Exploring Science: How Science Works – Technician's checklist (Year 8)

Unit/topic	Task number	Description	Resources	Health and safety	Practical selected?
8Aa	Exploring 3	**Simple food tests** Remind pupils that many scientists are employed to check what is in foods to make sure that their labels are accurate and consumers can trust what they are buying. The scientists use the same sorts of tests for fat, protein and starch (a carbohydrate) that are given in the Pupil's Book and on Worksheets 8Aa(2), 8Aa(3) and 8Aa(5). The blue–black colour produced by the iodine test shows up better in powdered food samples that have been mixed with an equal volume of water. Other, non-powdered foods can easily be tested by adding 'iodine solution' directly to the food. The test for fat is very simple, if a bit messy. A food sample is rubbed into a piece of paper. Filter paper tends to work best. A greasy mark, visible when the paper is held up to the light, indicates the presence of fat. The Biuret test for protein involves using either pre-made 'Biuret solution' or sodium hydroxide and copper sulphate solutions. The Pupil's Book indicates the former approach, since it is easier for pupils to do. Both approaches are indicated on Worksheet 8Aa(4). For both tests, the food sample has to be in water. A spatula of powdered food can simply be shaken with about 2 cm depth of water in the test tube. However, the tests work better if foods are mashed with 2–3 cm3 of water using a	**Resources (per group)** **Starch Test:** Iodine solution (1 g iodine in 100 cm3 1.0 mol dm–3 potassium iodide solution); spotting tile; test tube(s); stopper(s); food sample(s); pipette, water; eye protection; Worksheet 8Aa(2). **Fat Test:** Food sample(s); filter paper; Worksheet 8Aa(3). **Protein Test:** Food sample(s); test tube(s); pestle and mortar; Biuret solution (obtainable from an educational supplier or made) or dilute sodium hydroxide solution (0.2 mol dm–3) (labelled irritant) and copper sulphate solution (0.1 mol dm–3); eye protection; Worksheet 8Aa(5).	Iodine solution stains skin and may irritate the eyes. Wear eye protection. Biuret solution and sodium hydroxide are irritants. Wear eye protection. Pupils should not eat the foods tested.	

		pestle and mortar first. A positive result is indicated by a purple colour, which may take a couple of minutes to appear. Before starting the practicals, show pupils the apparatus they will be using and ask them how they will use the apparatus in a safe way. • **Must:** use worksheet 8Aa(4) to help them present their results. Do not do the protein test. • **Should:** do tests for starch, fats and proteins and use Worksheet 8Aa(7).			
8Aa	Exploring 4	**More food tests** Food standards scientists also test for sugars. Worksheet 8Aa(6) provides further food tests for two sugars (glucose and sucrose). This is a bit of a simplification since other sugars will also be detected. The tests are not the same due to the different molecular structures of the sugars (glucose is termed a reducing sugar and sucrose is a non-reducing sugar). It is suggested that only the test for glucose is performed by pupils. The sucrose test is best done as a teacher demonstration. Note that glucose is not found in normal packet sugar (which is pure sucrose).	**Resources (per group)** Bunsen burner; heatproof mat; boiling tube; Benedict's solution; tripod; gauze; pipette; food sample(s); pestle and mortar; eye protection; Worksheets 8Aa(6), 8Aa(7). **Resources (for demonstration)** Additionally for the sucrose test: dilute hydrochloric acid (0.5 mol dm–3) and sodium hydrogen carbonate solution (1 mol dm–3).	Boiling water hazard. Wear eye protection.	
8Aa	Exploring 5	**Testing for water** Water is an important component of the diet and some pupils may be interested in finding out which foods contain a lot of water. Food standards scientists also test the water content of foods, since some foods can have water pumped into them to make them look more appetising. Place anhydrous (blue) cobalt chloride paper on a food sample. It will turn pink in the presence of water. Obviously, food	**Resources (per group)** Anhydrous cobalt chloride paper; forceps; food samples.	Cobalt chloride paper should be directly handled as little as possible. Hands should be washed if direct contact is made with the skin.	

		scientists use more complicated tests but this experiment provides another example of how components in food can be tested.			
8Aa	Exploring 6	Pupils examine fibre under a microscope. This is easily done with boiled celery or well soaked All-Bran®. Iodine stains the fibrous tissue (but point out to pupils that it does not change colour – we are not testing for starch). Pupils could be encouraged to work out what fibre is made from, using their knowledge from Unit 7A about plant cell structure. Use Skills Sheets SS44 and SS45 from Year 7 CHAP.	**Resources (per group)** Microscope; boiled celery or 2-hour soaked All-Bran® in water; iodine solution (1 g iodine in 100 cm3 1.0 mol dm–3 potassium iodide solution); cavity slides; coverslips; eye protection; forceps; Year 7 CHAP Skills Sheets SS44 and SS45.	Iodine solution stains the skin and may irritate the eyes.	
8Ac	Exploring 2	**A model small intestine** Visking tubing will let small, soluble sugar molecules through it, but not large starch molecules. This practical will demonstrate that starch molecules are too big to pass through the tiny holes in the wall of the tubing. Worksheet 8Ac(2) contains the instructions. This model is built upon and extended in Topic 8Ad, where enzymes are used (see Topic 8Ad *Exploring 2*). The tubing should be soaked in water for about 15 minutes to make it easier to handle. A 15 cm length is cut and one end is tied. 5 cm3 of starch suspension is added. The top end of the tubing is tied and the outside of the tube is washed to remove any spilled starch solution. The tubing is secured inside a boiling tube with an elastic band and the boiling tube filled with water (preferably warm, at about 37 °C). The boiling tube is left for 20 minutes (preferably in a water bath at about 37 °C). The water from the boiling tube surrounding the tubing can then be tested for starch using iodine	**Resources (per group)** Visking tubing; beaker; boiling tube; elastic band; eye protection; iodine solution (1 g iodine in 100 cm3 1.0 mol dm–3 potassium iodide solution); 3 pipettes; starch suspension; syringe; well tray or spotting tile; access to warm water bath (37 °C); access to clean warm water (37 °C); Worksheet 8Ac(2).	Iodine solution stains skin and may irritate the eyes.	

		solution (a blue–black colour denotes the presence of starch). It should be found that no starch has diffused through the tubing.			
8Ac	Explaining 3	**Peristalsis (demonstration)** Explain that the movement of food along the gut is caused by waves of muscle contractions – known as peristalsis. This is simply demonstrated using a bicycle inner tube and a stone of slightly greater diameter. Soak the inner tube in water containing washing up liquid. Without rinsing the tube, insert the stone. Use your thumb and forefinger to form a 'circle of muscle' around the tube above the stone. By moving your forefinger along the thumb, the diameter of the inner tube can be made to get smaller, pushing the stone down the tube. Pupils could be asked to say what the inner tube, thumb and forefinger and stone represent in this model. The demonstration can also be done with a sock and a tennis ball.	**Resources (for demonstration)** Bicycle inner tube; washing up liquid solution; stone of similar diameter to the tube (or tennis ball and large sock). Optional: sheep lungs and oesophagus.	Lungs from sheep with the gullet (oesophagus) still attached may be available from a butcher, or it may be possible to order a length of oesophagus separately. These could be used in conjunction with the demonstration.	
8Ac	Explaining 4	**Absorption (demonstration)** • **Must:** A model, such as dried peas and sand in a sieve, can be used to think about the way in which smaller molecules will pass through the small intestine wall whereas larger ones will not. • **Should:** Many pupils will be familiar with the idea of soluble things being able to pass through filter paper, whereas insoluble things can not. This is basically true for substances getting into the body. A quick demonstration might include mixing some starch with water and filtering it, and comparing this with sugar solution. If you have used a number of the models suggested above (e.g. *Exploring 2*, *Explaining 1*), ask pupils to describe the	**Resources (for demonstration)** Must: coarse sieve; fine sand; dried peas. Should: filter paper; filter funnel; retort stand; beaker; sugar; starch; water.		

		strengths and weaknesses of each model. • **Could:** Show pupils the sieve model and the filtering model and remind them of the other models they have seen. Ask pupils to select the model that best represents what happens in the gut. They should justify their selection.			
8Ad	Exploring 2	**A model small intestine 2** This is a continuation from *Exploring 2* in Topic 8Ac. The set-up is the same, except that enzymes are added to the starch suspension. This is 1 cm3 of 0.5% pancreatin (a mixture of enzymes that will convert starch to small sugar molecules – the pupils can be told that it is the same as the mixture of enzymes found in the small intestine). The water from the boiling tube surrounding the tubing can then be tested for starch and glucose. It should be found that glucose has diffused through the tubing whereas the starch has not. If you do this as a teacher demonstration, the subtle addition of 1 cm3 of 5% glucose solution to the water is an effective cheat! Full instructions are given on Worksheet 8Ad(4).	**Resources (per group)** Beaker; Benedict's solution; boiling tube; Bunsen burner; digestive juice solution (0.5% pancreatin); 2 elastic bands; eye protection; gauze; heatproof mat; iodine solution (1 g iodine in 100 cm3 1.0 mol dm–3 potassium iodide solution); 4 pipettes; 1% starch suspension; tripod; 2 syringes; 2 test tubes; 15 cm Visking tubing (pre-soaked for 15 minutes in water); water bath (set to 37 °C); Worksheet 8Ad(4).	Eye protection should be worn. Iodine solution stains skin. Some pupils may be allergic to enzymes. When using the enzyme solutions avoid skin contact (and the rubbing of eyes). Wash hands at once if contact is made.	
8Ad	Exploring 3	**Amylase action** This practical can be used to carry out an AT1 Investigation. A set of level descriptions is provided on pages 33–35 of the ASP. The use of either Worksheet 8Ad(2) or 8Ad(3) will prevent the assessment of some strands (notably planning). Three test tubes containing 5 cm3 of 1% starch suspension can be set up, each at different temperatures in water baths. A further three test tubes each containing 1 cm3 of 0.5% pancreatin (or 1% amylase solution but see note in	**Resources (per group)** Iodine solution; 2 test tubes; test tube rack(s); two 5 cm3 syringes; pipette; 0.5% pancreatin solution or 1% amylase solution (making sure that its peak activity is at 37 °C – i.e. not bacterial amylase); 1% starch suspension; pH paper/meter; stopclock; eye protection; access to water baths at various temperatures (one should be near	Eye protection should be worn.	

		resources) are also placed at the same temperatures. The tubes are left for 5 minutes to allow the contents to reach the required temperature and then the pancreatin or amylase is added to the starch suspension. At regular intervals (e.g. every 2–5 minutes) one drop of each of the starch enzyme mixtures is added to one drop of iodine solution in the wells of a spotting tile or well tray. A blue–black colour indicates the presence of starch. When the blue–black colour fails to appear, it is safe to assume that all the starch in that tube has been broken down. The amylase in pancreatin works best at around 37 °C (body temperature). Other factors that affect the activity of amylase include the concentration of the amylase and the pH. For the latter, the starch and amylase should be added to 10 cm3 of buffer solution (see below). Alternatively, addition of dilute hydrochloric acid or sodium hydrogen carbonate solutions to the starch solution (prior to adding amylase) and testing with pH paper/meter will give a reasonable range of pHs to test. Amylase works best at about pH 7. • **Must:** Worksheet 8Ad(2) deals only with the effect of temperature on amylase action. It should be noted that this worksheet assumes bacterial amylase is not being used (it does not have an optimum activity of 37 °C). • **Should:** Worksheet 8Ad(3) is a sheet to help pupils plan the investigation. • **Could:** pupils plan their investigations using only the initiators given in the Practical box on page 16 of the Pupil's Book. Encourage pupils to think about the advantages and disadvantages of collating class results. They	body temperature, 37 °C); thermometers (one for each water bath); access to ice; access to water for washing pipette; access to distilled water and various concentrations of acids and alkalis (e.g. 0.2 mol dm–3 and 0.1 mol dm–3 sodium carbonate, 0.2 mol dm–3 and 0.1 mol dm–3 hydrochloric acid). Worksheets 8Ad(2), 8Ad(3). Citric acid buffer solutions can be found on p46 of the teacher's guide.		

		should think about what needs to be collected and how they would manipulate this secondary class evidence so that all the evidence was in the same format.			
8Ad	Exploring 4	**Sweet bread** This simply involves chewing bread. If bread is chewed for 5–10 minutes, the taste becomes sweeter. Pupils could be asked to chew the bread, describe what happens and try to explain why this happens.	**Resources (per pupil)** Small piece of bread.	Ensure that this practical is not done in a lab and only in an area suitable for consuming food (e.g. dining hall or food technology room).	
8Ad	Explaining 3	**Catalase (demonstration)** Hydrogen peroxide is poisonous in the body but is a by-product of some reactions in the body. Catalase is an enzyme that quickly destroys the hydrogen peroxide. Liver contains large amounts of catalase, which makes for a memorable demonstration of an enzyme in action (albeit not a digestive enzyme). Place a small piece of liver in a large beaker and add a pipette-full of 3% hydrogen peroxide. A fizzing will be observed. Point out to pupils that this fizzing would never occur in the body but does here because the hydrogen peroxide used is very strong.	**Resources (for demonstration)** Fresh liver; 3% hydrogen peroxide solution; large beaker.		
8Ac	Starter 3	**Modelling villi (demonstration)** This is an effective demonstration to get pupils to think about the effects of surface area. Take a length (say 50 cm) of wide fabric and lay it fl at on a worktop. Take another piece of the same fabric that is twice as long. Ask pupils what you would have to do to get the second piece of fabric to take up the same area of worktop as the first piece. Pupils should be able to see that scrumpling it up will have this effect. Now ask	**Resources (for demonstration)** Two lengths of the same fabric, one twice the length of the other.		

		which piece of fabric will be able to soak up more water. Most pupils will see that the second piece will because there's more of it. Explain that this is a model for the small intestine and that it has 'scrumpled up' walls (or more accurately projections) to increase its surface area and therefore increase the amount of digested food it can absorb in any period of time.			
8Ae	Explaining 2	**Starch synthesis (demonstration)** Question 6 on page 19 of the Pupil's Book mentions that some cells can take small molecules of glucose and build them into larger ones (e.g. glycogen). Glycogen is a storage material. Ask pupils what does the actual building, and elicit the idea that enzymes do this too. Plants perform a similar trick, which is how starch is built up from sugars made in photosynthesis. (This practical is also suggested for use in Topic 9Cc.) This practical will demonstrate this but it is only really appropriate as a teacher demonstration. Add 5 cm3 of 1% glucose monophosphate solution to a test tube. Then add 1 cm3 of 0.1% starch phosphorylase. Use a pipette to remove some of the mixture from the tube at 5-minute intervals. Add 5 drops to a spotting tile or well tray and test with 1 drop of iodine solution. After about 15 minutes the iodine solution should turn the sample blue–black, indicating the presence of starch. Starch phosphorylase can be bought commercially or a solution can be made up by grinding a small piece of raw potato with 15 cm3 of distilled water, using a pestle and mortar and	**Resources (for demonstration)** Well tray or spotting tile; 1% glucose monophosphate solution (glucose-1-phosphate disodium salt); iodine solution (1 g iodine in 100 cm3 1.0 mol dm–3 potassium iodide solution); pipette; stopclock; 0.1% starch phosphorylase solution or raw potato; pestle; mortar; sand; fi ltering equipment/centrifuge to make a solution containing starch phosphorylase as detailed above; eye protection.	Wear eye protection. Iodine solution stains skin and may irritate the eyes.	

		some sand. Filter the resulting suspension and test the filtrate with a drop of iodine to ensure that no starch is now present. If starch is still present, filter it again. A more effective way of removing the starch is to centrifuge the suspension for 3 or 4 minutes.			
8Ba	Exploring 3	**Yeast cells and respiration** Instructions are given on Worksheet 8Ba(2). Approximately 3 g of sugar should be added to 20 cm3 of 10% yeast suspension (see below). A sugar cube has a mass of approximately 3 g, so could be used by less able pupils, but this would need to be crushed before adding to the yeast suspension. 'Sugar' is actually made of sucrose and pupils may need to be told that this sugar is quickly broken down into glucose by yeast. If a rise in temperature as well as production of carbon dioxide is to be detected, the suspensions will need to be at room temperature before use. Ensure the thermometers have their bulbs well within the liquid in the tubes. Yeast suspensions will need to be prepared the day before. To produce an active yeast suspension, place 10 g of dried baker's yeast in 200 cm3 of 5% sucrose solution. Mix well and leave for 24 hours in a warm place. To prepare the dead yeast suspension, mix 10 g of dried baker's yeast in 200 cm3 of 5% sucrose solution. Mix well and leave for 1 hour to allow the yeast to fully rehydrate. Then boil the suspension for 5 minutes and allow to cool. Dilute both suspensions with distilled water just before use to obtain 10% solutions. • **Must:** pupils follow the instructions and	**Resources (per group)** 10% live, active yeast suspension (10 g dried baker's yeast added to 200 cm3 10 % sucrose solution and left for 24 hours in a warm place); 10% boiled and cooled yeast suspension; sugar or 2 sugar cubes; 2 boiling tubes; 2 test tubes; 2 bungs fitted with a thermometer and a delivery tube; 2 × 25 cm3 measuring cylinders; test tube rack; limewater; access to balance; marker pen; eye protection; Worksheet 8Ba(2) or 8Ba(3).	Eye protection should be worn when handling limewater.	

		answer the structured questions on Worksheet 8Ba(2). • **Should:** pupils plan the experiment using the guidance given on Worksheet 8Ba(3).			
8Ba	Exploring 4	**Signs of respiration** Pupils are presented with a range of observation activities and Worksheet 8Ba(4) on which to record their observations. **Body temperature** – Pupils measure their body temperatures. Liquid crystal strips are the safest and easiest approach. If clinical thermometers are used, pupils will need to be shown how to read the scale. **Peas** – Take enough dried peas to fill two vacuum fl asks. Soak them for 12–24 hours in water and then boil half of them for 2 minutes (to kill them) and allow to cool completely. Wash all the peas in 1% Virkon (to kill any micro-organisms growing on them) and fill one vacuum fl ask with living peas and the other with dead peas. Insert a thermometer or temperature probe (connected to a datalogger) deep into the peas in each flask and seal the tops with cotton wool. Hold each flask upside down in a clamp stand. Record the temperature every 12 hours or start the datalogger. Beakers sealed with cling film could be used instead of flasks and allow the peas to be seen, but using inverted vacuum flasks reduces the loss of heat and gives more reliable results. This demonstration should be set up several days before the lesson to allow the germinating peas time to show an increase in temperature. This should be pointed out to pupils. If sensors and datalogging software are used to monitor the temperature changes in the peas, pupils will	**Resources (per pupil)** Worksheet 8Ba(4). **Resources (per station)** **Body temperature** – liquid crystal strip thermometers or clinical thermometers in disinfectant. **Peas** – 2 vacuum fl asks; prepared living peas (see above for instructions); prepared dead peas (see above for instructions); 2 thermometers or temperature sensors and dataloggers; 2 cotton wool plugs; 2 clamp stands. **Hydrogencarbonate indicator** – rack containing 4 boiling tubes a third full of equilibrated hydrogencarbonate indicator (see above) labelled A to D (tube A contains germinating peas on a piece of gauze above the liquid, tube B contains maggots on a piece of gauze above the liquid, tube C contains a piece of pondweed in the liquid and the tube is enclosed in foil or black paper, tube D contains indicator only); 4 bungs.	Clinical thermometers will need to be disinfected each time they are used. If Milton™ is used as a disinfectant (the preferred method), this takes 30 minutes. Ethanol is quicker (5 minutes) but leaves an unpleasant taste. Rinsing with water is essential. Beware of pupils who shake down the liquid in mercury clinical thermometers too vigorously and break them. Ensure that a mercury spills kit is readily available (if using mercury thermometers, but this is not advised).	

		be able to see how long the experiment has been set up for. Otherwise information about how long the experiment has been set up for should be displayed next to the apparatus. For a diagram giving further information, please see page 61 of the teacher's guide **Hydrogencarbonate indicator** – Set up the apparatus as shown on Worksheet 8Ba(4). Pupils may not have used this indicator before so the colour changes will need to be explained. In a solution that has been equilibrated with the air, by bubbling air through it, hydrogencarbonate indicator looks pink in a test tube (in a bottle it looks cherry-red); if the pH is lowered due to an increase in carbon dioxide it turns yellow; if the pH is increased by reducing the amount of carbon dioxide dissolved it turns purple. Rinse out test tubes, etc., with the indicator; residues can effect the indicator. An information chart next to the apparatus would be useful. Once again, the timescale for the colour changes could form the basis of a discussion relating to the rate of respiration in different organisms. Avoid exhaling over the tubes as exhaled carbon dioxide will affect the indicator. Information about how long the experiment has been set up for should be displayed next to the apparatus. Note that there is an animation of this experiment on the **AT** (see *Explaining 2*). Care of living things should be discussed (i.e. what happens to the maggots after the experiment).			
8Ba	Explaining 3	**Yeast cells and respiration (demonstration)**	**Resources (for demonstration)**	Eye protection should	

		The method in *Exploring 3* could be used as a demonstration. Alternatively, if you do not need to show a temperature rise as evidence of respiration, the production of carbon dioxide by live yeast can easily be demonstrated within a lesson. The yeast suspensions will need to be prepared the day before. To produce an active yeast suspension, place 10 g of dried baker's yeast in 200 cm3 of 5% sucrose solution. Mix well and leave for 24 hours in a warm place. To prepare the dead yeast suspension, mix 10 g of dried baker's yeast in 200 cm3 of 5% sucrose solution. Mix well and leave for 1 hour to allow the yeast to fully rehydrate. Then boil the suspension for 5 minutes and allow to cool. Dilute both suspensions with distilled water just before use to obtain 10% solutions. Place 15 cm3 of the 10% solutions of boiled and live yeast suspensions in two small fl asks. Place in a water bath at 37 °C with two tubes containing 25 cm3 of 10% sucrose or glucose solution. This will help the reaction to begin quickly, and if all solutions are at 37 °C no air will be forced out due to expansion, which could cause confusion. Pour the sugar solution into the yeast suspension and insert a bung with a delivery tube into the top. Keep the fl asks in the water bath. The other end of each delivery tube should be placed in a test tube of limewater outside the water bath. Bubbles of gas will be seen coming from the fl ask containing live yeast within a couple of minutes. Within 10 minutes the limewater will have turned cloudy. • **Could:** show pupils the first part of the	Water bath at 37 °C containing 2 tubes of 25 cm3 of 10% sucrose or glucose solution; a small fl ask containing 15 cm3 of 10% live yeast suspension (10 g dried baker's yeast added to 200 cm3 10% sucrose solution and left for 24 hours in a warm place); a small flask containing 15 cm3 of 10% boiled yeast suspension; 2 bungs with delivery tubes; 2 tubes of limewater. The flasks will need to be clamped upright.	be worn when handling limewater.	

		demonstration (before adding the sugar to the yeast). Then ask them to identify the scientific question that is being asked and what scientific knowledge they would need to plan this practical.			
8Ba	Explaining 4	**Burning (demonstration)** Show pupils these experiments, which all demonstrate that burning is similar to respiration, but happens in a much less controlled way. Ignite some sugar on a deflagrating spoon and put into a gas jar of oxygen to show the release of heat and light. Water vapour is also usually seen on the inside of the gas jar. Gently heat a piece of Mars® bar in a boiling tube with a delivery tube leading into a tube of limewater to show that carbon dioxide is produced. Make a tin can bomb as shown in the diagram. The can will need a tight-fitting lid. A sustained rather than a quick puff of air is needed to disperse the powder into a cloud inside the can. When the dust explodes the lid is blown off, dramatically demonstrating that energy is released when something burns. For a diagram giving further information, please see page 63 of the teacher's guide	**Resources (for demonstration)** Gas jars of oxygen sealed with greased lids; deflagrating spoon; granulated sugar; small piece of Mars® bar; clamped boiling tube; boiling tube bung fitted with delivery tube; test tube of limewater in a rack; tin can with lid; icing sugar; candle; thick-walled capillary tubing; long length of rubber tubing and stopper; eye protection; safety screen.	The Mars® bar must be heated gently to prevent the bung being forced out of the tube. Eye protection should be worn when handling limewater. A safety screen and eye protection must be used for the 'bomb' and pupils should be 2–3 metres away.	
8Bb	Exploring 1	**Measuring pulses** Ask pupils to find and measure their pulses. Many pupils will have done this at KS2. The easiest places to measure it are in the wrist, at the elbow and in the neck – placing two fingers in the places shown. The fingers should be pressed gently on an artery where it runs next to	**Resources (per group/pupil)** Stopclock or stopwatch. Optional: book the school hall.	Ensure exercise is in a safe area and is safe for pupils, e.g. asthmatics, who should be encouraged to use their inhalers before	

		either a bone or firm tissue. The thumb should not be used to feel a pulse as it has its own pulse. See if pupils can find their pulses in each position. The wrist is usually easy and a pulse is quite easy to find just under the ear. The elbow can be a bit more tricky. Another place is just to he right of the trachea, right under the chin. Once pupils have found their pulses get them to measure them. This can either be done by counting the number of beats in 1 minute or by counting the number in 15 seconds and multiplying by 4. Ask pupils to comment on these two different ways and see if they can spot the possible errors that may occur in each. Then ask pupils to predict what would happen to their pulse rates if they did some exercise. If time/space permits, they can try this out doing star jumps or similar and see if their predictions are correct. Where space is limited, pupils can vertically raise a fixed mass, e.g. 1 kg, held in the hand, through a specified distance, e.g. I metre, and repeat a specified number of times. In this way, the amount of exercise is similar for all pupils. For a diagram giving further information, please see page 65 of the teacher's guide		exercise. Any equipment used must be robust and securely anchored. Any pupils excused from PE on medical grounds should be excluded (sensitively) from taking exercise. This can be done by pairing pupils up so that one exercises and the other takes readings. Ensure, with careful supervision, that exercise does not become competitive.	
8Bb	Exploring 2	**Back to resting (AT)** Point out that fitter people generally have pulse rates that are faster at returning to resting level. You can support this by using the **AT** video link on page 25 which opens *Pulse rates* – in which Anne Wafula-Strike explains why measuring pulse rates is important for athletes. Ask pupils to find their pulses and measure their	**Resources (per group/pupil)** Stopclock or stopwatch. Optional: book the school hall.	Ensure exercise is in a safe area and is safe for pupils, e.g. asthmatics, who should be encouraged to use their inhalers before exercise. Any pupils	

		pulse rates. This can either be done by counting the number of beats in 1 minute or by counting the number in 15 seconds and multiplying by 4. Pupils measure their pulse rates at rest and after 2 minutes of exercise. They then measure them every 2 minutes until it is back to resting. Line graphs should then be drawn of the data. • **Must:** pupils use Worksheet 8Bb(3). • **Should:** pupils plan and carry out this practical without help. Encourage pupils to think about how the practical can be done safely. Encourage them to think about what sort of graph or chart is best to display the data. A spreadsheet could be used to help with data plotting.		excused from PE on medical grounds should be excluded (sensitively) from taking exercise. This can be done by pairing pupils up so that one exercises and the other takes readings. Ensure, with careful supervision, that exercise does not become competitive.	
8Bb	Exploring 3	**Cardiac output (AB)** Pupils measure their pulse rates at rest, their heights and masses and use this information to calculate their cardiac outputs and stroke volumes. Full instructions are given on Worksheet 8Bb(4). • **Should:** the **AB** spreadsheet link on page 25 opens *Calculating cardiac output* – a spreadsheet that can be used by pupils to do the various calculations automatically.	**Resources (per group/pupil)** Stopclock or stopwatch; bathroom scales; ruler; tape measure; Worksheet 8Bb(4).		
8Bb	Exploring 4	**Stethoscopes** Heartbeats can be heard easily using a stethoscope. Point out to pupils that the 'lub-dub' sounds that they can hear are actually caused by the closing of the heart valves. • **Must:** ask pupils to listen to each other's hearts with stethoscopes. They could measure one another's heartbeat rates. • **Should:** extend this practical by asking pupils to compare a rolled up newspaper with a real	**Resources (per group)** Optional: stethoscope; rolled up newspaper; library/internet access; Worksheet 8Ld(5).		

