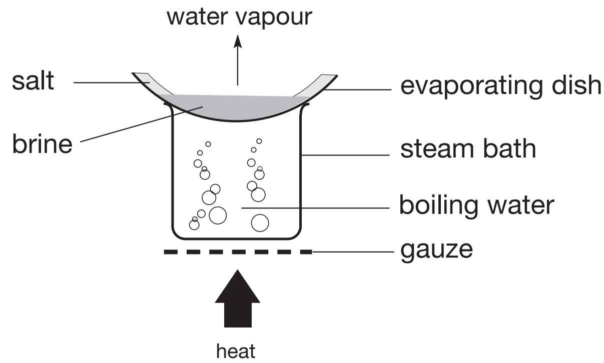
filtration

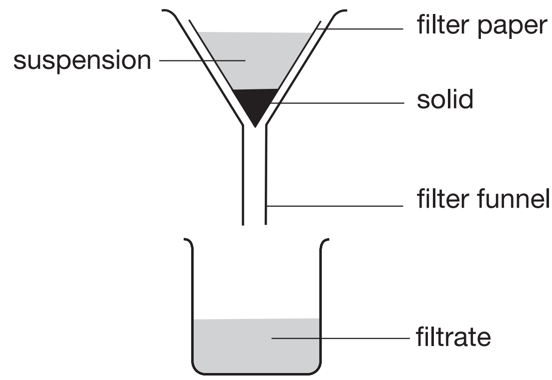
mixture

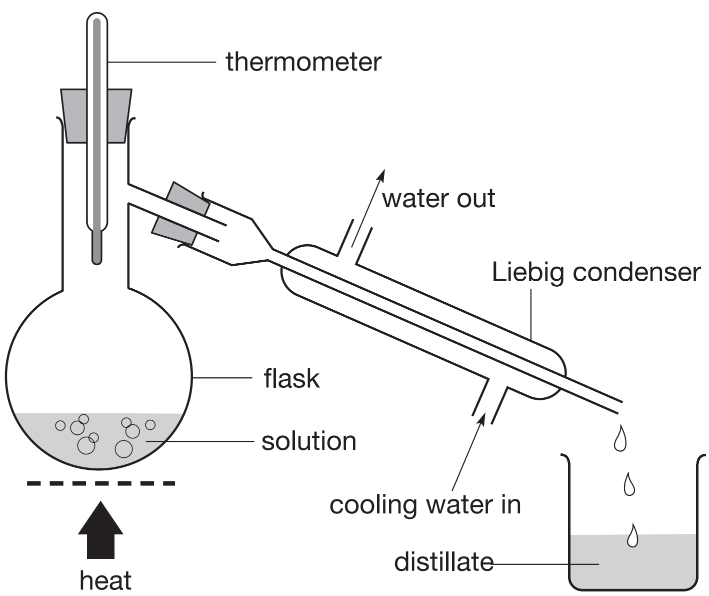
physical change

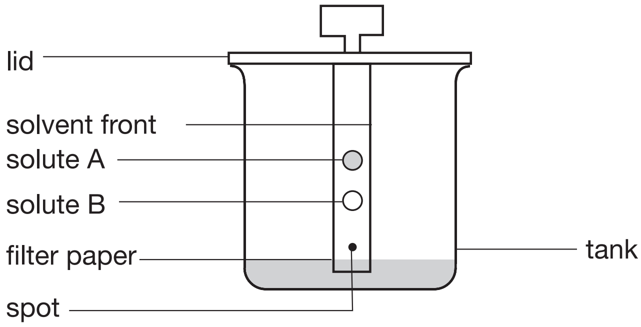
simple distillation

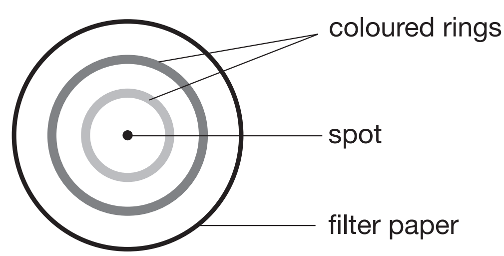
Separating techniques: summary











Mixtures word search

Find 10 words to do with separating techniques.

s	o	l	u	t	e	p	v	o	s	c
a	f	a	i	h	o	a	i	o	l	h
n	m	d	z	a	c	d	l	e	n	r
o	i	e	i	u	k	u	r	v	o	o
i	x	b	u	n	t	m	a	a	i	m
t	t	m	s	i	f	g	t	p	t	a
a	u	k	o	b	j	u	e	o	a	t
r	r	n	l	l	y	t	u	r	l	o
t	e	f	v	s	i	o	d	a	l	g
l	d	c	e	o	a	t	i	t	i	r
i	l	t	n	a	s	o	s	i	t	a
f	i	l	t	r	a	t	e	o	s	p
y	c	n	e	u	q	e	r	n	i	h
u	c	x	b	k	o	w	g	l	d	y

chromatography
distillation
evaporation
filtrate
filtration
mixture
residue
solute
solvent

Use the words you found to complete the sentences below.

1 ___________________ will help you to separate a mixture of lots of coloured dyes.

2 Air is an example of a _______________.

3 ____________________ occurs when a liquid turns into a gas.

4 You use a filter funnel and paper when you carry out _________________.

5 A ________________ is produced when salt dissolves in water.

6 __________________ is used to capture the water from ink.

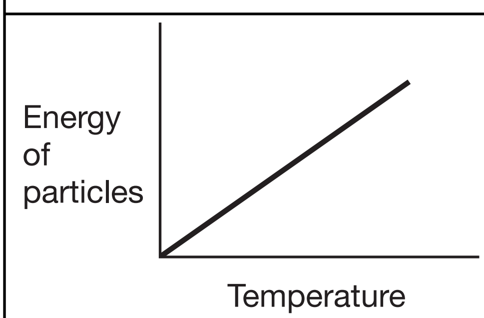
7 The solid left on the filter paper after you have filtered a mixture is called the _______________, and the liquid part of the mixture that drips through the funnel is called the ________________.

8 Water is sometimes called the universal ______________.

9 The part of a solution that dissolves is called the ________________.

What was the question? S5.4

Below are the answers to questions on separating techniques.
Try to work out what the questions were.

The answer is …	**What was the question?**
Solute	
Soluble	
Solution	
Evaporation occurs when a liquid changes into a gas.	
The particles in a mixture are not joined together.	
First you add water to the salt and sand, then you pour the mixture into the filter funnel.	
The salt water passes into the beaker.	
The particles of salt spread out between the particles of water.	
Because the iron does not dissolve.	
Because the particles of water have sufficient energy to leave the liquid.	
	

Physical changes: concept map S5.5

Draw a concept map using these words. Try to add other connections and words if you can.

Main theme: physical change

Connect with: solute, solvent, solution, filtrate, residue, filtration, evaporation, chromatography, soluble, simple distillation, insoluble, crystallisation, mixture

Lesson 6 Metals and non-metals

Objectives

Identify physical differences between metals and non-metals

Recall and review knowledge of elements and compounds; relate this to expected physical properties and uses

Vocabulary

metal, non-metal, model, element, compound, molecule, respiration, raw material, bauxite, aluminium, chemical bond, electrolysis, periodic table

Resources

Handouts of S6.1 (copy onto card and cut up beforehand; one set per pair)

OHT or handouts of S6.2

Handouts of S6.3–S6.6

Handouts of S6.7 (one per group of four)

Handouts of S6.8 (copy onto card and cut up beforehand – loop card game)

By the end of the lesson

pupils should be able to:

- use the words atom, molecule, element and compound correctly
- describe some differences between metals and non-metals
- describe some properties and uses of some common metals and non-metals

Possible follow-up activities or homework

Produce a poster which shows the uses and properties of metals and non-metals.

Produce 'element cards'. Draw out a grid of squares approx. 4 cm by 4 cm (do 20 squares). Choose 10 metal elements and 10 non-metal elements. On one side of the square write the symbol and name of the element. On the other write something about their chemical and physical properties and what they are used for.

Starter 15 minutes

Introduce the lesson objectives.

The opening activity (Classification) is a card sort to review prior knowledge and understanding of the physical property differences between metals and non-metals. (You may need to explain 'physical property'.) Give out the sets of cards (**handout S6.1**) to pairs of pupils and ask them to sort the statements, including those labelled 'Substance A', 'Substance B', etc., under two headings: 'Metals' and 'Non-metals'. Circulate and listen to how pupils make their decisions. This activity may bring to the surface any misconceptions and will feed in to later activities.

After about 7 or 8 minutes ask each pair to join with another and to compare their answers. Go through the correct answers but allow scope for thoughts from pupils. Ask pupils for suggestions for the names of substances A to H. Tell them the answers (A carbon; B chlorine; C lead; D iron; E nitrogen; F sodium chloride; G mercury; H carbon dioxide) and discuss whether or not they easily fit into the expected definitions for metals/non-metals (e.g. carbon).

Read, discuss and write 20 minutes

This activity reviews knowledge of elements and compounds and requires pupils to link this with their understanding of the differences. Pupils remain in groups of four. Show the task on **OHT S6.2**, and give everyone a copy of **handouts S6.3–S6.6**. Each pupil in the four takes one of the reading objectives and text-marks (highlights, underlines) the relevant parts of the passage. Allow pupils to read for 7 or 8 minutes; it is not important that they all read everything. Each pupil takes a turn to report back to the group what they have found out (7 or 8 minutes). The group should then produce a concept map which covers the four objectives. The concept map should have 'compounds' as the central theme.

True or false? 15 minutes

Give out **handout S6.7**. Pupils work in groups of four to decide upon the answers. This activity helps pupils to reflect on the previous work and sharpens their understanding and consideration of some of the anomalies in those definitions. Tell the pupils to decide first whether the two statements in each pair are true or false. The next decision to be made is: Does the second statement correctly explain the first? If it doesn't then pupils should write down why this is so. Note that both statements in the pair may actually be true but the second may not explain the first. Take feedback from group to group, asking for their answers and their explanations. Open the discussion to other groups for any alternative viewpoints.

Plenary 10 minutes

Use the loop cards on **handout S6.8** (16 cards in all). See the notes on page 24 of section 1 for details.

