INTERNATIONAL SECONDARY SCIENCE 1

TEACHER PACK

Helen Reynolds, Pam Large, Philippa Gardom Hulme

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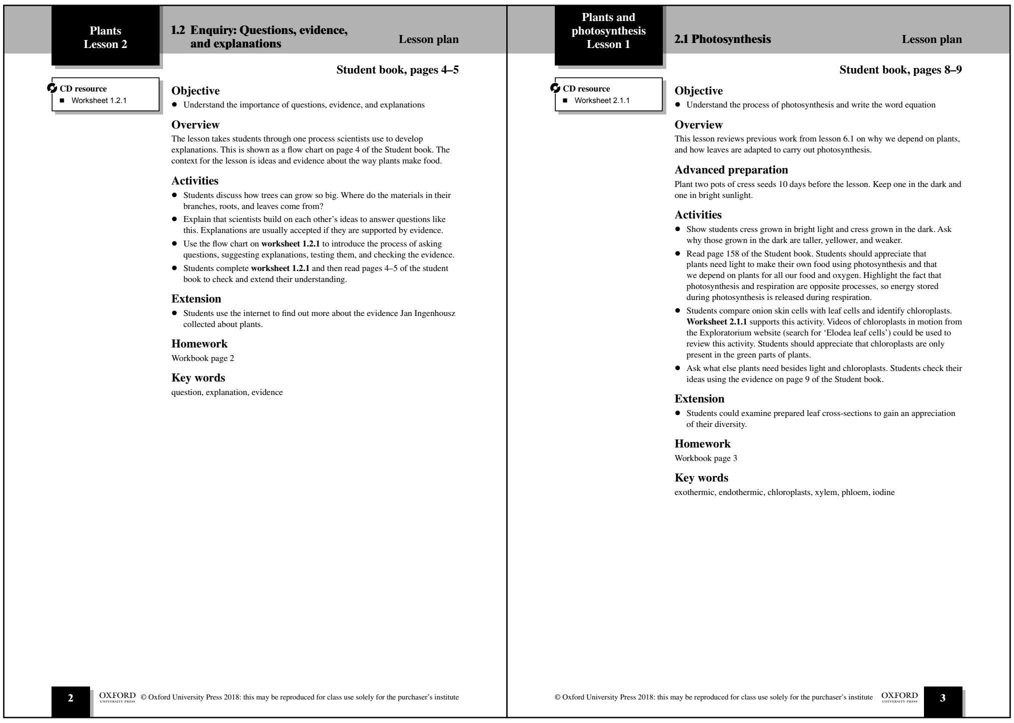
How to use your Teacher Pack

Welcome to your **International Secondary Science 1** Teacher Pack. This Teacher Pack has been written to provide teaching materials and classroom support.

Your Teacher Pack includes a book of lesson plans as well as answers to all of the Student Book and Workbook questions for your reference at any time. The accompanying CD-ROM includes a wide variety of additional resources to support you and your students in the classroom.

Using your book

This book contains suggested lesson plans and answers to all of the questions in the Student Book and Workbook.



Plants
Lesson 2

1.2 Enquiry: Questions, evidence, and explanations — Lesson plan

Student book, pages 4–5

CD resource
- Worksheet 1.2.1

Objective
- Understand the importance of questions, evidence, and explanations

Overview
The lesson takes students through one process scientists use to develop explanations. This is shown as a flow chart on page 4 of the Student book. The context for the lesson is ideas and evidence about the way plants make food.

Activities
- Students discuss how trees can grow so big. Where do the materials in their branches, roots, and leaves come from?
- Explain that scientists build on each other's ideas to answer questions like this. Explanations are usually accepted if they are supported by evidence.
- Use the flow chart on **worksheet 1.2.1** to introduce the process of asking questions, suggesting explanations, testing them, and checking the evidence.
- Students complete **worksheet 1.2.1** and then read pages 4–5 of the student book to check and extend their understanding.

Extension
- Students use the internet to find out more about the evidence Jan Ingenhousz collected about plants.

Homework
Workbook page 2

Key words
question, explanation, evidence

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Plants and photosynthesis
Lesson 1

2.1 Photosynthesis — Lesson plan

Student book, pages 8–9

CD resource
- Worksheet 2.1.1

Objective
- Understand the process of photosynthesis and write the word equation

Overview
This lesson reviews previous work from lesson 6.1 on why we depend on plants, and how leaves are adapted to carry out photosynthesis.

Advanced preparation
Plant two pots of cress seeds 10 days before the lesson. Keep one in the dark and one in bright sunlight.

Activities
- Show students cress grown in bright light and cress grown in the dark. Ask why those grown in the dark are taller, yellower, and weaker.
- Read page 158 of the Student book. Students should appreciate that plants need light to make their own food using photosynthesis and that we depend on plants for all our food and oxygen. Highlight the fact that photosynthesis and respiration are opposite processes, so energy stored during photosynthesis is released during respiration.
- Students compare onion skin cells with leaf cells and identify chloroplasts. **Worksheet 2.1.1** supports this activity. Videos of chloroplasts in motion from the Exploratorium website (search for 'Elodea leaf cells') could be used to review this activity. Students should appreciate that chloroplasts are only present in the green parts of plants.
- Ask what else plants need besides light and chloroplasts. Students check their ideas using the evidence on page 9 of the Student book.

Extension
- Students could examine prepared leaf cross-sections to gain an appreciation of their diversity.

Homework
Workbook page 3

Key words
exothermic, endothermic, chloroplasts, xylem, phloem, iodine

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There is one lesson plan for every spread in the Student Book, including enquiry and extension pages. Each lesson plan suggests activities for use in the classroom linked to the topics covered on the Student Book spread.

Each lesson plan begins with a reference to the pages of the Student Book that it covers and a summary of their objectives. Any key words from the Student Book pages are included at the bottom of the page.

The *Overview* section of the lesson plan reviews what the suggested activities will cover to fulfil the learning objectives. Here you will also find advice and tips about common misconceptions, what you may need to review from the Cambridge Primary curriculum framework or previous lessons, and suggested questions for a class discussion.

The *Activities* section of the lesson plan lists several different activities that can be used in the classroom. These activities include fun and engaging demonstrations, interesting practical ideas, group work suggestions, reading and research activities, and ways to explore a novel topic using models, class discussions or Internet research.

Lesson plans that are matched to enquiry spreads include activities that encourage students to use the skills they are learning about by planning and carrying out their own investigations, analysing data, and drawing conclusions individually or as part of a group.

Most of the lessons have suggested *Extension* activities to stretch your strongest students and help prepare them for the step up to Cambridge IGCSE® and O level. Some of these could be carried out in class, whilst others could be set as homework.

Every spread in the Student Book is matched to a page in the Workbook. At the end of each lesson plan the corresponding workbook page is suggested as *Homework*.

There are lots of extra resources on the CD to accompany every lesson plan. These are listed in the *CD Resources* box at the top of the page, and suggestions on how they can be used are given in the *Activities* section of the lesson plan.

At the back of this book are the answers for all of the questions in both the Student Book and Workbook for quick reference in the classroom. All of these answers have been written by the authors of this book and have not been provided by Cambridge International Examinations.

Using your CD-ROM

The CD-ROM that accompanies this book contains additional resources to support you in the classroom.

Every lesson plan in the book is also found on the CD-ROM as both a PDF, for easy printing, and as a Word document, so that you can tailor the lesson to your classroom and your students' needs.

All of the extra worksheets listed on the lesson plans can be found on the CD-ROM as PDFs and as Word documents, so that they can be added to or changed as required. Most of these worksheets are a single page so that they are easy to print and photocopy.

Extra worksheets for each chapter focus on the scientific vocabulary introduced in that chapter. These will help support lower ability students or students that speak English as an additional language.

There are animations and slideshows that can be used on an interactive whiteboard or screen at the front of the class to encourage interaction and discussion. They cover topics that are difficult to explain using just the words and pictures in the Student Book. The CD also includes a number of interactive spreadsheets, which can be used to record and analyse results during class activities and experiments.

Table of contents

Student book, pages 2–3

CD resource
- Worksheet 1.1.1

Objective

- Recognise leaves, stems, and roots, and know their functions

Overview

Students compare flowering plants and identify the four parts most flowering plants have.

Health and safety

Students must wash their hands after handling plants. Plant material may be poisonous or contaminated with agricultural chemicals, or it may cause allergic reactions.

Activities

- Students observe, draw, and label a young sunflower plant. **Worksheet 1.1.1** supports this activity. The sunflowers need to be planted about 3 weeks before the lesson.
- Use page 8 of the Student book to introduce the terms flowering plant and organ and check that students know what each organ does.

Extension

- Students observe as many flowering plants as possible. They describe how each plant is similar to a sunflower and how it is different.
- Read page 3 of the Student book to learn how some plant organs are adapted for different functions and how parasitic plants manage without a full set of organs.

Homework

Workbook page 1

Key words

flowering plants, leaves, stems, roots, organs, flowers, reproduce

Student book, pages 4–5

CD resource
- Worksheet 1.2.1

Objective

- Understand the importance of questions, evidence, and explanations

Overview

The lesson takes students through one process scientists use to develop explanations. This is shown as a flow chart on page 4 of the Student book. The context for the lesson is ideas and evidence about the way plants make food.

Activities

- Students discuss how trees can grow so big. Where do the materials in their branches, roots, and leaves come from?
- Explain that scientists build on each other's ideas to answer questions like this. Explanations are usually accepted if they are supported by evidence.
- Use the flow chart on **worksheet 1.2.1** to introduce the process of asking questions, suggesting explanations, testing them, and checking the evidence.
- Students complete **worksheet 1.2.1** and then read pages 4–5 of the student book to check and extend their understanding.

Extension

- Students use the internet to find out more about the evidence Jan Ingenhousz collected about plants.

Homework

Workbook page 2

Key words

question, explanation, evidence

Student book, pages 8–9

CD resource
- Worksheet 2.1.1

Objective

- Understand the process of photosynthesis and write the word equation

Overview

This lesson explains why we depend on plants, and how leaves are adapted to carry out photosynthesis.

Advanced preparation

Plant two pots of cress seeds 10 days before the lesson. Keep one in the dark and one in bright sunlight.

Activities

- Show students cress grown in bright light and cress grown in the dark. Ask why those grown in the dark are taller, yellower, and weaker.
- Read page 8 of the Student book. Students should appreciate that plants need light to make their own food using photosynthesis and that we depend on plants for all our food and oxygen. Highlight the fact that photosynthesis and respiration are opposite processes, so energy stored during photosynthesis is released during respiration.
- Students compare onion skin cells with leaf cells and identify chloroplasts. **Worksheet 2.1.1** supports this activity. Videos of chloroplasts in motion from the Exploratorium website (search for ‘Elodea leaf cells’) could be used to review this activity. Students should appreciate that chloroplasts are only present in the green parts of plants.
- Ask what else plants need besides light and chloroplasts. Students check their ideas using the evidence on page 9 of the Student book.

Extension

- Students could examine prepared leaf cross-sections to gain an appreciation of their diversity.

Homework

Workbook page 3

Key words

exothermic, endothermic, chloroplasts, xylem, phloem, iodine

Student book, pages 10–11

CD resources
- Worksheet 2.2.1
- Worksheet 2.2.2
- PowerPoint 2.2.3

Objectives

- Suggest and use preliminary work to decide how to carry out an investigation
- Decide which measurements and observations are necessary and what equipment to use

Overview

Students learn how preliminary tests are used to check that a method will work, and go on to investigate how the colour of light affects photosynthesis.