		stethoscope. Explain that the original stethoscope was in fact rolled up paper – invented by René-Thóphile-Hyacinthe Laennec (1781–1826) in France in 1816. See also Worksheet 8Ld(5). • **Could:** ask pupils to look at a picture of the heart (e.g. the one on page 24 of the Pupil's Book) and to predict which valves are shutting to cause the 'lub' and which ones shut to cause the 'dub'. Once they've made their predictions (with explanations) they should use the internet or other secondary sources to check their answers.			
8Bb	Explaining 2	**Heart dissection (demonstration)** Show pupils how to dissect a heart. Identify the external blood vessels before cutting the heart. Point out that the atria are very small and that the left ventricle is much bigger than the right ventricle because it has to pump blood around the body. Inside, the valves and tendons can easily be seen. Hearts can be obtained from a butcher or an abattoir. If 'plucks' (heart, liver and lungs together) are obtained, the hearts complete with long lengths of blood vessel can be cut out. Otherwise hearts may have had their vessels removed by the abattoir/butcher. The lungs from the pluck can be used in Topic 8Bd if kept in suitable conditions (e.g. frozen or refrigerated for a short period of time). At the end, ask pupils to compare the heart they have seen dissected with a model human heart and identify similarities and differences.	**Resources (for demonstration)** Animal heart or pluck; dissecting board; scalpel; forceps; disinfectant (e.g. Virkon); human heart model.	Care must be taken with sharp scalpels and scissors. All tissue must be bagged and disposed of by the technician. All dissecting boards, benches and sinks, etc. should be disinfected after the practical, preferably using 1% Virkon. Dissection instruments are best autoclaved after use, as disinfectants may attack metal instruments. Wash hands thoroughly afterwards. If pig/cow hearts are used, be aware of pupils with	

				cultural/religious objections to handling such material. Pupils who do not want to watch should be treated sensitively.	
8Bc	Exploring 1	**Exercise and breathing rate (AB/AT)** You could consider doing this practical jointly with the PE department. Pupils measure their breathing rate at rest and after light and hard exercise. Pupils should be encouraged to think about errors in the experiment, e.g. breathing rate may change when focusing mentally on it. They may suggest repeating the experiment several times and calculating means. More reliable conclusions can be drawn by combining the results from the whole class. Ask pupils what factors need to be taken into account when combining class results and how the results could be manipulated. If collating the class results in a spreadsheet, you could demonstrate what happens if some data is taken out and what impact this has on the conclusion drawn. As an alternative, the **AB** spreadsheet link on page 27 opens *Breathing rate data* – in which pupils need to construct a line graph and label it to show how breathing rate changes with different types of activity. • **Must:** Worksheet 8Bc(4) will help weaker pupils. • **Should:** pupils plan this practical from the Practical box on page 27 of the Pupil's Book. Remind pupils to include safety advice in their plans. They should also comment on the observation and recording methods used and if	**Resources (per pair)** Stopwatch or stopclock. Optional: book the school hall.	Ensure exercise is in a safe area and is safe for pupils, e.g. asthmatics, who should be encouraged to use their inhalers before exercise. Any pupils excused from PE on medical grounds should be excluded (sensitively) from taking exercise. This can be done by pairing pupils up so that one exercises and the other takes readings. Ensure, with careful supervision, that exercise does not become competitive.	

		these are appropriate to the task. In addition, pupils should comment on how charts and graphs will make any trends easier to see. • **Could:** pupils plan this practical without having seen Pupil's Book page 27.			
8Bd	Exploring 1	**Lung volumes (AB)** Pupils take a normal breath and breathe out normally into the disinfected end of a length of tubing. The air enters a water-filled bottle and pupils can read off the volume of air in one normal breath – the so called 'tidal volume'. This is normally about 200–300 cm3. Note that exhaling through narrow tubing requires some effort to force air into the bottle and it is difficult to breathe 'normally' in these circumstances. Wider-bore tubing is helpful. This practical can be used as an opportunity to revise measuring volumes and asks the pupils to calibrate their own plastic drinks bottle. Bar charts of the class results could be constructed. If you have a spirometer, get pupils to check their results using the spirometer and to state which method they think provides the more reliable data, and why they think this. Also ask them to comment on the possible sources of error in both methods (mainly due to having to think about breathing which alters the volume of a breath, rather than just breathing normally). A spirometer has wider tubing and is less likely to interfere with normal breathing. A third way of measuring tidal volume is outlined in *Exploring 2*. Lung volume bags are also available from suppliers and provide a fourth way of measuring tidal volume. Ask pupils to explain why the tubing is soaked in Milton®.	**Resources (per group)** Large bowl, bucket or sink of water; empty 1 litre plastic drink bottle; marker pen; 250 cm3 measuring cylinder; length of clean rubber tubing; Milton® solution; stopwatch or stopclock; Worksheet 8Bd(2). Optional: spirometer; lung volume bags.	Make sure the rubber tubing that pupils need to blow into is disinfected. Soaking the ends of clean lengths of tubing in Milton® solution for 30 minutes followed by rinsing is advised. See *CLEAPSS Handbook*, Section 14, for advice on using a spirometer safely.	

		Extend the practical by asking pupils to predict what would happen to the tidal volume when exercising. If there is time pupils could try this out or the **AB** spreadsheet link on page 30 opens *Breath volumes* – a spreadsheet in which pupils create a graph of changes in breath volumes with exercise and label it to explain the changes. • **Must:** Worksheet 8Bd(2) provides instructions for calibrating an empty plastic container for measuring the volume of air in a normal breath. • **Should:** challenge pupils to design their own methods of measuring the volume of air in one breath, showing them some of the apparatus that they might consider using. • **Could:** challenge pupils to design their own methods.			
8Bd	Exploring 2	**Lung capacity** Explain to pupils that the capacity of the lungs is often measured in people who have problems with their lungs (especially to monitor how well a treatment is working). Lung capacities of athletes are also checked because training should increase them. Lung capacity can be determined using either a bell jar or an empty 5 litre plastic container (e.g. the type used in catering to store orange squash). The latter approach is easiest, although the container will need to be marked out using a permanent marker, filling it in 250 cm3 amounts with water to create a scale going up in 0.25 l amounts. The container is submerged in a large bowl or sink of water and inverted, keeping the open end under the water. A length of disinfected plastic tubing is inserted into the open end and pupils take as deep a	**Resources (per class)** Large bowl, bucket or sink of water; empty 5 litre plastic container or bell jar; marker pen; 250 cm3 measuring cylinder; length of clean rubber tubing; Milton® solution. Optional: spirometer.	Make sure the rubber tubing that pupils need to blow into is disinfected. Soaking the ends of clean lengths of tubing in Milton® solution for 30 minutes followed by rinsing is advised.	

		breath as they can before blowing out all the air in their lungs into the tube. Again, use as wide a bore of tubing as possible. Some pupils will need to hold their noses. The amount of air breathed out is the ‘lung capacity’ or, more technically, the ‘vital capacity’ and can be read off the scale. Bar charts of the class results could be constructed. A spirometer could be used to check/compare results if one is available. See *CLEAPPS Handbook*, Section 14, for advice on using a spirometer safely. The tidal volume can also be measured with this apparatus. Half the container should be filled with air and the end of the tubing should be well into the part of the container with air in it. Ask pupils to breathe normally in and out of the tube. The water level will rise and fall inside the container giving an estimation of tidal volume. • **Must/Should:** show pupils the apparatus and ask them how they would use it. Ask them to write a list of all the variables in this practical and identify what they are keeping the same. Also ask them why Milton® solution is part of the apparatus. • **Could:** challenge pupils to design their own methods.			
8Bd	Explaining 2	**Sheep lungs (demonstration)** This is best done as a demonstration. Show the trachea with rings of cartilage to hold it open and the spongy texture of the lungs due to the air inside the air pockets. If a tube is inserted down one of the bronchi the lung can be inflated using a bicycle or foot pump. Unfortunately one or both of the lungs are often cut at the abattoir to check for parasites. If several lungs are ordered, the least damaged can be used for the	**Resources (for demonstration)** Sheep’s lungs; bicycle or foot pump and tube; dissection board; large knife; disinfectant; large plastic bag.	Do not inflate the lungs using your mouth; have disposable gloves available; disinfect the area after the demonstration. Wash hands properly after touching the lungs. All benches,	

		demonstration. Pupils can feel the trachea and lung texture.		dissection boards, etc. should be disinfected after the practical, preferably using 1% Virkon. Dissecting instruments are best autoclaved after use, as disinfectants may attack metal instruments. Since lungs are likely to have been cut, as they are inflated, air will escape. Any microbes on the moist surface of the lungs may therefore also escape into the air. It is best if lungs are enclosed in a large plastic bag when inflated.	
8Bd	Explaining 3	**Model lungs (demonstration)** Set up the apparatus as shown. Pinching the stretched balloon or rubber sheet and pulling it down will result in the balloon inside inflating slightly. Explain to pupils what each part represents and ask them to explain how the model helps us to understand breathing. This relates back to work on pressure in Unit 7G. Ask pupils to look at the three models of breathing presented in this topic – the two drawings shown on Pupil's Book page 30, the animation (*Lungs and breathing*; the second **AT** video link on page 30) and the bell jar	**Resources (for demonstration)** Bell jar; bottom covered in rubber sheet or cut and stretched balloon; bung fitted with tubing.		

		model. Ask them to evaluate each model, pointing out its strengths and weaknesses, and to state which they think is the best and why. For a diagram giving further information, please see page 75 of the teacher's guide			
8Be	Starter 2	**Burning 1 (demonstration)** Place an inverted jar or bell jar over a burning tea light. Ask pupils why the tea light eventually goes out, and how they think the air in the jar at the end of the demonstration is different to the air at the beginning. Then ask pupils how this demonstration is similar to respiration. *Exploring 1* extends this idea.	**Resources (for demonstration)** Heatproof mat; tea light candle; bell jar or large jar.		
8Be	Starter 3	**Inhaled and exhaled air** Full instructions for this practical are given on Worksheet 8Be(2). **Test 1:** Pupils will probably encounter problems in assembling the apparatus and it is wise to pre-prepare this apparatus for pupils (see diagram on Worksheet 8Be(2)). The experiment gives a quick and reliable comparison of the carbon dioxide content of inhaled and exhaled air (inhaled air bubbles through the limewater in tube A in the diagram and exhaled air bubbles through the limewater in tube B). For a diagram giving further information, please see page 77 of the teacher's guide **Test 2:** Condensation is seen on the mirror, but this could be any colourless liquid. The use of cobalt chloride paper shows it to be water. Commercially prepared cobalt chloride paper is often very pale in colour and paper prepared in	**Resources (per group)** **Test 1:** 2 boiling tubes; 2 bungs with a short and long piece of glass tube through; mouthpiece; limewater, eye protection, Worksheet 8Be(2). **Test 2:** mirror; 2 pieces of blue cobalt chloride paper; forceps; pipette; access to water. **Test 3:** thermometer. Optional: boiling tube, short length of glass tubing, elbow of glass tubing.	**Test 1:** Eye protection should be worn. Breathe *gently to* avoid getting limewater in the mouth. If this happens spit it out and rinse the mouth with water. Mouthpieces must be disinfected between uses by putting them in Milton® solution for 30 minutes. It is better to use lengths of pre-disinfected tubing that can be attached to the apparatus. **Test 2:** Cobalt chloride paper should	

		school is often better as it can be stained darker. The paper should be kept in a desiccator, since it quickly turns pink with moisture from the air. If this happens it can be dried in an incubator. **Test 3:** The bulb of a thermometer is cupped in the hand and exhaled onto several times. The bulb itself should not be touched; the hand just serves to catch the breath. How long this is done for obviously affects the final temperature. A more sophisticated apparatus can be made using a boiling tube and bung with a thermometer and breathing tube going through the bung as shown in the diagram. For a diagram giving further information, please see page 78 of the teacher's guide		not be handled with fingers. If it is, hands should be washed immediately. **Test 3:** The tube must be disinfected for 30 minutes in Milton® before and after each use. Alternatively use lengths of pre-sterilised tubing as in Test 1.	
8Be	Exploring 1	**Burning 2** Instructions for the practical are given on Worksheets 8Be(3) and 8Be(4). Pupils may need guidance on the collection of exhaled air by the displacement of water method. Similar sized gas jars with well-fitting deflagrating spoons need to be provided. Make sure that the gas jars are large. Smaller ones will mean that the candle goes out too quickly with exhaled air. • **Must:** pupils use Workheet 8Be(3) to do a simple investigation into the differences between inhaled and exhaled air. A good evaluation point is that upon opening the jars to put in the candles, some of the air inside escapes meaning that the test is not very fair. • **Should:** pupils use Worksheet 8Be(4) to plan and carry out an investigation to find out if there is a difference between exhaled air at resting and exhaled air during exercise. The exercise	**Resources (per group)** Two similar sized, large gas jars with greased lids; a deflagrating spoon and tea light; trough of water; clean tubing; stopclock or stopwatch; Worksheet 8Be(3) or 8Be(4).	It is suggested that teachers/assistants light the tea lights.	

		variable could be the strenuousness of the exercise or how long the exercise continues for. In the latter case it may be found that the oxygen levels in exhaled air decrease to start with but then start increasing again as the breathing rate increases and the lungs are absorbing as much oxygen from the air as they can. A good evaluation point is that exercise is difficult to quantify. In sports centres, they put people on treadmills or exercise bikes with speedometers on them to get a constant level of 'measurable' exercise. Where space is limited, pupils can vertically raise a fixed mass, e.g. I kg, held in the hand, through a specified distance, e.g. I metre, and repeat a specified number of times. In this way, the amount of exercise is similar for all pupils.			
8Be	Exploring 2	**Respiring organisms** This practical can be used to carry out an AT1 investigation. A set of level descriptions is provided on pages 63–65 of the ASP. Pupils should be guided in their choice of living material, e.g. yeast, germinating lentils, woodlice, maggots, pondweed. Yeast will produce reliable results fairly quickly, and is easy to handle. Lentils and pondweed will take longer to produce results. Variables that could be investigated: mass of the living material used, temperature, activity. Whichever variable is to be investigated, a control should be set up. If pupils choose to do different investigations there will be the opportunity to draw out many important points about the rate of respiration from the class results. Pupils may need reminding to avoid breathing	**Resources (depending on pupils' plans)** Hydrogencarbonate indicator; boiling tubes and bungs; gauze; access to balance; selection of living materials; stopclocks or stopwatches; Worksheet 8Be(5). In addition, for yeast experiments: delivery tubes; sugar; thermometer.	Pupils should be encouraged to consider the welfare of any small animals used. Wash hands and wipe benches with disinfectant after handling living material.	

		out over open tubes of hydrogencarbonate indicator as exhaled carbon dioxide will affect the indicator. • **Should:** pupils use Worksheet 8Be(5). • **Could:** pupils plan their investigations without help.			
8Ca	Exploring 2	**Yeast respiration 1** Pupil's may have done a similar practical in Topic 8Ba (*Exploring 3*) – and you may prefer to use that practical and associated worksheets here. From the Practical box on page 36, pupils can use a yeast culture to investigate the best conditions for respiration. A very simple way of doing this is to use balloons stretched over the tops of test tubes containing the yeast cultures. The balloons start to partially inflate as carbon dioxide is produced and the effect can normally be seen in about 30 minutes using ideal conditions (30 °C, 10% glucose solution). 4 cm3 of 10% glucose solution is added to a series of test tubes and each has 0.5 cm3 of an actively growing yeast culture added. Dried yeast can be used instead, but this takes longer to yield results. A balloon is placed over the neck of each tube and different tubes are then left at different temperatures. As a teacher demonstration, one balloon could be taken off a tube (pinching its bottom end so that gas does not escape), and placed onto another tube containing limewater. If the tube is shaken, the limewater will go 'milky' demonstrating the presence of carbon dioxide. Ask pupils whether they can see the organisms that are respiring and how they could find out if they were there (examine under a microscope). • **Should:** remind pupils of the word equation for	**Resources** 3 test tubes; test tube rack; 3–4 balloons; roughly 20 cm3 10% glucose solution (sucrose is an alternative); access to actively growing yeast culture (10 g dried baker's yeast added to 200 cm3 10% sucrose solution and left for 24 hours in a warm place); access to areas of different temperature (e.g. water bath at 30 °C, room temperature, fridge); optional access to different strengths of glucose (or sucrose) solution (e.g. 0.1%, 1% and 10%). Limewater; test tube (in addition to the above).	Eye protection should be worn when handling limewater.	

		aerobic respiration. Sucrose can be used in the experiment instead of glucose and it works nearly as well, although it may be wise to call this glucose to avoid causing confusion with the equation. Pupils could plan an investigation using different strengths of glucose solution to find out which strength of sugar solution causes the most carbon dioxide to be given off.			
8Ca	Exploring 3	**Microbial zoo** By wiping a moistened cotton wool bud on their skin, or on a lab surface, pupils could collect bacteria which can be grown on nutrient agar plates. The cotton wool buds can be wiped gently over the surface of an agar plate. Equally, fingers can be placed directly onto agar, although this method is used in Topic 8Cd. It may prove useful for the teacher to swipe an open nutrient agar plate through the air, displaying the results when discussing the work in Topic 8Cc to show that microbes are in the air. The plates should be taped (see below) with sticky tape and left upside down in a warm place (room temperature is usually adequate). Colonies of bacteria should be visible within 48 hours. Some moulds may also grow. Ask pupils what safety precautions they would take when doing this practical and then explain the reasons behind the precautions outlined below. • **Should**: tell pupils that hospitals often need to do tests to see if there are any 'microbe hotspots'. Ask pupils to come up with a brief plan as to how they think this might be done. Ask pupils to then describe what a hospital would do when the results of these tests come	**Resources (per group)** Cotton wool bud; nutrient agar in a Petri dish; sticky tape.	Pupils should not place cotton wool buds in their mouths, noses or ears. Plates should be taped as shown and not sealed all the way around otherwise potentially hazardous anaerobic microbes may grow. Used agar plates must *not* be opened and must be autoclaved at the end of this practical. The plates can be sealed completely *after* incubation (to make them more secure before pupils inspect them). Pupils should wash their hands well after handling plates. To guard against pupils deliberately removing an agar	

		back. It is generally unwise to carry out such a practical with pupils due to growth of potentially harmful bacteria (the ones found naturally on skin are usually less harmful). For a diagram giving further information, please see page 89 of the teacher's guide		plate from the lab for subsequent 'investigation', the number of plates should be counted out and back in before pupils leave the room.	
8Ca	Explaining 3	**Showing microbes (demonstration)** Show pupils a nutrient agar plate and tell them that this can be used to grow some kinds of microbe. Ask pupils what sort of microbe won't grow on the plate and establish that viruses won't grow because they need to be inside another living cell in order to function. You could use the analogy of a computer to explain that a computer virus on a storage device will do nothing. It's only when the computer is running that the virus can have its effect. Ask pupils what microbes could be grown on the agar and explain that bacteria and fungi may both grow, forming clumps (called colonies) that you can see. If you have a plate with some colonies on, let pupils have a look. This works best if you have a plate with both bacterial and fungal colonies on it – explain to pupils that the smooth, shiny colonies are bacteria and the fuzzy ones are mould (a kind of fungus).	**Resources (for demonstration)** Nutrient agar plate; nutrient agar plate showing colonies of bacteria and/or fungi.	Used agar plates must *not* be opened and must be autoclaved at the end of this practical. The plates can be sealed completely *after* incubation (to make them more secure before pupils inspect them). Pupils should wash their hands well after handling plates.	
8Cb	Starter 3	**Dough rising (demonstration)** Prepare two lumps of dough (see *Exploring 1* for instructions) and place them each in a beaker. Leave one in the fridge and the other in a warm place until the class come in. Then display both beakers and explain to pupils that the one that has risen started off looking like the	**Resources (for demonstration)** Mixing bowl or large beaker; 100 g strong or bread fl our; 5 g sucrose; 3.5 g 'Easy-blend' baker's yeast (or 7 g dried yeast or 14 g fresh yeast); 100 cm3 measuring cylinder(s); long stirring rod; water;		

		other one. Ask them to suggest why and elicit the idea that something or some kind of reaction is occurring in the dough to cause it to rise.	thermometer; tablespoon; cooking oil; warm place at 27–30 °C or water bath at 30 °C; Worksheets 8Cb(2), 8Cb(5). Optional: 5 boiling tubes.		
8Cb	Exploring 1	**Rising dough** The Practical box on page 39 of the Pupil's Book contains the initiator for this investigation. This practical can be used to carry out an AT1 investigation. A sheet of level descriptions is provided on pages 94–96 of the ASP. Use of the worksheets for this investigation will limit the number of strands that can be assessed. A dough mixture can be made by mixing 100 g of 'strong' or 'bread' flour, 5 g of sucrose (caster sugar) dissolved in 65 cm3 of water, and 3.5 g of baker's yeast. Pre-warming the water will help the experiment to get underway quickly. The fl our suggested will rise better than plain fl our. It is easiest to use 'Easy-blend' dried yeast or fresh yeast which can be mixed straight into the dough mixture. If using standard dried yeast, double the amount and double it again if using fresh yeast. Note that fresh yeast is normally the most active. If using standard dried yeast it is often better to add it to a small amount of the sugary water first and leave it for 15 minutes before adding the fl our and the rest of the sucrose solution. This gives the dried yeast time to absorb water and rehydrate before the start of the experiment. Once mixed, the dough can be kneaded (or not) and standard amounts (say 25 cm3) placed in measuring cylinders or beakers (a spoon is useful for this and a stirring rod may be needed to push it down) and left to rise in a warm place (27–30 °C). It is possible to	**Resources (per group)** Mixing bowl or large beaker; 100 g strong or bread fl our; 5 g sucrose; 3.5 g 'Easy-blend' baker's yeast (or 7 g dried yeast or 14 g fresh yeast); 100 cm3 measuring cylinder(s); long stirring rod; water; thermometer; tablespoon; cooking oil; warm place at 27–30 °C or water bath at 30 °C; Worksheets 8Cb(2), 8Cb(5). Optional: 5 boiling tubes.	On no account should any of the bread dough be eaten. If you leave the set-up for pupils to examine on another day, do not leave for more than 2 days or else moulds and bacteria will start to grow on it which could be a potential hazard.	

		place smaller pieces of dough into boiling tubes and these are more suitable if the ‘warm place’ needs to be a water bath. It is a good idea to lightly oil (with cooking oil) the inside surfaces of any tubes or measuring cylinders as this will stop dough sticking to the sides. The experiment could run in various ways. Pupils could change the amount of sucrose or the amount of yeast added, the temperature the dough is left at, the type of fl our, the type of yeast (dried, ‘Easyblend’ or fresh), whether the dough is kneaded or not (kneading dough can get a bit messy!) or the type of raising agent (comparing yeast with baking soda, baking powder and potassium bicarbonate for example). The worksheets suggest leaving the dough mixture to rise for 1 hour. You can shorten this to accommodate a shorter lesson time. Or leave the apparatus for pupils to examine on another day. However, if you do this, note that the dough will sag – although you should be able to see the height to which it reached in the cylinder (and this is the height that pupils should measure). Ask pupils to suggest how knowledge from investigations like this would be useful in food technology or the baking industry. • **Must:** Worksheet 8Cb(2) is a practical sheet leading pupils through an experiment with temperature as the variable. • **Should:** Worksheet 8Cb(5) is a planning help sheet to aid in the designing and evaluation of an investigation involving whole-class cooperation. Each pupil or group gets a chance to plan the investigation but then one approach			

		is agreed on, and everyone carries out that approach. The use of this sheet will limit the assessment of it. • **Could:** ask pupils to plan the investigation using only the Practical box on page 39 of the Pupil's Book for help.			
8Cb	Exploring 2	**Making yoghurt** Full instructions are given on Worksheet 8Cb(3). The investigation is designed to explore how microbes are used to make foods and the best conditions for microbe population growth. You may wish to carry out steps A–D on a large volume of milk beforehand and allow it to cool to about 50 °C ready for the pupils to use. Make sure that the yoghurt bought for use as a starter culture is 'live' and unflavoured. This will usually contain one or more of these bacteria: *Bifi dobacterium lactis*, *Lactobacillus acidophilus*, *Lactobacillus bulgaricus*, *Streptococcus thermophilus*. You will need a warm place in order to incubate the yoghurts. This is best done in a low oven, set to 40 °C. Or fill the bottom of an insulated picnic chest with hot water from the tap. Put the jars in that and put on the lid.	**Resources (per group)** 0.5 litres milk; natural, live yoghurt; pan or large beaker; access to sink of cold water; 2–3 sterile glass jars with lids (jam jars will do); tablespoon; thermometer.	If this is done in a food lab you could allow pupils to eat what they make in this experiment. However, everything must be scrupulously clean, and the jars into which the milk is poured must be sterilised by placing them in boiling water for 2 minutes. Great care must be taken if pupils are to move the hot pan/beaker into a sink of cold water.	
8Cb	Exploring 3	**Yoghurt bacteria** This practical could follow on from *Exploring 2* and *Exploring 4* can be used to extend it further. Pupils spread diluted yoghurt onto MRS agar plates in order to grow colonies of the bacteria found in yoghurt. This provides evidence for how yoghurt is made. If you want pupils to analyse the yoghurt bacteria plates, then you could consider preparing the plates yourself and sealing them well after incubation, with pupils	**Resources (per group/pupil)** MRS agar plate made up according to manufacturer's instructions, which has been stored in a carbon dioxide atmosphere; small (e.g. McCartney) bottle of sterile distilled water; incubator at 40 °C; live yoghurt (e.g. Yoplait 'Yop' is useful because it is liquid); marker pen; sterile spatula (autoclaved in	All plates must be autoclaved at the end of this practical. Disinfect used cotton buds in 1% Virkon pre-disposal.	

		only looking at them. The instructions for carrying out this practical are on Worksheet 8Cb(4), which also has questions, including the use of ratios.	foil or purchased as sterile); sticky tape; 3 sterile cotton buds; access to beaker of 1% Virkon in which to dispose of used cotton buds; Worksheet 8Cb(4). **For incubation/fresh plate storage:** tea light candle; glass container; kitchen foil; cling-film; incubator set to 40 °C.		
8Cb	Exploring 4	**Examining yoghurt bacteria** *Lactobacillus bulgaricus* colonies are large, white and flat. *Streptococcus thermophilus* colonies are smaller and a slightly yellow colour. Ask pupils to identify each type and then to use a sterile toothpick to touch a colony. *Lactobacillus bulgaricus* colonies are sticky when touched with a toothpick, *Streptococcus thermophilus* colonies seem to disappear slightly when touched. If you have access to a microscope with a x100 oil-immersion objective lens, prepare slides of each type of bacteria to show pupils. *Lactobacillus bulgaricus* are shaped like long rods. *Streptococcus thermophilus* are shaped like ovals.	**Resources (per group/pupil)** Pupils' plates from *Exploring 2* or teacher-prepared plates of yoghurt bacteria; sterile (autoclaved) toothpicks; 2 coverslips; microscope; forceps/tweezers or mounted needle. Optional: teacher-prepared slides of bacteria; microscope with x100 oil-immersion objective.	If pupils are to examine their own bacteria, check their plates first to make sure that only white and pale yellow colonies are on the plates. All plates and slides should be autoclaved after this practical.	
8Cb	Exploring 5	**Overcrowding** The effects of overcrowding in a yeast culture can be monitored over a period of a week or so. One gram of dried baker's yeast is placed into 100 cm3 of 10% sucrose in a conical fl ask. This should be thoroughly mixed, stoppered with cotton wool and left for about an hour in a warm place. A drop can be taken with a pipette and examined under a microscope and the number of cells visible in the field of view at ×400 counted or estimated. The use of a	**Resources (per group/pupil)** 1 g dried baker's yeast; 100 cm3 10% sucrose solution; conical flask with stopper; pipette; microscope and slide-making equipment; Year 7 CHAP Skills Sheets 44 and 45. Optional: haemocytometer slide.		