Classification

Metals	**Non-metals**	Poor conductors Act as insulators	Good conductors of electricity
Good conductors of heat	Poor conductors of heat Act as insulators	Make a clear ringing sound when struck (sonorous)	Produce a dull sound when struck
Shiny in appearance	Dull in appearance	Easy to bend	Tend to shatter when hit hard
Most are solids	Most are gases, some are solids	High density	Low density

Substance A A basic element of life Conducts electricity in one form Very high melting point (3150 °C)	**Substance B** Used to make bleaching agents Yellow/green gas at 20 °C Melting point –100 °C
Substance C Used in the production of alloys Highly toxic Density (11.34 g/cm^3) is half that of gold	**Substance D** Essential element in our diet Important role in the circulatory system Solid at 20 °C, and ductile
Substance E Key substance in the production of fertilisers and explosives Density of 0.88 g/cm^3 (measured at –200 °C)	**Substance F** Melting point of 1800 °C (similar to cerium, a soft grey metal element) Substance was used once as currency
Substance G A liquid at 20 °C Density similar to curium, a radioactive metal Conducts electricity well	**Substance H** Colourless gas at 20 °C A waste product of respiration

Read, discuss and write: task S6.2

In your group of four decide who will take on each reading objective (one each). The objectives are:

1 Find out what elements are and find some specific uses for metal elements.

2 Find out what elements are and find some specific uses for elements which are non-metals.

3 Find out what compounds are and how they are different from the elements that make them up.

4 Find out what compounds are and how some useful compounds are made.

Read the article and highlight the text that you think is relevant to your objective.

Read and highlight as far as you can until your teacher tells you to stop. You do not need to read everything.

Atoms and elements

What are all substances made from? This has been a question on the minds of scientists for many hundreds of years. As you know, we use models in science to try to picture what it is really like inside all substances. You have used a model of ‘particles’ to try to understand lots of things, but what exactly are those particles?

At the start of the 19th century, John Dalton, an eminent English scientist, thought that the smallest particles were spherical, like pool balls. He called them ‘atoms’ and we use his idea to this day.

There are only about a hundred different types of atom. They are listed in a periodic table of elements.

Molecules and elements

Take an individual red Lego brick; this could represent a single atom. Put two of these blocks together and you have a model of elements like oxygen (O_2) and hydrogen (H_2). These are called elements because they both consist of the same type of atom (2 oxygen atoms or 2 hydrogen atoms). The model we use to represent the element oxygen O_2 can also be called a molecule. This is because molecules consist of two or more atoms chemically bonded together.

If we used this model to represent a metal, then instead of just a few Lego bricks joined together we would have to use millions! So if we were building a Lego model of 1 g of iron, we would need
10 000 000 000 000 000 000 000 (ten thousand billion billion)
of the same coloured bricks!

Solids like metals are joined together in giant structures (molecules). That’s why we can see iron but we cannot see gases – their molecules are just too small. Iron is still classed as an element because it is made up of the same type of atom.

Elements and compounds

Many chemicals do not consist of just one type of atom. A famous and very important example is water (H_2O). In our model it is made up of Lego bricks (‘atoms’) of two different colours. However, because they are different, this chemical is now classed as a compound. This is because compounds consist of two or more different atoms chemically bonded together. H_2O could also be called a molecule. Why?

Read, discuss and write 2 S6.4

Strange but true

There are 26 letters in our alphabet. Just think about all of the different words you can make from this number of letters. Did you know that your body is made up of just 26 of the elements? How many different chemicals are there in a human body?

Think again about Lego bricks. If you had 26 different colours of bricks and you had a hundred of each colour, how many different things could you make out of them? It's difficult to imagine and you need to be good at maths to work it out.

In humans there are 26 different colours of bricks (elements) and millions of each are available to build things out of. This means that the possible number of compounds that are in and make up the human body is phenomenal. You can see why compounds do not appear on a periodic table.

Metals and non-metals

The hundred or so elements listed on the periodic table can be classified into two categories: metals and non-metals. There are a few elements that do not fit precisely into one category or the other but generally these are the two main types.

Useful materials

In our lives, we use many of these different elements every day. We also use the compounds that are formed by combining the elements. Some of the elements occur freely (on their own) in nature. For example, the element oxygen exists on its own. This element is vital to our existence for cellular processes like respiration. If this element did not have such a low melting and boiling point then it would not be a gas at normal temperatures and we would not be alive today.

Other elements are found only in compounds. Examples are the metal element sodium and the non-metal element chlorine. These are very useful elements to have on their own but in nature they tend to form compounds like sodium chloride. This is because the elements on their own are more unstable (reactive) than they would be when joined together.

Sodium chloride ($NaCl$) is another vital compound in life. You probably just call it 'salt' and it is sometimes used in cooking or on food. It is important in your nervous system and industrially it is the raw material for things like bleaches and detergents. It is difficult to separate the compound into sodium and chlorine but afterwards these elements are very useful for making other substances.

Read, discuss and write 3 S6.5

Saucepans and space shuttles

Hydrogen is a gas with a very low density. It is colourless and odourless and is extremely flammable and potentially explosive. Staying away from this non-metal element seems like a good decision but actually it is a very useful element.

One of the first uses of hydrogen was in airships. This was, of course, because of its low density compared with air. Unfortunately its chemical behaviour was a factor in the terrible Hindenburg disaster. One theory is that a 'spark' of electricity ignited flammable materials on the 'skin' of the airship; the hydrogen then burst into flames. This signalled the end of hydrogen-filled airships. Airships are making a comeback today, but these days they are filled with a different gas (helium).

The explosive property of hydrogen is put to good use in fuel for the rockets which propel space shuttles into orbit.

Aluminium metal (believe it or not) is also a good fuel for space shuttles. When in its powdered form and ignited with pure oxygen it produces a tremendous explosive reaction. These are the solid rocket boosters on space shuttles. So the clouds of white you see on take-off are not water clouds – can you suggest what they are? You can see why astronauts say that waiting for take-off is like sitting on top of a gigantic bomb!

Aluminium is also used in cooking. Some people still call it 'tin foil', but of course it isn't – it is aluminium foil. The metal is a good conductor of heat but have you ever wondered why they make one side shiny and the other one dull? And why doesn't a turkey wrapped in foil blow up when it is in the oven? There's aluminium, there's oxygen, and it's very hot!

Aluminium has been used to make saucepans for two reasons. It is a lower density metal than most so the pans are not heavy, and of course being a metal it conducts heat energy well. Aluminium pans are not used so much nowadays.

Nuclear reactors

Sodium is an odd metal in that it has a low melting point (97 °C compared with iron which has a melting point of 1535 °C). This can be put to good use in nuclear reactors. Sodium is used to transfer heat from the reactor to the steam generators. It is pumped around the nuclear plant in sealed pipes as a liquid. So this uses one property which is common to metals (good heat conductor) and one 'anomaly', sodium's low melting point.

Read, discuss and write 4 S6.6

So I can safely eat sodium and chlorine?!

NO! But you can safely put sodium chloride on your food. Why is this?

The properties of the compound sodium chloride are very different to those of the elements that make it up. You may be worried to note that when salt is taken into your body, it has a tendency to split up again! However, it cannot split into its original sodium and chlorine elements. Instead, sodium ions (charged sodium particles) and chloride ions are produced. Both of these are essential ingredients in the functioning of your nervous system.

True or false? S6.7

First decide whether the statements in each pair are true or false.
Then decide whether the second statement correctly explains the first.

A	Carbon could be classed as a metal.	True	False
B	Carbon (graphite form) conducts electricity.	True	False
A	Water is a compound.	True	False
B	The formula of water is H_2O. It is made up of 3 atoms.	True	False
A	The chemicals CO_2, H_2O and O_2 are all compounds.	True	False
B	Compounds consist of two or more different types of atom.	True	False
A	There are no non-metals that conduct electricity well.	True	False
B	Non-metals are poor conductors of electricity. They act as insulators.	True	False
A	A substance with a high melting point such as 1800 °C is most likely to be a metal.	True	False
B	All metals have high melting points.	True	False
A	The compound NaCl can be a dangerous substance.	True	False
B	Too much salt in the diet can lead to high blood pressure.	True	False
A	Potassium is a metal element and chemically it behaves in a similar way to sodium.	True	False
B	Sodium and potassium are in the same ‘group’ of the periodic table.	True	False
A	The compound potassium chloride is used in household salt to replace some of the sodium chloride.	True	False
B	Sodium is a very reactive metal. On contact with water it releases a lot of heat energy, producing hydrogen and sodium hydroxide as chemical products.	True	False
A	When elements react or combine together, the products they make are always safe.	True	False
B	The properties of compounds are always different from the properties of the elements that combined to make them.	True	False

Loop cards S6.8

Carbon, diamond	*Periodic table*	*Ores*	*Dalton*
The list of all known elements	The name for rocks containing important minerals	The scientist who first used the word 'atom'	A metal element used in nuclear reactors to transfer heat to the steam generators
Sodium	*Water, H_2O*	*Sodium chloride*	*Nitrogen*
A substance that is both a compound and a molecule	A vital compound for life, sometimes used in cooking or on food	An unreactive gas element that is important in manufacturing explosives	The non-metal element that is used in airships today
Helium	*Oxygen, O_2*	*Mercury*	*Hydrogen*
A substance that is both an element and a molecule	A metal element used in thermometers	An explosive and flammable gas	A metal element used as a solid fuel in space shuttle launches
Aluminium	*Element*	*Iron*	*Carbon dioxide*
A substance that contains only one type of atom	An element with a giant atomic structure that is used to make steel	A colourless compound that is a gas, a waste product of respiration	A very hard non-metal element with an extremely high melting point

Lesson 7 What are reactions?

Objectives

Recall the characteristics of reversible and irreversible changes and reactions in general

Recognise that when new products are formed energy transfer takes place

Explore some reactions of acids

Use secondary data to explore reactions producing gases

Vocabulary

indigestion, antacid, neutralisation, reaction, reactant, product, salt, metal, flammable, hydrogen, carbonate, pH, exothermic, reactive, characteristic

Resources

Handouts of S7.1 and S7.2 (cut out beforehand; one set per pair)

Handouts of S7.3–S7.5 (one set per pupil)

Handouts of S7.6 (one per pair)

OHT or handouts of S7.7

Cards from S7.8 and S7.9

A display of practical equipment/demonstration reactions (set up gas testing demonstrations; see DfES/QCA Scheme of Work, Unit 7F ‘Simple chemical reactions’)

By the end of the lesson pupils should be able to

- recall some common reversible or irreversible reactions
- describe some features of chemical reactions
- describe some characteristics of acid–alkali reactions and recall some common examples of such reactions
- describe the value of using gas production as a means of tracking an acid–metal reaction

Homework

Produce a concept map showing links between a couple of chemical reactions and their characteristics. Use handouts S7.1 and S7.2 as a starter.

Introduction 10 minutes

Introduce the lesson objectives.

The first activity is a quick quiz where pairs of pupils sort the statements on the cards (**handout S7.1**) into reversible or irreversible changes. Some are obviously chemical reactions but a significant number of the statements will provoke discussion about whether or not the change is permanent or is easily reversed. Listen to pupils as they make decisions about each statement. After about 8 minutes get pairs into fours to compare groupings and widen the discussion. You will need to go through the accepted answers (only four are not ‘reactions’) but allow time for thoughts from pupils.