Activities

- Discuss the differences between winter and summer in countries far from the equator. Greenhouse owners can use artificial lighting to make their crops grow quicker. LED lamps are best because they produce less waste heat. They come in red, blue, and green, but does the colour matter?
- Students read pages 10–11 of the Student book to learn how they could collect evidence to support their ideas.
- Demonstrate how to cut leaf discs and make them sink and make sure students understand how the method works. **PowerPoint 2.2.3** could be used to explain the method. Students compare the rate of photosynthesis with different light colours following the instructions on **worksheet 2.2.1**. Stress that they need to make sure the method works before they test different colours. If it doesn't work they need to adjust the values of their control variables until it does work. **Worksheet 2.2.2** could be used to record the results.
- Compare students' results and discuss the quality of their evidence. If a light meter is available it could be used to check that all the filters let the same amount of light through.

Extension

- Student use to learn how greenhouse owners maximise food production.

Homework

Workbook page 4

Key word

preliminary tests

Student book, pages 12–13

CD resources
- Worksheet 2.3.1
- Worksheet 2.3.2

Objective

- Understand the importance of water and minerals to plant growth

Advanced preparation

- Obtain healthy duckweed (*Lemna minor*) plants. Prepare or purchase a complete solution of minerals and solutions deficient in nitrogen, phosphorus, potassium, and magnesium. Recipes for these can be found on the Nuffield Foundation website (search for 'Investigating the effect of minerals on plant growth').

Overview

Students investigate the effect of mineral deficiencies on plant growth. They will need to observe their test solutions for the next 2–4 weeks.

Activities

- Use page 12 of the Student book to introduce the idea that plants can be grown without soil as long as they have everything else they need. Stress that growers need to ensure that the water they use contains the exact combination of minerals each crop needs. To collect evidence about mineral requirements, scientists start with a complete mixture and take one mineral away at a time.
- Students set up an investigation to show the effect of mineral deficiencies on the growth of duckweed. **Worksheet 2.3.1** supports this activity.
- Students use the effects of mineral deficiencies on maize leaves shown in the Student book to predict the appearance of each batch of duckweed in 2 weeks' time.
- **Worksheet 2.3.2** reviews the main minerals in fertilisers and their uses.

Extension

- Read page 13 of the Student book to learn why aeroponics gives higher crop yields than hydroponics.

Homework

Workbook page 5

Key words

transpiration, hydroponics, active transport, aeroponics

Student book, pages 14–15

CD resources
- Worksheet 2.4.1
- Worksheet 2.4.2

Objectives
- Understand the importance of water and mineral salts
- Explain results using scientific knowledge and understanding

Overview
Students learn how specialised plants can be used to clean soil and water.

Activities
- Students read pages 14–15 of the Student book to learn how hyperaccumulators can remove toxic metals from soil or water.
- **Worksheet 2.4.1** can be used to create a summary of the extraction process. The correct order of statements is 3, 5, 2, 1, 6, 4.
- **Worksheet 2.4.2** provides another example of this process being used to clean soil.

Extension
- Students use the internet to prepare presentations on the effects of arsenic poisoning and the use of ferns to remove this toxic metal from soil and water.

Homework
Workbook page 6

Key words
phytoextraction, hyperaccumulator

Student book, pages 16–17

CD resources
- Video 2.5.1
- Worksheet 2.5.2

Objectives
- Recognise each part of a flower and describe its function
- Understand how pollination and fertilisation take place
- Distinguish between insect-pollinated and wind-pollinated flowers

Preparation
Each group will need a drop of pollen culture medium made up as follows: dissolve 0.417 g of calcium nitrate, 0.200 g of boric acid, 0.101 g of potassium nitrate, 0.217 g of magnesium sulfate and 3.5 cm^3 of 1 mol/dm^3 ammonium hydroxide in 1 dm^3 of distilled water; dissolve 40 g of sucrose in 100 cm^3 of water; mix equal volumes of the two solutions.

Overview
Students name parts of a flower and learn what pollination, fertilisation, and seed formation involve.

Activities
- Show **video 2.5.1** and ask students why bees visit flowers and how the flowers benefit from this. Students should appreciate that bees collect nectar from flowers and flowers rely on bees to spread their pollen to other flowers.
- Use page 16 of the Student book to identify each part of a flower and discuss how insects aid cross-pollination.
- Students observe a selection of simple insect-pollinated flowers using hand lenses and draw their male and female parts.
- Use pages 16–17 of the Student book to discuss the differences between wind-pollinated flowers and insect-pollinated flowers.
- Students read about fertilisation on page 17 of the Student book and then observe pollen under the microscope. (**Worksheet 2.5.2**). If pollen tubes do not grow, reduce the concentration of the sucrose solution by up to 50%. A little crushed mature stigma sometimes speeds up pollen tube growth. Use a mounted needle to add this to the drop of water around the pollen grains.

Extension
- Pollen culture medium could be made up from sucrose solutions containing 20–40 g of sucrose in 100 cm^3 of water, as detailed in the Preparation section, to give final concentrations between 10 and 20 g/100 cm^3 of the culture medium. Students could determine which concentration gives faster pollen tube growth.

Homework
Workbook page 7

Key words
stamen, anther, pollen, filament, carpel, ovary, ovule, stigma, style, gamete, pollination, fertilisation, seed, fruit

Student book, pages 18–19

CD resources

- Worksheet 2.6.1
- Worksheet 2.6.2

Objective

- Understand seed dispersal in flowering plants

Preparation

Plant fast-growing seeds at different distances from each other, in shallow trays of compost, about 2 weeks before the lesson. Assemble a large collection of different seeds and a collection of different fruits that includes a coconut, an orange, berries, and fruit with hooks or wings.

Overview

Students learn how seeds help plant species to survive and how and why they are dispersed.

Activities

- Show students a variety of seeds and discuss what they have in common. They should appreciate that seeds allow embryo plants to survive until they can find the right conditions for germination.
- Students could open a bean seed to look for its embryo shoot and root. The split seeds could then be placed in a Petri dish and tested with a drop of iodine solution to show that they contain starch to feed the growing embryo.
- Show students the seedlings grown at different distances from each other. They should recognise that seedlings compete with each other for light, water, minerals, and carbon dioxide and need to get a long way from the parent plant to obtain enough of these.
- Students read page 19 of the Student book to learn about seed dispersal. Show students a variety of fruits and check that they can name the method used to spread them. They should recognise that many seeds survive being eaten and germinate from an animal's faeces.
- Students investigate how the wing size or the total mass of a fruit affects the time it remains in the air. **Worksheet 2.6.1** provides model fruits and **worksheet 2.6.2** supports the investigation.

Extension

- Students could extend their investigation to find out which makes most difference to the time a fruit takes to fall: the height it falls from, the mass, or the length of the wings.

Homework

Workbook page 8

Key words

dormant, germination, seed dispersal

Student book, pages 22–23

CD resource
- Worksheet 3.1.1

Objectives

- Identify the seven characteristics of living things
- Recognise these characteristics in familiar and unfamiliar organisms

Overview

This lesson introduces students to the seven characteristics of living things.

Activities

- Student pairs discuss how we can tell whether a plant or animal is alive.
- Use page 22 of the Student book to introduce the seven characteristics of living things. It is useful to have a pot plant to demonstrate that it shows sensitivity by turning its leaves towards the window and excretes waste by dropping older leaves. A vacuum flask of germinating peas could be compared with a vacuum flask of boiled peas to show that only living plants release heat energy using respiration.
- Optional video clip of the growth of plant brambles from *The Private Life of Plants* shows plants moving (search YouTube for ‘private life of plants brambles’), and a video clip on plant intelligence shows plants demonstrating sensitivity by communicating and responding (search YouTube for ‘plant intelligence – BBC clip’).
- Students use the cards from **worksheet 3.1.1** to match a human activity and a plant activity to each of the seven characteristics of life. The expected answers are: sensitivity – C, L; reproduction – F, K; nutrition – D, H; growth – E I; movement – G, M; excretion – A, J; respiration – B, N.

Extension

Students read page 23 of the Student book and use the internet to find the latest news about the exploration of Mars.

Homework

Workbook page 9

Key words

organisms, characteristics, movement, respiration, sensitivity, growth, reproduction, excretion, nutrition, fungus, spores

Student book, pages 24–25

CD resources

- Worksheet 3.2.1
- Worksheet 3.2.2
- Worksheet 3.2.3
- Video 3.2.4

Objectives

- Describe how a microscope works
- Recognise four types of micro-organism

Safety

Warn students not to open their Petri dishes once they have set them up. The dishes should be autoclaved as soon as the class has inspected the colonies that have grown.

Overview

This lesson gives students an opportunity to use microscopes and introduces the micro-organisms that can be seen using them.

Activities

- Show students some pond water. Discuss what organisms might be living in it, and how we could make them easier to see.
- Introduce students to the correct way of handling a microscope and demonstrate what each part does. Students could label the parts of a microscope using **worksheet 3.2.1** part A.
- Show students how to focus a microscope on a transparent ruler or a letter written on paper. They then use the microscopes to look for algae and/or protozoa in pond water. **Worksheet 3.2.1** part B supports this activity. **Video 3.2.4** shows a type of protozoan called an amoeba.
- Students read pages 30–31 of the Student book to learn about the four types of micro-organism and also viruses, which are even smaller. They should recognise that electron microscopes are needed to make the smallest micro-organisms visible.
- Demonstrate how to transfer microbes onto agar with the lid held over the Petri dish to minimise contamination. A Bunsen burner can be lit nearby to create an updraft. Then let students set up their own plates. **Worksheet 3.2.2** part A supports this activity, and part B prompts them to model the growth of a colony. **Worksheet 3.2.3** provides labelled axes for this activity.

Extension

Students use the internet to collect images of each type of micro-organism.
A useful starting point is http://www.amnh.org/nationalcenter/infection/index.html

Homework

Workbook page 10

Key words

microscopes, micro-organisms, microbes, magnify, specimen, electron microscopes, SEM, TEM, algae, protozoa, hyphae, yeasts, budding, bacteria, viruses

Student book, pages 26–27

CD resource
- Worksheet 3.3.1

Objectives

- Recognise that micro-organisms can be useful
- Recognise the importance of Pasteur's studies

Overview

The context of the lesson is Pasteur's work on fermentation. It reinforces students' understanding of micro-organisms and reviews the use of evidence to support explanations.

Activities

- Show students a fermenting mixture of sugar solution and yeast along with separate samples of yeast, sugar, and water. Ask why the mixture bubbles and why all the sugar eventually disappears.
- Introduce Louis Pasteur, who was the first person to answer these questions. Students sort cards from **worksheet 3.3.1** to match evidence from Pasteur's observations to the explanations he produced. The correct matches are: 1 – D; 2 – F; 3 – B; 4 – A; 5 – C; 6 – E.
- Students read pages 26–27 from the Student book to consolidate their understanding of Pasteur's work and learn how micro-organisms break down waste.
- The Time Out video clip *History of pasteurization* (search YouTube for 'history of pasteurization') summarises the content of the Student book.

Extension

- Students write a report to a alcohol maker explaining why their alcohol sometimes goes bad.