		haemocytometer slide may help in choosing a sample size. This sampling can be done every day for a week or two and a line graph plotted. Pupils should then analyse their graphs and identify and explain the different phases of growth.			
8Cc	Starter 1	**Examining plates** If pupils have done *Exploring 3* in Topic 8Ca or *Exploring 3* in Topic 8Cb, their plates may now be ready to examine. Ask pupils to look at their plates and to describe and explain what they see. (Worksheet 8Cb(4) will help pupils interpret the results of *Exploring 3* in Topic 8Cb and includes work on ratios.) Ask pupils to say what safety precautions they should take before and after looking at their plates, and why they should take these precautions.	**Resources (per group/pupil)** Plates from *Exploring 3* in either Topic 7Ca or Topic 7Cb; maybe Worksheet 8Cb(4).	The Petri dishes must not be opened. Now that they have been incubated, you can fully seal the plates to further prevent pupils from opening them, but do not re-incubate them. To guard against pupils deliberately removing an agar plate from the lab for subsquent 'investigation', the number of plates should be counted out and back in before pupils leave the room.	
8Cc	Exploring 1	**Spreading diseases** Pupils use a model to show how diseases are spread. Give each student a plastic cup, 1/3 full of water. Two students have colourless weak acid solutions in their cups. Pairs of pupils then exchange half the liquid in their cups with each other (the easiest way is to combine the contents of both cups and then divide the contents back into the two cups). Pupils move slowly around the room, and repeat this process	**Resources (per pupil)** Small container 1/3 full of water (e.g. plastic cup). **Resources (for the teacher)** 2 small containers 1/3 full of solution of a weak acid (such as citric or ascorbic) to mix in with other containers; universal indicator.	Tell pupils not to drink from their cups – you may decide that using lab beakers, or other containers may be more likely to prevent students tasting what's in their cups.	

		with other pupils. After 2–3 minutes call a halt to proceedings. Explain that at the beginning, two of the cups were contaminated and add a few drops of universal indicator to each cup to see how the contamination has spread. • **Should:** ask pupils to work in pairs to list ways in which this is a good model for how diseases are spread (e.g. the microbes/contamination can't be seen; some microbes are spread in bodily fluids). Then ask them to list ways in which this is a poor model (e.g. you don't often walk around swapping bodily fluids with all your friends; some diseases are not spread in this way at all). Pupils should contrast this model with the one met in *Explaining 2*.			
8Cc	Explaining 2	**Spreading microbes (demonstration)** Glogerm® is a commercial product used to show how easily microbes can be spread. Without the class knowing, rub some of the lotion onto your hands (which will distribute thousands of tiny plastic 'microbes' on your hands). Then during the lesson, touch certain places in the lab during an explanation of something and then mention to pupils that you have just remembered that you recently went to the toilet or chopped up some chicken but have forgotten to wash your hands. Darken the room, and use a UV light source (available as part of a Glogerm® pack) to show your hands glowing, and how the other parts of the lab that you have touched are also now glowing. You can now reveal that this is actually just a model, using Glogerm®. • **Should:** discuss with pupils how good a model this is for the way in which microbes can be transferred by touch (for instance, can it model	**Resources (for demonstration)** Glogerm® lotion (do an internet search for Glogerm® suppliers); portable UV source.		

		athlete's foot, in which the microbes can be transferred to a new person by touching where you have touched? How long does the fluorescence last compared to how long various microbes can survive?). Pupils should compare and contrast this model with the one met in *Exploring 1*.			
8Cd	Exploring 1	**Washing with soap** This is linked to the Practical box on page 43 of the Pupil's Book and most pupils should be able to have a go at a basic plan for the practical, based only on the information in this box and their past experiences in this unit. It is a good opportunity for individual practical work. Pupils take a Petri dish containing nutrient agar. On one part of the agar they press a thumb lightly onto the surface of the agar. After washing their hands with water, they press the same thumb lightly onto a fresh part of the agar. The process is repeated after washing hands with soap. The plate should be marked to show which section is which or different plates can be used. The plate is then taped and left upside down in a warm place (room temperature is usually sufficient). After 48–72 hours, more colonies may be observed on the unwashed thumb area. However, sometimes washing with water can loosen the resident bacteria causing more colonies on the washed area. The practical can be extended to include different variables, e.g. lengths of time spent washing hands, using different soaps. • **Must:** Worksheet 8Cd(4) provides instructions for carrying out this practical, although pupils should attempt plans of their own, even if just verbally, including what they must do to stay	**Resources (per pupil)** Access to soap (maybe of different types); Petri dish of nutrient agar; sticky tape; marker pen; Worksheet 8Cd(4).	Plates should be taped as shown for *Exploring 3* in Topic 8Ca. No used agar plates should be reopened and all must be autoclaved at the end of this practical. Plates can be sealed completely with sticky tape after incubation. Since it is possible that skin may carry pathogenic bacteria such as *Staphylococcus aurens*, it is absolutely essential that agar plates cannot be opened or taken away by pupils. Sealing around the circumference after incubation is essential, as is counting the plates out and back in. Pupils should wash their hands well after	

		safe. • **Should:** challenge pupils to plan and carry out their own methods, including an assessment of risk. • **Could:** challenge pupils to plan the investigation using more than one variable.		handling plates.	
8Cd	Exploring 4	**Antiseptics and disinfectants** Petri dishes containing nutrient agar freshly inoculated with lawns of *E. coli* or *Micrococcus luteus* are required for this practical in which pupils will determine the relative effectiveness of a variety of anti-bacterial substances. See apparatus list for examples of antiseptics and disinfectants to try. This practical can easily be adapted to compare a range of antiseptics, toothpastes, soaps or deodorants. You might allow pupils to bring in a sample of what they use at home to test. If small discs are punched out of filter paper with a hole-punch these can be soaked in the solution, shaken off well and then placed directly onto the surface of the agar using sterile forceps. To keep the forceps disinfected during this procedure they can be left soaking in a solution of 70% ethanol and patted dry with paper towel between placing each disc. Explain to pupils that the 70% ethanol kills any bacteria that might otherwise be on the forceps (we are only testing the bacteria that are spread on the plate, not others that may be in the immediate environment). Each Petri dish should be divided up into 'pie' sections and each section labelled clearly. The plates should then be left upside down in a warm place (room temperature is usually sufficient) for 48–72 hours by which time the	**Resources (per pupil or group)** Petri dish containing nutrient agar freshly inoculated with a lawn of *E. coli*; 4–6 hole-punched discs of filter paper; marker pen; sticky tape; forceps; paper towel; beaker containing 70% ethanol for disinfecting forceps; access to a selection of disinfectants/antiseptics in small beakers which may include: 50% solution of liquid toothpaste, anti-perspirant liquid (from a roll-on or similar), 100% ethanol, 70% ethanol, Dettol®, Virkon, TCP®, bathroom cleaner, kitchen cleaner, distilled water; Worksheet 8Cd(5).	Pupils must wash their hands thoroughly after setting up their dishes. Plates should be taped as shown for 8Ca *Exploring 3*. No used agar plates should be reopened and all must be autoclaved at the end of this practical. Plates can be sealed completely with sticky tape after incubation. Pupils should wash their hands well after handling plates. To guard against pupils deliberately removing an agar plate from the lab for subsequent 'investigation', the number of plates should be counted out and back in before pupils leave the room.	

		lawn of bacteria and the circular areas where the bacteria have not grown should be visible. You may need to reassure pupils that the *E. coli* used in this practical are of a different type to those that cause food poisoning. This investigation provides pupils with a good opportunity to explain the results in two different ways; either some chemicals are more effective than others or some chemicals diffuse through the agar more than others. Challenge pupils to come up with a better investigation design to account for this. A simple solution is to use a different agar plate for each chemical. Spread each agar plate with the chemical under test, and then to spread on a bacterial suspension. Worksheet 8Cd(5) is designed as a simple practical to compare a disinfectant with an antiseptic (e.g. Dettol® compared with TCP®). • **Must:** Worksheet 8Cd(5) provides instructions for carrying out this practical. • **Should:** challenge pupils to plan and carry out their own methods, including an assessment of risk. More quantitative results can be obtained by measuring the diameters of the areas where no bacterial growth has occurred. This can be demonstrated to pupils by placing a plate on an overhead projector. Part of the evaluation of the practical might include mention of the fact that some of the liquids were more viscous than others and thus spread less readily onto the surrounding agar. It might be suggested that drying the discs before use may help. • **Could:** challenge pupils to plan the investigation using a range of disinfectants and antiseptics to establish an order of 'strength'.			
8Cd	Explaining 2	**Cinnamon microbes (demonstration)**	**Resources (for demonstration)**		

		This is best done using three volunteers. Mix some vegetable oil and ground cinnamon in a beaker. Ask your volunteers to rub the mixture on their hands. Then ask one volunteer to wash their hands for 15 seconds with cold water, one to wash for 15 seconds with cold water and soap and one to wash for 15 seconds with warm water and soap. Get them to show the rest of the class their hands, and explain that this is a model for how important hand washing is. The cinnamon represents the microbes, and some of these are only fully removed by washing with warm water and soap. Remind pupils that you are using a model to illustrate.	Vegetable oil mixture with cinnamon powder in a small beaker; access to sink and soap.		
8Cd	Explaining 3	**Low temperatures and bacteria (demonstration)** Different samples of milk can be investigated to see if lower temperatures either kill bacteria or just stop them from growing. Three identical samples of milk should be left at room temperature, in a fridge and in a freezer for 24 hours. Prior to the experiment, the frozen milk is allowed to partially defrost (2 hours in the fridge) and one drop from each type of milk is added to and mixed with 10 cm3 of distilled water. Five drops of each of the diluted milk samples are added to the surface of a Petri dish containing nutrient agar. The dilution is necessary if individual colonies are to be seen. The drops should be spread around the plate using a glass spreader or sterile cotton wool buds soaked in distilled water. Between plates, the spreader should be dipped into 70% ethanol and briefly held in a Bunsen flame (just long enough to ignite the ethanol) and the ethanol allowed to burn off. If the spreader is left too long in the	**Resources (for demonstration)** 4 nutrient agar-filled Petri dishes; sticky tape; glass plate spreader and 70% ethanol solution or 4 sterile cotton wool buds; diluted milk samples (24 hour frozen, refrigerated and room temperature stored); 4 pipettes; distilled water.	Plates should be taped as shown for *Exploring 3* in Topic 8Ca. No used agar plates should be reopened and all must be autoclaved at the end of this practical. Plates can be sealed completely with sticky tape after incubation to allow inspection by pupils. The 70% ethanol solution should be kept at least 1 m from the Bunsen flame. Pupils should wash their hands well after handling plates.	

		flame, the agar will be melted. A control plate should be set up using five drops of distilled water. Ask pupils to predict the outcome. The plates should be sealed and then be left upside down in a warm place (room temperature should be sufficient) for 48–72 hours, by which time colonies should be visible.			
8Cd	Explaining 4	**Bacteria on teeth** Disclosing tablets can be used to show pupils the amount of plaque that build up on teeth and therefore the importance of brushing teeth well. Toothpaste contains a mild antiseptic that kills bacteria. Show pupils how to use disclosing tablets and the results before and after you brush your teeth. If you do not have access to a nonlaboratory space to do this demonstration, do it at home and take photos to show pupils.	**Resources (for demonstration)** Disclosing tablets (available in most chemists); drinking water; something to spit into; mirror. Possibly: camera.	This practical should not be carried out in a laboratory. Beware: lips and tongue can be stained.	
8Cd	Explaining 6	**Bacteria in the air (demonstration)** A simple demonstration can be set up to illustrate the experiment done by Pasteur (shown on Worksheet 8Cd(10)). The experiment illustrates the fact that life does not generate spontaneously from things like broth and that microbes are present and can be spread in the air. Two boiling tubes of sterlile ‘broth’ (chicken stock or similar) are stoppered with a tube coming out of each. One has a straight tube and the other is bent into a U-shape at the top. Ask pupils to predict what will happen and why. The broth in the former will be seen to go cloudy first. You could have pre-prepared this apparatus so that results can be seen now. Explain to pupils that the presence of microbes in the air, demonstrated by this practical, shows the need for cilia in order to stop these bacteria	**Resources (for demonstration)** 2 boiling tubes; boiling-tube rack; 2 holed bungs; one straight piece of glass tubing; one piece of glass tubing bent into a U-shape at the top; broth made using chicken stock cubes (or similar) and sterilised by autoclaving.		

		causing diseases in our bodies.			
8Ce	Starter 1	**Examining plates** If pupils have done 8Cd *Exploring 1* or 8Cd *Exploring 4*, their plates may now be ready to examine. Ask pupils to look at their plates and to describe and explain what they see, comparing their conclusions to predictions made (this may involve Worksheets 8Cd(4) and/or 8Cd(5)). If *Explaining 3* and/or *Explaining 6* were used in Topic 8Cd, the results of these experiments should also be ready for inspection now.	**Resources (per group/pupil)** Bacterial plates from tasks in last topic; maybe Worksheets 8Cd(4) and 8Cd(5).	The Petri dishes must not be opened. Now that they have been incubated, you can fully seal the plates to further prevent pupils from opening them but do not re-incubate them. Pupils should wash their hands after handling plates. To guard against pupils deliberately removing an agar plate from the lab for subsequent 'investigation', the number of plates should be counted out and back in before pupils leave the room.	
8Ce	Exploring 3	**Testing antibiotics** If pupils have already done 8Cd *Exploring 4* they should be able to plan this investigation for themselves in groups. The Practical box on page 47 also provides some hints. If pupils are planning their own investigations they should be encouraged to think carefully about the risks involved and how to control them. Small hole-punched discs of filter paper are soaked for 5 minutes in solutions of antibiotics and placed (using sterile forceps) on a nutrient	**Resources** (**per group)** Petri dish containing nutrient agar freshly inoculated with a lawn of *E. coli* or *Micrococcus luteus*; marker pen; sticky tape; forceps; beaker containing 70% ethanol for sterilising forceps; lab gloves; 3–4 hole-punched discs of filter paper; a selection of antibiotic solutions in small beakers which may include: streptomycin,	Pupils must wash their hands thoroughly after setting up their dishes. Pupils should not touch antibiotic discs. Plates should be taped as shown for 8Ca *Exploring 3*. No used agar plates should be opened	

		agar plate freshly inoculated with a lawn of *E. coli* or *Micrococcus luteus*. Pre-prepared discs for this purpose are also available commercially and these are preferred because each of the antibiotics will diffuse to the same amount in the agar (see below). To keep the forceps disinfected during this procedure they can be left soaking in a solution of 70% ethanol and patted dry with paper towel between placing each disc. Explain to pupils that the 70% ethanol kills any bacteria that might otherwise be on the forceps (we are only testing the bacteria that are spread on the plate, not others that may be in the immediate environment). The Petri dish should be divided up into 'pie' sections and each section labelled clearly, using a marker on the *bottom* of the plate. The plates should then be left upside down in a warm place (room temperature is usually sufficient) for 48–72 hours, by which time the lawn of bacteria and the circular areas where the bacteria have not grown should be visible. More quantitative results can be obtained by measuring the diameters of the areas where no bacterial growth has occurred. This can be demonstrated to pupils by placing a plate on an overhead projector. Worksheet 8Ce(3) is designed as a simple practical to compare two antibiotics and assumes the use of commercially bought antibiotic-impregnated discs. Putting the plates on an overhead projector displays the rings of limited growth clearly. This investigation can provide a good opportunity to explain results in two different ways; either some antibiotics are more effective than others or some antibiotics diffuse through	penicillin, aureomycin (or commercially bought antibiotic discs, some of which – mast rings – contain a variety of different antibiotics, but it is usually cheaper to purchase individual discs of penicillin and Streptomycin); Worksheet 8Ce(3).	and all must be autoclaved at the end of this practical. Pupils should wash their hands after handling plates. To guard against pupils deliberately removing an agar plate from the lab for subsequent 'investigation', the number of plates should be counted out and back in before pupils leave the room.	

		the agar more than others.			
8Da	Exploring 1	**Sorting kingdoms** Provide pupils with a circus of examples of animals from as many of the vertebrate and invertebrate groups as possible, including some that are difficult to classify (e.g. octopus, mite, scorpion, butterfly, whale, shark, sea horse). Also arrange a variety of mosses, ferns, conifers and flowering plants around the room. Some more unusual flowering plants should be included, (e.g. grasses, cacti, trees). Each organism should be labelled, avoiding use of the names of the groups in which they are found. Pupils then classify the organisms into the plant or animal kingdom, using Worksheet 9Da(3). Plants should then be classified into one of the four groups. For animals, students should first decide whether the organism is a vertebrate or invertebrate before trying to classify them into smaller groups. They should be encouraged to provide reasons for their classification.	**Resources (for circus)** Exhibition of plants and animals, or pictures, with name cards arranged around the room; Worksheet 8Da(3).	Warn pupils of the dangers of preservation fluids and do not allow them to pick up jars of any specimens preserved in liquids.	
8Da	Exploring 3	**Water loss in leaves** *Exploring 1* from Topic 7Ae in Year 7 is also See page 47 of the Year 7 TTPG for details. The **AB** spreadsheet link on page 52 opens *Water loss in leaves* – which contains some data about water loss in different types of leaves for pupils to interpret.			
8Db	Exploring 1	**Tack population (AB)** This task is linked to the Practical box on page 54 and can be done as a class practical or as a demonstration to explain how quadrats are used to estimate population sizes. The task is not only a practical but also a way of modelling this sampling method. Ensure that steel tacks are	**Resources (per group)** Large tray containing small steel tacks or ball-bearings buried in sand; bar magnet; small quadrat; Worksheet 8Db(2) or 8Db(4). The number of tacks and size of quadrat will depend on the size of the tray		

		used and that the magnets are sufficiently powerful to lift the tacks out of the sand. This practical is extended to a real situation in *Exploring 2*. Discuss with pupils about how the practical is a model and ask them how this model supports the idea of sampling in the field. Show pupils the apparatus they will use and ask them to say how they will keep themselves and others safe during this practical. • **Must:** pupils use Worksheet 8Db(2). • **Should:** pupils use Worksheet 8Db(4). • **Could:** pupils plan and carry out this task using just the initiator information from the Practical box on Pupil's Book page 54. You could ask some pupils to create the tack trays for others to examine, recording how many tacks they have put into the sand. The **AB** spreadsheet link on page 54 opens *Quadrat data* – which will give pupils ideas on how to manipulate their data using a spreadsheet.	used.		
8Db	Exploring 2	**Quadrats to measure populations (AB)** Use quadrats to estimate the population of a certain plant on a piece of land near the school. In Topic 7Ca pupils may have used quadrats to try to find a link between a physical environmental factor and the growth of a certain plant. In this task the quadrat is only being used to work out an estimate for a total population of a plant. If there is time, consider using *Exploring 1* as a preliminary investigation for this task, which models the sampling technique being used. • **Must:** pupils use Worksheet 8Db(3). • **Should:** pupils use Skills Sheet 47 from Year	**Resources (per group)** Quadrat; Worksheet 8Db(3) or Year 7 CHAP Skills Sheets 47, 48.	Pupils should wash their hands after this investigation – plants and soil may both be contaminated with animal urine and/or faeces. The area where this task is carried out should be assessed for risks beforehand and obvious physical hazards removed hygienically.	

		7 CHAP or they could use the area method (Year 7 CHAP Skills Sheet 48). • **Could:** pupils plan and carry out this task using information gleaned from the Pupil's Book. The **AB** spreadsheet link on page 54 opens *Quadrat data* – which will give pupils ideas on how to manipulate their data using a spreadsheet.			
8Db	Exploring 4	**Earthworm populations (AB)** Earthworms may be coaxed to the surface of the soil using mustard and water (15 cm3 Colman's® English mustard powder per litre and use 10 litres per 1 m2). Quadrats can be used and the mustard solution applied evenly to the ground. After 5 minutes, the numbers of earthworms can be counted. Pupils will need to work in groups and pool their results before calculating mean earthworms per square metre and an estimate of the total number of earthworms in the whole area. This is more likely to be successful if it has recently been raining as after a long dry spell, worms are likely to be far from the surface. If possible, use an area where there are worm casts on the surface: this soil is likely to contain worms that do come to the surface (not all do!). Pupils could be asked to think about what data they would need to collect from each group and how they are going to manipulate the data. It would also be a good time to discuss with the class what would happen if some of the class data was missed out or rejected. • **Should:** ask pupils to *plan* a way of finding out how accurate this method is (which will probably involve them digging up the earth and sifting	**Resources (per group)** Quadrat; mixture of Colman's® English mustard powder in water (15 cm3 Colman's® English mustard per litre and use 10 litres per 1 m2 of ground); watering can.	Pupils should wash their hands after this investigation – plants and soil may both be contaminated with animal urine and/or faeces. The area where this task is carried out should be assessed for risks beforehand and obvious physical hazards removed hygienically.	

		through it). Studies have shown that only about 40% of the worms in soil emerge when treated with mustard. There are other chemicals that are more effective but these can be harmful to the worms or plants, whereas mustard is not. Ask pupils to think about what they are going to write down as results, how accurate these results will be and why it is a good idea to display them as a table. The **AB** spreadsheet link on page 54 opens *Quadrat data* – which will give pupils ideas on how to manipulate their data using a spreadsheet.			
8Db	Exploring 5	**Sampling** Take pupils to an outside area and provide them with all the resources below. Some of these items will be useful and some will not. Ask pupils to pick an organism and to work out an estimate for that organism's population in the area. Pupils pick the equipment they need and say how they will stay safe before setting to work, modifying their ideas as they progress. Access to a digital camera for pupils to take pictures of organisms and their working methods will also be useful. At the end of the task pupils should prepare presentations to explain what they did. They should say: • what organism they investigated • whether they decided to investigate a different organism once they had started and why • how they carried out the sampling • what difficulties they had • why the sample method chosen was appropriate • what their estimate of population size is.	**Resources (per group)** Access to: quadrats, pooters, pond-dipping nets or buckets, white plastic trays, tree beating collection sheets, Tullgren funnel apparatus, pitfall trap apparatus, sweepnets; Year 7 CHAP Skills Sheets 47–50; Pupil's Book pages 54–55.	If using Tullgren funnels, the lamp should be at least 15 cm away from dried leaves, since there is a fire risk. Pupils should wash their hands after this investigation – plants/soil/water may be contaminated with animal urine and/or faeces. The area where this task is carried out should be assessed for risks beforehand and obvious physical hazards removed hygiencially. Pooter tubes should be sterilised in Milton® for 30 minutes before	

		• whether they had enough results to predict population size Presentations could be given using presentation software and some pupils asked to give their presentations to the class. **Could:** ask pupils to consider what they know about this habitat already and how this knowledge helped them to plan this investigation.		and after use. School/local authority guidelines for off-site visits must be observed.	
8Db	Explaining 4	**Tullgren funnel (demonstration)** Set up a Tullgren funnel before the lesson and use it to explain how it works. Use fresh leaf litter and preferably leave it set up for a good hour or so before the demonstration. Skills Sheet 49 from Year 7 CHAP provides details.	**Resources (for demonstration)** Funnel with a narrow end of about 5 mm in diameter; clamp and stand; lamp; freshly collected leaf litter; large beaker; Year 7 CHAP Skills Sheet 49.	The lamp should be at least 15 cm away from dried leaves, since there is a fire risk. Wash hands after handling leaf litter.	
8Dc	Exploring 1	**Invertebrates** This is a simple practical in which pupils look for woodlice in two different areas and draw conclusions about which areas woodlice prefer and why. • **Must:** pupils follow the instructions on Worksheet 8Dc(3). Encourage them to make suggestions on how to improve the practical (e.g. by using a moisture meter, thermometer, etc. To measure physical environmental factors). • **Should:** ask pupils to plan an investigation to answer the question: What places do woodlice prefer and why? Ask them to assess the risks involved in an investigation like this (they should consider both the risks to themselves, and the risks to other organisms). Ask pupils to think about how they are going to collect their results and how they will make sure that the results are	**Apparatus (per group)** Samples of soil/leaf litter from distinct sites; pooter; specimen tubes; paintbrush. Possibly: hand lens; graph paper; thermometer; light sensor; moisture sensor; datalogger; Worksheets 8Dc(3); Year 7 CHAP Skills Sheets 26, 49.	Pupils must wash their hands after handling leaf litter/ invertebrates. Pooter tubes should be sterilised in Milton® for 30 minutes before and after use. Any animals removed from a habitat should be replaced where they were found. For the Tullgren funnel, the lamp should be at least 15 cm away from the dried leaves, since there is a fire risk.	

		accurate. Pupils could also discuss the best way to display their results once they have been collected and any improvements they could make to the practical (giving reasons for the changes). When examining the results, pupils should be able to say whether their evidence is sufficient or not. • **Could:** challenge pupils to plan an investigation to answer the question using a Tullgren funnel. Ask them to assess the risks involved in an investigation like this.			
8Dc	Exploring 2	**Earthworms and moisture** *Exploring 4* from Topic 8Db could be repeated here but this time with the additional use of a moisture meter to see if there is a relationship between soil moisture and earthworm numbers. Moisture meters are very unreliable; a good evaluation point. A better way of measuring soil moisture is to take a sample of soil, measure its mass and then heat it gently in a low oven (50 °C) until it is dry. By measuring its mass again you can work out the moisture content of the original sample.	**Resources (per group)** Quadrat; mixture of mustard in water; moisture meter; watering can. Optional: access to balance; oven at 50 °C.	Pupils should wash their hands after this investigation – plants and soil may both be contaminated with animal urine and/or faeces. The area where this task is carried out should be assessed for risks beforehand and any obvious physical hazards removed hygienically.	
8Dc	Exploring 3	**Comparing environmental factors** In this practical pupils record how two environmental factors vary in a habitat and then look for a relationship between the two. Whilst doing this they look for and collect small organisms, identify them and count their numbers. They could also take pictures of organisms that they find. Physical environmental factors could be measured using dataloggers.	**Resources (per group)** Access to: pooters, quadrats, hand lenses, white plastic specimen trays, specimen bottles, paint brushes (for handling small invertebrates), camera, light meters, anemometers, moisture meters, pH meters and any other relevant measuring and sampling equipment (e.g. dataloggers), field guides and	Pupils should wash their hands after this investigation – plants and soil may both be contaminated with animal urine and/or faeces. The area where this task is carried out should be assessed for risks	

		Point out to pupils that organisms must be returned to the places in which they were found so that populations of organisms in an area remain as they were and diseases that some animals might have are not spread to new areas. Worksheet 8Dc(4) provides guidance but at the end of the task pupils should compile their findings in the form of a report, which could be word processed. They should include lists of organisms found, any photographs they have taken and graphs of environmental data. They should draw conclusions to say whether there are relationships between the two physical environmental factors that they have measured and between one of those factors and the abundance of certain organisms. The main focus of the reports is likely to be on evaluation. Pupils should be encouraged to think about how they can collect data of this type in a more systematic fashion and how this would help them to collect more reliable data.	keys; Year 7 CHAP Skills Sheets 26, 51; Worksheet 8Dc(4).	beforehand and any obvious physical hazards removed hygiencially. Pooter tubes should be sterilised in Milton® for 30 minutes before and after use. Any animals removed from a habitat should be replaced where they were found.	
8Dc	Explaining 2	**Stevenson's screen (demonstration) (AB)** If your school has a Stevenson's screen, explain what it does. If it's one that needs to be checked and reset each day, explain how automatic datalogging would make the evidence from the screen more reliable. If you have data from a number of years, point out daily and seasonal changes to pupils and ask pupils how they would look for any longer term changes (e.g. global warming). If possible show pupils how to use the data to spot long-term trends. The **AB** spreadsheet link on page 56 opens *Stevenson's screen* – a data set that could be used here.	**Resources (for demonstration)** Access to: Stevenson's screen and monitoring equipment.		

8Dd	Exploring 2	**Plant populations** Tell pupils that daisies, dandelions and plantains are all weeds and grow in similar areas, so are in competition with one another. Ask pupils to plan and carry out an investigation to find out which was the most 'successful' weed in this habitat. This would involve estimating the numbers of each one and determining which is the most successful based on its numbers or area covered. Plans should include how the practical is to be done safely. Ask pupils to think about how they are going to collect their results and how they will make sure that the results are accurate. Pupils could also discuss the best way to display their results once they have been collected and any improvements they could make to the practical (giving reasons for the changes). When examining the results, pupils should be able to say whether their evidence is sufficient or not. • **Must:** pupils should include how the practical is done safely. • **Should:** ask pupils to evaluate this definition of successful and to briefly plan how this could be done. A successful organism is one that out-competes its rivals. It would therefore be necessary to identify whether plants are being replaced by others due to competition. • **Could:** pupils might carry out a pre-investigation check to see if the plants are all evenly distributed over the area (to make sure that they are in competition with one another rather than just preferring different environmental conditions within the same habitat).	**Resources (per group)** Quadrat; possibly access to: light meters, anemometers, moisture meters, pH meters and any other relevant measuring and sampling equipment (e.g. dataloggers).	Pupils should wash their hands after this investigation – plants and soil may both be contaminated with animal urine and/or faeces. The area where this task is carried out should be assessed for risks beforehand and any obvious physical hazards removed hygienically.	