Characteristics of reactions 10 minutes

Now ask pupils for ideas on what they are likely to observe when reactions take place. They can scan the strips from the ‘irreversible’ pile in the first activity to find these. Widen the definition of ‘observe’ to mean ‘anything that you could see or measure’ and establish a list on the board.

Give out the ‘Reaction characteristics’ cards (**handout S7.2**). Blanks can be used for other characteristics pupils have identified. Ask pupils to match the reaction characteristics to the reactions they identified in the first activity. Pupils will recognise that some of the reactions have more than one measurable characteristic. It is important to distinguish the making of new products from energy changes. Later this may become a concept map – see the homework task. Encourage pupils to make as many groupings as they possibly can using the available statements.

Reactions of acids 20 minutes

The previous activity shows that we need to know what to measure or look for to follow reactions in a scientific or investigative way. This next activity allows pupils to explore this further by engaging with the reactions of acids in detail. Give each pupil **handouts S7.3–S7.5** and ask them, while they are reading, to highlight whenever an energy transfer takes place. Pupils can read alone or in pairs or in any way you feel will help them understand the passage.

Now give out **handout S7.6** and ask pupils in pairs to consider the statements in the bubbles. Tell them to write down which of the bubbles they agree with by writing ‘I agree with … because …’; this justification is an important feature of the activity. They should consider what they have just read along with any other ideas they may have and to talk through in pairs before making a decision about each bubble. Again circulate and listen to their thoughts.

Discussing results and choosing equipment 10 minutes

Put up **OHT S7.7** (or give it out). Explain that this shows how the production of a gas can be useful in following reactions. The graph shows the results of pupil experiments on two types of limestone rock. The volume of carbon dioxide was plotted over time. Refer to your display of equipment or give pupils some diagrams of apparatus and ask them to describe how the results for this graph could have been taken. Analyse the graph by addressing the questions on the OHT. Pupils could work in threes to allow for more viewpoints in the discussions. Take feedback by taking each question in turn and moving from group to group to get a range of answers. Discuss any misconceptions that are apparent and different methods of taking the results. Make clear reference to the appropriateness of the equipment needed to produce the most reliable results for these experiments.

Plenary — 10 minutes

This is a loop card game (**handout S7.8**). See section 1 (page 24) for more details on using loop cards.

Reversible or irreversible? S7.1

Boiling an egg	Fireworks	The action of acid rain on limestone rocks
Burning fuels like methane in Bunsen burners	Respiration	Launching the space shuttle
Bursting a balloon	Using antacid tablets for indigestion	Putting vinegar on a wasp sting
Eating a ‘Refresher’	Breathing	Taking a photograph
sulphuric acid (clear) + copper oxide (black) ↓ copper sulphate (blue) + water	Rusting nail	Ice melting
Baking a cake	1p and 2p coins losing their shine	Adding vinegar to washing soda (sodium bicarbonate)
The erosion of church gargoyles	Burning a candle	hydrochloric acid + iron (a metal) ↓ iron chloride + hydrogen

Reaction characteristics

S7.2

Light is produced	The temperature changes	A change of state occurs
Sound is produced	A pH change occurs	A colour change occurs
A gas is produced		

Reactions with acids 1 S7.3

Neutralisation reactions

If you have ever had indigestion then you will know how useful neutralisation reactions can be. Indigestion is caused by too much hydrochloric acid in your stomach. This is painful and sometimes having too much acid in your stomach can lead to ulcers. Normally this does not happen because your stomach produces a protective mucus to prevent the acid from getting to the cells of your stomach wall. The pain from indigestion can be treated quickly by using an indigestion (antacid) tablet. ‘Antacid’ is another word for alkali. In other words you take a tablet containing an alkali to neutralise the excess acid in your stomach. Acids and alkalis are chemical opposites; they ‘cancel each other out’. However, you definitely do not want your stomach to become completely neutral. So tablets contain enough alkali to neutralise excess acid in the stomach.

Acids and alkalis

The pH scale is used to show how acidic or alkaline a substance is. This scale ranges from 1 to 14. Strong acids have a pH of 1; strong alkalis have a pH of 14. Both strong acids and alkalis are corrosive and dangerous chemicals.

Sodium hydroxide and potassium hydroxide are strong alkalis.

Hydrochloric, sulphuric and nitric acids are strong acids. Hydrochloric acid is produced by your stomach.

Substances like vinegar are weak acids. Ascorbic acid (vitamin C) is found in fruits. The acid gives oranges and lemons their sharp taste. Fizzy drinks too are weak acids.

Acid rain and fizzy drinks are connected. They are both acidic because they are solutions with carbon dioxide dissolved in them. When carbon dioxide dissolves in water it produces carbonic acid. It gets into rain water because there is carbon dioxide in the atmosphere. It therefore gets into the ‘water cycle’.

If you mix together the right amounts of acid and alkali, they will react completely to produce a neutral solution. Neutral solutions have a pH value of 7.

Reactions with acids 2 S7.4

Salts

If you have ever been stung by a bee you may have put bicarbonate of soda on it to ease the pain. This is because bee stings are acid and the bicarbonate of soda is a weak alkali. When this neutralisation reaction happens, an acid reacts with an alkali to produce a 'salt' and water.

The acid and alkali are known as the **reactants**. Reactants are what you start with before a reaction occurs. The salt and water are known as the **products**. These are the new substances produced by the reaction. Products can only be chemical materials.

Sometimes reactions emit light (for example, when you burn methane gas in a Bunsen burner). The light transfers part of the energy that is released by many reactions. Another part of the energy released in burning reactions is, of course, heat energy.

Acid–alkali neutralisation reactions can be summarised as follows:

acid + alkali → salt + water

Examples

hydrochloric acid	+	sodium hydroxide	→	sodium chloride	+	water
sulphuric acid	+	calcium hydroxide	→	calcium sulphate	+	water

The name of the salt depends on which acid and which alkali are in the neutralisation reaction.

Reactions with acids 3 S7.5

Using carbonates to neutralise acids

Antacid tablets can be used to neutralise any excess acid in your stomach. These antacid indigestion tablets contain chemicals known as carbonates. One of the main ingredients of antacid tablets is calcium carbonate. The tablets contain only a small amount of the carbonate for two reasons. The first is that you do not want to neutralise all of the acid in your stomach, and the second is that a gas is produced. If you swallowed too much calcium carbonate you would burp for hours!

Acid–carbonate neutralisation reactions can be summarised like this:

acid	**+**	**carbonate**	→	**salt**	**+**	**water**	**+**	**carbon dioxide**

This type of neutralisation reaction is very similar to the first (acid + alkali). The only difference is that a gas (carbon dioxide) is produced.

Examples

hydrochloric acid	+	calcium carbonate	→	calcium chloride	+	water	+	carbon dioxide
nitric acid	+	copper carbonate	→	copper nitrate	+	water	+	carbon dioxide

Acids with metals

Not all metals react with acids, but when they do these reactions also produce a salt. This time, however, the reaction does not produce water (so it is not a neutralisation reaction); it produces hydrogen gas instead. The reactions are exothermic so they produce heat energy as well. Great care must be taken with these reactions because hydrogen is an extremely flammable and explosive gas. Some reactive metals react very quickly with acid and produce hydrogen and heat very rapidly and could explode.

So reactions between many metals and acids go like this:

acid	**+**	**metal**	→	**salt**	**+**	**hydrogen**

Example

sulphuric acid	+	magnesium	→	magnesium sulphate	+	hydrogen

Thought bubbles

1

I would use toothpaste. Toothpaste is a mild alkali because it neutralises acid produced by plaque on your teeth.

If I ever get stung by a bee, I would use sodium hydroxide on it. It would neutralise the acid faster.

2

To make the salt sodium chloride I would react a metal with an acid. I would use sodium metal and hydrochloric acid. This would work.

I would use a neutralisation reaction. I would use hydrochloric acid and sodium hydroxide.

3

If I got indigestion, I would crush up some calcium carbonate and swallow it! This would neutralise acid faster.

But if you chew an indigestion tablet that's the same.

4

The pH in your stomach is very low. This is because of the hydrochloric acid produced when you get indigestion. It's important to neutralise this acid.

The pH of hydrochloric acid is 1. So that would be the same in your stomach. The acid helps to digest food.

Hang on a minute. Our teacher showed us an experiment with a lump of steak in a beaker of hydrochloric acid last week. The meat is still there now!

5

When I did a neutralisation reaction I found that it was exothermic. I proved this by showing that the temperature increased.

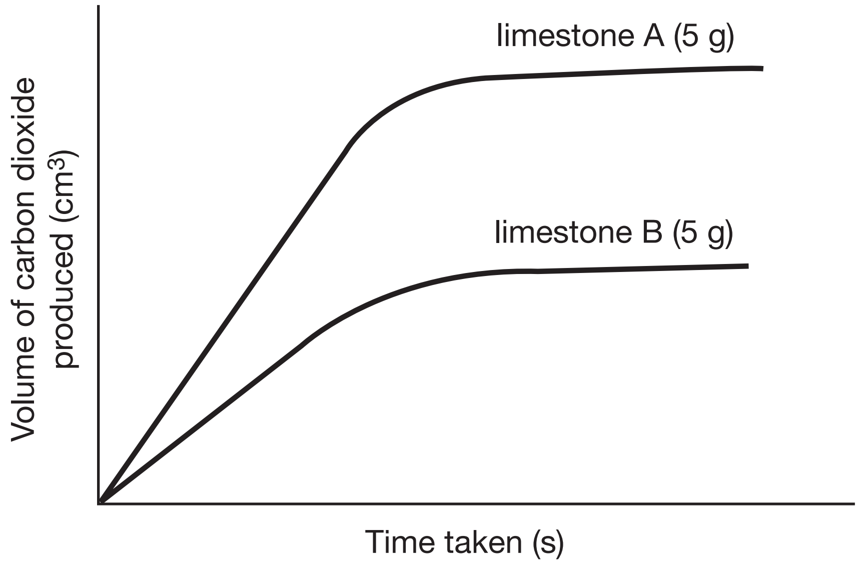
My neutralisation reaction got hot. The reactants were nitric acid and potassium hydroxide. The products were the salt potassium nitrate, water and heat energy.

6

When all metals are placed into acids, they react to produce a salt and hydrogen gas. You can show this by collecting the gas produced and doing the 'squeaky pop' test.

I did an experiment with hydrochloric acid and three metals. When I added magnesium, bubbles were produced very quickly. When I used iron, the bubbles were produced slower. I did not see any bubbles when I used copper.

Choosing equipment and discussing results S7.7



The graph shows the reaction between two types of limestone rock and hydrochloric acid.