Homework

Workbook page 11

Key words

ferment, alcohol, lactic acid, pasteurisation, organic matter, fermenters

Student book, pages 28–29

CD resource
- Worksheet 3.4.1

Objective

- Understand that scientists make predictions and check whether their evidence matches these predictions

Overview

The lesson shows how scientific explanations allow us to make and test predictions. The context is Pasteur's evidence that 'spontaneous generation' does not occur. Fermentation occurs only when existing yeasts are able to grow and reproduce.

Activities

- We are surrounded by micro-organisms but where do they come from? Introduce the idea of 'spontaneous generation' which was popular in the 1800s. People used to think that micro-organisms were created whenever sugary solutions fermented or waste materials rotted.
- Use page 28 of the Student book to introduce Pasteur's explanation for fermentation and the predictions it allowed him to make. **Worksheet 3.4.1** supports this activity.
- Students could use idea that micro-organisms grow and reproduce wherever there are nutrients to make predictions, with reasons, for example about which food will stay fresh longer: food left out in the open or food kept covered; food kept in the fridge or food kept warm; fruit juice that has been boiled or fresh fruit juice.

Extension

Students read page 29 to learn how Lister used Pasteur's ideas. He predicted that surgery could be made safer if micro-organisms were prevented from landing on patients' wounds.

Homework

Workbook page 12

Key words

spontaneous generation, predictions

Student book, pages 30–31

CD resource

- Worksheet 3.5.1

Objectives

- Know how micro-organisms are used in food production
- Understand how we make food last longer

Safety

Students must not taste the bread dough or yoghurt produced.

Overview

Students learn that many microbes are used to produce foods.

Activities

- Show students yoghurt or a fermented milk drink and explain that it is made by bacteria. The sour taste is lactic acid, one of the bacteria's waste products. Demonstrate how to make yoghurt by mixing a small amount of milk with a spoonful of natural live yoghurt. Then make the total volume up to about 100 cm^3 with milk. Place it in a conical flask and measure the pH with a pH meter or a pH probe linked to datalogging software. Keep the milk in a water bath at 40 °C and continue to collect pH measurements. The results can be compared with those on page 30 of the Student book at the end of the lesson.
- Show students bread made with yeast. Explain that the bread is soft and spongy because it is full of air spaces. The dough that bread is made from contains yeast. As the yeast respires it produces carbon dioxide. This forms tiny bubbles which expand as the bread bakes.
- Students follow the instructions on **Worksheet 3.5.1** to make dough and take measurements as the yeast makes it expand. The activity uses very runny dough so that it can be poured into a measuring cylinder. Warn students that the dough must not touch the sides of the measuring cylinder as it is poured in. To make this easier, the top could be cut off a plastic drinks bottle to make a wide-necked funnel.
- Students read pages 30–31 of the Student book to review the topic.

Extension

Display examples of dried, frozen, and very acidic foods and ask students to explain why micro-organisms aren't able to make them rot.

Homework

Workbook page 13

Key words

dough, sterilise

Student book, pages 32–33

CD resources
- Worksheet 3.6.1
- Spreadsheet 3.6.2

Objective

- Be able to plan an investigation

Overview

Students plan and carry out an investigation to find the temperature at which yeast makes carbon dioxide fastest.

Preparation

- Prepare four water baths at temperatures 30 °C, 40 °C, 50 °C, and 60 °C.
- Mix five packets of fast-acting dried bread yeast with 250 cm^3 of water. Stir until the yeast is evenly mixed and distribute it between five conical flasks.
- Dissolve 30 g of sugar in 250 cm^3 of water. Stir and distribute between the five conical flasks.
- Clamp a flask of sugar and yeast in each water bath and leave one set at room temperature.
- Put a pipette with the 1 cm^3 mark highlighted with a waterproof marker in each solution.
- Have one or more plastic jugs available for scooping water out of the water baths.
- Cut the thinnest part of the tips off microscience propettes. Then fit a metal washer over the propette tip with hole diameter of about 5 mm and outside diameter small enough to fit into a test tube. They must provide enough weight to stop the propette floating.

Activities

- Explain that students will be collecting evidence about the temperature at which yeast grows fastest. Demonstrate how to mix 1 cm^3 of yeast suspension and 1 cm^3 of sugar solution in a plastic tube. Then suck up enough of the mixture to half fill the bulb of a microscience propette. Show that this floats in a test tube of water but can be weighed down by a small washer or nut. Once it is underwater they should see bubbles of carbon dioxide gas escaping from the top.
- Explain that the yeast and sugar in each water bath are at different temperatures. To keep them like this, students need to create a mini-water bath around their test tubes. They can do this by scooping enough water from the bath to fill a test tube and the beaker their test tube rests in.
- Groups could collaborate to produce a class set of results. **Worksheet 3.6.1** supports the activity and the results could be displayed using **spreadsheet 3.6.2**. A mini-plenary will be needed to agree on a suitable time for which to count bubbles once they have tested the yeast at room temperature. The time should be long enough to give at least 10 bubbles at room temperature, but not so long that the beakers of water cool significantly. Five minutes should be enough.
- Students read pages 32–33 of the Student book, to see other ways of collecting evidence. Check that students understand why the bubble rate drops when the temperature is high enough to destroy the yeast cells.

Extension

Students use the internet to find out more about extremophiles – micro-organisms that grow best at very high temperatures or very low temperatures.

Homework

Workbook page 14

Key words

variable, valid, repeatable, controlled

Student book, pages 34–35

CD resource
- Worksheet 3.7.1

Objectives
- Understand what is meant by an 'infectious disease'
- Give some examples of diseases caused by micro-organisms
- Suggest how to avoid infections

Overview
Students discuss diseases they are familiar with, their symptoms, the micro-organisms that cause them, and how these micro-organisms enter their bodies.

Activities
- Ask students to list any diseases they have had, what their symptoms were, and how they caught each disease. Help students to distinguish between infectious diseases and other illnesses. Then use pages 34–35 of the Student book to show that infectious diseases can be caused by bacteria, fungi, protozoa, or viruses.
- Explain that our skin keeps most micro-organisms out but there are weak spots in our defences. Describe how microbes enter our bodies with the air we breathe, in our food and drink, when we rub our eyes with dirty fingers, or when infected insects bite us.
- Students use cards from **worksheet 3.7.1** to match each infectious disease with the best way to avoid it. The correct matches are: 1 – C; 2 – D; 3 – B; 4A; 5 – E; 6 – B; 7 – C.
- Students read pages 34–35 of the Student book to review the topic.

Extension
Students use the internet to find out more about any other diseases they have heard of. They should find out what type of micro-organism causes it and how it gets into your body.

Homework
Workbook page 15

Key words
infectious diseases, ringworm, Athlete's foot, faeces, typhoid, food poisoning, malaria, vector, sleeping sickness, leishmaniasis, colds, flu, hepatitis C

Student book, pages 36–37

CD resources

- Worksheet 3.8.1
- Worksheet 3.8.2
- Worksheet 3.8.3

Objectives

- Identify structures seen in plant and animal cells
- Compare plant and animal cells

Overview

This lesson begins with the introduction of cells as the ‘building blocks of life’ and leads on to differentiating between plant and animal cells, and their different parts and functions.

Health and safety

Warn students that cover slips are easy to break and mounted needles are sharp. They should place their cotton bud in disinfectant after use and must not touch anyone else’s. They need to avoid getting methylene blue on their skin and wash their hands after making a slide.

Activities

- Use page 36 of the student book to introduce cells as the building blocks of life.
- Show students how to make a cheek cell smear, add methylene blue, and lower a cover slip over it using a mounted needle or sharp pencil. Demonstrate how to peel the transparent skin from the inner side of a layer of onion, place it on a slide, and add iodine and a cover slip. Students can prepare their own slides, and draw the cells they see, using **worksheet 3.8.1** as a guide. **Worksheet 3.8.2** has drawings of cheek and onion skin cells that students could label instead of drawing their own.
- Use pages 36–37 of the Student book to name the parts of plant and animal cells, and look at the chloroplasts in leaf cells. Emphasise that cells are 3D even though they look 2D under a light microscope.
- If space is available, students could make a giant cheek cell. Two students link hands to form the nucleus, and the remainder link hands around them to form the cell membrane. Then they can rearrange themselves to model a plant cell.
- Small groups could sort the cell pictures on **worksheet 3.8.3** into plant and animal cells and justify their decision, for example: ‘it has a cell wall therefore it must be a plant cell’. The cells are: 1 – onion; 2 – *Elodea*, 3 – cheek; 4 – bone; 5 – human skin; 6 – tomato; 7 – leaf; 8 – red blood cells.

Extension

Students could think of analogies to describe the nucleus, cytoplasm, and cell membrane, for example, the nucleus is like the brain of a cell because it controls the activities inside it.

Homework

Workbook page 16

Key words

cell, nucleus, genes, cytoplasm, cell membrane, chloroplasts, vacuole, cell wall

Student book, pages 37–38

CD resources

- Worksheet 3.9.1
- Worksheet 3.9.2
- Video 3.9.3

Objective

- Relate the structure of cells to their functions

Overview

Students observe a range of specialised cells and relate their structures to their functions.

Activities

- Student pairs discuss what they know about cells. Our bodies are made of cells, but are they all the same? Lead students to the idea that they can't be because skin, muscles, and bones are very different. They must be made from different cells.
- Use pages 37–38 of the Student book, to introduce some of the specialised cells in plants and animals. **Video 3.9.3** supports this activity. It shows red blood cells moving through a blood vessel.
- Small groups match specialised cell cards from **activity sheet 3.9.1** to the structure and function cards from **activity sheet 3.9.2**.
- Individuals complete the questions on page 38 of the Student book.

Extension

Students choose one specialised cell and make a poster to show how its specialised features suit its function, e.g. red blood cells can carry oxygen because they contain haemoglobin.

Homework

Workbook page 17

Key words

specialised, adapted, haemoglobin, fibres, root hair, surface area, xylem, phloem

Student book, pages 39–40

CD resources
- Worksheet 3.10.1
- Worksheet 3.10.2

Objectives

- Relate the structure of nerve cells and sensory cells to their functions
- Recognise how explanations develop as new evidence becomes available

Overview

Students learn how the cells in nerves and sense organs are specialised to suit their function.

Activities

- Ask a volunteer to go out of the classroom for a moment. The others should all wave at the volunteer when they come back in. Then pose the question, 'what made your arms move?'.

  Explain that your eyes send signals to your brain. Your brain interprets these signals and decides what to do. When the volunteer came back in, the students' brains sent signals to their arm muscles to make their arms wave. Electrical signals travel to and from your brain all the time.
- To demonstrate how fast nerves can carry signals, ask students to hold hands in a circle. One student squeezes the hand of the person to their right and says 'start'. Students pass the 'squeeze' around the circle until it gets back to the starter, who must say 'stop'. Time how long it takes see if the speed can be increased. Explain that the fastest nerves can send signals at 100 m/s, but there is a delay every time the signal passes from one nerve to the next.
- Read page 39 of the Student book, to learn how our understanding of nerves gradually increased. Then ask students to list the similarities and differences between a nerve cell and an unspecialised animal cell. They should note that both have a nucleus, cytoplasm, and cell membrane. The nerve cell illustrated also has dendrites, an axon, and end plates. **Worksheet 3.10.1** supports this activity.
- Read page 40 of the Student book, to learn how nerve cells and sensory cells communicate with each other using chemicals. Students could complete **worksheet 3.10.2** to show the similarities and differences between light- and sound-detecting cells.