8De	Exploring 2	**Working out food chains 2** Using Skills Sheet 49 from Year 7 CHAP, pupils use a Tullgren funnel to investigate the numbers of organisms in leaf litter. Using secondary sources (including Skills Sheet 51 from Year 7 CHAP) they could identify the animals collected and, based on their relative numbers, construct food chains and/or pyramids of numbers. They could then check with secondary sources to discover if their food chains/pyramids are correct (e.g. that they do not have herbivorous animals like millipedes down as carnivores, and carnivorous animals like centipedes down as herbivores). In general terms, small herbivores are eaten by larger carnivores, which are eaten by even larger carnivores (refer to Skills Sheet 51 from Year 7 CHAP for commonly found examples). As a food chain progresses the numbers of each species decreases. Although it is recommended that the set-up is left for 6 hours, it is possible to get decent results in about 30 minutes and it is often preferable to keep a watch on what is falling out of the funnel since often the carnivores collected will eat any collected herbivores. An inverted paper cone can be taped around the top of the beaker to stop the animals escaping. If you aren't able to use Tullgren funnels, samples of leaf litter can be collected in large plastic trays with pupils hunting for the animals using a paint brush and collecting them with a pooter. Soak all mouthpieces in Milton™ solution for 30 minutes before and after use.	**Resources (per group)** Funnel with 5 mm minimum bore; leaf litter; clamp and clamp stand; large beaker; lamp that can be suspended over leaf litter; hand lens; pooter; specimen jars; sheet of A5 sized paper; sticky tape; Year 7 CHAP Skills Sheets 49 and 51. Possibly: water; 80% ethanol in water. *Or* Leaf litter in a large plastic tray; hand lens; paint brush; pooter.	The lamp should be at least 15 cm away from dried leaves, since there is a fire risk. Pupils should always wash their hands having handled living material.	
8Ea	Starter 1	**Making tea** Make a cup of tea in a beaker by pouring hot or boiling water onto a tea bag. Then write a list of	**Resources** Beaker; tea bag. Optional: ground coffee, cafetiere or coffee filter.	Take care when using hot water.	

		questions on the board and ask pupils to discuss the answers in pairs. After a few minutes, ask each pair to join with another pair, and each group of four should decide on the best answers to each question before having a whole-class feedback session. Suitable questions include: • Describe what you saw happening (elicit words such as transparent, colourless, coloured if necessary). • What is the tea bag for? • Why can the coloured water get through the tea bag? • What other things at home need separating? (Answers could include filters for making 'real' coffee, or sieves for getting lumps out of flour or chips from fat.) A possible alternative is making coffee from ground beans using a filter or a cafetiere. But no drinking it in the lab!			
8Ea	Exploring 2	**Soil filter** The Practical box on page 65 of the Pupil's Book suggests that pupils design a soil filter that could be used for survival in the countryside. • **Must:** pupils follow the instructions on Worksheet 8Ea(2) to build their filter, and then complete the exercise at the bottom of the sheet to explain how it works. • **Should:** Worksheet 8Ea(3) provides brief instructions for the construction of the filter, and then asks pupils to investigate how fast their filter works. • **Could:** pupils could be asked to design their own filter based only on the prompt in the Pupil's Book and/or materials provided, and asked to design their own investigation. They	**Resources (per group)** Plastic drinks bottle (bottom removed – ensure there are no sharp edges); moss or grass; ruler; small stones; sand (or soil); muddy/dirty water to filter (with bits of grass, twigs, etc.); stopclock; beakers; bucket to collect waste; Worksheets 8Ea(2) or 8Ea(3).	Do not allow pupils to drink their water. It could still be contaminated.	

		should evaluate each other's filters based on scientific tests to award one group/pupil with a 'best design' award.			
8Ea	Exploring 3	**Testing solubility** Provide pupils with a selection of solids and ask them to mix a spatula of each with water in a test tube or boiling tube. The mixture can be stirred with a spatula or glass rod. Pupils should be encouraged to use appropriate vocabulary to describe the resulting mixture, and then come to a judgement about whether the solid is soluble or insoluble. • **Should:** ask pupils to explain how they are making judgements about what is soluble and what is not. With some groups it may be appropriate to introduce additional gradations such as 'partially soluble', 'mostly soluble', and so on. You could also include some liquids. • **Could:** a light meter could be used to measure the amount of light coming through each test tube. Note that *Exploring 1* in Topic 8Eb looks at solubility in a more quantitative manner.	**Resources (per group)** 8 test tubes or boiling tubes; glass rods; spatulas. Suggested list of solids: sugar, salt, flour, instant coffee or tea, aspirin*, soap, pepper, baking soda. (*A brand such as Aspro ClearTM will dissolve completely.)	Aspirin can be harmful.	
8Ea	Exploring 4	**Effectiveness of solvents** Pupils compare the effectiveness of solvents in removing different types of marks. It is suggested that you keep a class set of 'offcuts' for this practical – for example material from discarded work surfaces, whiteboards or polished wood. A piece of the board (about 20 cm × 10 cm would be a suitable size) can be marked using a variety of substances, for example ball point pen, washable marker pen, permanent marker, wax crayon and liquid paper, and the marks labelled. Pupils should be	**Resources (per group)** Wooden or work surface 'offcuts' (about 20 cm × 10 cm) marked with (at least three from) biro, marker pens, nail varnish, liquid paper, wax crayon; access to solvents (e.g. Industrial Denatured Alcohol, propanone, white spirit); cloths; disposable gloves (preferably nitrile, not latex); eye protection.	Industrial Denatured Alcohol is highly flammable and harmful. Propanone is an irritant and highly flammable. White spirit is harmful and flammable. Ensure there are no naked flames in the lab. This practical should be carried out	

		given the opportunity to see which of these can be removed easily with a damp cloth. For those marks that are not easily removed in this way, other solvents should be tried, for example 'meths' (now called Industrial Denatured Alcohol), white spirit or propanone (acetone).		in a well-ventilated laboratory. Eye protection should be worn.	
8Ea	Explaining 2	**How to filter** Demonstrate how to use filter paper and a funnel to filter in the lab. Let pupils practise this to produce clean water from pure water plus dirt or from salt solution plus dirt. The products from this process could then be kept to use in the following topic.	**Resources (per group)** Funnel; filter paper; beaker; conical flask; samples of dirty water.		
8Eb	Starter 1	**Dissolving and mass** Have a couple of beakers of water ready and a balance. Let pupils see you finding the mass of the beaker of water, and the mass of some sand and some salt. Ask pupils to work in groups of 2 to 4 to discuss the answers to questions such as: • **Must:** what will happen to the sand if I add it to the water? What will happen if I put the salt in the water? What will happen if I keep adding more salt? Will this change if I heat up the water? • **Should:** what will the mass be if I add the sand to the water? What will happen to the mass when I add the salt to the water? Explain these answers. Will more sugar dissolve or more salt? • **Could:** how will the amount that dissolved change if there is more water? Ask for feedback on each question as you work through the demonstrations, if necessary eliciting the idea that all the original particles of	**Resources** Beakers of water; sand; salt; balance; stirring rod.		

		salt (sodium chloride) are still present in a solution, even if they cannot be seen. Pupils may realise from their own experience, or from KS2 work, that there is a limit to the amount of a solute that will dissolve in a certain volume of water.			
8Eb	Exploring 1	**How much salt/sugar will dissolve?** Salt and sugar are suggested in the Pupil's Book as suitable examples of solutes which might dissolve in different amounts. Note that the solubility of sodium chloride at 25 °C is approximately 36 g/100 ml, whereas the solubility of sucrose is over 200 g/100 ml. You may therefore wish to encourage pupils to use small volumes of water. • **Must:** pupils can follow a simple method based on, for example, counting the number of spatulas of solid that will dissolve in a given volume of water. • **Should:** pupils should be encouraged to develop a more sophisticated approach based on measuring out masses of solid. The solid should be added until no more dissolves.	**Resources (per group)** Salt; sugar; beaker (10 cm3); spatula. Optional: access to balances.		
8Eb	Exploring 2	**Temperature and solubility** Pupils can be asked to investigate the effect of the temperature of a solvent on the solubility of a solute. A variety of methods are possible. • **Must:** Worksheet 8Eb(3) presents the simplest method, whereby students find out how many spatulas of potassium chloride (referred to as 'salt' on the worksheet, for simplicity) dissolve in a fixed quantity of water at different temperatures. Ensure that pupils understand that it is the quantity of solute they are investigating, not how fast it dissolves. If you	**Resources (per group)** Potassium chloride; boiling tube; spatula; heating apparatus or access to kettle; access to balances (optional); Worksheets 8Eb(3) or 8Eb(4); eye protection.	Eye protection should be worn. Copper sulphate is harmful.	

		have water baths available, pupils should stand their beakers in water at appropriate temperatures. If not, then pupils should be encouraged to realise that if they heat the water to the appropriate temperature, and then put salt in, the water will be cooling down while they carry out their experiment. • **Should:** a more accurate method is to prepare hot solutions with different quantities of solute, and cool them until crystals start to appear. This method is outlined on Worksheet 8Eb(4), which suggests using copper sulphate, as the formation of coloured crystals will be easier to see. If time permits, pupils can prepare a range of solutions, or each group can be allocated a particular mass of solute and results can be pooled. Alternatively, different groups can investigate the solubility of different salts with temperature. Pupils can produce graphs of solubility against temperature. If there is time, pupils could be encouraged to plan this practical before they are given the method on Worksheet 8Eb(4). Pupils should attempt to identify the variables in this experiment and also any possible safety issues. You could discuss with them the difficulty of deciding on an end point and how they will record their results. At the end of practical lesson, you could discuss with pupils the reliability of their results and if they have sufficient data to be able to draw a conclusion. Any suggestions about improvements to the practical should be accompanied by a reason for the suggested change. Pupils could also be encouraged to pool their results and think about how these could be manipulated to help provide			

		further evidence for their conclusion. • **Could:** pupils could be asked to extend their investigation to the solubility of various substances in different solvents. This practical can be used to carry out an AT1 investigation. A set of level descriptions is provided on pages 153–154 of the ASP.			
8Eb	Exploring 3	**How fast does sugar dissolve?** The time taken for materials to dissolve can be investigated in the laboratory using sugar as an example. In this case a number of variables could be investigated, e.g. temperature, amount of solute, volume of solvent, type of sugar (granulated, caster, lump, etc.). This experiment can also be adapted to be carried out at home. Note that most pupils will have carried out an experiment into the speed of dissolving at KS2, but may not have investigated all the variables listed.	**Resources (per group)** Sugar (granulated, caster, lump, etc.); water; stopclock; beakers; heating apparatus; thermometer; spatulas; access to balance; mortar and pestle; copper sulphate.		
8Eb	Plenary 1	**Snowstorm in a test tube** Lead iodide provides a very good visual demonstration of the change of solubility with temperature, although this does not lead to the production of large crystals. Heat a little lead iodide in a boiling tube about half full of distilled water. Alternatively, the lead iodide may be precipitated by mixing equal volumes of dilute potassium iodide and lead nitrate solutions. The solid will dissolve when the water is close to boiling point. Allow the solution to cool slowly and crystals of lead iodide will precipitate as a 'golden snowstorm' effect – the glittering crystals give quite a spectacular effect as they fl oat in the water. Once a set of tubes has been set up, they can be re-used repeatedly. Show	**Resources** Boiling tubes; lead iodide (solid); 250 cm3 beakers. Alternatively, use dilute lead nitrate and potassium iodide solutions (0.005 mol dm–3); eye protection.	Lead compounds are toxic. Wash hands after handling them. Eye protection should be worn.	

		pupils the demonstration, and ask them to explain why it happens.			
8Ec	Starter 1	**Separating sand and salt** Show pupils a small pile of salt, then mix it with some sand and ask pupils to work in small groups to suggest a way of separating the salt and sand again. • **Must:** show pupils a beaker of water, filtering and heating apparatus to act as a hint. • **Should:** pupils should work out a method without seeing the apparatus. Pupils will have allowed solutions to evaporate to dryness at KS2, but may not remember the details of what they did, or have had the opportunity to heat a solution to obtain a dissolved solid.	**Resources** Salt; sand; beaker of water; heating apparatus; eye protection.	Eye protection must be worn when heating.	
8Ec	Starter 2	**Hard water (demonstration)** Put pupils into groups and give each group samples of hard water and soft water mixed with soap solution. Put this into context by telling them that the different samples have come from different parts of the country. Ask the groups to shake the tubes and to comment on what they observe. Elicit the idea that the two samples of water must have different chemicals dissolved in them, and ask for suggestions as to how this can be determined. If necessary, ask what will happen if the water is heated. Pupils will have allowed solutions to evaporate to dryness at KS2, but may not remember the details of what they did, and may not have had the opportunity to heat a solution to obtain a dissolved solid.	**Resources (per group)** Samples of hard and soft water; soap solution; boiling tubes. If you are in a hard water area, use distilled water for your soft water. If you are in a soft water area, add approximately 0.45 g of calcium sulphate per litre of water to make up the hard water sample.		
8Ec	Exploring 1	**Investigating water** Pupils analyse three or more different water samples to determine how pure they are – the	**Resources (per group)** Measuring cylinder; balance; labelled water samples (made up	Check pupils' plans before they start. Eye protection must be	

		most pure will contain the least dissolved solid. Heating a known and fixed volume of each of the water samples will enable a fair comparison to be made. If you make up water samples for use (from distilled water plus different quantities of salts), keep a note of the quantities used to help you to assess the accuracy of pupils' findings. You may wish to carry out *Explaining 1* (demonstrating how to evaporate a solution to dryness safely) before pupils carry this out. • **Must:** instructions are provided on Worksheet 8Ec(2). • **Should:** an apparatus list and hints for pupils to plan their own method are provided on Worksheet 8Ec(3).	with different quantities of dissolved salts); evaporating basin; heating apparatus; eye protection; Worksheet 8Ec(2) or 8Ec(3).	worn.	
8Ec	Exploring 2	**Salt from rock salt** Pupils can obtain samples of pure salt from rock salt. This will provide further practice in the techniques of filtering and evaporation. You can give this practical a context by providing 'samples' of rock salt from different mines, and ask pupils to determine which would be the best 'mine' to use for making salt. They should be encouraged to use distilled water to avoid any salts in tap water affecting their results. You may wish to carry out *Explaining 1* (demonstrating how to evaporate a solution to dryness safely) before pupils carry this out. • **Must:** show pupils how to do the practical, and then ask them to use Worksheet 8Ec(5) to explain the process. • **Should:** pupils follow the instructions on Worksheet 8Ec(6) and answer the questions. • **Could:** ask pupils to work in groups to plan their own method, and to explain the reasons for	**Resources (per group)** Rock salt, or a variety of rock salt samples (see below); access to electronic top pan balance; mortar and pestle; evaporating basin; filter funnels and papers; beaker; conical fl ask; stirring rod; heating apparatus; eye protection; Worksheet 8Ec(5). For a table giving further information, please see page 149 of the teacher's guide If possible, different grades and/or colours of sand should be used to alter the appearance of the samples.	Eye protection must be worn. Do NOT heat the salt to dryness in the evaporating basin. Hot specks of salt will spit out. Stop heating when crystals are forming at the edge and let the last of the water evaporate without heating.	

		each step.			
8Ec	Exploring 3	**Testing water for hardness (AT)** Ask pupils to test different samples of water for hardness, by shaking up a sample of water with some soap solution and measuring the height of the lather produced. Pupils will have seen what happens if you have carried out *Starter 2*. If this has not been done, the first **AT** presentation link on page 69 opens *Testing water for hardness* – which shows the effects of adding different quantities of soap solution to different water samples. Pupils should discuss how to measure the results of the practical and how the observations are appropriate to the task. • **Must:** show pupils what to do, and ask them to test and rank the samples in terms of hardness. • **Should:** ask pupils to plan a fair, quantitative investigation, and write a report stating the relative hardness of the different samples in terms of the height of lather formed.	**Resources (per group)** Numbered water samples made up using distilled water and calcium sulphate (see below); boiling tubes; measuring cylinders; soap solution; ruler. For a table giving further information, please see page 149 of the teacher's guide		
8Ec	Explaining 1	**Evaporating** Demonstrate or let pupils practise evaporation of a solution to dryness. Instructions are provided on Worksheet 8Ec(4). Heat a solution until a little remains so that the solid can be formed as the heat stored in the watch glass or evaporating basin evaporates this remaining amount. This will stop the solid residue from 'spitting' at the pupils and also limit the number of breakages! This process is known as heating to dryness. If the solid is heated beyond this point, it may 'jump' out of the container and be changed by the heat.	**Resources (per group)** Evaporating basin; copper sulphate solution; heating apparatus; beaker; eye protection; Bunsen burners; Worksheet 8Ec(4).	Copper sulphate is harmful when solid or in concentrated solution. Eye protection must be worn.	
8Ec	Explaining 3	**Modelling filtration and evaporation (demonstration)**	**Resources (per demonstration)** Flour, powdered copper sulphate		

		This demonstration can be linked to *Exploring 2* which asks pupils to extract salt from rock salt. Show pupils a mixture of fl our, powdered copper sulphate and dried pea or lentils. The flour represents the water, the copper sulphate is the salt and the peas represent the sand and dirt. Shake the mixture in a sieve, collecting the flour and copper sulphate in a basin below. Pupils should understand that the sieve is acting as the filter paper would. Ask pupils to think about this as a model and to relate it to their knowledge of particles.	(or other coloured powder), dried peas or lentils, sieve, basin.		
8Ed	Starter 1	**Chromatography introduction** Demonstrate chromatography to the whole class as a starter activity. Use a dark-coloured ink that includes a range of different colours to make the chromatogram more interesting (either test different pens containing water soluble inks to find one with a good mix of colours, or make up a mixture of different coloured inks). If time is short, you may wish to have a ready-prepared chromatogram made from the same ink, so that you do not have to wait too long for the water to travel up the paper. Some pupils may have used chromatography at KS2 to investigate the mix of colours in ink or in the dye used to colour Smarties™, so this starter is a good way of finding out what pupils already know.	**Resources** Mix of coloured ink; chromatography paper or filter paper; beaker of water; support for paper; pipette. OR: pre-prepared chromatogram made from a mix of coloured inks.		
8Ed	Exploring 1	**Chromatography of inks** The easiest way to set this up is as shown on Skills Sheet 54 from Year 7 CHAP. Remember to check that you have a variety of felt-tipped pens that have water-soluble inks. It is possible to get a range of black pens that are all water	**Resources (per group)** 100 cm3 beaker; water; filter paper; scissors; water-soluble ink; access to means of drying filter papers; Year 7 CHAP Skills Sheet 54.		

		soluble, but that contain different mixtures of coloured inks. The use of a non-water-soluble based black pen will make the point about the solubility of the ink used, but do not get pupils to try this one as their only chromatogram – they will only get frustrated if they have no pattern to see at the end. Ensure that chromatograms are removed from the solvent before the water soaks to the top/edge. Any labels/marks on the paper should be made in pencil so they are unaffected by the solvent.			
8Ed	Exploring 2	**Chromatography using food colourings** This is similar to *Exploring 1*, but more easily set up using the second method shown on Skills Sheet 54 from Year 7 CHAP. A small spot of each food colouring should be placed on a different spot along the pencil line. Make sure that the pencil line on the chromatography paper is at least 0.5 cm above the water level in the beaker.	**Resources (per group)** 100 cm3 beaker; water; filter paper; scissors; a range of food colourings; access to means of drying filter papers; Year 7 CHAP Skills Sheet 54.		
8Ed	Exploring 3	**Getting it right** Worksheet 8Ec(3) lists some mistakes that could be made when carrying out chromatography, and asks pupils to suggest what could happen if these mistakes are made. This sheet could just form the basis for individual work or a class discussion, or the answers to the questions could be treated as predictions that pupils can then check.	**Resources (per group)** Water-soluble and permanent inks; large beakers/jars; pencils and rulers; water; square filter paper or chromatography paper; samples of food colourings with fine pipettes; access to means of drying filter papers; Year 7 CHAP Skills Sheet 54.		
8Ed	Explaining 1	**Biro ink** Demonstrate that a chromatogram can be made from a non-water-soluble ink by using a solvent in which the inks do dissolve.	**Resources** 100 cm3 beaker; ethanol (or Industrial Denatured Alcohol); biro pen or a ‘permanent’ marker pen.	Ethanol is highly flammable. Industrial Denatured Alcohol is highly flammable and harmful.	

8Ee	Starter 2	**Distillation brainstorm** Start by asking pupils to think about evaporating a solution and what is left in the basin, and what they would need to do if it was the water from the solution they wanted to keep, rather than the solute. Put pupils into groups and pose questions for them to discuss in their groups before having a class feedback session. • **Must:** show pupils the apparatus needed for simple distillation and ask them to suggest how it works, including any safety precautions they should take. • **Should:** ask pupils to work out how to obtain water from a solution without showing them the apparatus first. They should describe the kind of apparatus they would need and how to use it. • **Could:** as for Should, but have a further discussion session to see if pupils can work out how to separate two liquids with different boiling points.	**Resources** Bunsen burner; tripod; gauze; evaporating basin; heatproof mat.		
8Ee	Exploring 1	**Distilling ink** Pupils distil ink using side-arm test-tubes. Ensure that the tube or fl ask is not allowed to boil dry. (If boiling tubes with delivery tubes are used, bungs with two holes will be needed so that a thermometer can be used.) Pupils should be instructed to heat the inky water gently to avoid it bubbling over into the delivery tube. Note that if the apparatus has been used for distilling ink by earlier classes, the water produced may not be clear if earlier users have allowed the ink to boil over.	**Resources (per group)** Side-arm test-tubes, or boiling tubes with delivery tubes; heating apparatus; heatproof mat; inky water; anti-bumping granules; thermometer and bung (to fit test tubes); collecting beaker; eye protection.	Eye protection should be worn. Do not fill the boiling tube more than 1 / 3 full.	
8Ee	Exploring 2	**Survival still** Pupils produce a survival 'still' using a black plastic bag and a clean container. Support the	**Resources (per group)** Black bin liners; garden trowel; string; canes/sticks; stones; sticky	Ensure that pupils wash their hands after contact with the	

		black bag (in a bowl shape), just above some freshly dug/exposed earth on a hot day, with the container under the plastic to catch the drips of condensation. Some possible methods are illustrated below. For a diagram giving further information, please see page 155 of the teacher's guide	tape; clean container (e.g. plastic cup/jam jar); access to open ground.	soil.	
8Ee	Explaining 3	**Liebig condenser** Demonstrate the distillation of inky water, using a Liebig condenser. Pupils should be told that ink is often made by dissolving solids in water. Heat the fl ask gently whilst the mixture boils. Point out the reading on the thermometer, condensation inside the condenser and collection of the pure water. Discuss with pupils the reason why the water in the cooling jacket goes in at the bottom.	**Resources** Long neck, side-arm round-bottomed fl ask; Liebig condenser; water supply; anti-bumping granules; thermometer and bung; Bunsen burner; ink/water mixture; heatproof mat; eye protection.	Eye protection should be worn.	
8Ee	Explaining 4	**Distilling alcohol/water** Demonstrate the distillation of an alcohol/water mixture using an electric heating mantle to avoid alcohol fumes igniting and giving a flash flame. Demonstrate to pupils how to smell chemicals safely (fill the lungs with clean air, then wave a hand above the container to waft the smell towards you). Identify alcohol by smell (do not allow pupils to take a large sniff or taste it). This demonstration can be more effective if Completely Denatured Alcohol (CDA) is used (but be aware that this is very smelly!) – the dye remains in the flask.	**Resources (per group)** Long neck, side-arm conical fl ask; Liebig condenser; water supply; anti-bumping granules; thermometer and bung; electric heating mantle; mixture of 20cm3 ethanol or Completely Denatured Alcohol to 150cm3 water; heatproof mat; eye protection.	Ethanol is highly flammable. Completely Denatured Alcohol is highly flammable and harmful. Eye protection should be worn. Ensure that pupils smell the distillate following the recommended method.	
8Fa	Starter 2	**Sorting materials** Pupils' existing ideas about materials can be determined by showing pupils a collection of different kinds of materials, and asking them	**Resources** A display of samples of various materials, each labelled with the name and hazard symbol; heat-	Mercury (toxic), chlorine (toxic) and bromine (very toxic and corrosive) should	

		how they might be sorted. Possibilities include: solids, liquids and gases, metals and non-metals, natural and manufactured. Discuss which of the materials can be recycled. Teachers can record pupils' answers for use in *Starter 1* in Topic 8Fe.	resistant mat; eye protection. Possible materials: sulphur, copper, mercury, chlorine, bromine, oxygen, iron, carbon, aluminium, wood, polythene (or other plastic), glass, brass, limestone, brick.	be stored in strong, sealed containers. The correct hazard warning symbols should be on the containers. If there are doubts about the capability of the class to examine these samples without damaging the containers, do not use these substances.	
8Fa	Explaining 3	**Limelight (demonstration)** Explain that when lime (calcium oxide) is heated, it does not turn into a different chemical but it does glow with a bright white light. This was first used in 1855 for theatre spotlights, before electric lighting. The actor was said to be 'in the limelight' – a phrase that we still use today. The effect can be demonstrated to some extent using a piece of limestone held in a roaring Bunsen flame. Calcium oxide is produced *in situ*, and a glow should be seen, although the full effect would need the higher temperatures attainable with a hydrogen/oxygen or oxy-acetylene flame. Because of the difficulty of decomposing lime using heat, it was believed to be an element (one of the alkaline 'earths' or rocks), until the discovery of calcium metal in 1808. A similar effect can be seen with a gas mantle at a lower temperature, although in this case the oxide used is not calcium.	**Resources (for demonstration)** Tongs; limestone chip; Bunsen burner; heat-resistant mat; eye protection. Optional: blowpipe; glassblowing burner; gas powered camping light with mantle.		
8Fc	Exploring 1	**What is a metal?**	**Resources (per group)**	Check pupils' plans	

		Pupils carry out three tests to examine the thermal conduction, electrical conduction and density of metals. A number of the tests draw on ideas introduced in earlier units. • **Must:** Worksheet 8Fc(2) gives a structured approach to the three properties tested. • **Should/Could:** pupils use the more open-ended approach on Worksheet 8Fc(3) to help plan an investigation to classify substances as metals or non-metals using three properties.	Test (1): 250cm3 beaker; access to kettle; rods of iron, copper, plastic, wood, glass and aluminium. Test (2): Circuit board or equivalent; cell; connecting wires; bulb; crocodile clips; samples as for Experiment 1. Test (3): Blocks/cubes of materials as listed in (1) (*which must have equal dimensions)*; access to balance. Worksheets 8Fc(2), 8Fc(3).	before the practical work starts.	
8Fc	Exploring 2	**sorting metals** Pupils use a ramp and magnet system to design a simple materials sorter. In the real world context, magnets would be used to separate iron from other metals. If ball bearings of non-ferrous metals can be obtained, this would be the most realistic set-up. In practice, it is likely that a separation of steel ball bearings from glass marbles is a more practical option. Tell pupils that you are using this arrangement to model the behaviour in a genuine recycling facility. • **Must:** instructions are provided on Worksheet 8Fc(4) – this is a trial and error method, and pupils are encouraged to experiment with varying the magnet position and position of the marbles on the ramp to provide a reliable separation that will collect the different marbles in the two 'bins'. • **Should/Could:** Worksheet 8Fc(5) provides prompts to help pupils to plan their own, more formal, systematic investigation to look at the effect of one or more variables on the amount of deflection of the ball bearings.	**Resources (per group)** Ramps; magnets (ceramic magnets will probably be best); two plastic pots (e.g. small ice cream containers); metre ruler; ball bearings; glass marbles of roughly similar size to ball bearings; Worksheet 8Fc(4) or Worksheet 8Fc(5).	Care should be taken to avoid the marbles going on the floor.	