- What equipment would you choose to collect results for these experiments?
- From the graph, what can you deduce about 'fair testing'? How would you ensure that this was a fair-test investigation?
- Where does the carbon dioxide come from?
- Why is no more carbon dioxide produced after a while?
- Suggest why limestone B did not produce as much carbon dioxide.
- A third experiment was carried out using limestone A with sulphuric acid (another strong acid). The reaction was over much sooner than that with hydrochloric acid. Why?

Loop cards 1 S7.8

Cloudy or milky	*A lighted splint produces a squeaky pop*	*They are both corrosive*	*In fire extinguishers*
The test for hydrogen gas	One way strong acids and strong alkalis are similar	A use for carbon dioxide gas	A cake rising is a good example of what?
A gas being produced during cooking reactions	*Very reactive metals*	*An acid and carbonate*	*A syringe*
Lithium, sodium and potassium are what?	What two chemicals can react to produce a salt, water and carbon dioxide?	Apparatus used to measure the amount of gas produced in a reaction	What pH is sodium hydroxide?
14	*Salt and water*	*Magnesium*	*A physical change*
Finish the reaction: acid+alkali produces what?	Which metal was used in flash photography?	Melting is an example of what?	Reactions that give out heat energy are called what?

Loop cards 2

Exothermic reactions	*Salt*	*Greater than 7*	*They both produce gases*
Another name for sodium chloride	An alkaline solution has a pH that is …	Acid–carbonate and acid–metal reactions are similar because …	What do acids react with to produce hydrogen gas?
Many metals	*Less than 7*	*A fair test*	*The salt produced covers the limestone surface and stops the reaction*
An acidic solution has a pH that is …	Changing one variable while keeping everything else the same is an example of …	Sulphuric acid soon stops reacting with limestone because …	Bubbling carbon dioxide into limewater makes it go …

Lesson 8 Electric circuits

Objectives

Draw and make simple series and parallel circuits.

Describe and explain how increasing the number of bulbs decreases the brightness in a series circuit and allows a parallel circuit to stay the same

Make and explain predictions

Vocabulary

circuit, series, parallel, component, bulb, cell, battery, switch, current, voltage, resistance

Resources

Green and red cards (one each per pupil)

OHT/poster of S8.1 (word list)

OHTs of S8.2–S8.6

Handouts of S8.7

Whiteboards

By the end of the lesson pupils should be able to:

- identify series and parallel circuits including from circuit diagrams
- draw simple circuit diagrams of circuits that work
- predict and describe the brightness of bulbs in some simple series and parallel circuits

Homework

Jane's mum has just bought some new Christmas tree lights and has told her that although they were expensive, they are much better than their old lights. This is because this year they will not have to spend hours searching for the bulb that has blown. Explain using a circuit diagram how the new lights are different.

Introduction — 10 minutes

Introduce the lesson objectives and what pupils should learn by the end of the lesson. A quick mental warm-up will identify prior knowledge and misconceptions. Show each diagram on **OHTs S8.2–S8.6** and ask the pupils 'Will the circuit work?' Pupils reply using the coloured cards (green 'yes', red 'no'). After each one, say whether the drawing shows a circuit that will work. You may wish to repeat any that a substantial number of pupils answered incorrectly to reinforce correct answers. (This would be a good time to highlight the important words, perhaps using **OHT/poster S8.1**).

Designing circuits — 25 minutes

Ask pupils to work in groups of four. Explain the task (**handout S8.7**):

1. Draw a circuit diagram that contains two bulbs, a six-volt power pack and a closed switch. In the first circuit diagram put the bulbs in series and in the second put them in parallel.
2. Build the electrical circuits to see if they work.
3. If a circuit does not work, draw a corrected version in the section provided on the handout. (They should not try out these redesigned circuits.)

Groups that complete the main activity can try the extension task described on the handout. During the review of the activity, focus on the circuits that the pupils have redesigned. Encourage them to explain why their first design didn't work and why the new circuit would; this promotes greater understanding and consolidates ideas.

Whole-class demonstration — 20 minutes

Demonstrate the following circuits, where appropriate both in series and in parallel, using first an 8 V power supply and then a 10 V power supply:

- a power supply, two bulbs and a buzzer;
- a power supply, one bulb and a buzzer;
- a power supply and a buzzer.

Ask pupils to predict the outcome (brightness/loudness) of each circuit before starting, and to review their predictions before the final two demonstrations. Choose a couple of pupils to explain how they decided on their prediction and, if appropriate, why they changed it.

At this stage include the term 'current' with an appropriate explanation (current carries energy) and possible demonstration. Encourage pupils to explain their answers in terms of current variation.

Use a quick question-and-answer session to encourage pupils to use prior knowledge to explain why increasing the number of bulbs in a series circuit causes the bulbs to get dimmer but increasing the number of bulbs in a parallel circuit allows each to shine equally bright.

Plenary — 5 minutes

Read out an explanation (see overleaf) and ask pupils to identify the relevant word or phrase. As an extension, show electrical component symbols and ask pupils to work out what the component is.

Words and explanations for plenary

Explanation	Word or phrase
A device that converts electrical energy into light	Bulb
Used to increase resistance in a circuit	Resistor
A circuit where the electricity has to flow through all the components	Series circuit
Used to stop the flow of electricity in a circuit	Switch
The push of an electrical supply	Voltage
A substance that does not let electricity pass through it	Insulator
Converts electrical energy to movement energy	Motor
Device that produces electrical energy from a chemical reaction	Battery
A term for the amount of electricity in any part of a circuit	Current

battery

bulb

cell

circuit

component

current

parallel

resistance

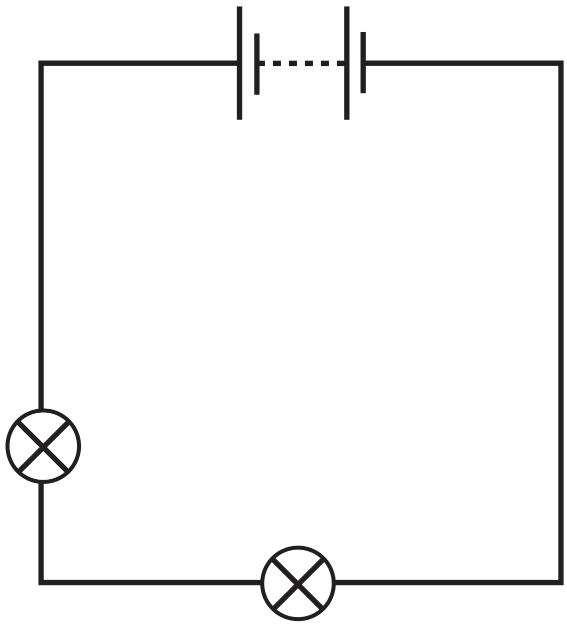
series

switch

voltage

Will it work?

1



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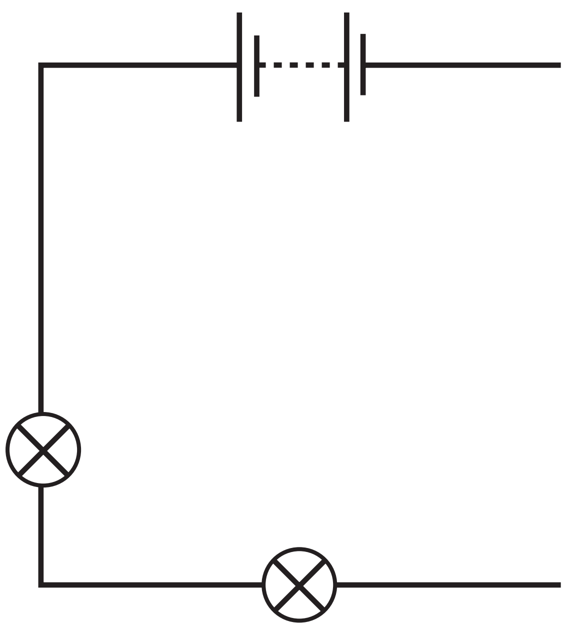

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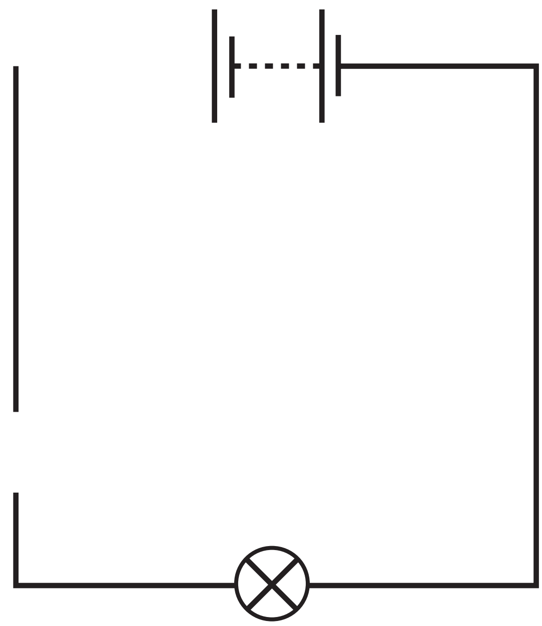

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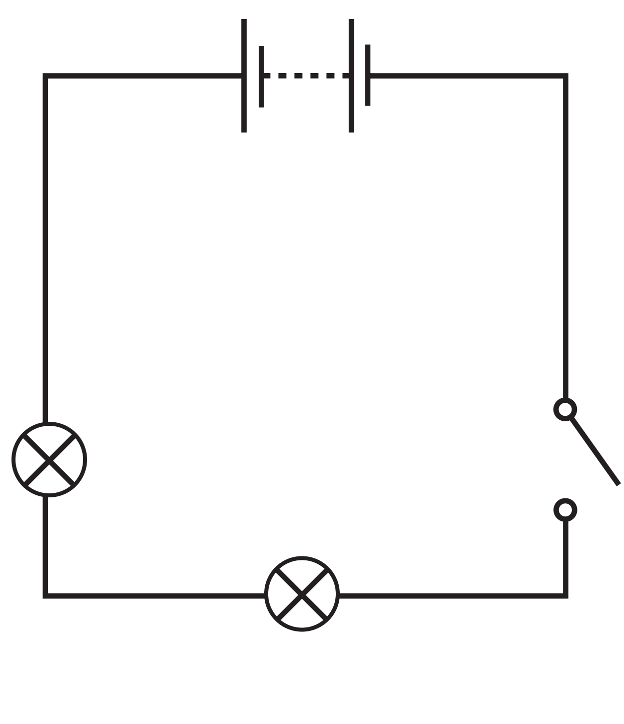