Extension

Students find out where the sensory cells in their eyes and ears are located.

Homework

Workbook page 18

Key word

sensory cells

Student book, pages 42–43

CD resource
- Worksheet 3.11.1

Objective
- Understand that cells work together to form tissues, organs, and whole organisms

Overview
This lesson looks at different tissues and their functions and links cells, tissues, and organs.

Activities
- Ask students to feel around their mouth with their tongue. What types of tissue can they find? Students should distinguish the hard bone in their jaws, the muscle tissue that opens and closes their mouth, moves their tongue, and helps them swallow, the soft tissue in their cheeks, the tissues that produce saliva, and the firm gum tissue that supports their teeth.
- Use page 42 of the Student book to show the main tissues in our arms and legs. Explain that organs are made up from at least two types of tissue working together and that each tissue is different because it contains different cells.
- Students use the cards from **worksheet 3.11.1** to match the tissues in skin to the types of cells they contain. They complete the questions in the Student book.

Extension
- Students read page 43 of the Student book to learn how stem cells could be used to replace damaged tissues and organs.

Homework
Workbook page 19

Key words
tissue, stem cells, differentiated, growth factors

Student book, pages 46–47

CD resources
- Worksheet 4.1.1
- Worksheet 4.1.2
- Worksheet 4.1.3
- Worksheet 4.1.4

Objective

- Describe how organisms are adapted to their habitat

Overview

Students describe and explain simple adaptations of plants and animals to different environments.

Activities

- Groups match the animal cards from **worksheets 4.1.1** and **4.1.2** to the environments shown on **worksheet 4.1.3**. The animal cards for each habitat are labelled A–E. Animal A is a well-known animal. Moving from A to E, the animals become harder to place. Each card highlights one adaptation that other animals from that habitat might share. The correct matches are:

  Rainforest – A monkey, B flying frog, C great hornbill, D pit viper, E sloth.

  Desert – A camel, B addax antelope, C fennec fox, D water-holding frog, E kangaroo rat.

  Savannah – A zebra, B impala, C giraffe, D cheetah, E termite.

  Arctic – A polar bear, B walrus, C arctic fox, D ground squirrel, E shorthorn sculpin.

  Woodland – A squirrel, B stag beetle, C hedgehog, D red fox, E sparrowhawk.

  Mountain – A mountain goat, B llama, C yak, D pika, E chinchilla.
- Use pages 46–47 of the Student book to introduce the term 'adaptation' and show how adaptations help animals survive in their usual environment.
- Students choose the three most important adaptations of the animals in each environment and produce a summary using **worksheet 4.1.4**.

Extension

Students use the internet to find out more about two animals whose habitats are very different. They describe a day in each animal's life and show how its adaptations help it survive.

Homework

Workbook page 20

Key words

climates, habitat, adaptations, adapted

Student book, pages 48–49

CD resources

- Worksheet 4.2.1
- Worksheet 4.2.2
- Worksheet 4.2.3
- Worksheet 4.2.4

Objective

- Draw simple food chains and link them to form a web

Overview

Students construct food chains and webs to explain feeding relationships.

Activities

- Use page 48 of the Student book to introduce the idea that wherever there are prey animals, there will be predators. **Worksheet 4.2.1** could be used to record the words used to describe each member of a food chain.
- Explain that the food chain on page 48 of the Student book shows how energy is transferred from the producer to the carnivore. But acacia trees are eaten by more than one sort of herbivore and lions have other prey. Students use cards from **worksheet 4.2.2** to construct four different food chains and link them to form a food web.
- Introduce the idea that food webs can show what happens in feeding relationships when the numbers of one species increase or decrease. The following questions could be posed:
  1. How are other animals affected if hunters kill all the cheetahs and leopards?
  2. How are they affected if cows are moved into the area and start eating all the grass?
- Students review their learning by completing **worksheet 4.2.3**.

Extension

Worksheet 4.2.4 is a more challenging version of **worksheet 4.2.3**.

Homework

Workbook page 21

Key words

herbivores, carnivores, predators, prey, scavengers, consumers, producers, biomass, food chain, food web, top predators, decomposers

Student book, pages 50–51

CD resources
- Worksheet 4.3.1
- Worksheet 4.3.2

Objective

- Discuss the positive and negative effects humans have on food chains

Overview

Students learn how farming and invasive species damage food chains and how we could reduce this damage in the future.

Activities

- Use page 50 of the Student book to show how deforestation affects plants and animals.
- Introduce the term ‘yield’ and explain that yields can be doubled by using chemical sprays. Page 50 of the Student book introduces the benefits and drawbacks of these chemicals.
- Groups use cards from **worksheets 4.3.1** and **4.3.2** to match inappropriate uses of these chemicals with consequences and solutions. The expected answers are:

Action	Consequence	Precaution
1	D	B
2	A	C
3	B	D
4	C	A

- Students could summarise the topic by drawing up a table of the chemicals used on farms, what they do, and problems they can cause.
- Students read page 51 of the Student book to learn how we could reduce the amount of damage humans do in the future. Groups could be challenged to suggest a way to double the amount of food their country grows without harming any wild animals.

Extension

Students use the internet to find the names of the invasive species in their country and the problems they cause.

Homework

Workbook page 22

Key words

fertilisers, herbicides, insecticides, pollution, invasive

Student book, pages 52–53

CD resource
- Worksheet 4.4.1

Objective

- Discuss the positive and negative effects humans have on air pollution and ozone depletion

Overview

The lesson introduces the three main sources of air pollution, the damage they do, and what we can do to reduce this damage.

Activities

- Student pairs discuss what they know about air pollution. What causes it? Where does it come from? What harm does it do?
- Burn a candle or a Bunsen burner with a yellow flame and demonstrate that it produces particles of soot by holding a test tube of water over the flame. These soot particles cause breathing difficulties when they build up in the air we breathe. Students could estimate the amount of soot in the air outside can by sticking strips of clear sticky tape to solid surfaces such as trees and fences, then peeling it off and sticking it to white paper. Stress that most air pollution is invisible.
- To demonstrate the effect of CFCs: ask a student to hold an umbrella. Shine a torch onto it to represent ultraviolet light (UV) from the Sun. The umbrella is like the ozone in the atmosphere – it protects us from the light from the torch just as the ozone layer protects us for harmful UV rays. But CFCs destroy ozone and have made a hole in this umbrella. This lets harmful UV radiation reach the Earth.
- To demonstrate the effect of acid rain: drop acid onto a piece of limestone or chalk. Acid rain is more dilute but has the same effect over many years. Stress that acid rain also damages living things.
- To demonstrate the effect of carbon dioxide: ask a student to put a blanket over their shoulders. We need carbon dioxide in the atmosphere because the greenhouse effect keeps Earth warm. Add another blanket and explain that Earth could get too warm if the layer of carbon dioxide gets too thick.
- Students read pages 52–53 of the Student book and complete **worksheet 4.4.1** to summarise the causes and consequences of air pollution.

Extension

Students use the animations on the International Polar Foundation Educapoles website (choose ‘multimedia’ from the menu bar) to find out more about the effects of climate change.

Homework

Workbook page 23

Key words

ozone, ultraviolet, CFC, sulfur, acid rain, neutralise, greenhouse, global warming

Student book, pages 54–55

CD resource
- Worksheet 4.5.1

Objective
- Understand how we can conserve endangered plants and animals

Overview
Students find out why some animals are endangered and consider ways of preventing their extinction.

Activities
- Students discuss what they know about extinction. What does it mean and which animals have become extinct?
- Use page 54 of the Student book to show why the Yangtze River dolphin became extinct. Students could consider other animals threatened with extinction. Show YouTube video on *Amur leopard survival,* the rarest type of cat on Earth due to loss of habitat, *The endangered Chinese giant salamander* that shows the salamander is illegally hunted for its meat, *Lonesome George – the last surviving Pinto tortoise,* a captive breeding program for endangered tortoises and *Tigers and their fight for survival* which shows a sanctuary for tigers.
- Students read pages 54–55 of the Student book to learn about four ways of preventing further extinctions.
- Groups take an animal each from **Worksheet 4.5.1.** They prepare presentations to explain how their animal is endangered and what could be done to save it.
- Students listen to each presentation and decide which plan is most likely to succeed.

Extension
- Students could produce a leaflet designed to raise funds to protect their endangered animal.

Homework
Workbook page 24

Key words
extinct, conservation, wildlife sanctuaries, captive breeding program

Student book, pages 56–57

CD resource
- Worksheet 4.6.1

Objectives

- Recognise a variety of sources of energy
- Distinguish between renewable and non-renewable energy sources

Overview

This lesson shows where our energy comes from and why some sources are renewable.

Activities

- Students discuss how electricity is made. If a dynamo is available show how electricity is generated as it turns. Stress that any form of movement can be used to generate electricity. Most power stations burn fuels and use the heat to boil water and make jets of fast-moving steam.
- Show students a solar cell e.g. in a calculator and stress that large banks of solar cells can give us useful amounts of electricity.
- Students use page 56 of the Student book to find out more about our main energy sources and complete **worksheet 4.6.1**. The expected answers are:

Non-renewable energy source	**Why is it non-renewable?**	**Where can it be used?**
Fossil fuels	it cannot be replaced and it will soon run out	anywhere with a good supply of fossil fuels and space to build a power station
Renewable energy sources	**Why is it renewable?**	**Where can it be used?**
Solar cells	because the Sun constantly replaces the energy they use	places with plenty of sunshine especially isolated places which use small amounts of energy
Biofuels	because more plants can be grown to replace those used to make fuels	in warm, wet climates where plants grow fast; where liquid fuels are needed for cars
Wind power	because the Sun's heat makes winds blow	anywhere windy, e.g. near a coast or on a hill
Water power	because the Sun's heat makes water evaporate and fall as rain	somewhere high, usually in the mountains
Geothermal energy	because there are a lot of hot rocks under the Earth's surface	where there are hot rocks close to the surface, e.g. East Africa

Extension

Students use the internet to prepare posters about one of these energy sources.

Homework

Workbook page 25

Key words

fossil fuels, non-renewable, renewable, solar energy, solar cells, biofuels

Student book, pages 58–59

CD resources

- Worksheet 4.7.1
- Worksheet 4.7.2
- Worksheet 4.7.3
- Worksheet 4.7.4

Objectives

- Recognise some sources of renewable fuels
- Recognise that each biofuel has advantages and disadvantages

Overview

Students learn more about biofuels.

Health and safety

Cellulase might produce allergic reactions, so ensure there is no contact with skin.

Activities

- Discuss where the fuel that we use in our cars comes from. Most cars run on petrol or diesel made from oil, but we will need to use biofuels when these run out.
- Explain that the two main biofuels we have now are biodiesel made from oil and bioethanol made from sugar. But sugar and oil can both be used as food. It would be better if we could make biofuels from waste plant material. Unfortunately most plant waste is made of tough cell walls. These need to be broken down before they can be turned into fuels.
- Students mix cellulose from plant cell walls with cellulase and leave it to digest for at least an hour. **Worksheet 4.7.1** supports this activity. The tubes can be refrigerated if they need to be left for more than a day before they are tested for glucose.
- Groups of students take part in a structured discussion about whether or not we should increase our use of biofuels. First they share out the Fuel facts cards from **worksheet 4.7.2** and take turns to read them out. They do the same thing with the Biofuel issues cards from **worksheet 4.7.3** and sort them into reasons for growing more biofuel and reasons for growing less. (To make the activity easier to manage, **worksheets 4.7.2** and **4.7.3** should be copied onto different coloured card.) Finally groups decide how they will vote and present their reasons to the rest of the class.