8Fd	Starter 1	**making compounds** These are intended as teacher demonstrations only. Some or all of these demonstrations can be used as a way of showing that a compound can be very different from the elements that make it up, as well as a way of engaging pupils' interest. **a** Demonstrate the reactions that take place when copper and magnesium are heated in the air. Warn pupils not to stare directly at the flame; they should look through a narrow gap between their fingers. **b** The reaction of iron with chlorine can be demonstrated by heating some wire wool on the end of a deflagrating spoon. Once the wool starts sparking or glowing, it should be placed into a gas jar of chlorine (toxic). Dense brown fumes of iron(III) chloride are formed as the iron burns in the chlorine. **c** The reaction of aluminium and iodine can take place at room temperature, and is catalysed by the presence of water. Mix 5 g of aluminium powder (highly flammable) and 5 g of iodine crystals (corrosive) together in an evaporating dish. Add about five drops of water with a little detergent, and leave the reaction mixture to stand. After an induction period of 1–2 minutes, a vigorous reaction takes place. The heat generated by the reaction is usually sufficient to vaporise some of the iodine, and clouds of purple vapour (harmful) are produced. **d** A small balloon filled with hydrogen can be burnt safely by attaching it to a long piece of string (above pupil height), or by allowing it to fl oat on to the ceiling of the room (ensure there are no flammable ceiling tiles). Ignition can be	**Resources** Copper foil; magnesium ribbon; Bunsen burner; tongs; aluminium powder; iodine (solid); gas jar of chlorine; deflagrating spoon; iron wool; eye protection; balloon or gas jar filled with hydrogen; metre rule; splint; detergent.	Eye protection should be worn by demonstrator and audience for all these demonstrations. Chlorine is toxic. This reaction should be carried out in a fume cupboard. This reaction must be carried out in a fume cupboard. Hazardous fumes of iodine are likely to be released. Iodine is harmful and crystallises painfully on the eye. A small volume, totalling no more than 250 cm3, can be ignited inside a laboratory. Exploding a hydrogen/oxygen mixture is significantly more dangerous and should not be attempted in a confined space. Hearing protection should be used by the demonstrator if a large volume of hydrogen and oxygen is exploded outside	

		effected by means of a lighted splint attached to the end of a metre stick or broom handle.		and the audience should be at least 10 metres away. If the school does not possess a hydrogen cylinder, a gas jar of hydrogen could be ignited – this will revise the 'squeaky pop' test introduced in Year 7. Pupils should wear eye protection.	
8Fd	Exploring 1	**Practical: Burning magnesium page 87 (AB/AT)** This is a good opportunity for the development of both practical skills and theoretical understanding. This practical can be used to carry out an AT1 investigation. A set of level descriptions is provided on pages 180–182 of the ASP. Worksheets 8Fd(2) and 8Fd(3) accompany this practical. You may wish to give pupils some time to discuss and think about their predictions before starting the practical work. A class prediction, with each person voting on their thoughts on the change of mass, will often produce a majority expecting a mass decrease. Pupils should heat magnesium in a crucible, having taken the mass before heating. Strips of magnesium about 8–15 cm long will be needed to generate a sufficient change of mass to be detected reliably. A balance reading to 0.01 g will be needed – readings to 0.1 g are unlikely to be sufficiently accurate to show up the differences in mass. While pupils will probably	**Resources (per group)** Pipe clay triangle; crucible and lid; tongs; tripod; Bunsen burner; heat-resistant mat; eye protection; access to balance capable of reading to 0.01 g; Worksheet 8Fd(2); Worksheet 8Fd(3).		

		be conscious of the need to keep the smoke in, the main errors in practice are likely to result from insufficient heating, so that some magnesium remains unreacted. Strong heating is therefore needed. The theoretical gain in mass would be 67%. • **Must:** pupils use the structured support sheet 8Fd(2) to record their results and carry out the calculations. The **AB/AT** spreadsheet link opens *Burning magnesium* – a spreadsheet version of the results table so that pupils enter their experimental data and the computer calculates the gain (or loss!) in mass automatically. This will enable you to tabulate class results – you can then give a printout to pupils so that analysis could take place after the class. • **Should:** pupils use Worksheet 8Fd(3) and tabulate their results in a format of their own design. They work out which calculations need to be undertaken to work out whether there is a gain or loss in mass. • **Could:** introduce the idea of reheating the magnesium oxide to constant mass to check that the reaction has been completed, increasing the reliability of the results. This activity gives pupils the opportunity to study secondary evidence (i.e. the class results). If there are some results that do not fit the pattern you could ask pupils what would happen to the class result if you just used the anomalous results or if you just used only the ones that matched the prediction. If you have time, you could put the results into a spreadsheet and look at the effects of selection and rejection of data.			
8Fe	Exploring 1	**Recycling paper**	**Resources (per group)**		

		Worksheet 8Fe(2) gives a practical method for making recycled paper from old newspaper. Alternatively, given the resources required, this task could be set as a homework. The paper produced could be used for display work.	400 cm3 (or larger) beaker; wire coat hanger; nylon stocking; plastic mixing bowl or washing up bowl; cutting board; paper towels; (access to) food blender; electric iron; mops/cloths to deal with wet, slippy floors.		
8Ga	Exploring 1	**Iron and sulphur** Pupils can make a compound from the two elements iron and sulphur. • **Must:** pupils follow instructions on Worksheet 8Ga(3), which also provides guidance on recording and considering results. • **Should:** pupils use Worksheet 8Ga(4) to plan their investigation. A mixture of iron and sulphur, about 1/5 g, can be heated in an ignition tube. Once the reaction has started the tube should be removed from the flame, and the red glow will continue to spread through the tube, indicating that a reaction is taking place. To remove the iron sulphide it will almost certainly be necessary to break the tube – for this reason the use of small ignition tubes is recommended. To remove the iron sulphide from the tube, wrap the tube in a cloth or rag and break the glass with a pestle or hammer. Use tongs to pick up the pieces of iron sulphide. Alternatively, the reaction could be carried out on a larger scale as a teacher demonstration (using 2 g of mixture). There is some risk of the sulphur catching fire to form the toxic gas sulphur dioxide. This risk is reduced if excess iron is used. A mineral wool plug in the mouth of the tube will also reduce the risk of sulphur vapour escaping and igniting to form sulphur dioxide. The stoichiometric ratio of iron	**Resources (per group)** Test tubes; test tube rack; one small test tube (ignition tube); ignition tube holder; Bunsen burner; mineral wool; magnet; iron; sulphur; mixture of iron and sulphur (2:1 mixture of iron to sulphur by mass); heatproof mat; cloth or rag; pestle or hammer; tongs; eye protection; Worksheet 8Ga(3) or 8Ga(4).	Hydrogen sulphide is very toxic and extremely flammable. Although the quantities involved are likely to be small, this reaction should be carried out in a fume cupboard. The human nose can detect hydrogen sulphide in very low concentrations. Eye protection should be worn when heating the iron and sulphur and when breaking the glass. Broken glass should be placed in the broken glass bin.	

		to sulphur is 1:1 in terms of atoms, or 56:32 in terms of mass. The exact ratio by mass will therefore be 7:4; a 2:1 mixture of iron to sulphur will therefore contain a small excess of iron. Pupils are asked to test iron filings, sulphur and sulphur dioxide for magnetism and flotation. It is a good idea to use bought samples of iron sulphide for these tests. The iron sulphide formed from the pupils' practical is likely to be attracted to the magnet (due to the excess iron in the mixture, iron sulphide is not magnetic). Pupils could be asked to test the substances with dilute acid. Iron sulphide should release the gas hydrogen sulphide. This gas has a strong and distinctive smell. Iron filings should give off the gas hydrogen but if the iron filings contain even minute quantities of iron sulphide then a 'false positive' will be obtained (i.e. the smell of hydrogen sulphide). For these reasons, this test has not been included on the worksheets, and teachers are recommended to try out the test in advance with the iron filings that they have in stock to judge whether it is worth adding this test to the magnetism and flotation tests.			
8Gb	Starter 1	**Physical and chemical change** Remind pupils of the criteria for deciding whether or not a chemical reaction has occurred (colour change, evolution of gas, energy change) by demonstrating a few chemical reactions and physical changes. Discuss with pupils what they observe. Pupils should have encountered reversible and irreversible changes at KS2, and discussing these reactions is one way of assessing their prior knowledge. Ask pupils which changes are physical changes and which are chemical reactions, and ask them to	**Resources (for demonstration)** 0.5 mol dm-3 lead nitration solution; 0.5 mol dm-3 potassium iodide solution; 0.5 mol dm-3 hydrochloric acid; zinc granules; boiling tubes and rack or conical fl asks; lemon juice; bicarbonate of soda; baking powder; plaster of Paris; zinc oxide (solid); iron wool (or filings); 0.5 mol dm-3 copper sulphate solution; anhydrous copper sulphate; thermometer (0 –	Lead nitrate solution and lead iodide are toxic. Hydrogen gas is flammable. Solid copper sulphate is harmful.	

		explain how they made their decisions. • Lead nitrate solution mixed with potassium iodide solution will give a vivid yellow precipitate of lead iodide. • Pieces of zinc placed into a beaker of dilute hydrochloric acid will show some fizzing due to hydrogen gas being given off. • Ice melting. • Changes suggested in Topic 7Fa (*Exploring 3*). • Displacement reaction shown in the Pupil's Book between iron and copper sulphate solution.	100 °C); spatula; heatproof mat; Bunsen burner; ice cubes. Note: plaster of Paris is $CaSO_4.½H_2O$. Some substitutes used for model making are not genuine plaster of Paris.		
8Gb	Exploring 1	**Is there a reaction? Observing chemical changes** Pupils should be asked to carry out, in test tubes, some chemical reactions in which visible changes occur. Pupils could be reminded of the criteria for deciding whether a reaction has occurred. They should be reminded that they are looking for evidence that new materials have been made using chemical reactions. • **Must:** pupils follow instructions on Worksheet 8Gb(2) which also provides guidance on recording results. • **Should:** pupils use Worksheet 8Gb(3) to plan their investigation and record their results. Some pupils may then be able to go on to produce word equations for some of the reactions. **Likely outcomes** **1** Sugar will melt (physical change) and start to darken (chemical change). If heating is excessive, the sugar will decompose to black carbon and steam will be given off. **2** Initially a pale blue gelatinous precipitate	**Resources (per group)** Test tube rack; test tubes; Bunsen burner; heatproof mat; thermometer; eye protection; Worksheets 8Gb(2) or 8Gb(3); access to: sugar (sucrose); copper sulphate solution (0.4 mol dm^{-3}); dilute hydrochloric acid (0.4 mol dm^{-3}); ammonia solution (0.4 mol dm^{-3}); magnesium carbonate (solid); iron chloride solution (0.2 mol dm^{-3}); sodium carbonate solution (0.4 mol dm^{-3}); salt (solid); anhydrous copper sulphate (solid); Worksheets 8Gb(2) and 8Gb(3).	At the concentration suggested, the chemicals are low hazard. Copper sulphate solid is harmful however. Eye protection should be worn as a matter of good practice.	

		(copper(II) hydroxide) will form. With excess ammonia, the precipitate will redissolve to give a dark blue solution containing a complex copper/ammonia ion. **3** Fizzing will occur as carbon dioxide is given off. A solution of magnesium chloride is formed. Temperature will probably fall slightly. **4** Blue/green precipitate of iron(II) carbonate will form – together with some iron(II) hydroxide. **5** No reaction will occur, unless you get the tube hot enough to melt the salt. **6** Copper sulphate turns from white to blue. Some of the copper sulphate will dissolve in the water. There is a temperature rise.			
8Gb	Explaining 2	**Concentrated sulphuric acid and sugar** A demonstration of the dehydration effect is the decomposition of sugars using concentrated sulphuric acid. The reaction is sufficiently exothermic to convert some of the water formed into steam, which results in the formation of a 'foam' of carbon, which rises up out of the beaker. This allows discussion of the chemical and physical changes that occur. In addition this is a spectacular example of a chemical reaction which does not need heat energy supplied to start it off.	**Resources (for demonstration)** Concentrated sulphuric acid (corrosive); sugar (granulated or caster sugar); beaker or jam jar; glass rod.	This reaction must be carried out in a fume cupboard, as quantities of sulphur dioxide and carbon monoxide may also be formed in side reactions. Concentrated sulphuric acid is corrosive.	
8Gc	Exploring 1	**What sort of water?** This activity builds on techniques developed in Unit 8E in a slightly different context. • **Must:** pupils follow instructions on Worksheet 8Gc(2) which also provides guidance on recording and considering results. • **Should:** pupils use Worksheet 8Gc(3) to plan their investigation and record their results. Pupils carry out a number of tests on different	**Resources (per group)** Universal indicator paper and colour charts; 4 watch glasses; boiling tubes; boiling tube holders; eye protection; infrared heat lamps (if available); samples of pure (distilled or deionised water); mineral water (still); 'sea water' (this should contain enough dissolved salt to	Wear eye protection.	

		water samples to identify which is which. The activity revises practical skills and techniques, and reinforces the idea that properties of a mixture are different from that of a pure substance. There is unlikely to be much difference between the pH of the different waters (test 1), although distilled water is usually slightly acidic (due to dissolved carbon dioxide – so it isn't *totally* pure!) and some mineral waters are slightly alkaline, typically pH 8. In test 2, evaporation using an infrared lamp will speed up the process, and ensure that all results are obtained within the lesson. If 'natural' methods are used, the dishes may have to be left overnight. Sea water should leave the greatest amount of solid, followed by mineral water, and then distilled water, which should leave little, if any, mark on the watch glass. If tap water is used, the solid deposit will reflect the hardness of water in your area.	give a noticeable elevation of the boiling point and leave a definite deposit when the water is evaporated); tap water; Worksheets 8Gc(2) or 8Gc(3). NB: only 3 of the samples are used on Worksheet 8Gc(2).		
8Gd	Starter 1	**Alloying (demonstration)** Introduce alloys by demonstrating the formation of the lead/tin alloy solder. This is formed by simply mixing small strips of each metal in a ceramic bowl, heating until molten and pouring onto a ceramic tile in a (wooden) tray. Any amounts of each metal can be used. Alloys are mixtures and there is no formula for an alloy. Emphasise that mixing in alloys alters the properties of the metal. Show pupils the mixture and ask them what it is. Then add more tin and ask them what it is again. Make sure pupils understand that this is a mixture of tin and lead, not a compound, and mixtures can have different proportions. Ask pupils to comment on	**Resources (for demonstration)** Bunsen Burner; tripod stand; ceramic bowls; tin and lead foil.	Wear eye protection. Care needed with molten metals. Lead and lead compounds are toxic.	

		colours of tin/lead solder. • **Could:** you could also show that solder has a lower melting point than lead or tin and this is why it is more useful. This can be demonstrated (with some practice) by heating a metal lid with a piece of lead, tin and solder on it. Note the lowest melting point of lead/tin solder is approximately 60% tin and 40% lead by mass. NB: the use of lead-based solder is being phased out.			
8Gd	Exploring 3	**More about conductivity** Pupils can do simple experiments to illustrate some ideas about conductivity. They should start by testing the conductivity of a range of materials, using a simple circuit, with an ammeter, bell or bulb used to test for conductors and insulators. They should find that all metals conduct electricity while non-metals like pure water and all solid compounds do not. **Could:** Then show that some solids dissolved in water will conduct electricity. Introduce the term 'electrolysis'. Ask the pupils to classify the substances by their conductivity.	**Resources (for demonstration)** Variable low-voltage power supply 1–12 volts; demonstration ammeter; 2 wires and crocodile clips; carbon electrodes; fine emery paper; 100/200 cm3 beakers; copper rod; tin sheet; mercury; pure water; ethanol; copper chloride; sodium chloride; sodium carbonate and sucrose.	Wear eye protection. Care needed with copper chloride solution. Mercury is toxic. Ethanol is highly flammable and harmful. Copper chloride solid is harmful and sodium carbonate solid is an irritant.	
8Gd	Exploring 5	**Nickel electroplating** Introduce the experiment by reviewing the electrolysis of copper chloride. In particular, emphasise at which electrode the metal was deposited and ask the pupils to predict where the metal should deposit if the electroplating is to work. Instructions for the practical work are given on Worksheet Gd(3). Note it is illegal to deface UK coins but you could use foreign coins. The best plating is obtained by cleaning and preparing the coins properly and using a	**Resources (per group)** Low-voltage power supply set to 4 V or a battery; 2 wires and crocodile clips; nickel plating solution; piece of nickel metal foil; cleaned copper coin (or piece of copper); fine emery paper; 1×100 cm3 beakers; Worksheet 8Gd(5).	Eye protection should be worn. Note that chlorine gas is toxic and particularly irritating to people with respiratory ailments. (Cleaning solutions should only be used by teachers or technicians, 3 mol dm–3 sodium hydroxide and	

		suitable plating solution. Before the practical, the coins should be cleaned as follows: • Rub with fine steel wool and wash with soap and water. • Soak for 1 to 2 minutes in 3 mol dm–3 sodium hydroxide solution. • Use tongs to remove coin – avoid skin contact with sodium hydroxide. • Rinse in distilled water. *• Soak for 1 to 2 minutes in 3 mol dm–3 sulphuric acid.* • Rinse with distilled water. A suitable commercial quality plating solution, for use at low temperatures, can be made by dissolving 50 g of nickel sulphate, 20 g of nickel chloride and 5.0 g of boric acid in water and making up to 250 cm3 of solution.		sulphuric acid are corrosive.) Nickel compounds are harmful. Avoid skin contact, wear gloves.	
8Gd	Explaining 3	**Looking at electrolysis (demonstration)** Demonstrate the electrolysis of copper chloride solution and discuss what happens. The discussion should illustrate the following facts: energy is needed to break up a compound; breaking up a compound using electricity is called electrolysis; the copper chloride must be in solution to conduct; both electrodes must be in the solution for electrolysis to take place; copper is formed at the negative electrode and chlorine is formed at the positive electrode.	**Resources (for demonstration)** variable low-voltage power supply 1–12 volts; demonstration ammeter; 2 wires and crocodile clips; carbon electrodes; fine emery paper; 200 cm3 solid copper chloride.	Wear eye protection. Chlorine is a toxic gas, needs good ventilation and electrolysis should be stopped as soon as its presence is confirmed. Copper chloride is harmful.	
8Ge	Starter 1	**Looking at changes of state (demonstration)** Review changes of state by showing pupils a number of substances and asking 'what state are they?' Then show some changes of state and ask what each change of state is called. Examples include: warming ice on the hand –	**Resources (for demonstration)** Ice; propanone; bottle of smelly stuff; freezing spray; dry ice; block of wood; conical fl ask of warm water.	Dry ice can cause damage due to its extremely cold temperature (–78.5 °C, or –109.3 °F). Use tongs or gloves	

		melting; placing a beaker on a block of wood and spraying it with freezing spray so that ice forms and the beaker sticks – *freezing*; opening a bottle of perfume or something smelly – *evaporation*; placing a drop or two of propanone on the wrist and blowing on it – *evaporation*; breathing out onto a cold mirror – *condensation.* You could also drop some dry ice into a conical flask of warm water. Note that at normal pressures solid carbon dioxide does not melt, then evaporate, it sublimes. That is, it turns straight from a solid into a gas. The clouds of white fog are not the carbon dioxide gas, but condensed water vapour. The cold causes the water vapour in the air to condense into clouds.		when handling dry ice. In addition, always wear eye protection when crushing or grinding dry ice.	
8Ge	Exploring 1	**Boiling point of water** Use this practical to get pupils to find out if adding salt to water has any effect on its boiling point. They will need to plan their own investigation by considering: how to measure boiling point; the mass of salt and the volume of water to use; how they are going to make the test fair; how many experiments they should do; how to present their results and the safety precautions they should put in place. • **Must:** go through the planning sheet with pupils (Worksheet 8Ge(2)), agreeing a plan which you write up on the board. • **Should:** pupils use Worksheet 8Ge(2) independently. • **Could:** pupils plan their investigations without help. This practical can be used to carry out an AT1 investigation. A set of level descriptions is provided on pages 208–209 of the ASP.	**Resources (per group)** Thermometer; measuring cylinder; access to a balance; salt; spatula; heating apparatus (Bunsen burner, tripod stand and heat resistant mat); eye protection; Worksheet 8Ge(2).	Eye protection should be worn.	

8Ge	Exploring 2	**Freezing of pure water and salt water** Carry out this practical either as a class, or as a teacher demonstration with temperature probes linked to a datalogger and display screen. Two samples of water, A (distilled water) and B (salt water – approximately 2 g of salt per litre) are cooled down using an ice/salt bath. The temperature of each type of water is monitored at regular time intervals. Pupils should be asked to note the state of the water. Pupils may be able to draw on their work in Topic 8Gc, on the nature of mixtures and pure substances, to help them make predictions and explain the results that they have obtained.	**Resources (per group)** Crushed ice; salt; large (at least 400cm3) beakers or plastic tubs; 2 boiling tubes; water samples A (distilled water) and B (brine); 2 thermometers capable of reading down to –10 °C; Worksheet 8Ge/3. **(for demonstration option)**, in place of thermometers: datalogger and temperature probes; computer and display monitor; Worksheet 8Fe/3.		
8Ge	Exploring 3	**Salty ice** This activity is accessible to all pupils and provides for a wide range of approaches. • **Must:** pupils should add a spatula of salt to some crushed ice and record the temperature when they think the ice has melted. • **Should:** pupils can use different masses of salt and record the temperature when they think the ice has melted. • **Could:** pupils might ensure that they carry out a fair test by using the same mass of crushed ice, with predetermined masses of salt being added to gather a range of data using datalogging equipment to measure and record accurately. Class data can be collected and analysed, or pupils can repeat their readings.	**Resources (per group)** Large supply of crushed ice; salt and spatulas; thermometer reading to −10 °C or lower; stopclock; access to balance; (datalogging equipment); Worksheet 8Ge(4).		
8Ge	Exploring 4	**Does hot water freeze faster than cold?** This is an unusual investigation for a school science class in that there is no agreed 'answer', nor agreement on why hot water	**Resources (per group)** 2 yoghurt pots or an ice-cube tray; access to a freezer; Worksheet 8Ge(5).		

		sometimes appears to freeze more quickly than cold water. This is a useful practical exercise as it not only allows pupils to identify a question that the scientific process cannot answer, but also offers an opportunity to discuss/debate disparate results from the same investigation and relate them to the control of variables. This investigation could also be done at home if pupils have access to a freezer. Instructions are given on Worksheet 8Ge(5).			
8Ha	Exploring 1	**Examining rocks (AT)** This links to the Practical box on page 107 of the Pupil's Book. Pupils examined various rock types at the beginning of Unit 7H (7Ha *Exploring 1*). This is a repeat of the task, but with more emphasis on sorting the rocks into sedimentary, metamorphic and igneous rocks. Give pupils a range of labelled rock specimens, and ask them to describe their appearances in as much detail as they can. Encourage them to use the correct terms when describing rock textures, such as interlocking, crystals, grains, and so on. The second **AT** presentation link on page 105 opens *Rock textures*, which can be used to remind pupils how textures can be described. Pupils may need reminding how to use a hand lens – Skills Sheet 43 from Year 7 CHAP provides instructions. Pupils can make data cards for the rocks they examine, which can be used in later topics or can be displayed. Worksheet 8Ha(2) provides a format for data cards. When pupils have described the rocks in detail, ask them to sort the rocks into categories of their own choosing, describing the features they	**Resources (per pupil)** Labelled rock specimens (e.g. sandstone, limestone, granite, basalt, gabbro, gneiss, marble, chalk, quartzite, slate); hand lens; Worksheet 8Ha(2); Year 7 CHAP Skills Sheet 43.		

		have used to classify the rocks. Follow this up by describing the criteria that geologists use to separate rocks into these three groups (sedimentary rocks are made from grains that are often rounded, igneous and metamorphic rocks are made from interlocking crystals, the latter with the crystals often arranged in layers or bands). Ask pupils to re-sort their groupings if necessary and to comment on whether they have enough information to sort all the rocks they have into the 3 groups. The final slides of *Rock textures* can be used to reinforce these ideas. • **Must:** pupils record information on data cards and enter them into the database. • **Should:** pupils record the information on the data cards and help to build the database. Pupils could also be asked to explain how the observation and recording methods are appropriate to the task. • **Could:** pupils help to design the database and record the information into it. Pupils use both qualitative and quantitative methods, i.e. measuring crystal sizes.			
8Ha	Exploring 2	**Database of rocks** Ask pupils to make a database with detailed descriptions of a selection of rocks. This could be a follow-up to *Exploring 1*, where pupils were asked to examine a selection of rocks in detail. Alternatively, there are various 'virtual microscopes' or 'virtual rock kits' available on the web or from software suppliers, which show close-ups and thin sections. The Earth Science Education Unit at Keele University has one in their resources for schools section, which pupils can use to examine rocks in detail (search using	**Resources (per pupil)** Labelled rock specimens (e.g. sandstone, limestone, granite, basalt, gabbro, gneiss, marble, chalk, quartzite, slate); hand lens; access to computers and a database program. Optional: access to a virtual rock kit via the internet or other software.		

		the key words ‘ESEU virtual rock kit’). Pupils may find it easier to complete data cards (Worksheet 8Ha(2)) for each rock before entering the information into a database. The database created can be used later in the unit to help pupils to compare the different groups of rocks (see 8Hc *Exploring 2*).			
8Ha	Exploring 3	**Describing sedimentary rocks (AB)** This is a repeat of *Exploring 2* in topic 7Ha that you may wish higher attaining pupils to attempt if they did not do it when studying Unit 7H. Worksheet 7Ha(3) *Describing sedimentary rocks* introduces pupils to some of the criteria used to describe sedimentary rocks that are made from fragments of silicate minerals (i.e. rocks such as sandstones and shales, as opposed to limestones). Ask pupils to describe sedimentary specimens in as much detail as they can, using the information on the worksheet. Ask them to interpret their observations in terms of how the rocks were formed – referring to topic 7He if necessary. This exercise will be of most value if you have a range of rocks for pupils to examine. Rock kits can be bought from school science equipment suppliers, but you can also buy rocks from specialist geology suppliers, such as UKGE Ltd (www.ukge.co.uk). A suggested list would be mudstone, shale, Permian sandstone, millstone grit, greywacke, conglomerate, breccia.	**Resources (per pupil)** Rock specimens (e.g. mudstone, shale, Permian sandstone, millstone grit, greywacke, conglomerate, breccia); hand lens; Worksheet 7Ha(3) Year 7 CHAP Skills Sheet 43.		
8Hb	Starter 1	**Sorting rocks** Give pupils a selection of different igneous rocks and ask them to examine them closely. Pupils could compile data cards for any rocks they have not already examined in the previous	**Resources (per group)** Samples of rocks to include obsidian, basalt, granite, gabbro, and also the following, if available: pumice, rhyolite, driorite, andesite;		

		topic (see 8Ha *Exploring 1* and Worksheet 8Ha(2)). Ask them to compile a list of the similarities between the rocks (interlocking crystals) and the differences (different minerals/combinations of minerals, different crystal sizes). Pupils could keep the samples and their notes for *Plenary 1* or *Plenary 4*.	hand lens; Year 7 CHAP Skills Sheet 43.		
8Hb	Exploring 1	**Cooling rate and crystal formation** The context of a TV studio given in the Practical box on page 109 of the Pupil's Book emphasises the need for pupils to think about and explain their actions, results and conclusions to others. Pupils should collect a drop of molten salol from a stock in the water bath by dipping a glass rod into the container and transferring the drop quickly to their warmed or chilled microscope slide. When the salol has solidified, pupils can examine the samples using a microscope. Skills Sheet 45 from Year 7 CHAP will remind them how to use microscopes. If graticules are available for the microscopes, pupils can make approximate measurements of the sizes of crystals formed at different cooling rates. A cheap alternative to graticules can be made by fastening acetate copies of graph paper onto the back of microscope slides with sticky tape. • **Must:** instructions in the form of a cloze exercise are provided on Worksheet 8Hb(2). • **Should:** Worksheet 8Hb(3) provides questions to help pupils to plan their own investigation.	**Resources (per group)** Pre-molten salol (or stearic acid); access to water bath set to 50 °C; microscope; stirring rod; graticules; access to a freezer; warmed microscope slides; chilled microscope slides; eye protection; Worksheet 8Hb(2) or 8Hb(3); Year 7 CHAP Skills Sheet 45.	Wear eye protection. Salol is an irritant.	
8Hb	Exploring 2	**Cooling curves** Ask pupils to model the cooling rates of intrusive and extrusive magmas by measuring the	**Resources (per group)** 2 small beakers; 2 deep trays or large beakers; sand; access to	Wear eye protection. Take care handling beakers of boiling	

		cooling rate of two beakers of boiling water, one surrounded by sand (representing rock) and one surrounded by air. If they have already carried out *Exploring 1*, ask them to predict which model would have produced rock with the largest crystals. Pupils could use a spreadsheet to collate the class results. Pupils could be asked to think about what data they would need to collect, how the data could be manipulated and how it helps to support the conclusions from their own practical. If pupils have done *Exploring 1* as well as this practical they could be asked to compare the two models of intrusive and extrusive rocks. • **Should:** ask pupils to compare the two models and discuss the strengths and weaknesses of both. • **Could:** ask pupils to compare the two models, discuss the strengths and weaknesses of both and decide which one is most appropriate. They should justify their choice.	kettle; 2 thermometers; stopclock; eye protection. Optional: temperature probes; datalogging equipment.	water.	
8Hb	Exploring 3	**Densities of igneous rocks (AB/AT)** Pupils measure the densities of different igneous rocks, and relate these to the minerals they contain. Instructions and questions are provided on Worksheet 8Hb(4). Granite is an example of a silicarich igneous rock (formed by continental volcanoes) whereas gabbro is an example of an iron-rich igneous rock (formed by oceanic volcanoes). Basalt has a similar composition to gabbro and rhyolite has a similar composition to granite. The **AB** spreadsheet link on page 109 opens *Densities of igneous rocks* – which provides a similar activity based on data provided in the	**Resources (per group)** Samples of granite gabbro, rhyolite and basalt; large measuring cylinder, beaker or displacement can; large bowl; accurate electronic top pan balance (measuring to 2 d.p.); Worksheet 8Hb(4); Year 7 CHAP Skills Sheet 22.		