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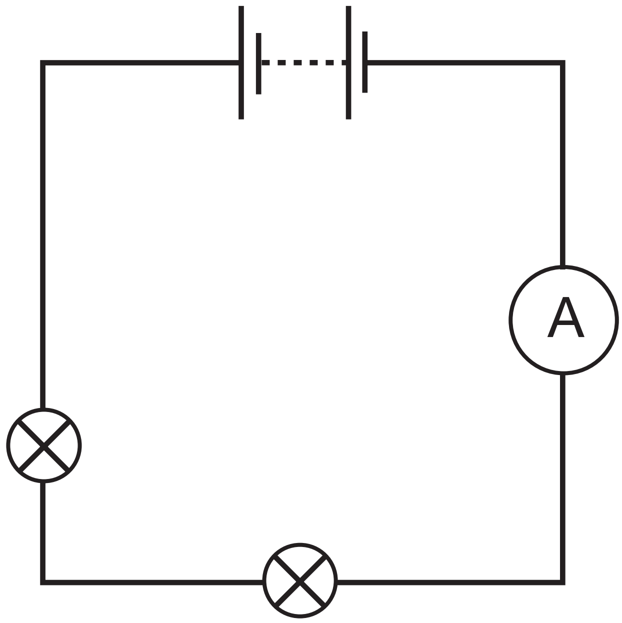

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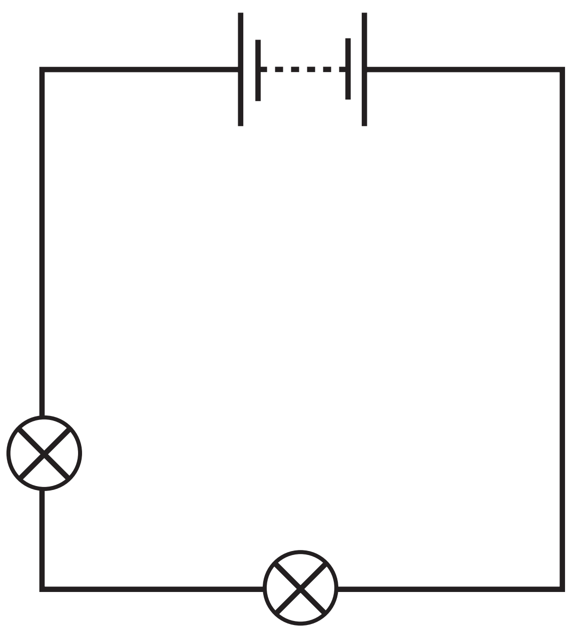

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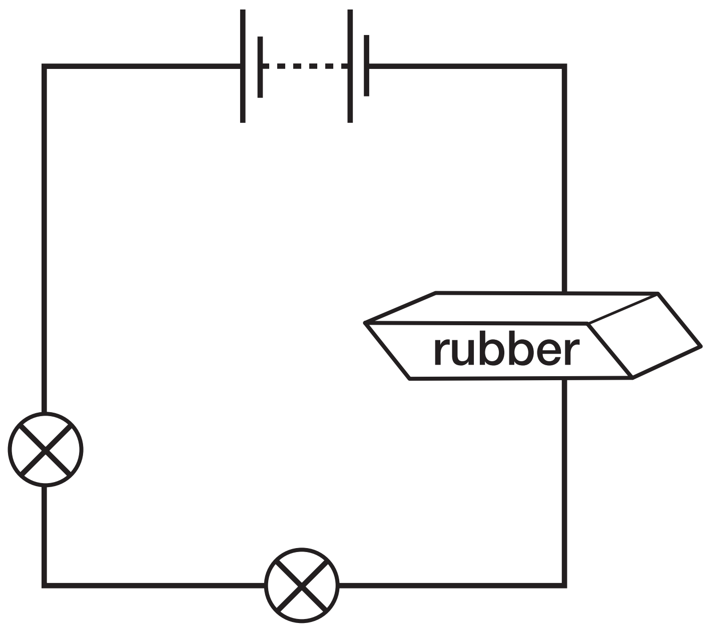

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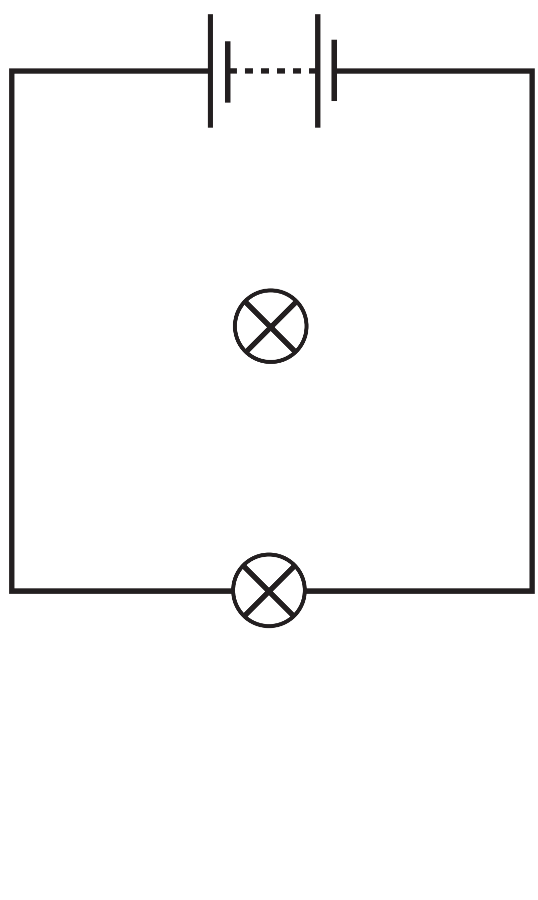

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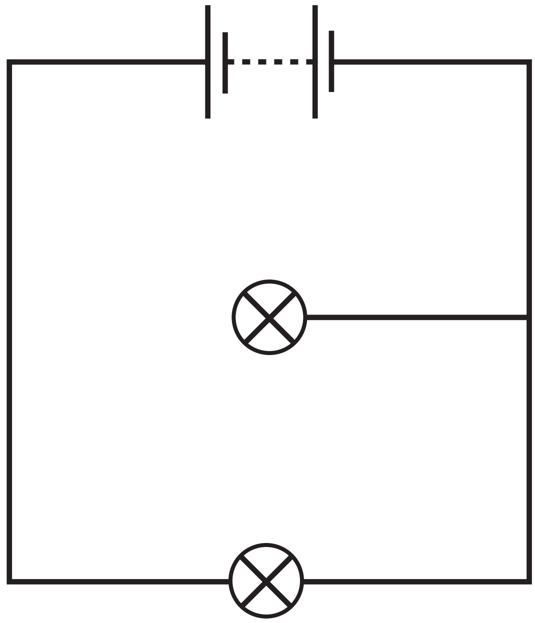

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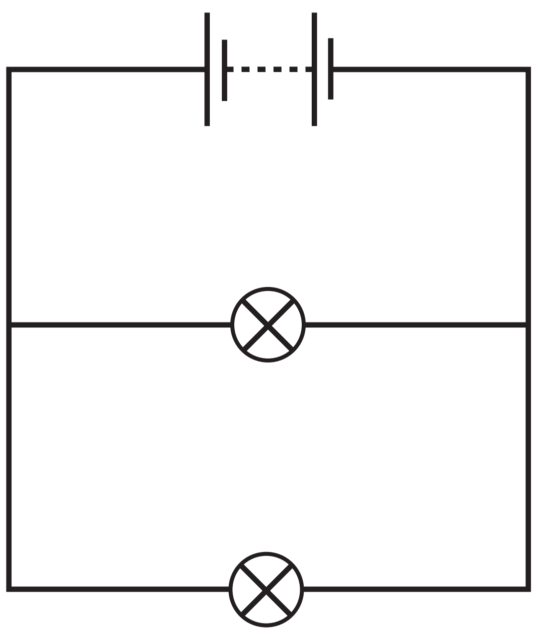


Designing circuits S8.7

Task 1 Using circuit symbols, design a series circuit that has two bulbs. Construct the circuit. Does it work? If the circuit did not work, discuss why it didn't. Use your discussion to redesign the circuit.	**Task 2** Using circuit symbols, design a parallel circuit that has two bulbs. Construct the circuit. Does it work? If the circuit did not work, discuss why it didn't. Use your discussion to redesign the circuit.

Extension

Design a parallel circuit that contains a 6 V power supply, three bulbs and a switch that turns only two of the bulbs on or off.

Try to explain how the differences in brightness of the bulbs is brought about by changes in energy in different parts of the circuit.

Lesson 9 Reflection of light

Objectives

Know that light travels from a source in straight lines

Interpret and annotate light ray diagrams using arrows to show reflection and the path of reflected light rays

Draw accurate ray diagrams using standard symbols and notation to show the path of light

Recall that a light ray at 90° to the surface of a plane mirror will be reflected back along its original path and is referred to as the normal

Vocabulary

light ray, reflection, normal, reflected ray, plane mirror

Resources

OHT/poster of S9.1 (word list)

Handouts of S9.2 (cut up beforehand; one set between two pupils)

OHT/handouts of S9.3 and S9.5

Handouts of S9.4

Sharp pencils and rulers

Projector

Light boxes

Power-packs

Plane mirrors

Light brainstorm 10 minutes

Brainstorm vocabulary, key ideas, diagrams, etc. related to previous work on light. Give pupils one minute to write down on their own three ideas/words, then a further two minutes to compare ideas with a partner.

Take one suggestion at a time, asking weaker pairs first. Summarise ideas as a spider diagram on the board or an OHT. Discuss with the class where each additional point should go and why. (Any references to the eye should only be in the context of how we see; no structural details are required.)

Pupils could take down a copy of the completed spider diagram if you wish. Note poor/inconsistent spellings and any misconceptions that pupils convey during this session. Address these throughout.

Finally highlight the aspects of the spider diagram that relate to mirrors and reflection, for example, by circling or underlining these items in the same colour. Tell pupils this is the focus for today's work and that they will now complete a series of activities that will check their understanding and, where necessary, provide them with a chance to recap. Make the lesson objectives explicit including the appropriate vocabulary.

Light definitions 5–10 minutes

Give out the cards on **handout S9.2**. Pupils work in pairs to match the definitions with the key words/phrases.

Discuss the correct answers with the group as a whole, encouraging pupils to challenge each other's incorrect responses.

Predicting the behaviour of light rays 20 minutes

Demonstrate the equipment needed for this activity, and rehearse the terms 'plane mirror', 'light box' and 'light ray'. Ask these questions:

1 What effect will the mirror have on a ray of light travelling towards it from the light box?

2 What would happen to the ray of light if the mirror were not placed in its path?

Insist on pupils explaining their answers, as far as possible in full sentences using scientific language. In 1 you are looking for the idea of the light ray being reflected back off the shiny surface of the mirror. Answers to 2 should identify that the light ray will continue to travel in a straight line. Confirm by demonstrating that when a light ray is shone at a mirror it is reflected. Draw attention to the fact that the reflected light ray leaves the mirror from the same point as the incoming light ray hit it.