Extension

Students consider future demands for energy using **worksheet 4.7.4**.

Homework

Workbook page 26

Key words

carbon-neutral, biodiesel, bioethanol, photobioreactors

Student book, pages 62–63

CD resources
- PowerPoint 5.1.1
- Worksheet 5.1.2

Objective

- Explain the ways in which living things are adapted to their habitats

Preparation

Arrange to have woodlice or maggots available for the investigation. For the extension activity an open area is needed where students can walk around freely. It should be divided into 'damp' and 'dry' areas using chalk.

Safety

When working with invertebrates, students need to cover any cuts with waterproof plasters and wash their hands when they have finished the investigation. The animals need to be returned to their natural environment straight after the investigation.

Overview

Students review and extend the ideas about adaptation they developed in lesson 4.1.

Activities

- Student read pages 62–63 of the Student book to learn how animals use different adaptations to find food and avoid predators.
- Various video clips could be used to show how specific animals have adapted to be particularly well suited to different environments.
- Use **PowerPoint 5.1.1** to introduce the idea that animals have behavioural adaptations as well as useful physical features. These help them stay in suitable habitats.
- Demonstrate how to use a choice chamber to observe the behaviour of woodlice or maggots. **Worksheet 5.1.2** supports this activity.

Extension

- If woodlice were used for the investigation, students could role-play being woodlice. Divide an open space into 'damp' and 'dry' areas. On the 'damp' area they need to walk slowly – heel to toe – and turn often. On the 'dry' area they need to walk fast without turning. They turn round if they come to a wall and stop where they are if they meet another woodlouse. If all the students start off on the dividing line between the 'damp' and 'dry' areas they should soon begin to form a huddle on the 'damp' side.
- Emphasise that invertebrates inherit simple rules for moving around, but things they detect in their environment – such as moisture – control when they use each rule.

Homework

Workbook page 27

Key words

adaptations, camouflage, streamlined

Student book, pages 64–65

CD resource
- Worksheet 5.2.1

Objective
- Explain the ways in which living things are adapted to challenging environments

Overview
Students consider how plants and animals have adaptations to survive in extreme environments and produce a presentation about one plant and one animal's adaptations.

Activities
- Use page 64 of the Student book to introduce the adaptations that help living things survive in hot deserts.
- Use page 65 of the Student book to show how living things stay warm in the Arctic.
- Students choose different plants and animals from extreme environments and prepare presentations to show how their adaptations help them to survive. **Worksheet 5.2.1** supports this activity.

Extension
- Go on Internet to show some unusual animals found in the deepest parts of the oceans, such as the angler fish.

Homework
Workbook page 28

Key word
insulator

Student book, pages 66–67

CD resources
- PowerPoint 5.3.1
- Worksheet 5.3.2

Objective

- Recognise that existing adaptations can become less useful if the environment changes

Overview

Students see how climate change is making some living things less suited to their environments than they used to be.

Activities

- Students read page 66 of the Student book to see how global warming is threatening the survival of quiver trees and polar bears.
- Use page 67 of the Student book to introduce the idea that some species suffer more than others when the climate changes because they have different physical or behavioural adaptations.
- **PowerPoint 5.3.1** could be used to discuss the patterns shown in the graphs on page 67 of the Student book. Students should appreciate that there is not enough evidence to draw conclusions about the effect of climate change on the chinstrap penguin. Recent evidence shows that chinstrap numbers are also falling.
- A video clip from the NOAA Ocean Today website (select 'Ocean life' then 'Adelie penguins') could be used to show scientists monitoring adelie penguins.
- Students complete **worksheet 5.3.2** to see another example of an animal affected by climate change.

Extension

- Students use the internet to research the effect global warming is expected to have on whales.

Homework

Workbook page 29

Key word

climate change

Student book, pages 68–69

CD resources
- Worksheet 5.4.1
- Worksheet 5.4.2
- Worksheet 5.4.3
- PowerPoint 5.4.4

Objective

- Describe how sampling techniques can be used to estimate populations

Overview

Students learn how to estimate the numbers of animals or plants in an area.

Activities

- Use pages 68–69 of the Student book to show how we can estimate the size of an animal population using the mark and recapture technique.
- Students complete **worksheet 5.4.1** to practise the calculation.
- Use page 69 of the Student book to show how we can compare the number of plants in different areas using quadrats.
- Students could measure the ground cover at different distances from a tree using **worksheet 5.4.2** as a guide, or analyse specimen results from this investigation using **worksheet 5.4.3**. **PowerPoint 5.4.4** has guidance about how to estimate the percentage plant cover and how to analyse the results.

Extension

- Students could use quadrats to sample a large area to estimate the size of a population of plants. The method is outlined in the Student book at the bottom of page 69.

Homework

Workbook page 30

Key words

mark and recapture, quadrat

Student book, pages 70–71

CD resources
- Worksheet 5.5.1
- Worksheet 5.5.2

Objective

- Understand how scientists study the natural world

Preparation

- Arrange for brine shrimps to be available. Instructions for keeping them can be found in *Brine Shrimp Ecology* by Stephen Tomkins and Michael Dockery, available as a free download from the British Ecological Society website (search for 'brine shrimp'). The salt water they need is made by dissolving 35 g of sea salt per litre in tap water that has been standing in an open container for 2 days to allow the chlorine to disperse.

Overview

Students find out how animals are studied in the wild and carry out a laboratory study of brine shrimps.

Activities

- Use page 70 of the Student book to introduce the insight we can gain from animals by studying them in the wild. Stress that many animals live in inaccessible places such as treetops where they are difficult spot, and many only move around at night.
- Students read 70 of the Student book to learn how automatic cameras and electronic tags make some animals easier to study.
- Students observe brine shrimps to find out how they respond to light. **Worksheet 5.5.1** supports this activity. Encourage students to consider how the behaviour they have seen helps the brine shrimps to survive. They should find that brine shrimps swim towards bright light but will avoid really strong light. They dart away if a shadow passes over them suddenly. This behaviour could help them find food and avoid predators.

Extension

- Students could observe other living things. **Worksheet 5.5.2** supports this activity.

Homework

Workbook page 31

Key word

electronic tags

Student book, pages 74–75

CD resources
- Worksheet 6.1.1
- Worksheet 6.1.2
- Worksheet 6.1.3

Objective

- Use ideas about particles to explain the behaviour of substances in the solid, liquid, and gas states

Overview

This lesson introduces the simple particle model, which explains changes of state, and properties such as expansion. A more complex particle model, involving atoms and bonding, explains chemical change. Students meet this model later in the course.

A common misconception is that solids, liquids, and gases are different types of matter. To avoid students picking up this idea, this course emphasises that any one substance can exist in three states. The particles do not change, only their arrangement and behaviour.

Activities

- Students imagine they had a bar of chocolate. Could they cut it into smaller and smaller pieces for ever? Greek philosophers asked a question like this 2500 years ago. Two of them – Leucippus and Democritus – thought that matter is divided into tiny separate bits, with empty space between. This is the particle theory of matter. It is a scientific model that explains observations.
- Display diagrams of the particle arrangements of a substance in its three states. Describe the behaviour of the particles in each state.
- Students examine samples of substances and decide whether each is in its solid, liquid, or gas state. How might the particle model explain observed properties? **Worksheet 6.1.1** supports this activity.
- **Practical activity (first part):** Demonstrate trying to compress samples of sand, water, and air in sealed syringes. Students use the particle model to explain their observations. Part 1 of **worksheet 6.1.2** supports this activity.
- **Practical activity (second part):** Demonstrate trying to open the metal lid on a tightly closed jar. Pour hot water over the lid – it is easier to open. Explain that the metal has expanded. This is because the particles vibrated more, so taking up more space. The particles themselves have not expanded. Part 2 of **worksheet 6.1.2** supports this activity.

Extension

Worksheet 6.1.3 summarises learning from the whole lesson.

Homework

Workbook page 32

Key words

particles, states, solid, liquid, gas, compress, expands, contracts

Student book, pages 76–77

CD resources

- Worksheet 6.2.1
- 6.2 Changes of state illustration

Objectives

- Name the changes of state involving liquids and gases
- Explain changes of state using ideas about particles

Overview

The lesson starts with a look at wax and at water in different states, and a reminder about how particles behave in these states. Students then consider changes of state involving liquids and gases. They measure the boiling point of water, and display their results in the form of a line graph. To finish the lesson, students use ideas about particles to explain boiling, evaporating, and condensing. They act out these changes of state.

The illustration from page 76 of the Student book is included on the CD-ROM with and without labels. This could be used as plenary activity to find out what students already know about changes of state.

Activities

- Burn a candle. Elicit that the wax exists in three states – solid, liquid, and gas. It is the gas that burns. Boil some water. Elicit that the water is present in two states – as a liquid, and as a gas (steam). This lesson focuses on changes of state involving liquids and gases.
- **Practical activity:** Students do an experiment to find the temperature at which liquid water boils. They display their results as line graphs. **Worksheet 6.2.1** supports this activity.
- Students read the section on *Liquid to gas* on page 76 of the Student book. Student pairs discuss differences between boiling and evaporation, and use ideas about particles to explain these differences.
- Students read the section on *Gas to liquid* on page 77 of the Student book. They draw diagrams to show what happens to the particles during condensation.

Extension

As a class, act out boiling, evaporation, and condensation. Each student takes the role of one particle.

Homework

Workbook page 33

Key words

ice, steam, evaporation, boiling, boiling point, condensation

Student book, pages 78–79

CD resources
- Worksheet 6.3.1
- Worksheet 6.3.2
- Scientific investigation flowchart

Objective
- Understand why questions, evidence, and explanations are important in science

Overview
This lesson takes students through one process by which scientists develop explanations, and which is summarised in the flow chart on page 79 of the Student book. Students start by discussing a selection of questions – which could be answered scientifically? This leads to the point that scientific questions are ones that the collection of evidence will help to answer. The lesson then focuses on one question – why does water boil at different temperatures in different places? Students use evidence to test a possible explanation for this question.

The flowchart on page 79 of the Student book is included on the CD-ROM with and without the text. This flowchart can be used to guide students through the process of developing scientific theories.

Activities
- Student pairs discuss the questions on **worksheet 6.3.1**. Which could be answered scientifically? Make the point that scientific questions are ones that the collection of evidence will help to answer.
- Student book pages 78–79 (for teacher reference – do not show students at this stage). Tell students that water boils at different temperatures in Mumbai, a city by the sea, and Leh, a city in the mountains (use local examples if possible). Ask students to suggest a scientific question based on this evidence, for example: *Why does water boil at different temperatures in different places?* Begin building up a flow chart with this question at the top (Student book page 79).
- Suggest an explanation to the question in the previous activity – boiling point depends on altitude. Add this stage to the flow chart (Student book page 13).
- **Worksheet 6.3.2** (first part): Ask students how they could test the explanation suggested in the previous activity. Students plot line graphs of boiling temperature vs. altitude. Add this stage to the flow chart (Student book page 79).
- **Worksheet 6.3.2** (second part): Students check the evidence supports the explanation. Add this stage to the flow chart. Point out that scientific explanations may lead to more questions!