		spreadsheet.			
8Hb	Exploring 4	**Viscosity and lava flow** *Exploring 1* 8He *Runny lava* could be used in this topic if required. In this investigation jelly is used as a model to look at how viscosity affects the distance lava will flow.			
8Hb	Explaining 2	**Pupils as a model of cooling lava/magma** First, ask or tell pupils what a scientific model is. Then explain how they can use themselves as a model to represent the atoms found in the molten lava as it cools. Initially, allow pupils to move about in an open space – as the atoms do in the molten lava. On cooling (indicated by a whistle), the pupils begin to stick together to begin to form crystals by placing one hand on the shoulder of the person nearest to them. Give them a fixed period of time to link up – start with a longer period of time, about 20 seconds, and repeat the process, reducing the amount of 'cooling time' by half, and half again. Finally, give only 1 second of 'cooling time'. The more time that is available, the larger the crystal will become, and the fewer crystals there will be. Use questioning to elicit the relationship between crystal size (number of pupils bonded together) and number of crystals (number of groups of pupils) to the cooling time, and hence explain the size of the crystals in igneous rocks in terms of the particle theory of matter. Ask pupils how this model helps when thinking about the rate at which crystals form.	**Resources** Open space; whistle; clock.		
8Hb	Plenary 1	**Explaining rocks** Revisit *Starter 1* and ask pupils to group the rock samples according to how they think they were formed, and explain their groupings. Ask	**Resources (per group)** Samples of rocks to include obsidian, basalt, granite, gabbro, and also the following, if available:		

		them to suggest how what they have learned in this topic has helped them to make their groupings. This will be easier if pupils have the rock samples in front of them again, as opposed to just their notes. Note that obsidian is a glass-like material that forms when lava cools down too quickly to form any crystals at all. Extrusive rocks from the suggested list are basalt, andesite, rhyolite, pumice and obsidian. Skills Sheet 43 from Year 7 CHAP could be used to remind pupils how to use a hand lens.	pumice, rhyolite, driorite, andesite; hand lens; Year 7 CHAP Skills Sheet 43.		
8Hc	Starter 1	**Comparing rocks** Give pupils a selection of different igneous rocks and metamorphic rocks, and ask them to examine them closely. Tell them which rocks belong in each group, and ask them to compile a list of similarities and differences between the two groups.	**Resources (per group)** Rock samples, incl. granite, gabbro, schist and gneiss; hand lens.		
8Hc	Starter 2	**What am I?** Give a pupil a rock sample that the rest of the class cannot see. They have to describe the rock sample to the class without using its name or type (i.e. sedimentary, igneous, metamorphic). The rest of the class have to work out what type of rock it is, suggest how it was formed (if they can), and to name it (if they can). This will help to remind pupils of the characteristics of the three groups of rocks that they looked at in the first topic. Repeat this with other rock samples, using a different pupil as the describer each time. Follow up by asking pupils which group of rocks they have not studied. Tell them that these rocks (the metamorphic ones) have been made	**Resources** Samples of rocks, which could include limestone, marble, granite, gabbro, mudstone, slate, schist, gneiss.		

		by changing other rocks, and have a quick brainstorm on things that might make rocks change.			
8Hc	Exploring 1	**Metamorphic ice crystals** Pupils examine separate ice crystals with a hand lens, and then make a ball of ice crystals and squash it between their hands. The pressure and temperature will change the crystals. Pupils cut open their compressed balls, re-examine the crystals and record the differences. The ice crystals must be taken from the freezer when they are required – this will mean that they must be collected from the freezer as close to the time of need as possible and stored in a large shallow plastic container until use. This will prevent them from becoming fused together. Help pupils to link what they have seen to the changes that rocks go through when heated and compressed. Encourage them to identify similarities and differences between rocks and their ice model.	**Resources (per group)** Fresh ice crystals; hand lenses; sharp knife (blade warmed with hot water); paper towels.	Care must be taken when cutting the compressed ice, to prevent injury. Wear eye protection when cutting.	
8Hc	Exploring 2	**Pairs of rocks** Pupils work in pairs to investigate the properties of paired sedimentary and metamorphic rocks. Pupils should consider the appearance, texture, hardness and porosity of each rock. Worksheet 8Hc(2) provides data cards to complete. Worksheet 8Hc(3) provides questions for pupils to answer based on their observations.	**Resources (per group)** Hand lens; water; access to top pan balance; paper towels; nail for scratching rocks; access to paired samples of sedimentary and metamorphic rocks; Worksheets 8Hc(2), 8Hc(3).		
8Hc	Exploring 4	**Metamorphism and fossils** Ask pupils to recall how fossils are formed, and then ask them to suggest what can happen to fossils if the rock they are in undergoes metamorphism. Explain that if the rock is	**Resources (per group)** Shell or other ‘fossil’ item; coloured Plasticine® or modelling clay; plastic cup; bench mat.		

		subject to mainly pressure (as opposed to temperature) the fossils may still be visible in the rock, but may be distorted. High temperatures will cause mineral transformations and will obliterate traces of fossils. This activity may take some time to set up and the first part provides revision of the formation of sedimentary rock. Pupils place a shell into the bottom of a plastic cup and build up layers of 'sediment' using coloured Plasticine® balls to represent the grains of sediment. Different layers can be made using different coloured 'grains' of Plasticine®. The layers should be compressed into the cup, so that each layer remains complete and the 'grains' of Plasticine® fuse together. After a couple of layers have been made, the Plasticine® 'sedimentary rock' should be removed from the plastic cup. The shell should be removed leaving the 'fossil' imprinted in the 'sedimentary rock' model. Metamorphism can now be demonstrated by exerting pressure on the model's side. This will show the effect of pressure on the fossil's shape – the fossil and the layers of rock will be changed.			
8Hc	Explaining 2	**Modelling metamorphism** Worksheet 8Hc(4) looks at some models to help pupils to understand metamorphism. The statements below the line on the sheet are intended to act as hints to inform pupils' answers, and could be removed for higher attaining groups. You could illustrate the models by showing pupils unbaked cake mixture and a baked cake, emphasising that there have been no chemicals added in the transformation of one to the other.	**Resources:** Worksheet 8Hc(4). Optional if models are demonstrated: raw cake mixture; baked cake; beaker; Plasticine® in three colours; matchsticks, pieces of spaghetti or pieces of wooden splints; beads; two rulers or wooden blocks.	No eating in the lab!	

		The Plasticine® model shows the deformation of grains in a sedimentary rock. The alignment of platy minerals when mudstone or shale is converted to slate can be modelled using matchsticks, bits of wooden splint, or bits of broken spaghetti, as outlined on the sheet. In this case, the minerals realign themselves. Under conditions of higher temperature and pressure, new minerals actually grow in directions at right angles to the applied pressure.			
8He	Exploring 1	**Runny lava** Fruit jelly (or filtered mud) of different consistencies can be released to flow down a ramp. The easiest and least messy ramp to use is a piece of square-section guttering; a wide piece of melamine also works well. The angle of inclination of the ramp should be kept constant throughout the investigation and the distance reached by the jelly recorded after a fixed period of time. The more viscous the jelly, the less distance it will flow. The consistency of the jelly can be varied by using different numbers of cubes of jelly, or different volumes of warm water to dissolve it. The number of cubes will depend on how long you have to let the jelly cool and begin to set before it is used – some trial and error may be necessary first. • **Must:** Worksheet 8He(2) provides instructions, and assumes that pupils are provided with five ready-made jelly mixtures of different concentrations labelled A to E. You may need to adjust the time given in instruction D on the worksheet, depending on the consistencies of the jellies and the steepness and length of the ramp.	**Resources (per group)** Ramp (plastic guttering, wide melamine, or a tray); metre ruler; stopclock; fruit jelly cubes and beakers of warm water or access to beakers of ready-made fruit jellies of different consistencies, or mud of different consistencies; measuring cylinder; cloths to wipe up spills; bucket for jelly remains; Worksheet 8He(2) or 8He(3). Optional: access to a fridge.	Pupils should not be allowed to eat this model of lava! Ensure any spills are mopped up straight away.	

		• **Should:** Worksheet 8He(3) provides questions designed to help pupils to plan their own investigation. If pupils are to work out their own concentrations of jelly, the investigation might be best spread over two lessons, as the trial and error process could take some time. A fridge to help cool the jelly will speed things up a bit. Class results could be collated using a spreadsheet. Ask pupils what results they would need to collect from each group and how they could be manipulated in order to draw a conclusion from them. • **Could:** pupils plan their own investigation, given only an initial question, such as 'What affects the distance that lava will flow?' This practical can be used to carry out an AT1 investigation. A set of level descriptions is provided on pages 236–237 of the ASP. Note that use of Worksheet 8He(2) will limit the level it is possible to achieve in the planning strand.			
8Ia	Exploring 1	**Is skin a reliable thermometer?** Ask pupils to suggest why we don't just feel things to judge temperature. Allow pupils to see the unreliability of the human body at judging actual temperatures (as opposed to relative temperatures) by setting up three bowls, one containing hot water, one with warm water and one with cold water. A pupil puts one hand in the hot water and one in the cold water for a minute, then puts each hand into the warm water. They can compare their perceptions with temperatures as recorded by a thermometer.	**Resources (per group)** 3 large bowls; hot, warm and cold water; stopclock; thermometer.	Ensure the hot water is not uncomfortably hot or cold. Pupils should not be forced to experiment on themselves. Mop up any spills straightaway.	
8Ia	Exploring 2	**Measuring temperature (AB)** Set up a circus of beakers containing water at	**Resources (for circus)** Beakers or water baths with water	Ensure that thermometers are not	

		different temperatures (or use water baths if enough are available). Ask pupils to record the temperature of the water at each station. As any water put out in beakers will cool as the pupils are circulating, compare results in a plenary at the end and elicit the reasons why different groups have different results. Pupils could also be asked to measure the air temperature at various places, such as near a radiator, near an open window, etc. • **Must:** ensure that pupils know how to use thermometers properly – in particular, that the bulb should be in the substance whose temperature is being measured, it should be left there until the liquid has stopped moving, and it should not be removed in order to read the scale. • **Should:** provide pupils with a variety of different types of thermometer and temperature sensors, and ask them to suggest advantages and disadvantages of each type of thermometer. The second **AB** document link on page 121 opens *Different thermometers* – which gives details of different thermometer and temperature sensors, and includes questions to help pupils to think about their advantages and disadvantages.	at different temperatures set up as a circus. Each station to be labelled with a letter. **Resources (per group)** A range of different types of thermometers and temperature sensors.	put in temperatures above their ranges, e.g. in a Bunsen burner flame. Mop up any spills straightaway.	
8Ia	Exploring 3	**Comparing heat energy and temperature** Pupils plan an investigation to demonstrate that a smaller volume of water will take less time to reach a given temperature than a larger volume. Start by asking pupils to predict which will heat up the fastest. With some groups you may wish to elicit the suggestion that if the volume of water is doubled, it will take twice as long to	**Resources (per group)** 250 cm3 beaker; thermometer; tripod; gauze; Bunsen burner; heatproof mat; measuring cylinder; stopclock; eye protection; Worksheets 8Ia(3) or 8Ia(4).	Eye protection should be worn if heating water to boiling point.	

		heat up. • **Must:** pupils follow the instructions on Worksheet 8Ia(3). • **Should:** pupils plan their investigation using the hints on Worksheet 8Ia(4). • **Could:** pupils plan their own investigation using only the prompts in the Pupil's Book. Discuss results when pupils have completed their investigation. If they have found that it takes a little longer than twice the time to heat twice the volume of water, ask them to suggest reasons for this, and how heat losses during the experiment could be reduced.			
8Ia	Exploring 4	**Heating different materials** Pupils heat up water and blocks of different metals, all of the same mass, using an immersion heater, and record the temperature change over a fixed time. This will demonstrate the dependence of temperature on material. This is an opportunity to introduce pupils to the use of dataloggers and temperature sensors to record the temperature changes over time as the different materials are heated. You may also wish to discuss the accuracy of the results – a material that has reached a higher temperature in the fixed time will also have lost more heat to the surroundings. • **Should:** ask pupils to consider the advantages and disadvantages of pooling the class results. They should think about what data they would need and how the results would need to be manipulated. If you have a range of results, it may be possible to put them into a spreadsheet and discuss with pupils the effect of taking out some of the results – in some cases, a change in the selection of secondary data can lead to a	**Resources (per group)** 1 kg metal block calorimeters of different metals; immersion heater; power supply; beaker or tank to contain 1 litre of water; stopclock; thermometer; datalogger and temperature sensor.	Check the temperature rise with the blocks and immersion heaters you have available to ensure that the final temperature does not exceed around 50 °C to avoid burns. Take care with electrical wires near water. Mop up any spills straightaway.	

		different conclusion. • **Could:** ask pupils to explain whether their evidence is sufficient for the conclusions they have drawn, and to explain any manipulation of their results, such as the omission of outliers when calculating means.			
8Ia	Exploring 5	**Hot and cold** Mix different volumes of water at different temperatures. Ask pupils to predict the temperature of the resulting mixture. This is a good opportunity to reinforce the difference between heat and temperature. Help pupils to explain why their predictions did (or did not!) match the observed results. This could be done by the pupils themselves or, if time is short, as a demonstration. • **Could:** if pupils have done *Explaining 2* they could be given the formula to work out the energy contained in volumes of water at different temperatures (taking the coolest as the 'zero' level), and helped to predict what the temperature will be after mixing. Energy (J) = mass (kg) × temperature change (°C) × 4200 J/kg/°C	**Resources (per group)** 3250 cm3 beakers; a kettle; 3 thermometers; eye protection.	Care with boiling water/kettle. Wear eye protection. Mop up any spills straightaway.	
8Ib	Starter 2	**Touching materials** Provide pupils with a range of different materials, including metal objects and insulating materials such as polystyrene foam. Ask pupils to touch each material and decide whether it feels warm or cold to the touch. Ask them to suggest why the materials feel different to the touch, and elicit the idea that the ones that feel cold are conducting body heat away faster than the ones that feel warm.	**Resources (per group)** Range of different materials, to include metal objects and some made from insulating materials.	Warn against touching materials of unknown temperature (either hot or cold).	
8Ib	Exploring 1	**Good conductors?**	**Resources (per group)**	Warn against	

		Investigate which metals are the best conductors by fastening rods of different metals to a tripod and use a Bunsen burner to heat one end. Use a temperature probe at the other end of the rod to determine how long it takes for the temperature to rise by 5 °C. • **Must:** Worksheet 8Ib(2) provides instructions for this method. • **Should:** Worksheet 8Ib(3) provides more open-ended directions to help pupils to plan their own method. If datalogging equipment is not available, the practical can be done by sticking drawing pins to the ends of the rods using petroleum jelly. When the heat from the Bunsen burner has been conducted along the rod it will melt the petroleum jelly and the pins will fall. The first pin to fall should be the one stuck to the best conductor.	Copper rod; glass rod; iron rod; rods of other materials (if available); tripod; heatproof mat; Bunsen burner; wrap-around temperature sensors and datalogging equipment; stopclock; Worksheet 8Ib(2) or 8Ib(3). Optional: wax or petroleum jelly; drawing pins.	touching hot metal.	
8Ib	Exploring 2	**How fast does metal conduct heat?** Clamp a metal rod horizontally and place temperature sensors at equal intervals along it. Heat the end of the rod furthest from the clamp, and note the temperature rises at different places. If datalogging equipment is not available this can be done by using petroleum jelly to stick drawing pins at equal intervals along the rod, and timing how long it takes for each pin to fall off. Pupils could be asked to predict how fast the heat will travel along the bar. If using the drawing pins method, discuss the potential inaccuracies (e.g. different amounts of petroleum jelly).	**Resources (per group)** Clamp and stand; metal rod (the vertical rod from a clamp stand is suitable, unscrewed from its base); Bunsen burner; eye protection; heatproof mats; temperature sensors aid; datalogging equipment. Optional: petroleum jelly; drawing pins; stopclock.	Eye protection should be worn.	
8Ib	Explaining 1	**Water as an insulator (demonstration)** Demonstrate that liquids do not conduct heat well by heating a boiling tube of water with an	**Resources (for demonstration)** Boiling tube; water; ice cube; gauze; clamp and stand; Bunsen	Water can spit from the end of the tube. Eye protection should	

		ice cube held at its base with a piece of gauze. If the boiling tube is heated near the top, the surface water will boil and the ice will not melt straight away. If datalogging equipment is available, temperature sensors could be used to monitor the temperature at different places in the boiling tube.	burner; eye protection. Optional: temperature sensors and datalogging equipment.	be worn. Mop up any spills straightaway.	
8Ib	Explaining 2	**Air as an insulator** Demonstrate that most effective insulators mostly consist of air. This can be done by asking pupils to examine a piece of foam rubber or expanded polystyrene using a hand lens. You could also use a vacuum pump to evacuate the air from a piece of duvet filling or other insulating material. The sample will have to be firmly sealed in a plastic bag. You will need to have a tube connected to the pump with a filter over the tube to protect the pump. Alternatively, put pieces of expanded polystyrene chips or foam rubber in a bell jar and evacuate the air.	**Resources (per group)** Pieces of expanded polystyrene and foam rubber; hand lens. **Resources (for demonstration)** Duvet filling; other insulating materials; vacuum pump; strong clear plastic bag or bell jar.	Ensure the bell jar is not cracked or otherwise damaged, to reduce the risk of implosion.	
8Ib	Explaining 7	**Conduction simulation** Discuss how pupils could use themselves as model particles to increase their understanding of the transfer of heat energy by conduction. You need a clear space to do this. The pupils should link arms firmly so that each pupil represents a particle in a solid. One pupil gets heated and gently pushes backwards and forwards so that heat energy is conducted along the line. This can be repeated for a liquid but this time holding hands loosely. It will be seen to be less effective. For a gas the pupils stand separately and hardly any energy is passed along. (Note in gases and liquids energy is passed by collision, in metals it is passed by	**Resources** Access to hall or playing field.	Take care that pupils do not take the colliding too seriously!	

		electrons. This information is not needed for this demonstration but doing it is great fun – with care and good discipline.) • **Must:** pupils should use the model to explain conduction. Ask them whether this model has helped them to think about particles and conduction. • **Should:** ask pupils to think about the model and discuss with them how it helps us to think about conduction.			
8Ib	Explaining 8	**Ball and ring** Demonstrate the expansion of solids by using the ball and ring apparatus. Ask pupils to explain what happens using ideas about particles.	**Resources (for demonstration)** Ball and ring equipment; Bunsen burner; tongs; heatproof mat.	Practice the demonstration before the lesson. Have heatproof mats and tongs to hand for hot objects.	
8Ib	Plenary 1	**Wood and metal** Use a wood and metal cylinder (one end is wood, the other is metal, available from equipment suppliers) and wrap the centre of the bar with a piece of paper. Holding the wooden end of the bar, play a Bunsen burner flame gently over the paper where the two materials join. You should find that the paper becomes scorched where it lies over wood, but not where it lies over the metal. Ask pupils to explain why this happens in terms of conductors and insulators.	**Resources (for demonstration)** Metal/wood bar; Bunsen burner; heatproof mat.	Practice the demonstration before the lesson. Have heatproof mats and tongs to hand for hot objects.	
8Ib	Plenary 2	**Bimetallic strip** Show pupils a bimetallic strip, and explain that it is made from two different metals stuck together. Show what happens when it is heated, and ask them to suggest why this happens. Ask them to predict what will happen when it cools, and why. Cool it by holding it under a running	**Resources (for demonstration)** Bimetallic strip; Bunsen burner; heatproof mat; access to tap.	Take care with hot metals.	

		tap. Then turn the strip over, and ask them to predict and explain which way it will bend this time when it is heated.			
8Ic	Starter 2	**Expansion (demonstration)** • **Liquid:** almost fill a round-bottomed fl ask with coloured water and insert a bung with a hole in the top, fitted with a narrow-bore glass tube. Warm the flask with your hands and watch the water rise up the tube as the warming water expands. Ask pupils to explain why the liquid expands in terms of particles. • **Gas:** fit a round-bottomed flask with a bung and narrow-bore glass tube, and hold it upside down with the end of the tube in a beaker of water. Warm the flask with your hands, and point out the bubbles of water that come from the bottom of the tube. Ask pupils to explain why this happens in terms of particles.	**Resources (for demonstration)** **Liquid:** round-bottomed flask; bung and narrow-bore glass tube; water; food dye or ink. **Gas:** round-bottomed fl ask; bung and narrow-bore glass tube; beaker of water.	Use a narrow-bore tube and pre-fit it. Take care when pre-fitting. Mop up any spills straightaway.	
8Ic	Starter 3	**Density and floating revision (for demonstration)** Ask pupils to explain how they could work out whether or not a particular object would fl oat in water. Elicit the idea (first met in Topic 7Kc) that the object will fl oat if its density is less than the density of water. Extend this to discuss floating or sinking in other fluids. Show a balloon filled with air and one filled with hydrogen or helium, and ask pupils to explain why one floats and the other does not.	**Resources (for demonstration)** Balloon filled with hydrogen or helium; balloon filled with air.		
8Ic	Exploring 1	**Making a thermometer** Worksheet 8Ic(2) provides instructions for making a thermometer from a fl ask fitted with a bung and narrow-bore tubing. This shows pupils one application of the expansion of fluids on heating. The task involves waiting for several	**Resources (per group)** Conical fl ask; large bowl; beaker; crushed ice; water bath set to 50 °C; piece of narrow-bore glass tubing fitted in a bung; food dye; ruler; marker pen; eye protection;	Be very careful when using tubing as it can break easily. The tubes should be pre-fitted into the bungs and a narrow-bore	

		15-minute periods. Because of this, the task is best combined with another so pupils have something to do while they are waiting.	Worksheet 8Ic(2).	tube should be used, not thin-wall tubing. Wear eye protection if heating water to boiling point. Mop up any spills straightaway.	
8Ic	Exploring 2	**Hot air balloon** Pupils could construct their own hot air balloon using thin tissue paper. Large leaf-shaped sections are cut out and six to eight glued together. The balloon should be tied to a high point and tethered by threads around the opening, tied to weights, to keep the hole open. Small candles could then be placed underneath to show that hot air rises. This activity is often carried out with a hair dryer but using the fan would not show that hot air is the direct cause of the balloon rising. Encourage pupils to explain why the balloon rises using ideas about particles.	**Resources (per group)** Thin tissue paper; night light candles; cotton; glue; scissors.	Take care with naked flames near tissue paper. Be prepared to put out small fires!	
8Ic	Exploring 3	**Convection in water** Drop a potassium manganate(VII) crystal down a tube into the bottom of a beaker of water. Heat the beaker over a Bunsen flame, positioning the flame beneath the crystal. Ask pupils to explain why some of the water turns purple, and then why the purple water moves in the way it does.	**Resources (per group)** Beaker; water; small tube; forceps; potassium manganate(VII); Bunsen burner; tripod; gauze; heatproof mat.	Potassium manganate(VII) is an oxidising agent and is harmful. Wash hands after use. Mop up any spills straightway.	
8Ic	Exploring 4	**Hot and cold (demonstration)** Fill a gas jar with hot water coloured with ink or a food dye. Fill another gas jar with cold water, and cover with a thin plastic sheet. Invert the jar of cold water and place it on top of the jar of hot water. Remove the sheet and observe what	**Resources (for demonstration)** 2 gas jars; hot water; food dye or ink; thin plastic sheet.	Care needed if water used is near boiling point. Mop up any spills straightway.	

		happens to the dye. Repeat with the jar of cold water on the bottom. Ask pupils to explain their observations.			
8Ic	Explaining 2	**Convection simulation** Explain that convection can be modelled using the pupils themselves to represent particles, and counters or pieces of coloured paper to represent energy. Spread pupils out in a large room, and give those near one end a number of counters. This is the 'hot' end of the room. Tell them that the pupils with the most counters move fastest, towards the back of the room, and that they should pass on one counter every time they meet someone with fewer counters. As the 'hot' pupils move away from the 'hot end', others move in to take their place and pick up 'energy'. This should continue until the 'energy' is fairly evenly distributed amongst all pupils. Help pupils to relate their simulation to what happens in a real convection current. • **Must:** pupils should use the model to explain convection. • **Should:** ask pupils to think about the model and discuss with them how it helps us to think about convection.	**Resources** Approximately 100 counters or small pieces of coloured paper; access to hall or other large space.		
8Ic	Plenary 3	**Smoke box (demonstration)** A smoke box is a glass-fronted box with two glass chimneys, available from equipment suppliers. Set up the box with a candle or tea light beneath one chimney. A smouldering straw or paper towel can be used to provide the smoke – ask pupils to suggest what will happen if you hold the straw over first one chimney, then the other, and challenge them to explain what is happening.	**Resources (for demonstration)** Smoke box; tea light or small candle; paper towel or drinking straw.	Smoke can spread so be aware of any asthmatics in the class.	