Refer to **OHT/handout S9.3**. Discuss the standard symbol used to represent a plane mirror, emphasising which is the back and the front. Point to the lines labelled 1 to 5. Establish that they are light rays travelling towards the mirror. Ask pupils how they can show that these pre-drawn lines are rays of light travelling towards the mirror. Introduce/remind pupils of the use of arrows to show direction. Annotate the lines on the OHT with arrows, saying as you do it: 'I am drawing arrows pointing towards the mirror because that is the direction the light rays are travelling in.' Ask pupils to predict the position of the reflected ray for each of these rays.

Give groups two or three minutes to sketch their predictions on their sheets. They will need to number the rays to match the original rays.

By the end of the lesson pupils should be able to:

- describe how we can see using the idea of light travelling in straight lines and reflecting off surfaces
- accurately predict where reflected light rays will appear when using plane mirrors
- use rulers and sharp pencils to draw accurate ray diagrams which include use of the symbol for a plane mirror and arrows to show direction of travel

Homework

Draw ray diagrams to show how:

- a car driver a night can see a child wearing a reflector tag;
- you can see a shooting star;
- you can see ice-cream dripping.

Pupils now carry out the practical activity. Ask different groups to start with a different ray number followed by ray 1 so that you can keep the time for the activity down to about five minutes.

Use **OHT S9.3** to discuss the results for each ray. Identify ray 1 as special because the light is reflected back along its original path and introduce the word 'normal' to describe this special situation.

Ask how arrows can be used to identify the reflected ray. Add arrows, again verbalising out loud as before.

Finally ask pupils to look at the way rays 2, 3, 4, 5 appear and suggest what patterns can they see. You are looking for pupils to note that:

- each reflected ray lies on the opposite side of the normal from the ray travelling towards the mirror;
- the space/gap between the ray travelling towards the mirror and the normal is the same as the space/gap between the reflected ray and the normal.

Use **handout S9.4** to summarise the results.

Plenary 15 minutes

Refer pupils to incomplete light ray diagrams on **handout S9.5**. Model an example for the class on **OHT S9.5**. Emphasise the need for a ruler and make explicit: how accurate the drawing of rays should be; how the light ray travelling towards the object/surface should meet and touch the object/surface and how the reflected ray should leave the surface of the object/surface from the same point. Allow pupils 5 minutes to complete. Then ask individuals to demonstrate their answers using **OHT S9.5**.

Use a pre-drawn OHT to highlight common errors when drawing ray diagrams:

- light rays that do not touch the surface;
- light rays that are drawn into the object/surface;
- light rays that are drawn freehand;
- reflected light rays that do not leave the surface from the same point as the incoming ray.

light ray

reflection

normal

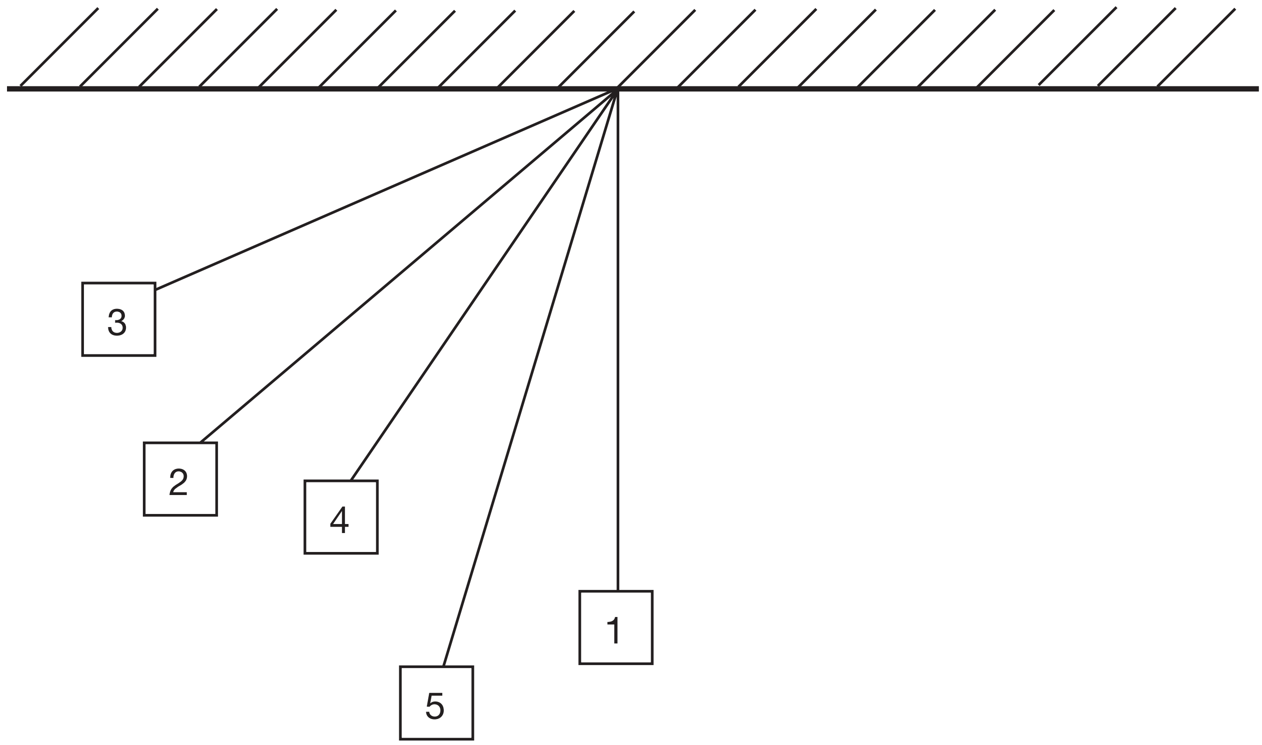
reflected ray

plane mirror

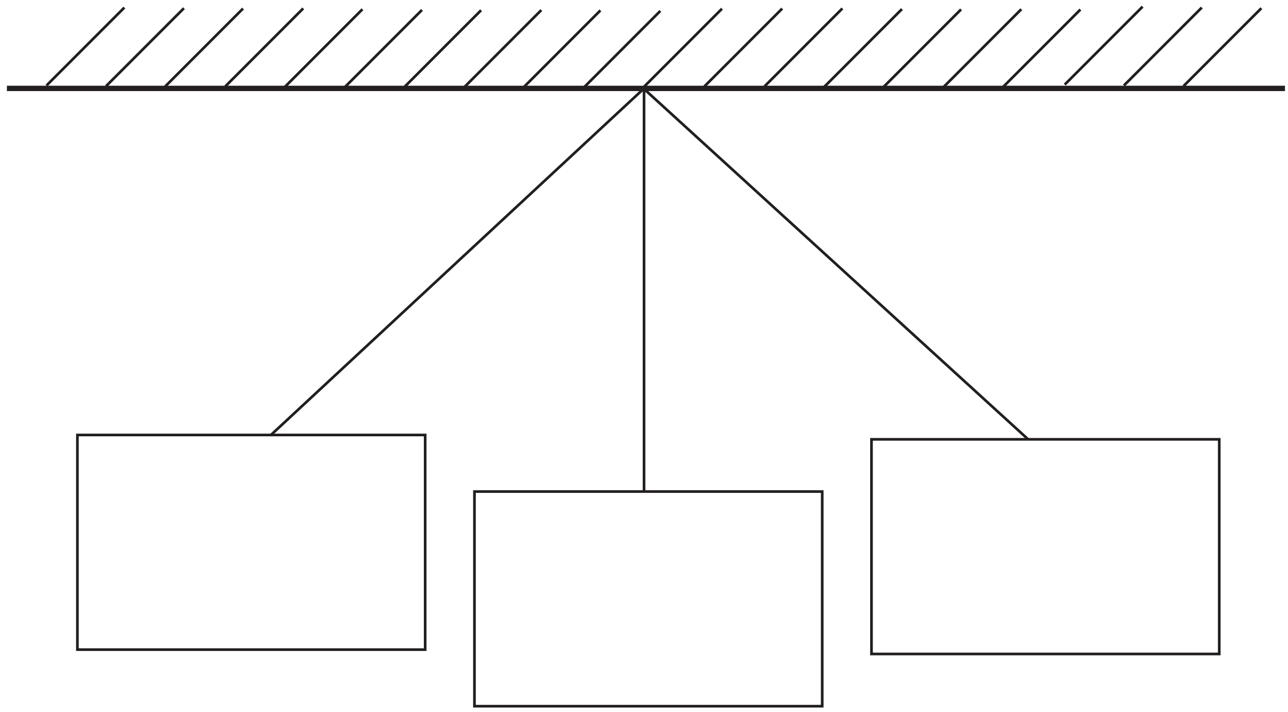
Light definitions S9.2

Reflection	When rays of light are bounced away from a shiny surface
Ray diagram	A drawing to show the path of rays of light from a source
Ray of light	Represents the path of the light travelling from a source, in a straight line
Shadow	Formed when rays of light are blocked by an object
Plane mirror	A flat mirror that reflects light
Darkness	The absence of light
Normal	A line drawn at right angles to a surface, for example, a plane mirror