Homework
Workbook page 34

Key words
question, evidence, explanation

Student book, pages 80–81

CD resource

- Worksheet 6.4.1

Objectives

- Name and explain changes of state involving solids
- Describe how melting points help identify substances

Overview

This lesson explains changes of state involving solids. It starts by getting students to think about particles – how does their behaviour change when a solid melts, or a liquid freezes? Students then plot heating and cooling curves for stearic acid, to find its melting point. There is then a short demonstration in which students learn that melting temperatures give information about both the purity and identity of a substance. The lesson ends with a demonstration to illustrate the process of sublimation.

Activities

- Lead a discussion to elicit how particle behaviour changes on melting and freezing. As a class, students act out melting and freezing, with each student taking the role of one particle.
- Students follow the guidance to plot heating and cooling curves for stearic acid, to find its melting point. **Worksheet 6.4.1** supports this activity.
- Explain that melting temperatures indicate the purity of a substance – if a substance has a sharp melting point, it is pure. If a material melts over a range of temperatures, it is not pure. Illustrate this point by inserting a thermometer into solid butter or ghee (mixtures) and heating gently to melt. Students melted a pure substance in the previous activity. Melting point data also help identify substances – students read about this on page 80 of the Student book.
- Use solid iodine to demonstrate sublimation. Place one iodine crystal in a sealed container. Warm it gently with your hands. A purple vapour forms. Students take on the roles of particles to act out sublimation.

Homework

Workbook page 35

Key words

melting, melting point, pure substance, freezing, freezing point, sublimation, sublime

Student book, pages 82–83

CD resources

- Worksheet 6.5.1

Objective

- Use ideas about energy to explain changes of state

Overview

In this lesson, students use ideas about energy to explain changes of state. The main activity is a group activity, in which students work together to answer four key questions: How can we use ideas about energy to explain boiling, evaporation, melting, and freezing? Student groups then create posters or short plays to demonstrate what they have learnt.

Activities

- Student pairs speculate about why substances change state – what makes a solid melt, or a gas condense?
- Divide students into groups of four. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 6.5.1**.

  Students doing the same question then get together in new groups of three or four. These are *expert groups*. Expert groups tackle the questions using information from the Student book, and plan how to teach their home groups what they have learnt.

  Students return to their home groups, and teach each other what they have learnt.
- Students remain in home groups. They create posters or short plays to demonstrate what they have learnt about energy and state changes.
- Home groups present their posters or plays to one other group. The other group peer assesses. Part 5 of the **worksheet 6.5.1** supports this activity.

Homework

Workbook page 36

Key words

energy, boiling, evaporation, particles, melting, freezing

6.6 Using particle theory to explain dissolving

Student book, pages 84–85

CD resources
- Worksheet 6.6.1
- Worksheet 6.6.2
- Worksheet 6.6.3

Objectives
- Use particle theory to explain dissolving
- Understand what a secondary source is
- Practise making conclusions from data

Overview
The lesson begins by a demonstration of dissolving salt in water, and a matching activity to reinforce the meanings of key words. Students then observe a second demonstration to show that total mass is conserved when a substance dissolves in a solvent. The next activity involves students using rice and dried beans to model the particles when a solute dissolves in a solvent. Finally, students learn about saturated solutions and solubility. They draw bar charts using data from a secondary source, and make conclusions from the data. **Worksheets 6.6.2** and **6.6.3** review work that students would have done as part of the Primary curriculum framework.

Activities
- Demonstrate dissolving one spatula measure of salt in water. Use the words solvent, solute, solution, dissolve, and soluble. Student pairs use cards to match these words – and others – to their definitions. **Worksheet 6.6.1** supports this activity.
- Demonstrate that mass is conserved when a substance dissolves by pouring water into a beaker and measuring the mass. Add a known mass of salt and stir to dissolve. Show that:

  mass of solution = mass of solute + solvent

  Students record the results on Part A of **worksheet 6.6.2**.
- Students follow the guidance on Part B of **worksheet 6.6.2** to model dissolving using rice and dried beans.
- Demonstrate adding sugar (sucrose) to 100 cm^3 of water, one spoonful at a time. Students guess how many spoonfuls will dissolve. At 25 °C, 200 g of sugar dissolves in 100 cm^3 of water. This is approximately 40 teaspoonfuls. Explain what a saturated solution is. Part C of **worksheet 6.6.2** supports this activity.
- Students follow the guidance to draw bar charts on solubility, using data from a secondary source. They make conclusions from the data. **Worksheet 6.6.3** supports this activity.

Homework
Workbook page 37

Key words
dissolve, solution, solvent, solute, saturated solution, solubility, soluble, secondary source, scientific journal

Student book, pages 86–87

CD resources
- Worksheet 6.7.1
- Worksheet 6.7.2

Objective

- Understand the processes involved in planning an investigation

Overview

The purpose of this lesson is to teach students to plan investigative work, and for students to obtain evidence about the relationship between temperature and solubility for one solute. The lesson starts with a reminder about solubility from lesson 6.6 – how much sugar dissolves in water? Students then speculate about the effect of temperature on the solubility of sugar, before planning their investigations. They will go through the following stages – suggesting ideas to test, considering variables, outlining a plan, making predictions, choosing apparatus, making observations and measurements, and presenting evidence in tables. The investigation continues in lesson 6.8.

Activities

- Demonstrate dissolving sugar in water, to remind students of the fourth activity of lesson 6.6. Student pairs speculate about the effect of temperature on sugar solubility.
- Student pairs discuss ideas they could test to investigate the effect of temperature on solubility, and suggest questions to investigate. Discuss some of these as a class. Pairs finalise their investigation questions.
- Students plan an investigation on the effect of temperature on the solubility of a particular substance. Guidance is given on **worksheet 6.7.1**, but students are likely to need further help. It would be useful to display the apparatus. Suitable solutes include sodium hydrogencarbonate, potassium chloride, or ammonium chloride. **Worksheet 6.7.2** also supports this activity.
- Students carry out their investigations and collect their results in a table. **Worksheet 6.7.2** supports this activity.

Extension

Students use the Internet to research solubility curves.

Homework

Workbook page 38

Key words

prediction, variables, fair test, measuring cylinder, beaker, thermometers, balance, electric balance, Bunsen burner, stirring rod

Student book, pages 88–89

CD resources

- Worksheet 6.8.1
- Worksheet 6.8.2

Objective

- Present evidence in tables and line graphs

Overview

In this lesson, students continue the investigation they started in lesson 6.7. They decide whether to present their evidence in a line graph or bar chart, and then produce line graphs. Students then write a conclusion for the investigation, and discuss what to do about any results that do not fit into the pattern. The lesson finishes with a matching activity to remind students of key terms from lessons 6.6 to 6.8 – some of the cards are repeated from lesson 6.6.

Activities

- Discuss the evidence obtained in lesson 6.7. Is it easy to make conclusions from the evidence presented in tables? Elicit that it would be better to present the evidence graphically.
- Student pairs discuss whether to draw bar charts or line graphs. Tell students that bar charts are suitable if the variable you change is discrete. Line graphs are suitable if the variable you change is continuous. In this investigation, line graphs should be drawn.
- Students draw line graphs and write conclusions for their investigations. **Worksheet 6.8.1** supports this activity.
- As a class, discuss any results which do not fit into a pattern. Discuss what could be done about these.
- Student pairs match key words to definitions to remind themselves of key terms from lessons 6.6 – 6.8. **Worksheet 6.8.2** supports this activity.

Homework

Workbook page 39

Key words

discrete, continuous, range, line graph

Student book, pages 92–93

CD resources

- Worksheet 7.1.1
- Worksheet 7.1.2

Objectives

- Understand what materials are
- Explain what an element is
- Find metals and non-metals on the periodic table
- Give examples of elements

Overview

The lesson begins with a look at materials – how many can students see? What are their properties? Students are then introduced to elements as substances from which all materials are made, and which cannot be split up. They examine the properties of as many elements as possible, and find them in the periodic table. Finally, there is an optional research activity in which each student finds out key facts about one element.

Activities

- Students list the materials they can see, and describe their properties. Make sure they give properties of the materials, not of the objects made from them.
- Explain that every material is made from one or more elements. Elements cannot be split up. There are 92 elements found naturally on Earth. Every element is made of its own type of particle, which is unique to that element. If possible, play the element song – search the Internet for *element song*. The *privatehand* animation is recommended. Part A of **worksheet 7.1.1** supports this activity.
- Tell students that the periodic table lists all the elements. Elements on the left of the stepped line are metals. Elements on the right are non-metals. Students should look at page 93 of the Student book.
- Students examine real samples of as many elements as possible, note their properties, and find them in the periodic table. Make the point that every element has unique properties. Part B of **worksheet 7.1.1** supports this activity.

Extension

Each student uses the Internet to research a different element. They produce small posters for display. **Worksheet 7.1.2** supports this activity.

Homework

Workbook page 40

Key words

materials, properties, periodic table, metals, non-metals

Student book, pages 94–95

CD resources
- Worksheet 7.2.1
- Worksheet 7.2.2
- Worksheet 7.2.3

Objectives

- Identify typical metal properties
- Link the properties of two metals to their uses

Overview

The lesson starts with an opportunity to elicit student's prior knowledge of metals and their properties. There is also a short matching activity to ensure that students understand the meanings of words describing properties. Students then do a practical activity to explore the properties of metals (and non-metals) in more detail. The lesson ends with a card sorting activity to reinforce the properties of typical metals.

Activities

- Students look at Part B of **worksheet 7.1.1** from lesson 7.1. They use the properties they recorded to pick out metal elements from those they examined. The purpose of this activity is to elicit students' prior knowledge about metals and their properties.
- Student pairs match cards to build knowledge of vocabulary that describes properties. **Worksheet 7.2.1** supports this activity.
- Students test the following properties for a selection of elements: thermal and electrical conduction, hardness, and appearance. They pick out the properties that are typical of metals. **Worksheet 7.2.2** supports this activity.
- Students sort cards to reinforce their knowledge of typical metal properties. **Worksheet 7.2.3** supports this activity.

Extension

Students use the Student book to find out how the properties of gold and iron are linked to their uses, or the Internet to discover how the properties of other metals determine their uses.

Homework

Workbook page 41

Key words

sonorous, strong, hard, density, malleable, ductile

Student book, pages 96–97

CD resources
- Worksheet 7.3.1
- Worksheet 7.3.2

Objectives

- Identify typical non-metal properties
- Link the properties of non-metals to their uses

Overview

This lesson develops learning from the previous lesson by providing opportunities for students to explore the properties of typical non-metal elements. First, students pick out typical non-metal properties from the property cards they used at the end of lesson 7.2. They then examine samples of non-metal elements to check that they have these properties. Students next present melting point and boiling point data on bar charts. Finally, students explore links between the uses and properties of some non-metal elements.