8Id	Starter 1	**Cooling by evaporation** Let pupils feel the cooling effects of an evaporating liquid by dropping one drop of ethanol onto the backs of their hands. Ensure the ethanol is at room temperature to start with, and discuss the fact that the liquid itself is not cold – the feeling of cold as it evaporates is due to the liquid absorbing energy from their hands.	**Resources (per group)** Ethanol in dropper bottle.	Pupils should wash their hands after this demonstration. Ethanol is highly flammable; ensure there are no ignition sources and do not use more than one drop. Do not inhale the vapour –it has a narcotic effect.	
8Id	Starter 3	**Handwarmer (demonstration)** Show pupils the type of handwarmer that uses a state change to produce heat. These are normally liquid, and have a metal disc inside that is 'clicked' to initiate the state change to solid. Flex the handwarmer before setting it off to show that it is liquid, then click the disc and pass it around to allow pupils to feel the heat being given off. Ask them to use ideas about particles to explain why it feels warm. If they cannot answer at this point in the lesson, ask them to remember the demonstration and discuss it again at the end of the lesson (*Plenary 4*). The handwarmer can be recharged after use by boiling it – refer to the instructions supplied with it.	**Resources (for demonstration)** Reusable handwarmer.		
8Id	Exploring 1	**Ice to steam** Pupils heat a beaker of ice and record the temperature at regular intervals until the ice has melted and the water has been boiling for some time. The temperature the pupils record may vary depending on atmospheric pressure, the accuracy of the thermometer used, etc. A temperature probe and datalogging equipment	**Resources (per group)** Ice; Bunsen burner; tripod; heatproof mat; gauze; 250 cm3 beaker; stopclock; thermometer; eye protection. Optional: temperature probe and datalogging equipment.	Do not touch ice that has come straight from the freezer. Wear eye protection. Mop up any spills straightaway.	

		could be used to monitor the temperature.			
8Id	Exploring 2	**Cooling curve** Provide pupils with a boiling tube of melted stearic acid, and ask them to record the temperature at regular intervals as it cools down. The tubes of stearic acid for the whole class can be kept in a water bath until ready for use. Note that the stearic acid is referred to as 'wax' on the worksheets, for simplicity. Temperature sensors and datalogging equipment could be used to record the temperature. After they have plotted the cooling curve, ask pupils to predict what they think will happen if the 'wax' is heated up again until it melts. If time permits they could use a water bath to remelt the stearic acid and check their predictions. This practical can be repeated with other substances such as salol (phenyl salicylate). • **Must:** pupils can follow the instructions on Worksheet 8Id(2). • **Should:** pupils can plan their own method with the help of Worksheet 8Id(3).	**Resources (per group)** Boiling tube of melted stearic acid (about one-third full); thermometer; test tube rack; stopclock; eye protection; Worksheets 8Id(2) or 8Id(3). Optional: temperature sensor and datalogging equipment; water bath; salol (phenyl salicylate).	Slearic acid should be kept off the skin (it burns, especially on solidification). Warn pupils not to try to remove thermometers from solidified 'wax' as they may break. Wear eye protection.	
8Id	Exploring 3	**Sweat and cooling** Following the prompt on page 127 in the Pupil's Book, ask pupils how they would investigate whether a body cools down faster if it is wet. A body can be represented by a plastic drinks bottle filled with warm water, covered in damp paper towels or kitchen roll. A second plastic bottle covered with dry paper towels will be needed as a control. Pupils could carry out preliminary work to determine a suitable starting temperature, suitable time intervals between temperature measurements, etc. If datalogging	**Resources (per group)** 2 plastic drinks bottles; paper towels or kitchen roll; elastic bands; access to kettle; thermometers; stopclock; Worksheets 8Id(4) or 8Id(5), Year 7 CHAP Skills Sheet 12. Optional: temperature probes and datalogging equipment.	Mop up any spills straightaway.	

		equipment is available, it could be used to measure the temperatures. Pupils should be reminded to include safety instructions in their plan. They should note how accurate their method of recording results was and comment if the results are sufficiently accurate and reliable to allow them to draw a conclusion. Any suggestions for improvements should include a reason. Pupils working at a higher level should be encouraged to think about the advantages and possible disadvantages of collating class results. They should suggest what results would be collected and how they could be manipulated. Pupils should be encouraged to consider the validity of their model, perhaps by researching relevant information about the human body and comparing it to similar information about their model. Factors to be considered include body size and mass, body temperature and normal temperature of the surroundings, etc. If a fan is available, blowing air over the model bodies will reduce the time needed for a temperature difference to become apparent. This practical can be used to carry out an AT1 investigation. A sheet of level descriptions is provided on pages 263–264 of the ASP. • **Must:** instructions are provided on Worksheet 8Id(4), although use of this sheet will limit the possible marks available for the planning strands of AT1. • **Should:** Worksheet 8Id(5) provides questions to help pupils to plan their own investigation. • **Could:** pupils could be asked to plan their investigation using only the prompt in the Pupil's Book and Skills Sheet 12 from Year 7 CHAP.			

8Ie	Starter 2	**Light and infrared radiation** Show pupils that light from a heat lamp can be focused onto a piece of paper, and leave the lens in place until the paper starts to scorch. Ask them to suggest how the heat is getting from the lamp to the paper, and elicit the idea that there must be a means of heat transfer other than conduction or convection.	**Resources (per group)** Convex lens; heat lamp; paper. Optional: lens holder; clamp and stand.	Pupils should be warned not to use this on skin or to use the Sun. They must NOT look at a heat or light source through the lens.	
8Ie	Exploring 1	**Shiny suits** Pupils investigate whether the colour of a material affects how well it absorbs infrared radiation. A ray box is an adequate source of heat, and at its simplest, pupils can just clamp two thermometers with bulbs painted in different colours in front of the ray box and record the temperature every minute. Instructions are given on Worksheet 8Ie(4). • **Must:** pupils follow the instructions on the worksheet. • **Should:** discuss with pupils how the investigation could be improved or adapted to look at different colours (e.g. by sticking pieces of different coloured paper in front of the thermometer bulbs using Plasticine®). • **Could:** ask pupils to plan an investigation to find out if the colour of an object affects how well it emits radiation. In practice, this can be done as part of the same investigation, by continuing to record the temperatures on the two thermometers for 10 minutes after the ray box has been switched off.	**Resources (per group)** 2 thermometers, with painted ends (one silver, one matt black); ray box and power supply; stopclock; Worksheet 8Ie(4).	Do not allow pupils to touch the heat source. Take care when clamping gas thermometres.	
8Ja	Exploring 1	**Investigating streamlined shapes** Pupils investigate the effect of shape on drag. Different shapes can be made from Plasticine®, and pupils should be encouraged to carry out a	**Resources (per group)** Plasticine®; made-up wallpaper paste or fl our/water mixture; large measuring cylinder or tank; large	Most wallpaper pastes contain fungicides or other chemicals that may	

		fair test by using pieces of equal mass to make their shapes. Pupils will need to use a dilute mixture of wallpaper paste and water in a large measuring cylinder or tank to make the falling time long enough to measure the differences with reasonable accuracy. If suitable equipment is available it should be possible to use light gates and datalogging equipment to measure the times. Instructions are given on Worksheets 8Ja(4) and 8Ja(5). • **Should:** point out to pupils that this experiment is a model of how objects pass through the air. Ask them how the model helps them to think about drag.	beaker; stopclock; balance; metre rule; eye protection; Worksheet 8Ja(4) or 8Ja(5). Optional: light gates and datalogging equipment.	cause skin irritation: warn pupils not to touch their eyes or mouth during the practical. Follow any safety instructions on the packet and ensure that pupils wash their hands after use, before leaving the lab. Care should be taken when dropping shapes into the paste to avoid splashes getting into the eyes. Wear eye protection.	
8Jb	Exploring 3	**Investigating pressure** Pupils demonstrate the effects of pressure by placing various masses on Plasticine® and measuring the depth of the impression made. They will need to work out the weight of each mass, and the area of its base. • **Could:** if pupils also measure the depth of the impression made they can enter their results into a spreadsheet and use that to work out the pressure, and to graph pressure against the depth of the impression.	**Resources (per group)** Plasticine®; variety of masses; ruler; calculator or access to computer and spreadsheet package.	Wash hands after the practical. Take care with larger masses.	
8Jc	Starter 1	**Floating paper clip (demonstration)** Have the ‘floating paper clip’ practical set up at the front of the class as pupils enter. This should provide some instant discussion as to why the paper clip stays up, and this can lead onto a discussion of magnetic materials.	**Resources (for demonstration)** Clamp and stand; bar magnet; paper clip; cotton thread.		

		For a diagram giving further information, please see page 270 of the teacher's guide			
8Jc	Starter 2	**Magnetic toys** Have available a selection of items that use magnetism – from basic fridge magnets to magnetic construction models or 'executive toys' using magnetism (e.g. floating pens). Use these to initiate a brainstorming or free-writing activity, asking pupils to write what they know about magnets and magnetism.	**Resources (to pass around)** Selection of toys using magnets, ideally including a 'floating pen'.		
8Jc	Exploring 1	**Blocking magnetism** Pupils work in small groups to investigate different materials to find out which ones magnetism will pass through. Set up the apparatus as shown in the diagram with *Starter 1* and insert thin sheets of different materials between the magnet and the paperclip. The paperclip will fall when a magnetic material is used.	**Resources (per group)** Clamp and stand; magnet; paper clip; cotton; labelled thin sheets of iron, copper, wood, paper, nickel (if possible), aluminium, Perspex, etc.	Beware of pinching fingers between very strong magnets.	
8Jc	Exploring 2	**Attraction and repulsion** Pupils determine the rules for attraction and repulsion between the poles of bar magnets by suspending one magnet in a stirrup and bringing another close to it. Longer lasting, more durable stirrups can be made using polythene sheeting.	**Resources (per group)** Two bar magnets; clamp and stand; paper stirrup (made by stapling a strip of paper, and trapping a length of cotton thread in the staple).	Beware of pinching fingers between very strong magnets.	
8Jc	Exploring 3	**Which is the magnet?** Have a selection of large nails, some of which are magnetised and some which are not. Twice as many magnetised nails are needed as un-magnetised ones. Label half the magnetised nails A, and half C. Label the un-magnetised nails B. Give pupils a set of nails and ask them to decide which one is not magnetised. This activity will reinforce the idea that only repulsion	**Resources (per group)** Two magnetised nails (labelled A and C); an un-magnetised nail (labelled B) that looks the same as the magnetised ones.	Beware of pinching fingers between very strong magnets.	

		between two pieces of metal will demonstrate that they are both magnets. When pupils have made their decision, ask them to explain their reasoning.			
8Jc	Exploring 4	**Strength of electromagnets** Pupils investigate ways of changing the strength of an electromagnet. This practical can be used to carry out an AT1 investigation. A set of level descriptions is provided on pages 288–289 of the ASP. Worksheets are provided at two levels, but if this practical is being used for a complete AT1 assessment, pupils should do their own planning. The variables that could be investigated are the number of coils/ turns of wire, voltage, and the type of core. Ensure that any iron nails or rods used as cores are demagnetised before beginning the practical (see Background information). It is actually the current that determines the strength of the magnet (as stated in the Pupil's Book) and it is the number of coils of wire per unit length of electromagnet that affects the strength, not the total number of turns. The worksheets suggest that pupils count the number of paperclips that can be picked up as a measure of the strength of their electromagnets. However the strength can be measured as a continuous variable by sticking a piece of iron or steel (such as the lid of a food can) to the pan of an electric balance using Blu-Tack®. If the electromagnet is held above the steel lid it attracts it and the reading on the balance changes. This could also lead to an interesting discussion on fair tests, as the distance of the electromagnet from the balance will affect the	**Resources (per group)** Insulated wire; connecting wires; power supply (ammeter); two crocodile clips; paper clips; soft iron rod or nail; glass rod; wooden rod or pencil; Worksheet 8Jc(2) or 8Jc(3). Optional: balance; piece of iron or steel (such as the lid of a food can); Blu-Tack®; clamp and stand.	Low voltages should be used with insulated wires, as many types readily overheat and may melt the insulation. Overheated wires will produce fumes from the insulation. Ensure the lab is well ventilated and warn asthmatics of the potential risk. See Background information.	

		reading. • **Must:** pupils follow the instructions on Worksheet 8Jc(2). • **Should:** pupils plan their own investigation with the help of the questions on Worksheet 8Jc(3). • **Could:** more able pupils should be able to plan and carry out this practical with no help form the worksheets. They should be encouraged to plan their practical using their existing scientific knowledge, to identify dependent and independent variables and to include safety advice in their plan. When evaluating their practical pupils should explain how and why they would make improvements to the method.			
8Jc	Explaining 3	**Homemade magnet** Pupils make their own magnets by the stroking method, and use them to attract paperclips or other iron/steel objects. Steel dressmaking pins can be used, but you may wish to file down sharp points before using them. Straightened out paperclips could also be used. Ensure that pupils stroke the pin in a single direction, rather than using a back and forth movement. More able pupils could follow this up with *Explaining 4*.	**Resources (per pupil)** Bar magnet; pin or straightened paperclip; paperclips.	Sharp points must be filed down before using steel pins.	
8Jd	Exploring 1	**Homemade compass** Ask pupils to work in groups to devise a way of suspending a magnet so that it can swing freely enough to point north. Pupils could also be asked to decide whether to use a bar magnet or whether they should magnetise something smaller such as a pin (see *Explaining 3* in Topic 8Jc). Possible designs include suspending the	**Resources (per group)** Bar magnet; pin; cork or wood; bowl or large beaker; cotton thread; clamp and stand; paper; Blu-Tack® or Plasticine®; stapler.		

		magnet from a clamp and stand using thread or a paper stirrup, or floating it on a cork or piece of wood in a bowl of water. Small magnets such as pins will be sensitive to draughts. This works best if there are no steel gas pipes around, etc. This activity could be a competition to find who can make the best compass. Ensure that pupils are not working near any iron or steel objects which could affect their results, and also that you know which way is north! Encourage pupils to evaluate their designs and, if time allows, modify them and test them again. They should present their designs to the rest of the class.			
8Jd	Exploring 2	**Field pattern using iron filings** Pupils find the shape of a magnetic field by placing a sheet of paper over a bar magnet, and sprinkling iron filings onto the paper. This is easier if the paper is kept horizontal by resting it on two books, with a gap in the middle for the magnet. This should be repeated with an electromagnet – point out the similarity in the field patterns, if necessary. Pupils may need help to relate the iron filings pattern to that obtained with plotting compasses or shown in the Pupil's Book. If you have horseshoe magnets available, you could extend this activity by getting pupils to find the shape of the field of a horseshoe magnet, and discuss why they are different. If bar magnets are wrapped in cling-film or sealed in small plastic bags, it will be much easier to remove all the iron filings from them at the end of the lesson. An alternative method is to use iron filings inside a plastic Petri dish which is sealed with sticky tape. This can then	**Resources (per group)** Two books; bar magnet; electromagnet (coil of wire, iron core, power supply); sheet of paper; iron filings in shaker; eye protection. Optional: iron filings sealed in Petri dish.	Pupils must wear eye protection in case they get iron filings in their eyes. Low voltages should be used with insulated wires, as many types readily overheat and may melt the insulation. Overheated wires will produce fumes from the insulation. Ensure the job is well ventilated and warn asthmatics of the potential risk. See Background information.	

		be placed directly above the magnet. • **Must:** for less able pupils, or if pupils are to carry out *Exploring 3*, it may be best to demonstrate the field shape using a sheet of Perspex placed on an OHP – it is then easy to point out the relevant features to the whole class. Ask pupils to suggest the best way of recording this pattern.			
8Jd	Exploring 3	**Field pattern using plotting compasses (AT)** Worksheet 8Jd(2) explains how to use plotting compasses to find the shape of a magnetic field. Encourage pupils to move the compass around above and below the magnet – either holding it vertically or observing the dip of the needle – to emphasise that the magnetic field is all around the magnet, not just in the plane of the paper. Pupils should plot the fields for both bar magnets and electromagnets, and compare them. The **AT** animation link on page 142 opens *Plotting a magnetic field* – which shows pupils how to use a plotting compass to plot the magnetic field of a bar magnet. This could be used instead of the worksheet. Using the prompt in the Pupil's Book, this activity can be extended to plot the fields of two bar magnets next to each other – end to end or side by side. More able pupils should be able to predict some of the features by discussing what would happen to a north pole placed near the magnets. Worksheet 8Jd(3) provides instructions for this part of the activity.	**Resources (per group or per pupil)** Two bar magnets; electromagnet (coil of wire, iron core, power supply); plotting compass; sheet of paper; pencil; Worksheets 8Jd(2) and/or 8Jc(3).	Low voltages should be used with insulated wires, as many types readily overheat and may melt the insulation. Overheated wires will produce fumes from the insulation. Ensure the job is well ventilated and warn asthmatics of the potential risk. See Background information.	
8Jd	Exploring 4	**Magnetic field around a wire** Pupils determine the shape of a magnetic field around a straight wire using plotting compasses	**Resources (per group)** Insulated wire; connecting wires; crocodile clips; power pack or cells;	Low voltages should be used with insulated wires, as	

		(usually more convincing than using iron filings). The wire should be fed through a hole in the centre of a piece of card. The piece of card is then fixed in a clamp so it is horizontal. It will probably also be necessary to fasten the wire above the card to another clamp to keep it vertical, before connecting the ends of the wire to the power pack. It may be necessary to demonstrate how to set up the wire and card. Pupils should use plotting compasses in a similar way to that used in *Exploring 3* (draw a dot on the card, place the tail of a plotting compass over it, and draw a new dot at the point of the compass). The relationship between the directions of the current and field is not important at this level, but pupils should appreciate that the direction of the field reverses if the current is reversed. They should be asked to predict what will happen if they swap over the connections at the power pack to reverse the current, and then test their prediction. This activity can be carried out in conjunction with *Explaining 5.*	card; plotting compass; clamp stand; pencil. **Resources (per group)** Insulated wire; connecting wires; crocodile clips; power pack or cells; card; plotting compass; clamp stand; pencil.	many types readily overheat and may melt the insulation. Overheated wires will produce fumes from the insulation. Ensure the job is well ventilated and warn asthmatics of the potential risk. See Background information.	
8Jd	Explaining 3	**Field pattern using a magnaprobe (demonstration)** Use a magnaprobe to demonstrate the three-dimensional shape of the field around a bar magnet. Pupils can investigate the shape of the field for themselves if sufficient magnaprobes are available.	**Resources (for demonstration)** Bar magnet; magnaprobe.		
8Jd	Explaining 4	**Direction of a magnetic field (demonstration)** Magnetise a pin or needle, and stick it vertically through a cork so that it fl oats with its north pole uppermost. Hold or fix a bar magnet so that it is just above the surface of a bowl of water	**Resources (for demonstration)** Magnetised pin; cork; bar magnet; bowl of water.		

		and ask pupils to predict what will happen to the needle and cork if it is put in the water near the magnet. If the needle is put in the water near the north pole of the magnet, it should follow a curved path around to the south pole. Use this to reinforce the fact that a magnetic field has a direction, defined as the way a freely moving north pole would move.			
8Je	Starter 2	**Examples of levers** Show pupils a couple of different examples of the same type of machine, such as a pair of embroidery scissors and a pair of kitchen scissors, or a small and large spanner. Ask pupils why the things are made in different sizes, and to suggest situations in which they would use the large or the small example. Elicit the idea that these things are levers, and that the ones with the longer handles allow more force to be applied to the object being cut/moved using only the same amount of effort. You could also show a tin with a tightly fitting lid, such as a paint tin, and ask pupils whether they would use a coin or a long screwdriver to get the lid off.	**Resources** One or more pairs of machines (such as embroidery scissors and kitchen scissors, wire cutters and bold cutters, garden hand secateurs and long-handled loppers, small and large spanners). Optional: tin of paint; coin; screwdriver.	Take care if pupils are allowed to use machines. Over-enthusiasm could lead to slips, resulting in cuts or bruises.	
8Je	Exploring 1	**Investigating levers** The aim of this practical is to show that a longer lever makes lifting a load easier. • **Must:** instructions are given on Worksheet 8Je(2). Pupils working with this sheet will investigate the number of masses needed for different lengths of lever. • **Should:** Worksheet 8Je(3) encourages a more open-ended approach to investigating levers, and pupils using this sheet may need to be reminded that a 100 g mass has a weight of 1N.	**Resources (per group)** Metre rule; sandbag; triangular block of wood (pivot); 100 g slotted masses; Worksheet 8Je(2) or 8Je(3).	Sandbags should not be any heavier than 2 kg.	

		Ensure that the sandbags (if used) have a suitable mass and can be lifted using the masses available.			
8Je	Exploring 2	**Using levers** Set up a circus and allow pupils to try different levers. Suitable examples are using a variety of levers to open an empty custard tin (e.g. 50p piece, teaspoon, long-handled screwdriver), using the tips of scissors to cut paper, using scissors to cut thick cardboard, using wire cutters and bolt cutters, using secateurs and branch cutters, using cutters to cut a piece of metal. Other items such as torque wrenches and wheel braces may have to be items for discussion, unless you have something suitable to use them on. In all cases, ask pupils to identify the pivot and the position of the effort. Ask them to note the different way they use scissors when cutting paper or thick card, and why bolts cannot be cut with small wire cutters.	**Resources (for class circus)** As many of the following as possible: custard tin and spoon, 50p piece, long-handled screwdriver; scissors, paper and thick card; wire cutters and wire; bolt cutters; secateurs, branch cutter, thin and thick branches; metal cutters, metal sheet (old food cans will do). Optional (for demonstration): torque wrench, wheel brace.	If cutting metal, ensure that pupils take care not to cut themselves on sharp edges. You may not wish to allow some classes to use items such as bolt cutters, secateurs, etc. Prepare for cut fingers! Over enthusiasm could lead to slips, resulting in cuts or bruises. Don't cut towards hands or body. Care should be taken to prevent tools slipping in use.	
8Je	Explaining 2	**A model arm demonstration** Discuss the arrangement of bones, joints and muscles in the arm. Show a model arm, and ask pupils to explain how the forearm operates as a lever, and discuss how this lever is different from the levers examined in *Exploring 2*. (In *Exploring 2* the levers suggested are class 1 levers, with the pivot between the effort and the load; the arm is a class 3 lever, with the effort between the pivot and the load – see Background information. Pupils are not expected to know about the different classes of lever, but should realise that the effort required	**Resources (for demonstration)** Model arm; or cardboard, paper fastener, string or elastic bands; eye protection.	Elastic bands can break or fly off. Wear eye protection.	

		from the biceps to move a load is greater than the load.) If necessary, a model arm can be made from strips of card with a paper fastener to act as the pivot, and string or elastic bands can be used to represent the muscles. Reinforce the idea that antagonistic muscles are needed for movement in both directions as muscles can only pull, not push. For a diagram giving further information, please see page 279 of the teacher's guide			
8Ka	Exploring 1	**Making a shadow theatre** This is a simple version of the investigation suggested as *Exploring 2*, and serves to revise work on shadows from KS2. Instructions are provided on Worksheet 8Ka(2). Pupils can investigate which slot gives the clearest image and how the size of the image changes when the puppet is moved. The easiest way to do this is to measure the height of the shadow. If sufficient measurements are made, then the height can be compared to the distance from the bulb and a graph plotted. The size of the hole and the clarity of the shadow can also be compared.	**Resources (per group)** A box such as a shoe box with slits cut in the side, a large hole in one end and a small one in the other; tracing paper; strong light bulb; card; scissors; glue; stick; Worksheet 8Ka(2).	Pupils must not look directly at the bulb, or touch it when it is hot.	
8Ka	Exploring 2	**Shadow investigation (AB)** Use a ray box to produce a strong ray of light. Mount a piece of card on a stand, and place a screen so that the shadow of the card falls on it. Show pupils the apparatus and ask them to plan an investigation to find the relationship between the distances and shadow sizes. Worksheet 8Ka(3) provides some hints for planning their practical and analysing their results. Alternatively, the **AB** spreadsheet link on page	**Resources (per group)** Ray box; card; stand; sheet of white paper or a screen; glue or sticky tape; Worksheet 8Ka(3).	Pupils must not look directly at the bulb, or touch it when it is hot.	

		149 opens *Shadow investigation* – which provides the results of some experiments for pupils to use to plot graphs and draw conclusion.			
8Ka	Explaining 2	**Straight lines (demonstrations) (AT)** Use one or more of these suggestions to demonstrate that light travels in straight lines. **Light beams:** In a darkened room shine a beam of light onto a wall (the light from an OHP will do). Bang two board rubbers together near to the beam. The chalk dust should illuminate the beam of light more clearly. Talcum powder can be used if no chalk dust is available. This can be carried out with a laser beam but care must be taken. Ensure that pupils understand that we can see the beam of light only because the dust put into the air is scattering some of the light towards our eyes. **Rubber tubing:** Try to shine a light down rubber tubing. Light can only be seen through the tubing if it is perfectly straight. **Lining up the holes:** Shine a lamp at a screen or wall and support a card with a hole in it on a retort stand in front of the lamp. Support further holed cards on retort stands in front of the lamp to demonstrate that light travels in straight lines and will only go through aligned holes (or parts of holes). You can demonstrate that the holes are in a straight line by threading a piece of cotton through them and pulling it taut.	**Resources (for demonstration)** Source of light (OHP or class 2 laser); board rubbers or talcum powder; clamp. **Resources (for demonstration)** Source of light (OHP or torch); length of rubber tubing. **Resources (for demonstration)** Lamp; 3–4 pieces of card, each with a hole; clamp and retort stand to support each card.	Lasers should be class 2 and obtained from a reputable supplier. They should be secured to a clamp. Laser pointers are usually class 3 and should not be used. Any use of lasters must follow strict procedures to ensure stray reflections do not enter eyes. Consider any pupils with breathing difficulties before using talcum powder or chalk dust. Do not look down the beam from the lamp.	
8Ka	Explaining 3	**Speed of light thought experiment (demonstration)** Shine a light (or laser beam) towards a screen from a close distance. Most pupils will say that the light appears on the screen as soon as the	**Resources (for demonstration)** Torch, lamp or laser.	Lasers should be class 2 and obtained from a reputable supplier. They should be secured to a	

		light is switched on. Ask them to suggest what might happen if the source were moved further and further away from the screen and then switched on again. Would there be a time delay between switching on and the light appearing on the screen? Ask pupils to suggest how far away the source would need to be to give an appreciable time delay. A distance of 300 000 km would give a time delay of 1 second.		clamp. Laser pointers are usually class 3 and should not be used. Any use of lasters must follow strict procedures to ensure stray reflections do not enter eyes.	
8Kb	Starter 2	**Materials brainstorm** Show pupils a selection of materials (see list in resources section). Ask them to list the differences between the materials, and then ask them to say how they are different in terms of light. Elicit the fact that some are transparent, some are translucent and some are opaque (they should recall these words from KS2 work). You could go on to ask why the white paper looks brighter than the black paper, eliciting the idea that the white paper reflects morelight. Ask what has happened to the light hitting the black paper (most of it has been absorbed). Ask them to explain how they can see the objects at all: Where is the light coming from? What path does it follow? You could also remind pupils at this point that light is a way of transferring energy, and ask what happens to the energy transferred by light that is absorbed by black objects (it is transferred to heat energy, so the paper will get warmer). Pupils may suggest this if they have already studied Unit 8I and can make the link with the ways in which different coloured materials absorb or reflect infrared radiation.	**Resources (for class discussion)** White paper; black paper; greaseproof paper; metal block; glass block; Perspex block; beaker of water; beaker of copper sulphate solution; beaker of fl our/water mixture (and stirring rod).		
8Kb	Exploring 1	**What does light do?** The aim of the practical is to classify materials	**Resources (per group)** Torch or ray box; clamp and stand;	Remind pupils not to stare at light sources	

		into opaque, translucent or transparent, and then consider reflection, absorption and transmission of light. A torch or a ray box can be used as a luminous source. Ask the pupils to explain what is happening in each case then introduce the idea of reflection, absorption and transmission. Instructions are provided on Worksheet 8Kb(3).	selection of materials such as wood, white paper, black paper, a mirror, a plastic beaker, a coloured mug, a soft drinks bottle, thin fabrics; Worksheet 8Kb(3).	or to touch ray boxes when they are hot.	
8Kb	Exploring 2	**Reflecting light** Pupils use a light sensor (and optional datalogger) to measure the amount of light reflected by different materials. By measuring only the amount reflected, the problem of controlling the thickness of material is avoided. • **Must:** pupils follow the instructions on Worksheet 8Kb(4), ignoring the further questions at the end. Discuss the conclusions and evaluations at the end of the sheet with pupils. You may wish to limit the investigation for some pupils to different colours of the same material, or to different materials of the same colour, so that they are only investigating one variable. • **Should:** pupils carry out the instructions on the worksheet, and discuss the further questions, planning a further investigation in their groups. If you have a range of materials of constant thickness they can carry this out. They should be able to measure the light transmitted and reflected by a material, and work out the proportion absorbed from those results. The discussion of the ways of controlling variables, controlling light from the surroundings, etc., is likely to be more valuable learning than the actual results obtained.	**Resources (per group)** Datalogging equipment; light sensor; ray box or torch; selection of materials such as wood, different coloured papers, tracing paper, different coloured fabrics; a mirror; Worksheet 8Kb(4).	Remind pupils not to stare at light sources or to touch ray boxes when they are hot.	