Predicting the behaviour of light rays S9.3



The behaviour of light rays: summary S9.4



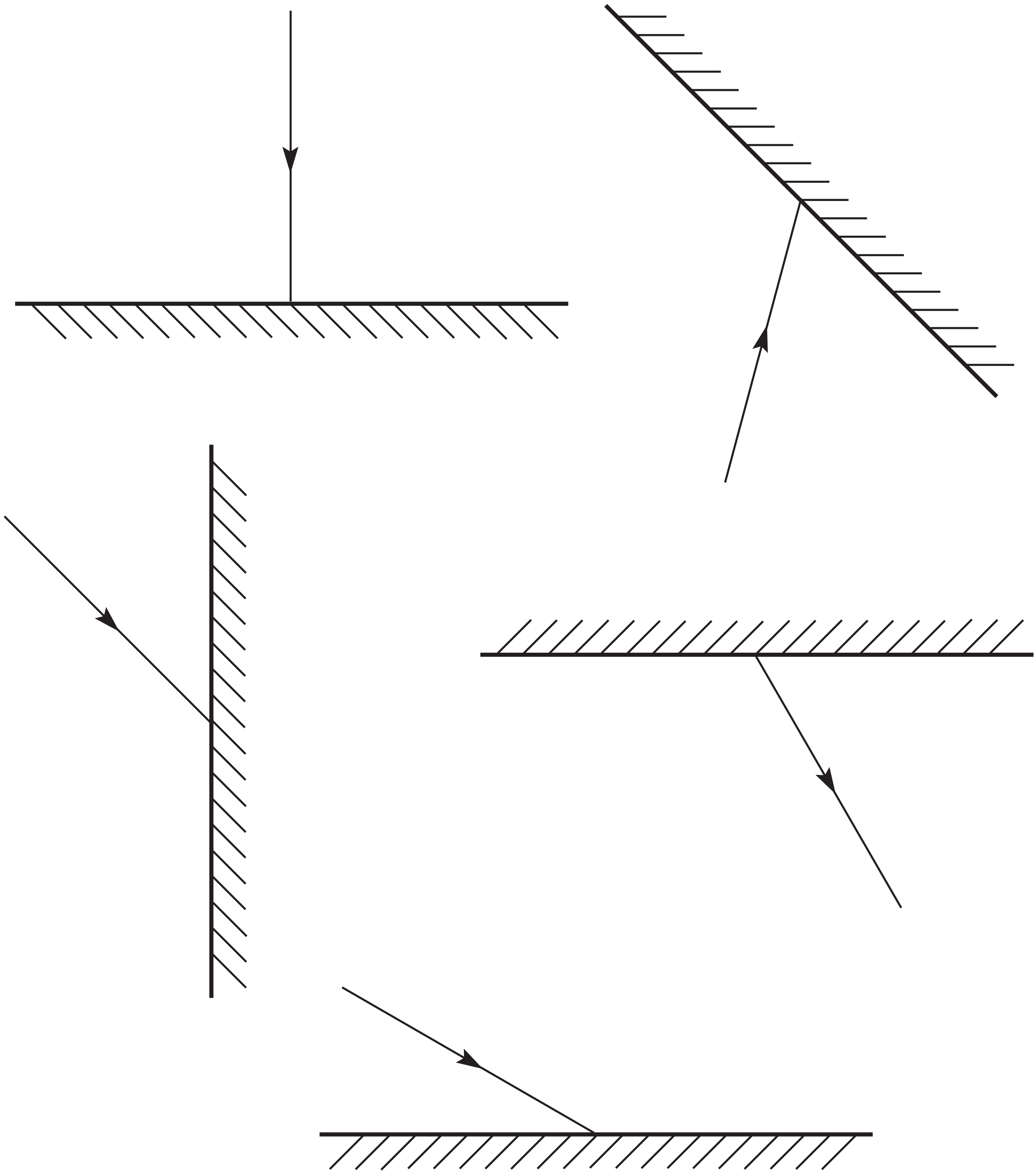
Draw a red arrow on the light ray travelling towards the mirror.
Draw a green arrow on the light ray that is reflected by the mirror.

Choose from this list a word or phrase to complete the empty boxes:
normal, mirror, reflected ray, ray travelling towards the mirror

Light rays

S9.5

Complete the light rays on these diagrams.
Use a ruler and a sharp pencil.



Lesson 10 Magnetic fields and electromagnets

Objectives

Identify the factors that affect the strength of an electromagnet

Describe a model of the field lines around an electromagnet and explain that they indicate the strength of a magnet

State that magnets both attract and repel

Draw conclusions from patterns in evidence

Make predictions based on scientific knowledge and understanding

Vocabulary

north pole, north-seeking pole, south pole, south-seeking pole, magnetic field, magnetic field lines, core, solenoid

Resources

OHT/poster of S10.1 (word list)

Handouts of S10.2 and S10.3

Two magnets as described, and a compass or map per working group (for warm-up)

Circus of electromagnets (see main activities)

By the end of the lesson pupils should be able to:

- recall the main properties of magnets and use them to solve a simple magnet problem
- describe how they investigated the strength of the field round a magnet, what factors affect it, and what a solenoid is
- describe the field lines around a magnet and explain that they indicate its strength

Homework

Identify two items that use a permanent magnet and explain why a permanent magnet was used in preference to an electromagnet.

Mental warm-up — 20 minutes

Introduce the lesson objectives and key words (**OHT/poster S10.1**).

Identify prior knowledge and misconceptions using the following mental warm-up activity. Pupils should work in pairs or small groups, each with the following equipment:

- a bar magnet (magnet A) hanging in a paper stirrup from a wooden table or retort stand – align it as close as possible north–south and leave it to hang until it stops swinging;
- another bar magnet (magnet B) and a local map or a compass.

Set the groups the following task:

> Using the map or compass and the bar magnets A and B, find a way of identifying the north and south poles of magnet B. (Point out that a bar magnet is a permanent magnet and if necessary give brief explanation.) Make some quick sketch notes on how you worked.

In the plenary, ask pupils to display their strategies on the board or wall. Ask a group to explain briefly their strategy. If groups have not managed to find a solution, use the emerging strategies as an aid, then use targeted open questions to enable the class to find a solution as a whole. Stress the use of the key words, and invite the class to identify misconceptions, missing information, etc.

What affects the strength of an electromagnet? — 15 minutes

Pupils gather data from a circus of experiments and use their observations to answer the question on **handout S10.2**. Set up a circus of electromagnets (e.g. solenoids with different numbers of coils; solenoids with same number of coils but different voltages; solenoids with same number of coils and voltage but different cores). Pupils, working in pairs, test the strength of each electromagnet by measuring the closeness of a plotting compass to the electromagnet at the point of deflection. They record their results on the handout and use them to answer the question.

As an extension, ask pupils to plot the magnetic field of a weak and strong magnet using plotting compasses and compare the difference to draw conclusions.

What is a magnetic field? — 10 minutes

Use a solenoid on the overhead projector, covered with a piece of Perspex, to demonstrate the magnetic field lines around a solenoid. Show pupils several examples using different voltages then ask: ‘How does changing the voltage affect the field lines?’

Ask the pupils who completed the extension task: ‘Are there any similarities between the field lines around a solenoid and a bar magnet?’

Use further questions to elicit pupils’ ideas about how the pattern of the magnetic field lines can be used to show different strengths of magnets.

Plenary 15 minutes

Ask pupils in pairs to develop a concept map on magnetism (**handout S10.3**). If there is time, ask each pair to join with another to compare their maps, particularly to identify omissions or incorrect linkages.

Pay close attention to what each group puts so that you can challenge misconceptions that persist, and ask groups to explain aspects of their concept maps.

See the notes on pages 22–23 of section 1 for more information about concept maps.

core

magnetic field

magnetic field lines

north pole

north-seeking pole

solenoid

south pole

south-seeking pole

What affects the strength of an electromagnet? S10.2

Work station	Number of coils	Voltage	What the core is made of	Distance of plotting compass to electromagnet before deflection

Use your results to identify the factors that affect the strength of an electromagnet.

Magnetism: concept map S10.3

Draw a concept map using these words. Try to add other connections and words if you can.

Main theme: magnetism

Connect with: bar magnet, north pole, south pole, core, solenoid, magnetic field, current, voltage, uses of bar magnets, uses of electromagnets

Lesson 11 Sound

Objectives

Know that sound is transferred by vibrating particles

Link particle arrangements in solids, liquids and gases to speed of sound travelling through different materials

Explain using particle ideas why sound cannot pass through a vacuum

Vocabulary

vacuum, vibration, medium, frequency, pitch, echo, particles

Resources

OHT/poster of S11.1 (word list)

OHT/handouts of S11.2

Handouts of S11.3 (cut up beforehand; one set per pair)

Handouts of S11.4 (optional; for homework)

Two different tuning forks per group for warm-up activity

G-clamps

Suspended ping-pong balls

Cork bases, or rubber or felt mats

Beakers of water

CRO and microphone

Electric bell, bell-jar and vacuum pump

Note

Tuning forks should not be banged on the desk, nor should they come into contact with the teeth, because teeth have been known to shatter

By the end of the lesson pupils should be able to:

- describe, using particle ideas, how sound is able to travel through air, water and wood

How sound is generated 15–20 minutes

Introduce the seven activities:

1. Listen to the pitch of two different tuning forks.
2. Vibrating tuning forks are placed in a bowl of water. The water splashes out demonstrating that sound is produced by a vibration.
3. Hold a tuning fork in mid-air and observe its vibrating prongs.
4. Sound a tuning fork and bring towards a suspended ping-pong ball to show sound vibrations (use this to demonstrate different frequencies).
5. Place vibrating forks on a bench to show that the sound gets louder but the pitch stays the same.
6. Vibrating forks are placed on a cork or rubber mat. The sound can now hardly be heard.
7. Vibrating tuning forks are held near a microphone attached to a CRO to show vibration patterns (use also to show amplitude).

You can demonstrate the activities but involve the class by inviting pupils to help carry out each activity and through asking individuals to record class comments and observations on the board and/or an OHT. Alternatively pupils can carry out the activities as a circus or give a specific activity to a pair of pupils and ask them to give a report to the class.

Emphasise that the pupils need to make observations and use the key words where appropriate.

Recording and explaining results 10 minutes

Summarise on the OHT or board the class responses. Encourage use of full sentences and appropriate vocabulary, including that identified above, whenever possible. Ensure there are comments relating to the behaviour of the air particles and particles in the solids and water. Each pupil records this on **handout S11.2** and highlights the key vocabulary.

Use the following questions when discussing particular activities.

- Activity 2: Can you explain how it happens using particle ideas?
- Activity 3: What is happening to the air particles surrounding the fork?
- Activity 4 (the ball jumps away from the prongs): What is happening to the air particles? How was the ping-pong ball forced to move without the fork actually touching it?
- Activity 5 (the sound gets louder but the note stays the same): What is vibrating when the tuning fork is hand-held, and when it is placed on the bench?

Development/reinforcement 15 minutes

Demonstrate the bell, bell-jar and vacuum. Introduce the term ‘vacuum’ to describe the space that is left behind in the bell-jar when all the air in it has been removed.

Model what is happening by asking five pupils to stand up in front of the class side by side and remain still. Tell the class that these pupils each represent an air molecule. First of all use a pencil case (for example) and give it to the first person in the row. Ask how the case could reach the person at the end of the row. Now get each person in turn to take the case and pass it along to the end of the row. Explain that sound is transferred in a similar way in that the air molecules pass it along from one to the other but through vibrating. Ask the first person to model an air molecule vibrating by moving their elbows outwards and inwards at a regular rate and tell them to do 10 vibrations but then stop. As they touch the next person get that person to do the same action 10 times then stop – and so on until the last person in the row is vibrating. Emphasise that the sound does not cause the air particles to move position, only to vibrate. Now remove the middle three pupils. Describe the gap left by them as an empty space and ask the first pupil to begin vibrating again. What is pupil 5 unable to do and why?

Plenary 10 minutes

Give a set of cards from **handout S11.3** to each pair of pupils who try to match the definitions to the words. Encourage pupils to discuss answers with another pair.

Homework

Complete **handout S11.4** (the word list on the top right can be omitted for more able pupils).