Activities

- Students return to the card sort activity from the end of lesson 7.2. This time, they pick out properties that are typical of non-metal elements and record these. **Worksheet 7.2.3** completed in the previous lesson supports this activity. Look at page 96 of the Student book.
- Students examine a selection of non-metal elements and check – as far as is possible – that they have the properties identified in the previous activity.
- Students plot bar charts of melting point and boiling point data, and answer the questions on **worksheet 7.3.1** based on their charts. Lead a discussion to elicit that, in general, metals have higher melting and boiling points than non-metals. Point out some exceptions – mercury has a relatively low melting point (it is liquid at room temperature) and carbon has high melting and boiling points.
- Students use the Student book to explore the links between the uses and properties of some non-metal elements. They record their findings as a table or poster. **Worksheet 7.3.2** supports this activity.

Extension

Students use the Internet to discover how the properties of other non-metal elements determine their uses.

Homework

Workbook page 42

Key words

brittle, semiconductor, semi-metal, metalloid

7.4 Enquiry: making conclusions from data

Student book, pages 98–99

CD resources
- Worksheet 7.4.1
- Worksheet 7.4.2

Objective
- Practise drawing conclusions from data in tables and graphs

Overview
This lesson focuses on making conclusions from data in tables and graphs, and also examines what to do when results do not fit an expected pattern. Students begin by doing an experiment to compare the time taken for heat to move along different metal rods. They write a conclusion for their investigation. There is a then a short demonstration on stretching springs. What can an experimenter do if one result does not fit the expected pattern?

Activities
- Show students strips or rods of four metals. Pairs discuss how they could find out which of the metals is the best conductor of heat.
- Students follow the guidance on the sheets to finish planning, and to carry out, an experiment to compare the time taken for heat to move along different metal rods. They use their data to draw a conclusion for the investigation. **Worksheets 7.4.1** and **7.4.2** support this activity.
- Demonstrate the investigation shown on the lower half of page 99 in the Student book, in which masses are added to a spring and the extension of the spring is measured. Show students the graph in the Student book, in which one result does not fit the pattern. Student pairs discuss what the experimenter could do about this result. Tell students that the experimenter could repeat the extension reading at this force twice more – if both results now fit the pattern they could ignore the first result.
- If time permits, students answer the questions in the Student book.

Homework
Workbook page 43

Key words
anomalous, metal, non-metal, conductor, bar chart, line graph, conclusion

Student book, pages 100–101

CD resource
- Worksheet 7.5.1

Objectives

- Know what alloys are
- Give examples of alloys and their properties and uses
- Explain why alloys have different properties from the elements in them

Overview

This lesson is about alloys. It begins with an opportunity for students to share what they already know about alloys. It continues with a group activity, in which students work together to answer four key questions: What are alloys, and how are their properties different from those of their elements? Why are the properties of alloys different from those of their elements? What is steel, and why and how is it useful? What is bronze, and why and how is it useful?

Activities

- Student pairs discuss what they already know about alloys, including common alloys such as steel. Ask a few pairs to feed back.
- Divide students into groups of four. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 7.5.1**.

  Students doing the same question then get together in new groups of three or four. These are *expert groups*. Expert groups tackle the questions using information from the Student book, and plan how to teach their home groups what they have learnt.

  Students return to their home groups, and teach each other what they have learnt.
- Students remain in home groups. Ask them a few questions – perhaps to tackle as a group test – so as to check learning from the previous activity.

Extension

Students research shape memory alloys, such as nitinol. Typing *shape memory alloy* into a search engine yields useful websites.

Homework

Workbook page 44

Key words

alloy, steel, bronze, particle arrangement, properties

Student book, pages 102–103

CD resource
- Worksheet 7.6.1

Objective

- Describe everyday materials and their physical properties

Overview

The lesson draws on knowledge and understanding about properties from lesson 7.2. It begins with a look at everyday materials around the room. What properties does a material have? Why do these properties make the material suitable for its uses? Students then do a practical activity in which they examine various materials and record their properties. They discuss which of a material's properties make it suitable for a particular use of the material. The lesson finishes with a poster-making activity.

Activities

- Student pairs discuss the materials they can see around the room. What properties does a material have? Why do these properties make the material suitable for its uses? Make sure that students discuss properties of materials, not objects that are made from them.
- Student groups follow the guidance on **worksheet 7.6.1** to carry out a practical activity. This involves recording the properties of a material, and choosing one way in which the material is used. Students then choose the properties that make the material suitable for this use. Lead a class discussion to draw out key points from this activity.
- Students make posters using pages 102–3 of the Student book as a starting point. Give them a choice of two themes:
  - A poster about the uses of several materials, and why their properties make them suitable for these uses.
  - A poster advertising one material, its uses, and why its properties make it suitable for these uses.

Homework

Workbook page 45

Key words

brittle, flexible, stiff, strong, hard, soft, conductor, absorbent, waterproof

Student book, pages 104–105

CD resources
- Worksheet 7.7.1
- Worksheet 7.7.2

Objective
- Understand what polymers are and how they are used

Overview
This lesson starts with an introduction to polymers, both natural and synthetic – what are they? How do their physical properties make them suitable for their uses? Students then investigate the physical properties of five polymers, and consider how their properties make them suitable for their uses. The next activity involves answering questions based on data about polymer properties. The lesson ends with an explanation of the properties of poly(ethene).

Activities
- Display a selection of objects made from polymers, both natural and synthetic. Student pairs discuss how the properties of the polymers make them suitable for these uses. Tell students that polymers are made up of very long particles.
- Students examine objects made from different polymers and note their properties. They answer questions based on their findings. Suitable polymers for this activity can be found by looking at the recycling symbols on plastic objects. **Worksheet 7.7.1** supports this activity.
- Students study data about five polymers, and answer questions based on the data. **Worksheet 7.7.2** supports this activity.
- Teacher explains why poly(ethene) is strong and flexible, based on the explanation on page 104 of the Student book.

Homework
Workbook page 46

Key words
polymer, synthetic polymer, natural polymer

Student book, pages 108–109

CD resources
- Worksheet 8.1.1
- Worksheet 8.1.2

Objectives
- Give examples of acids and alkalis
- Compare the properties of acids and alkalis
- Make conclusions from data

Overview
This lesson introduces acids and alkalis. Students begin by considering whether acids are harmful or useful. They then look at examples of acids and alkalis, and record their properties. At this stage, alkalis are simply regarded as the chemical opposites of acids. Finally, students analyse data on sulfuric acid production.

Activities
- Students choose where to stand on an imaginary line with *acids are dangerous* written at one end and *acids are useful* at the other end. Ask some students to justify their positions on the line.
- Student groups sort cards into two piles – examples of acids being useful, and examples of acids being harmful. This activity is designed to generate discussion. **Worksheet 8.1.1** supports this activity.
- Students list all the acids they have heard about so far, and, where possible, note down their properties and uses. They use the Student book to make similar notes about alkalis. Part 1 of **worksheet 8.1.2** supports this activity.
- Students place cards on the table to show typical properties of acids and alkalis. Part 2 of **worksheet 8.1.2** supports this activity.
- Students answer question 4 on page 108 of the Student book to make conclusions from data presented in a pie chart.

Homework
Workbook page 47

Key words
acid, corrosive, alkalis

Student book, pages 110–111

CD resources

- Worksheet 8.2.1
- Worksheet 8.2.2
- Worksheet 8.2.3

Objectives

- Know the pH of acidic, alkaline, and neutral solutions
- Use indicators to measure pH
- Choose suitable apparatus

Overview

This lesson builds on lesson 8.1. It begins by encouraging students to see the need for distinguishing acids from alkalis – and hence the need for indicators. Students then make their own indicator from red cabbage or hibiscus flowers. Finally, students learn about the pH scale.

Activities

- Display a bottle containing a colourless solution. Students discuss how to find out whether the solution is acidic, alkaline, or neither. Could they drink it? Put it on their skin?

  Display a second, identical, bottle with a *corrosive* hazard label. Does this help them decide? Point out that none of the suggestions are good ideas – the first two are risky, and both acidic and alkaline solutions can be corrosive.
- Introduce the idea of indicators by dropping dilute hydrochloric acid, dilute sodium hydroxide, and pure water onto red and blue litmus paper.
- Students follow the instructions on **worksheet 8.2.1** to make a natural indicator. They calibrate the indicator by observing its colours in known acidic, alkaline, and neutral solutions. Finally, they use their indicator to test an unknown solution.
- Students answer the questions on **worksheet 8.2.2** to reinforce their learning so far.
- Demonstrate the colours of Universal Indicator in solutions of different pH. Students tackle the questions on **worksheet 8.2.3**. Read page 44 of the Student book.

Homework

Workbook page 48

Key words

litmus indicator, Universal Indicator, dilute, concentrated

Student book, pages 112–113

CD resources

- Worksheet 8.3.1
- Worksheet 8.3.2

Objectives

- Understand what neutralisation is
- Give examples of applications of neutralisation

Overview

This lesson begins with a brief demonstration – rainbow in a burette – to remind students that the pH scale is continuous. Students then carry out a practical to illustrate the process of neutralisation and the pH changes that occur during the process. There is then an optional extension activity, in which students work out how to reverse the neutralisation process they have just carried out. The lesson concludes with an opportunity to apply ideas about neutralisation to soil pH and crop choices.

Activities

- Demonstrate that the pH scale is continuous by making a ‘rainbow’ in a burette:
  - Mix 20 cm^3 0.1 mol/dm^3 sodium hydroxide with Universal Indicator to get a strong colour. Pour into a burette.
  - Add 10 cm^3 sodium hydrogencarbonate solution (2 spatula measures dissolved in 10 cm^3 pure water).
  - Add 10 cm^3 0.1 mol/dm^3 hydrochloric acid.
  - Place a bung over the end of the burette. Hold it with your thumb and invert to mix. Allow to settle.
  - Observe the rainbow, and question students about the pH in different regions. Why is it neutral in the middle?
- Students do a practical to illustrate neutralisation and the pH changes that occur during the process. **Worksheet 8.3.1** supports this activity.
- Students apply ideas about neutralisation to soil pH and crop choices. **Worksheet 8.3.2** supports this activity.

Extension

Students consider how to reverse the neutralisation process on **worksheet 8.3.1**, and test their ideas.

Homework

Workbook page 49

Key words

neutralise, neutralisation, acid rain

Student book, pages 114–115

CD resources
- Worksheet 8.4.1
- Worksheet 8.4.2

Objective
- Understand how to plan an investigation, and collect and consider evidence

Overview
In this lesson, students plan and carry out an investigation to compare different types of indigestion tablet. The lesson begins by discussing how to choose ideas to test, and how to decide which variables to control, change, and observe. Students then plan their investigations and, having checked with the teacher, carry them out. Students then use their collected data to make conclusions.

Activities
- Display a variety of indigestion tablets, and tell students that they work by neutralising excess stomach acid. Student pairs discuss ideas to test to compare the tablets, and suggest questions they could investigate. Create a class list of suitable questions, for example: *Which type of tablet causes the greatest increase in pH when added to acid?*
- Ask pairs to list possible variables. Discuss these as a class – if investigating the question above, which should they control, change, and observe?
- Students follow the guidance on **worksheet 8.4.1** to help them plan their investigations. Having confirmed their plans are suitable, they carry out their investigations. **Worksheet 8.4.2** also supports this activity.
- Students make conclusions from their collected data. Discuss these as a class. **Worksheet 8.4.2** supports this activity.