8Kb	Exploring 4	**Pinhole cameras** Pinhole cameras can be bought from equipment suppliers, or can be made using a tube (such as half a kitchen roll tube) or a box. Cover one end with tracing paper and the other with either black sugar paper or foil and make a small pinhole in the centre. Sticky tape is helpful for anchoring the paper. It may be necessary to add an extra piece of sugar paper as a tube around the screen end to stop too much light falling on it. Foil is good because it moulds better to the shape, preventing light entering. The pinhole camera image is viewed from the screen end with the pinhole pointing at a light source. This could be a window on a bright sunny day. Otherwise it will have to be a light bulb, preferably one with a distinctive shape or filament so that it is clear that the image is upside down. A candle may work, if the daylight is not too bright. Worksheet 8Ka(5) provides instructions and questions to encourage pupils to explain what they have seen. They should not need to renew the paper with the pinhole if they do the investigation in the order suggested (small hole, three small holes, large hole). You may wish to discuss the nature of the screen in a pinhole camera with more able pupils. If it were transparent you would not see the image. The screen is translucent, so some light is scattered rather than going straight through, allowing us to see the image on the screen.	**Resources (per group)** Pinhole camera (or foil/black sugar paper, tracing paper, sticky tape, toilet roll or box); bulb (carbon filament lamps work well); Worksheet 8Kb(5).	Cameras should not be pointed directly at the Sun (although scientists do this!) or placed too near the light source.	
8Kb	Exploring 5	**Photograms** A photogram is a 'shadow picture' made using photographic paper. This activity can be used to	**Resources (per group)** Black and white photographic paper or sensitised paper (made by	Eye protection may be necessary (check which chemicals are	

		illustrate how a simple image can be recorded. Contact speed paper is suitable as it can be handled in normal laboratory blackout conditions and takes up to 30 minutes to darken completely (depending on the intensity of light it is exposed to). This type of paper will not need developing, only fixing. Pupils arrange various translucent and opaque objects on a piece of photographic paper, and then use a table lamp to expose the paper until it turns black. Refer to the manufacturer's instructions for the fixer, and handle the paper with tongs when using fixer. Fixed photograms should be rinsed in a second tray before being left to dry. Discuss the safety precautions necessary with pupils before they start the practical.	soaking filter paper in 1 mol dm–3 sodium chloride solution and then painting 1 mol dm–3 silver nitrate solution onto it in dim light and allowing it to dry in dim light), kept in lightproof bag until ready for use; tray of made-up fixing solution at the correct temperature; rinsing tray (a shallow tray with a slow-fl owing water supply); table lamp; tongs; collection of translucent and opaque objects.	in the fixer). Do not get fixing chemicals on the skin. Wash well with soap and water if contact occurs. Eye protection and gloves must be worn when preparing and using the silver nitrate solution.	
8Kc	Starter 2	**Light for seeing (demonstration)** Reinforce the idea that we see non-luminous things because of reflected light. Darken the room and use a torch to illuminate part of it. Ask what the light source is, and how the light travels to allow them to see the illuminated object. Restore normal lighting again, and elicit ideas about the many different possible paths of light that allow them to see objects in the room (for example, light from ceiling lights, or from the windows, spreading in all directions and being scattered). Finish by holding up a piece of white paper and a mirror, and asking for as many differences as possible between the two objects, including the fact that an image can be seen in the mirror.	**Resources (for demonstration)** Torch; white paper; mirror.		
8Kc	Exploring 1	**Investigating mirrors** Demonstrate the use of a ray box, using a	**Resources (per group)** Ray box; plane mirror; pencil;	Remind pupils not to stare at light souces	

		single slit to produce a ray of light. Show pupils how to mark the path of light with dots and then join the dots with a ruler. Also explain that the angles of incidence and reflection are measured from the normal, and show them how to do this, if necessary. Encourage pupils to make a prediction about what happens when a ray of light is reflected from a mirror. They should be encouraged to make a generalisation from their results, such as the light is reflected at the same angle at which it hits the mirror. • **Must:** instructions are provided on Worksheet 8Kc(2). Worksheet 8Kc(3) provides a set of angles drawn from the normal which pupils can use with a ray box and mirror to avoid the need to use protractors. • **Should:** pupils carry out their own measurements after being shown how to draw the normal and measure angles from it. They could use Worksheet 8Kc(2) if they need more help. Pupils could be asked what they would do to keep themselves and others safe during this practical.	protractor; ruler; Worksheets 8Kc(2) and 8Kc(3).	or to touch ray boxes when they are hot.	
8Kc	Exploring 2	**Make a periscope** Look at photo E on page 153 of the Pupil's Book, and ask pupils why the people shown are using periscopes. Ask pupils to design their own periscope, using their knowledge of mirrors and reflection. The mirrors should be positioned at 45°, facing and parallel to each other at opposite ends of the periscope. • **Must:** Worksheet 8Kc(4) provides a template that can be copied onto card and given to pupils. • **Should:** pupils design their own way of holding two mirrors at the appropriate angles.	**Resources (per group)** Card; 2 mirrors; sticky tape; Worksheet 8Kc(4).	Ensure glass mirrors are firmly attached to periscopes to avoid breakages. With some groups it may be better to use plastic mirrors.	

		Ask them to draw a ray diagram to explain how their periscope works.			
8Kc	Exploring 3	**Investigating curved mirrors** Ask pupils to investigate how curved mirrors reflect light. Worksheet 8Kc(5) provides some ideas for pupils to investigate, and suggests that they attempt to explain their results by thinking of a curved mirror as lots of separate plane mirrors arranged in a curve.	**Resources (per group)** Concave and convex mirrors (if necessary, mirrors suitable for use with ray boxes can be made by bending flexible strips of plastic mirror); ray box and power supply; Worksheet 8Kc(5).	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	
8Kc	Exploring 4	**Treasure Island** Worksheet 8Kc(6) provides a map of a treasure island where pupils have to accurately draw in the path of rays to find the location of the treasure (a). This could also be done using mirrors and a ray box (b). Pupils could also draw their own Treasure Island, possibly using a drawing package on a computer. Pupils should use a number of mirrors to reflect light from and work out how far the ray has to travel. A competition for the best island puzzle could be held.	**Resources (per group)** a) Worksheet 8Kc(6); protractors; rulers; large sheet of plain paper. b) Ray box; mirrors and stands; Worksheet 8Kc(6); large sheet of plain paper.	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	
8Kc	Exploring 5	**Mirrors and patterns** Give pupils two mirrors and a protractor. • **Must/Should:** ask pupils to use the two mirrors to see themselves as others see them. This can be done by holding the two mirrors at right angles to each other and looking towards the place where the two mirrors meet. • **Could:** ask pupils to find out the relationship between the number of images and the angle between mirrors. (It is $A(N + 1) = 360$, where A is the angle and N is the number of images.) It is probably best to stick to factors of 360. For example, an angle of 90º gives 90(3 + 1) = 360 so the number of images is three.	**Resources (per group)** Two plane mirrors; protractor.		

8Kc	Explaining 2	**Images in plane mirrors (demonstration)** Demonstrate the various properties of an image in a plane mirror. The distance of the image behind the mirror can be demonstrated simply by laying a ruler at right angles to the mirror. Point out that the size of the gaps between each centimetre mark does not appear to change as you move your view from the ruler to its image. A more sophisticated way of demonstrating this is to use an object such as a pencil stuck in a blob of Plasticine. Set up a similar pencil behind the mirror, and position it so that if you look at this second pencil above the mirror, it does not seem to move relative to the image of the first pencil when you move your head. The image is therefore in the same place as the second pencil. Pupils can look at their own faces to see the lateral inversion. Point out that the image is not reversed top to bottom. The 'lateral inversion' of an image in a mirror can present the problem of why it is not also inverted top to bottom. However, the lateral inversion is because we are used to the right hand of a person facing us being on our left, and we interpret the image in a mirror in a similar way. The problem goes away if pupils consider that the reflection always appears to be in the equivalent place to the relevant part of the object; i.e. the top of the image corresponds to the top of the object, the left side of the image (*not* the left hand of the person in the image) corresponds to the left of the object, etc.	**Resources (for demonstration)** Plane mirror and stand; 2 pencils; Plasticine or Blu-Tack.		
8Kd	Starter 1	**Refraction (demonstration)** Show pupils some examples of refraction.	**Resources (for demonstration)** Beaker; water; pencil; mug; coin;		

		• Stand a pencil in a beaker of water, and get pupils to note that the pencil appears bent. • Put a coin into a mug at the side nearest a pupil. Ask a pupil to move his/her head until they cannot see the coin. Then pour water into the mug, and the pupil should be able to see the coin without having to move. Ask pupils to try to explain the effects. They could jot down their ideas now and revisit them as part of *Plenary 2*.	water.		
8Kd	Exploring 1	**Investigating refraction** Demonstrate what happens when a ray is shone onto a glass block using a ray box. Explain that it is often very difficult to see what is happening to the ray of light inside the glass block, and that it is usually sufficient to mark the points at which the ray enters and leaves the block and then join these points with a ruler. Ask the pupils to predict, then investigate, what happens when the angle is changed. The numerical relationship between the angles of incidence and refraction is not needed at KS3, just a comparison, so only generalisations should be encouraged, although pupils should draw and measure the angles of incidence and refraction accurately. • **Must:** instructions are provided on Worksheet 8Kd(2), although using this sheet will restrict the marks that pupils can obtain in the planning strand if this investigation is used for AT1 assessment. • **Should:** pupils plan their own investigation. In addition to the suggestion above, they could also investigate the amount of refraction in different materials if you have them available (although the differences may be too small	**Resources (per group)** Ray box and cylindrical lens; single slit; sheet of white paper; pencil and ruler; rectangular and semicircular glass blocks; Perspex blocks, or blocks of other materials; Worksheet 8Kd(2).	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	

		compared to the inaccuracies involved in ray tracing), the relationship between the angle and position of the ray entering the block and the one leaving it (they should be parallel, but how does the offset depend on the angle of incidence?), or they could find out what happens as the angle increases. Pupils should identify variables and assign suitable values to them; they should explain clearly what results they are going to collect and how they are going to display them. Pupils could explain why displaying results as a graph or table is a good idea and whether they have sufficient results to draw a firm conclusion. Any evaluation of the practical should include improvements that could be made and the reasons for these improvements. • **Could:** when planning the practical, those working at a higher level should be able to refer to their own scientific knowledge or use other sources of evidence such as textbooks. They should choose an appropriate range, number and value for variables (and this may entail them doing some preliminary work). Pupils at this level should be able to explain how the use of tables and graphs makes it easier to see trends. They should also be able to evaluate their practical and explain what improvements could be made next time round and why these improvements might be necessary. This practical can be used to carry out an AT1 Investigation. A set of level descriptions is provided on pages 313–314 of the ASP.			
8Kd	Exploring 3	**Total internal reflection** Pupils investigate the point at which the semicircular glass block and the 45° prism	**Resources (per group)** Ray box and cylindrical lens; single slit; sheet of white paper; pencil and	Remind pupils not to stare at light souces or to touch ray boxes	

		reflect light instead of refracting it. Instructions are provided on Worksheet 8Kd(3). You may need to explain to pupils that the semicircular block is used because if the light ray is aimed at the centre of the straight side, it crosses the curved edge at right angles and so no refraction takes place there. They can therefore concentrate only on what happens when the light hits the inside of the fl at edge.	ruler; semicircular glass block; 45° prism; protractor; Worksheet 8Kd(3).	when they are hot.	
8Kd	Exploring 4	**Investigating lenses** Pupils shine parallel rays of light through converging lenses of different thicknesses, and note the results. This can be extended by using a convex lens to form an image of a window or lamp on a screen to illustrate the effect of making light rays converge to a point. The relationship between the curvature of the lens and the distance between the lens and screen to achieve a focused picture can then be investigated.	**Resources (per group)** Ray box and cylindrical lens; triple slits; sheet of white paper for ray tracing; card or sheet of white paper for a screen; range of cylindrical and spherical lenses (convex and concave).	Remind pupils not to stare at light sources or to touch ray boxes when they are hot.	
8Kd	Explaining 2	**Lens (demonstration)** Pages 154–155 in the Pupil's Book ask pupils to visualise a lens as a combination of prisms of different shapes. Use a ray box with triple slits to show pupils how a convex lens affects light, then simulate a convex lens using two narrow prisms (available from equipment suppliers) placed base to base and using two ray boxes with single slits. Repeat using a concave lens, and simulate by placing the two narrow prisms with their apices together.		Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	
8Ke	Starter 3	**Colour questions (demonstration)** This starter idea is most suitable for pupils who are going to use the Focus on: page 158–159 which looks at how we see colour. Use three ray	**Resources (for demonstration)** 3 ray boxes; 3 primary colour filters (red, blue, green); screen.	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	

		boxes and coloured filters and shine them on a wall or screen so they overlap. Put a hand or other object in the paths of the light so that multiple, different coloured shadows are formed. Ask pupils to suggest explanations for the patterns and colours seen. If necessary, elicit the idea that some places on the screen are receiving only one or two colours of light. This demonstration is revisited again in *Explaining 3*, so pupils may wish to jot down their suggestion so that they can look at it and amend it later, once they have learnt more about colours and vision. Alternatively, LED 'colour mixers' can be obtained from equipment suppliers that can be used in similar investigations.			
8Ke	Exploring 1	**Splitting light** • **Must:** instructions are given on Worksheet 8Ke(4). Before beginning the investigation ask pupils to look through the prisms to see if they can see a rainbow. Most should be able to. Shine a single ray of light from a ray box through a prism to produce a spectrum. This works best if a partial blackout can be achieved in the room. Some pupils may need help positioning their prism to obtain a spectrum. • **Should:** in addition to the above, challenge the pupils to recombine the rainbow using a converging lens and a second prism to make white light again. Tell them that this is one of the ways in which Newton demonstrated that the colours were part of the white light, rather than being added to the light by the prism.	**Resources (per group)** Ray box; single slit; sheet of white paper; Worksheet 8Ke(4); assorted triangular prisms; plus some other glass shapes to demonstrate.	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	
8Ke	Exploring 2	**Exploring filters** Pupils use white light from a ray box and shine it through different filters onto a white screen. Ask	**Resources (per group)** Ray box; coloured filters; screen; prism.	Remind pupils not to stare at light souces or to touch ray boxes	

		them to explore what happens when they use two filters, one after the other, and to suggest explanations for what they see happening. Follow this up by asking them to use a prism to produce a spectrum, and then to investigate what happens when they shine the spectrum through different filters. The filters should be tested before the lesson to ensure they give the desired effects, as many filters actually allow a mix of colours to pass through.		when they are hot.	
8Ke	Exploring 3	**Colours in coloured light** Pupils set up a ray box so the light shines through a colour filter onto a screen. They put different coloured objects into the path of the light and record what colour they appear to be, and repeat this for all three primary colours. Pupils should be able to design a table with the object colours down the side and the colours of the filtered lights across the top. Ask them to try to make a general statement to say what happens for each colour of light. This practical works best if the objects are in a closed box with a hole for viewing in order to prevent extraneous light from entering.	**Resources (per group)** Ray box; coloured filters; coloured objects. Optional: closed boxes with a viewing hole and hole for the ray box wire.	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	
8Ke	Exploring 4	**Combining colours** Instructions are provided on Worksheet 8Ke(5). The circles can either be made in advance, pupils can use compasses and scissors to draw and cut out their own, or they can print them from a computer drawing package and stick them onto card before cutting them out.	**Resources (per group)** Card circles (or card and a pair of compasses and scissors); coloured pencils or pens; small motor connected to a cell or power pack; stand for motor; Worksheet 8Ke(5).		
8Ke	Explaining 3	**Combining primary colours (demonstration)** This is best done after *Explaining 2*. Use three ray boxes and coloured filters to demonstrate how combining the primary colours produces	**Resources (for demonstration)** Three ray boxes; 3 primary colour filters (red, blue, green); screen.	Remind pupils not to stare at light souces or to touch ray boxes when they are hot.	

		white light. If the areas of light overlap you can also show the secondary colours. If *Starter 3* was used, make the coloured shadows again and ask pupils to explain them now they have looked at colour and vision.			
8La	Exploring 1	**Changing the pitch 1** Place equipment around the lab, numbered to match Worksheets 8La(2) and 8La(3). Pupils carry out each experiment and record their results before drawing a conclusion. A. A plastic water bottle that can contain water at different levels. Pupils fill or empty the bottle and blow across the top. B. A wooden block containing four nails of different lengths and something to tap each with (e.g. a metal spoon). C. Wind chimes of different lengths and something to hit each with (e.g. an old spoon). D. Wooden blocks of different lengths to drop on the floor. E. A shoe box with elastic bands of different thicknesses wrapped around it. F. A ruler attached to the end of a desk with a G-clamp. • **Must:** pupils use Worksheet 8La(2). • **Should:** pupils use Worksheet 8La(3).	**Resources (per group)** Plastic bottle; wooden block containing 4 nails at different heights; metal spoon; set of wind chimes; 4 wooden blocks of constant thickness but at different lengths from 10 cm to 40 cm.	Ensure pupils clear up any water spills as soon as they happen.	
8La	Exploring 2	**Making different sounds** Pupils have to explore and find out the effect of changing length, width and material for a series of metal tubes. Each group is provided with a set of seven tubes, based on the three tests mentioned in Worksheet 8La(4). The first test involves pupils having to compare the pitches of the sounds made by an aluminium tube, a copper tube and a brass tube, all of which are	**Resources (per group)** 3 metal tubes made from aluminium, copper and brass respectively; 2 further aluminium tubes of the same length; 2 further aluminium tubes of different diameter.		

		the same length and have the same diameter. This can be performed by dropping or hitting the tubes in order for the sounds to be produced. The next test involves pupils dropping tubes of the same metal and length, but of different diameter. Finally, the third test involves pupils comparing the pitches made by three tubes of the same material and diameter, but of different lengths.			
8La	Explaining 3	**Slinky and Ruben's tube (demonstration)** A slinky spring can be used to demonstrate how sound waves travel in the form of a longitudinal wave composed of compressions and rarefactions. Pupils could also have a Ruben's tube demonstrated to them and be told that each one shows a model of a sound wave. You could then ask pupils to describe the pros and cons of each model, hopefully concluding that the slinky spring is a better model.	**Resources (for demonstration)** Slinky.	Consider any pupils with breathing difficulties before using talcum powder or chalk dust.	
8La	Explaining 4	**Musical vibrations (demonstration)** Use a selection of musical instruments to demonstrate vibrations taking place. You could use a guitar to show the strings vibrating. Similarly, you could use a xylophone covered in chalk dust (or talc) so that pupils see how the notes are produced when the keys are struck. Or examine the inside of a whistle with a ball in it. You could show these things to pupils via a camera attached to a monitor and the recorded footage could be shown in a slowed down manner so that a better appreciation of the vibrations can be achieved.	**Resources (for demonstration)** Xylophone; talc or chalk dust; guitar; whistle with ball in. Optional: video camera.	Consider any pupils with breathing difficulties before using talcum powder or chalk dust.	
8La	Explaining 5	**Other vibrations (demonstration)** Mary D Waller (1887–1960) did some simple experiments on vibrations and sound. Her work	**Resources (for demonstration)** Thin brass (or other metal) plate (Chladni plate); violin bow or small		

		was actually used to help perfect the jet engine, which used to shake itself to pieces until her discoveries concerning resonant frequencies were published. A thin metal plate (brass works well) is covered in a fine layer of sand. This is often called a Chladni plate. The plate can be held in the middle with the fingers (if it is small enough) or hammered into a central support. The edge can be stroked with a violin or 'cello bow. A small hammer can also be used. The sand bounces around and a sound is heard. The sand bounces off parts of the plate that are vibrating and settles into the parts that are still, forming some interesting patterns. A more effective way of carrying out this demonstration is to support the thin metal plate on top of some wine corks cut in half. Then pour on the sand. Hold a piece of dry ice in some forceps and touch it to the plate. The subliming carbon dioxide causes vibrations in the plate with the same effect as above. • **Should:** explain to pupils that the patterns seen are due to waves in the plate. • **Could:** explain that these Chladni patterns are caused by many waves being generated in the same object. At some places the waves cancel each other out (e.g. when the 'crest' of one wave coincides directly with the 'trough' of another wave). Where this happens there is no net movement of the plate and so sand particles will tend to collect in these areas (called nodes). The surfaces of instruments like violins and guitars are tested like this to determine where the nodes are, since this effects the sound of the instrument.	hammer; fine, dry sand. Optional: Cork supports (e.g. wine corks cut in half); dry ice; forceps.		

8Lb	Exploring 1	**Frequency of instruments** Pupils can investigate how a number of different instruments can be used to produce sounds of different pitches and intensities. In particular, the recorder and the glockenspiel can be used and pupils could investigate what causes the change in the note being produced. As an extension, pupils could investigate how a note changes on a bass guitar or classical guitar when the thickness of the string changes. They could also be asked to find notes of the same pitch on different thickness strings. There is an opportunity here for pupils to bring in their own instruments and demonstrate to the class how notes of different pitches and hardness can be made.	**Resources (per group)** Recorder; glockenspiel. **(per class)** Guitar.		
8Lb	Exploring 5	**Oscilloscopes in action** Pupils can use a signal generator and an oscilloscope to see how changing the frequency and intensity of the sound can lead to the trace of the sound wave changing on the screen. If possible, a loudspeaker can also be used to show how the sounds change, provided that this does not cause the room to become too noisy. • **Could:** ask pupils to investigate how changing the time base and voltage sensitivity controls can also lead to the trace visibly changing, despite the frequency of the wave being constant. If the number of oscilloscopes is limited, this activity could be run as part of a circus with *Exploring 1*.	**Resources (per group)** Signal generator; oscilloscope; connecting leads. Optional: loudspeaker.		
8Lb	Explaining 2	**Ruben's tube and oscilloscopes (demonstration)** Show pupils what happens to the trace on an oscilloscope when the pitch made by a signal	**Resources (for demonstration)** Loudspeaker; frequency generator; oscilloscope. Optional: instruments and music.	The volume on the signal generator must not be too loud.	

		generator is changed. You could extend this by playing music or an instrument, and displaying the associated traces on the oscilloscope This could be followed by showing pupils a YouTube clip of a Ruben's tube and how the flames change with different notes.			
8Lb	Explaining 3	**Oscillating masses (demonstration)** Use this demonstration to reinforce the idea that the heavier the mass the slower the vibrations it makes. This is the general rule of vibrating things; the more mass they have, the slower they vibrate and so that lower pitch of the sound produced. Suspend a spring from a clamp on a retort strand and attach a mass hanger with 100 g on it. Pull down the spring gently and ask pupils to watch what happens. Now add another 100 g mass and pull down on the spring again. It will be seen that the spring bobs up and down more slowly. Adding another 100 g mass and repeating the process will confirm the idea.	**Resources (for demonstration)** Retort stand and clamp; spring; mass hanger and slotted masses.		
8Lc	Exploring 1	**Travelling sound** Pupils investigate how sound travels through solids, liquids and gases. • **Must:** pupils will need to use the instructions provided on Worksheet 8Lc(2), recording their data as they work. • **Should:** pupils plan the practical using Worksheet 8Lc(3) and provide an evaluation of their method.	**Resources (per pair)** Stethoscope; two wooden blocks; tank of water; Worksheets 8Lc(2) or 8Lc(3).	Do not place ear(s) or stethoscopes in direct contact with solids through which loud sounds are passing. Keep all volumes under control.	
8Lc	Exploring 4	**Measuring the speed of sound** If you have a wall in the school grounds on which sounds can echo, then this experiment works well and provides a good opportunity to look at the accuracy of measurements.	**Resources (per class)** Stopwatches; paper on which to record results. Optional: clapper from PE department; microphone; datalogger; laptop.	Ensure that any work outside is well supervised and in line with your school's safety policy.	

		If your PE department has a clapper, this is very useful. (It's two hinged pieces of wood, each with a semi-circle attached, so that when the two pieces of wood are brought together the semi-circles form a full circle and a clap is heard.) Send one pupil about 50 metres away and ask them to clap the board. The other pupils should be able to see that the circle is formed before they hear the clap – light is faster than sound. Ask pupils to measure out a distance of 50 m (smaller distances are possible but will yield even less accurate results) between themselves and the wall. Using the clapper or clapping your hands, generate an echo. Explain to pupils that the sound from the clap has travelled to the wall and back again and ask them what distance this is. Then ask them how they might work out the speed. Some might know that speed is distance divided by time taken. Explain this and ask them how they would measure the time taken. The time can then be measured using stopwatches and the speed calculated. Ask pupils how the accuracy might be improved (extending the distance or using a datalogger and microphone are both ways in which this can be done). Reliability can be improved by repeating the measurements and making sure that they are in agreement. Ask pupils to explain how these improvements to the practical will lead to the collection of more accurate, reliable and valid evidence to draw a more secure conclusion. If you have datalogging equipment, a laptop and a microphone, it is possible to record and see the sound traces of both the initial clap and the echo on the computer. Clap your hands near			

		the microphone. You will see a large trace on the screen, followed by a smaller trace when the microphone picks up the echo. The distance between the traces can be used to work out the time taken. This is much more accurate than using stopwatches. It is important that pupils remain very quiet when doing this. The **AB** spreadsheet link on page 166 opens *Speed of sound* – which allows pupils to record their data and calculate the speed of sound.			
8Lc	Explaining 2	**Newton's cradle (demonstration)** A demonstration of how sound energy is passed from one particle to another in a solid can be conducted using a Newton's cradle. Particular mention could be given to how quickly the energy is transferred when the particles are touching (as they are in the Newton's cradle). Pupils could then be asked what the Newton's cradle might look like if it were representing the movement of particles and the transfer of sound energy in a liquid or a gas. This could lead on to further questions and answers or even a practical where pupils try to design a similar model to represent energy transfer in all three states of matter.	**Resources (for demonstration)** Newton's cradle.		
8Lc	Explaining 3	**Bell jar and alarm (demonstration)** Use the bell jar and alarm demonstration to show that sound waves can only travel from one place to another if a medium is present. Pupils can hear the alarm ringing inside the bell jar when it is filled with air. Removing the air with a vacuum pump causes the sound to become progressively quieter until it eventually becomes inaudible. Allowing air to re-enter the chamber causes the sound to become audible once	**Resources (for demonstration)** Bell jar; alarm; vacuum pump; safety screen.	Wear eye protection and erect safety screens around the bell jar.	

		again and pupils can be questioned as to what the demonstration shows.			
8Ld	Exploring 5	**Direction of hearing** Ask pupils what they could do to find out if two ears are better than one for determining the direction of sounds. Give pupils a few minutes to work together in groups to discuss this and then ask for some ideas. Decide on an appropriate approach, which could be based on the following. Put pupils into groups of about 9 or 10. One pupil sits on a chair with a blindfold on. The others stand around the chair at the different points of a compass, all at the same distance (to make sure this is a fair test). One pupil in the ring, makes a clap and the pupil sitting on the chair points to the pupil who clapped. The test is repeated several times before repeating it again with one ear covered up (or blocked with an ear plug). Ask pupils to determine whether it is easier to determine direction of sound with one ear or with both ears. It is easier with both ears because a sound which comes from the side will arrive at one ear before the other and this is detected by the brain.	**Resources (per group)** Blindfold; chair. Optional: new ear plug.	Use only new foam ear plugs and do not allow pupils to share them. Do not allow pupils to force them too far into their ears.	
8Le	Exploring 1	**Soundproof design** This practical asks pupils to investigate which materials are the best for soundproofing. Pupils are expected to collect and display information and evaluate their own method of working. This practical can be used to carry out an AT1 Investigation. A set of level descriptions is provided on pages 339–341 of the ASP. • **Must:** pupils use Worksheet 8Le(2) to help them carry out the practical.	**Resources (per group)** Electric bell; cardboard box; materials to test such as paper, card, cloth, bubble wrap, sponge foam, etc.; a sound intensity meter; cells or power pack.		

		• **Should:** pupils use Worksheet 8Le(3) to help them plan the practical. • **Could:** pupils could be shown the equipment available and asked to plan their practical work accordingly.			
8Le	Exploring 6	**How far away can sound be heard?** Find out how far away pupils can hear a 'standard sound' such as a pin being dropped onto a heat proof mat. This is best done in a large hall. Ask pupils what the key variables are in this investigation and to assign value to them (e.g. using a small pin, a heatproof mat, a large room, a 1m drop height). Ask pupils which variables they will control. The best way of doing this is to get pupils to line up in a straight line away from the sound source. Then drop the pin and ask pupils for a show of hands as to who could hear it. Repeat the experiment several times to get a more reliable result. • **Should:** explain that the reason that sounds get less loud as you get further from them is because sound waves spread in a spherical manner from the source. So the energy of the sound is being spread over a greater and greater area as it travels. • **Could:** explain that as well as the energy becoming more spread out, some of the energy is used to vibrate the mass of particles rather than being transmitted. This is one way in which soundproofing works – the greater the amount of mass that needs to be vibrated the greater the energy needed to do this and so the less well the sound waves are transmitted. For a diagram giving further information, please	**Resources** Small pin; heatproof mat; a large room – you may wish to book the school hall.		

		see page 331 of the teacher's guide			
8Le	Explaining 3	**Soundproofing (demonstration)** Pupils need to understand how soundproofing works in terms of the particles involved. This could be done as a demonstration, with the teacher showing how effective different materials (such as brick, paper, lead, glass and air) are at stopping sounds travelling through them. In order to do this, a sound source, set of materials and a sound meter need to be used and the concept of fair testing needs to be addressed. This demonstration can be used to discuss with pupils how different materials act as soundproofing agents. Generally gases allow sound to be transmitted whilst solids tend to absorb or reflect the sounds.	**Resources (for demonstration)** Frequency generator; different materials such as brick, paper, water, glass, etc.; sound intensity meter.		