Rank the following materials in order of how fast sound travels through them, starting with the slowest: water, copper, ice, air, wood, cork. Explain your order using your knowledge of particle arrangements in solids, liquids and gases.

amplitude

eardrum

echo

frequency

noise

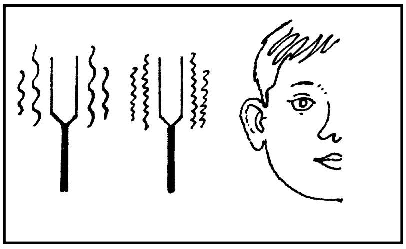
pitch

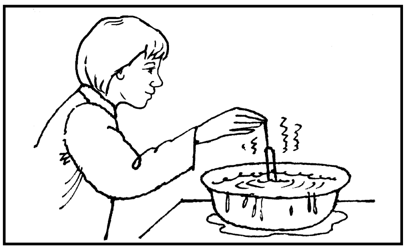
vacuum

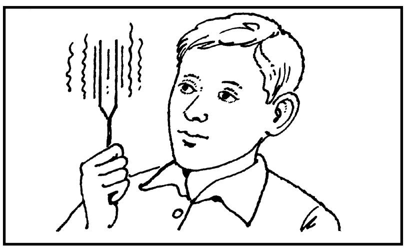
vibration

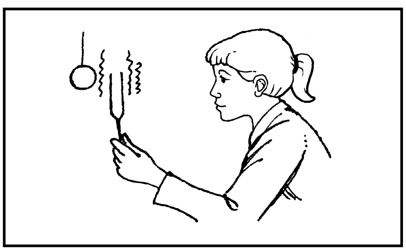
How sound is generated

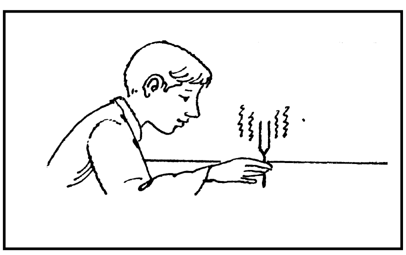
S11.2

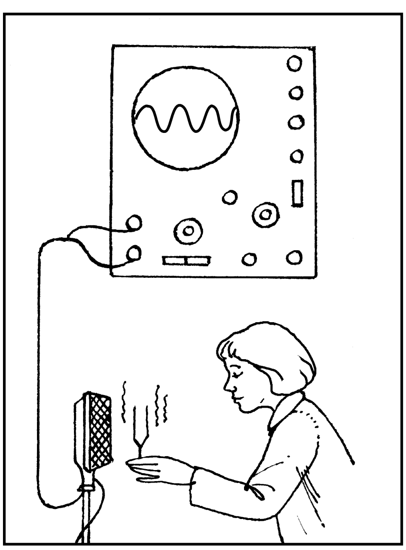












Sound definitions S11.3

Frequency of sound	This is the number of sound waves produced each second.
Echo	This is made when sound is reflected.
Eardrum	Tightly stretched piece of skin inside the ear that vibrates when sound waves hit it.
Ear	Organ of hearing and balance.
Amplitude	The loudness of a sound.
Vibration	Movement backwards and forwards in a fixed position (e.g. rocking backwards and forwards on the edge of your seat).
Pitch	This is used to describe how high or how low a sound is.
Medium	Material or substance that sound can travel through, for example wood, air, water.
Vacuum	A space that contains ABSOLUTELY NOTHING! Sound cannot travel through it.

Sound bites: word search S11.4

Find 9 words to do with sound.

c	o	g	d	x	b	p	v	o	n
n	f	a	i	h	o	a	i	m	l
e	g	d	z	a	c	d	b	e	a
p	x	e	i	u	k	q	r	c	z
g	a	b	u	n	a	m	a	h	h
e	f	m	b	k	f	g	t	o	c
a	i	k	p	b	j	u	i	r	t
r	h	z	x	l	y	t	o	s	i
d	w	f	e	s	i	o	n	v	p
r	d	c	d	o	a	t	s	k	y
u	l	t	r	a	s	o	u	n	d
m	a	b	f	e	g	a	z	d	x
y	c	n	e	u	q	e	r	f	e

frequency
eardrum
noise
vibrations
vacuum
ultrasound
amplitude
echo
pitch

Now use the words to complete the sentences below.

1 A tuning fork produces sound by ____________________ .

2 When a sound is reflected off a surface you can hear an __________________.

3 __________________ is high frequency sound which bats use for direction finding.

4 The ______________ describes how high or how low a note is.

5 The louder the sound, the bigger its ____________________.

6 Sound cannot travel through a ____________________.

7 The __________________ is part of the ear.

8 Loud __________________ can damage your hearing permanently.

9 A high pitch sound has a high ________________________.

Lesson 12 Balanced and unbalanced forces, and speed

Objectives

Review knowledge and understanding of balanced and unbalanced forces

Identify the direction and magnitude of forces

Calculate speed from distance and time

Make suggestions for an investigation

Vocabulary

air resistance, friction, balanced/unbalanced forces, acceleration, constant speed

Resources

OHT/poster of S12.1 (word list)

OHT/handouts of S12.2

Handouts of S12.3 (one per group)

Materials and tools (wire cutter, compasses or small drill) to make dragsters

Bat, tennis ball and squash ball

Safety note

The pupils will need close supervision while cutting the wire coat hanger.

By the end of the lesson pupils should be able to:

- describe examples of balanced and unbalanced forces
- explain that forces act in a direction and can vary in size
- explain that friction slows down moving objects
- calculate simple examples of speed

Homework

Ask pupils to draw a distance–time graph for their journey home from school.

Warm-up 15 minutes

Introduce the lesson objectives. Use a mental warm-up to identify prior knowledge and misconceptions. Show pupils **OHT S12.2** and ask them ‘Is Jo right?’ Encourage pupils to give extended answers, making full use of the technical vocabulary. Challenge pupils to correct any misconceptions that their peers may have. Use open questions during this starter. Focused questions should only be used to promote further discussion.

Dragster challenge 35 minutes

Tell the pupils that they are going to construct a dragster, test it and explain the forces which make it move and slow down. Instructions for making the dragster are on **handout S12.3**. Pupils should work in small groups and use the following (or any similar materials you have to hand):

- a washing-up bottle and a wire coat hanger;
- four cotton reels, or card, wood or similar modelling wheels;
- spacers made from short lengths of rubber or plastic tubing;
- Blu-Tack or sticky tape.

The aim is to produce the fastest dragster over a distance of 2 metres.

Ask the pupils to identify the variables that need to be controlled and measured. Use the identified variables to help pupils to state that the speed is given by the distance divided by time. Finding the speed of the dragster could be done by:

- timing how long the dragster takes to complete a measured distance;
- using light gates (difficult if the dragster doesn’t run in a straight line).

During testing, a spokesperson should describe the forces used to make the dragster move it and those which slow it down. Use questions to identify when forces are balanced or unbalanced.

Extension: Ask pupils to evaluate their own or each other’s dragster in terms of the size of the frictional forces and the design.

Plenary 10 minutes

Gently(!) demonstrate a bat (any sort) hitting a tennis ball into the air. Ask the pupils to draw a simple sketch of the forces on the ball just after it has been hit by the bat. Remind them that arrows can illustrate the direction and magnitude of a force. Tell them to compare sketches with a partner. Once agreement has been reached ask them to draw the forces on the ball just after it bounces up off the ground.

Now show a squash ball alongside the tennis ball and explain that it ‘seems easier to hit the squash ball harder’. Ask them to work in pairs and think about the forces involved and (a) whether the statement is true, (b) how they could find out.

Possible suggestions may be that the squash ball is smaller/smoother/lighter, or the tennis ball is heavier/rougher/larger.

Encourage pupils to make suggestions. It is more important that they explore their ideas than that you give them the correct answer.

Balanced and unbalanced forces: word list S12.1

acceleration

air resistance

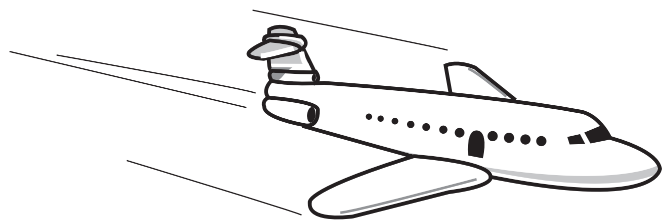
balanced forces

constant speed

friction

unbalanced forces

Forces and their effects   S12.2



The parachutist drops safely to the earth because the upward force is greatest.

The upward force is greater than the force of gravity.

The forces acting on the parachutist are balanced.

The parachute is more aerodynamic than the plane.

Before the parachutist opens the parachute, the only forces acting on her are gravity and friction.

Is Jo right?

Making a model dragster S12.3

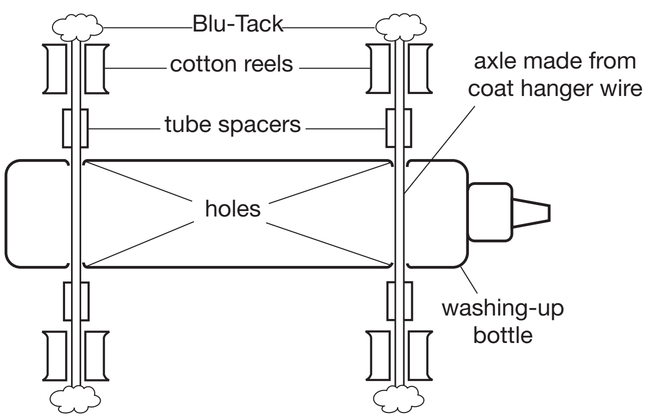
Use a wire cutter to cut off the hook of a wire coat hanger. Throw the hook away. Straighten the remaining wire and cut it into two equal pieces.

Use compasses to make four holes in the washing-up bottle. Make sure that corresponding holes are parallel.

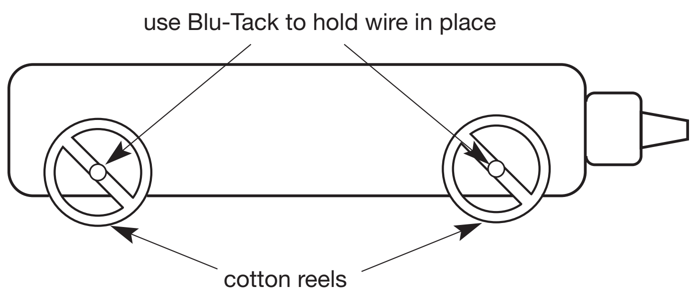
Push the wire through the holes as in the diagram below.

Use four short lengths of rubber or plastic tube as spacers to keep the wheels away from the sides of the bottle. Then place a cotton reel on each end of the wires and secure using Blu-Tack or sticky tape.

Cross-section (from above)



Side view



Use an inclined plane or an elastic band between two chair/stool legs to make the dragster move. If you use the elastic band method, the dragster will need to be weighted down – cut a small hole in the washing-up bottle and insert some 100 g masses.