Homework
Workbook page 50

Key words
pH, neutralise, suggesting ideas, variable, anomalous

Student book, pages 118–119

CD resources

- Worksheet 9.1.1
- 9.1 Structure of the Earth illustration

Objectives

- Describe a model for the structure of the Earth
- Explain how we know about the Earth's structure

Overview

The lesson begins with a brief look at evidence for the Earth being spherical. It continues with an activity in which students create posters or models to represent the structure of the Earth and the states of each of its layers. The lesson finishes with an optional activity about a recent proposal to drill into the mantle. What will we learn from this research? Why should it be funded?

The illustration from page 118 of the Student book is included on the CD-ROM with and without labels. This could be used as plenary activity to find out what students already know about the structure of the Earth.

Activities

- Students pairs role play a discussion that might have taken place many years ago about the shape of the Earth. One student uses evidence from their own observations to assert that the Earth is flat. The other student uses evidence described on page 118 of the Student book to support their view that the Earth is spherical.
- Display an egg that has been boiled for about 10 minutes in its shell. Cut it in half. Tell students that the egg is a model for the structure of the Earth. Pairs use pages 118–119 of the Student book to discuss similarities and differences between the modern model of the structure of the Earth, and the egg model.
- Students make posters or models to represent the modern model of the structure of Earth. They add detailed labels to their models, giving the state of each layer. Models could be made from plasticine or clay. Use pages 118–119 of the Student book.

Extension

Students use the information on **worksheet 9.1.1** to write a request for funding for a research project to drill to the Earth's mantle.

Use the Internet to research how ideas about the shape of the Earth changed over time. The Wikipedia article *Flat Earth* is a suitable starting point.

Homework

Workbook page 51

Key words

scientific model, crust, mantle, outer core, inner core

Student book, pages 120–121

CD resource

- Worksheet 9.2.1

Objectives

- Describe the properties of igneous rocks
- Give examples of igneous rocks
- Explain how igneous rocks were formed
- Link igneous rock properties to their uses

Overview

The lesson begins by looking at a sample of granite, and speculating how it was formed. Students then examine the crystallisation of liquid salol in warm and cool conditions to help explain why different samples of igneous rocks have different-sized crystals. The lesson continues with an opportunity to study the properties of igneous rocks, and an optional research activity.

Activities

- Give student groups samples of granite, or any other igneous rock. Ask students to speculate how they were formed.
- Students now study a model to illustrate how granite was formed. Begin with a quick demonstration – place a few drops of liquid salol on a microscope slide. Observe as the liquid cools and solidifies. Tell students that some rocks, such as granite, formed when liquid rock cooled and solidified to form crystals. These are igneous rocks. The liquid rock may have cooled underground, on the surface, or under the sea.
- Students follow the guidance on **worksheet 9.2.1** to do an investigation to compare rocks formed when magma cools underground and under the sea. Smaller crystals form quickly on the cooler slide.
- Students observe samples of different igneous rocks with a hand lens. What do they have in common? They are all made up of interlocking crystals.

Extension

Use the Student book and the Internet to research how the properties of different igneous rocks determine their uses.

Homework

Workbook page 52

Key words

granite, igneous rock, magma, crystals, basalt, non-porous, minerals

Student book, pages 122–123

CD resources

- Worksheet 9.3.1
- Worksheet 9.3.2

Objectives

- Describe sedimentary rock properties
- Identify and name sedimentary rocks

Overview

This lesson begins with an introduction to some differences between igneous and sedimentary rocks. Students then do tests to distinguish sedimentary rocks from rocks of other types. The lesson continues with the production of a poster about the properties of particular sedimentary rocks, and how their properties are linked to their uses. Finally, students consider what they know about the formation of sedimentary rocks, in preparation for lesson 9.4.

Activities

- Student groups each examine one igneous rock, for example granite, and one sedimentary rock, for example limestone or sandstone. Elicit the differences.
- Students follow the guidance on **worksheet 9.3.1** to do tests to distinguish sedimentary rocks from rocks of other types.
- Students use the Student book and the Internet to research the properties and uses of different sedimentary rocks, for example sandstone, claystone, mudstone, and limestone. They display their findings on posters. **Worksheet 9.3.2** supports this activity.
- Finish the lesson with a short discussion in pairs. What do students know about how sedimentary rocks are formed? The next lesson will build upon this knowledge.

Homework

Workbook page 53

Key words

sedimentary rock, porous, grains

Student book, pages 124–125

CD resources
- Worksheet 9.4.1
- Worksheet 9.4.2
- Worksheet 9.4.3
- Worksheet 9.4.4

Objectives
- Explain how rocks are weathered
- Explain how sediments form rocks

Overview
In this lesson, through a series of experiments, students model the different stages by which sedimentary rocks are formed. They use an acidic solution and calcium carbonate powder to simulate the chemical weathering of limestone. They shake rocks in bottles to simulate physical weathering. Students use sand and water to model deposition and transport, and coins and matchsticks to help them picture compaction and cementation.

Activities
- Begin by referring back to the final activity of lesson 9.3 – what do students know about sedimentary rock formation? Refer to the flow diagram on Student book page 122. The purpose of this lesson is to explain each stage shown.
- Students follow the guidance to do the five activities on **worksheets 9.4.1–4**. These could be set up around the room, allowing students to move from one activity to another. Activities can be tackled in any order. Students record their findings.
- Return to the flow diagram on page 122, and ask students to describe and explain what the models taught them about each stage.

Extension
Students consider the models in the second activity – how are they like, and unlike, the actual processes?

Homework
Workbook page 54

Key words
weathering, sediments, chemical weathering, physical weathering, biological weathering, transportation, erosion, deposition, compaction, cementation

Student book, pages 126–127

CD resources
- Worksheet 9.5.1
- Worksheet 9.5.2
- Worksheet 9.5.3

Objectives
- Explain how metamorphic rocks are made
- Identify metamorphic rocks
- Give examples of metamorphic rocks

Overview
The lesson begins with a practical activity in which students compare the properties of limestone and marble. Students then complete a writing frame to explain how metamorphic rocks are formed, and how to recognise them. They then make model fossils, and subject them to various forces, as can happen when a sedimentary rock is subjected to pressure as it becomes a metamorphic rock.

Activities
- Tell students that marble and limestone are different types of rock, but that both types of rock consist mainly of the same compound, calcium carbonate. Students follow the guidance on **worksheet 9.5.1** to compare the properties of the two rocks. Make the point that the rocks look and feel different, but the change observed on adding acid is the same for both rock types.
- Students use the Student book to help them complete the writing frame on **worksheet 9.5.2** to explain how metamorphic rocks are made, and to describe how to recognise them. As an extension activity, students could use the Internet to add detail to their notes.
- Students make model fossils, and – during the process – squash them in one of three possible directions. Once the models are dry, they exchange with another group who must work out the direction in which the fossils were squashed. The formation of fossils is covered in detail in lesson 9.9. **Worksheet 9.5.3** supports this activity.

Homework
Workbook page 55

Key words
metamorphic rock, slate, gneiss, marble

Student book, pages 128–129

CD resources
- Worksheet 9.6.1
- Worksheet 9.6.2

Objectives

- To understand why questions, evidence, and explanations are important in science
- To interpret the rock cycle

Overview

Students start by reading about the observations and explanations of two early scientists – Ibn Sina and Chu Hsi. Next, they look carefully at the rock cycle in the Student book and observe as the teacher uses wax to demonstrate one possible route around the rock cycle. The lesson finishes with a rock cycle communication challenge – can students explain the rock cycle to a particular audience?

Activities

- Students read about the observations and explanations of two early scientists – Ibn Sina and Chu Hsi on pages 128–129 of the Student book. They speculate as to why early scientists were interested in the Earth and the formation of its features.
- Teacher uses the diagram in the Student book to help explain the rock cycle. Teacher then uses the wax model described on **worksheet 9.6.1** to demonstrate one possible route around the rock cycle.
- Student groups follow the guidance on **worksheet 9.6.2** to plan how to communicate the rock cycle to a particular audience. Groups then share their plans with another group, and peer assess.

Extension

Ask students to suggest rock cycle processes not represented by the wax model. The final row of the table on **worksheet 9.6.1** supports this activity.

Homework

Workbook page 56

Key words

geologist, rock cycle, uplift

Student book, pages 130–131

CD resources
- Worksheet 9.7.1
- Worksheet 9.7.2
- Worksheet 9.7.3
- 9.7 Volcanic eruption illustration

Objective

- Understand how scientists use science to explain predictions

Overview

The lesson begins with an introduction to the work of vulcanologists, and a sequencing activity based on this. Next, there is a demonstration of a tiltmeter – how does it work? Why are data from tiltmeters useful? The third activity is a short role play in which students take the roles of vulcanologists explaining to government officials the scientific explanations for their predictions. A final activity is an opportunity for students to consider the work of vulcanologists. During the lesson, it is vital to make the point that scientists can never be sure exactly when a volcano will erupt.

The illustration from page 130 of the Student book is included on the CD-ROM with and without labels. This could be used as plenary activity to find out what students already know about volcanoes.

Activities

- Teacher tells students that vulcanologists make observations and measurements, look for patterns in their data, and use these patterns to help them make predictions about future volcanic activity. Students sequence the tasks on Part A of **worksheet 9.7.1**.
- Teacher demonstrates the action of a tiltmeter using the guidance on **worksheet 9.7.2**.
- Student pairs role play a vulcanologist explaining to a government official the scientific explanations for their predictions. Part B of **worksheet 9.7.1** supports this activity.
- Students plan and present talks on the work of vulcanologists for a school careers day. **Worksheet 9.7.3** supports this activity.

Extension

Use the Internet to research recent or local volcanic eruptions. Find out what the volcano emitted, and the impacts of the eruption.

Homework

Workbook page 57

Key words

magma, lava, volcano, vulcanologist

Student book, pages 132–133

CD resources
- Worksheet 9.8.1
- Worksheet 9.8.2
- Worksheet 9.8.3

Objectives

- List soil components
- Name soil types
- Describe soil properties

Overview

This lesson introduces soil types and properties. It is linked to lesson 9.9, in which students study soil in further detail. The lesson starts by setting up a practical to look at the components of a soil sample. Lesson 9.9 provides an opportunity to classify the soil based on the relative amounts of different sized rock fragments. Students then compare the texture and drainage of three different soil samples, and use their findings to attempt to classify the samples. Finally, students make notes about the origins and roles of soil components.

Activities

- Students set up the apparatus on Part A of **worksheet 9.8.1**, to separate soil components. They return to this in lesson 9.9.
- Students compare the texture and drainage properties of three different soil samples. Later, they will attempt to classify each soil. **Worksheet 9.8.2** supports this activity.
- Teacher describes the components of soil and the origin and role of each component. Students complete the written tasks on **worksheet 9.8.3** using the Student book to help them.
- Students examine their results from the second activity. They record their observations and answer the questions on **worksheet 9.8.2**.

Homework

Workbook page 58

Key words

rock fragments, humus, clay soil, loam, sandy soil

9.9 Enquiry: more about soil

Student book, pages 134–135

CD resources

- Worksheet 9.8.1 (from lesson 9.8)
- Worksheet 9.9.1
- Worksheet 9.9.2

Objectives

- Describe soil properties
- Explain why soil properties are important

Overview

This lesson continues the work on soil started in lesson 9.8. Students begin by returning to the first activity of lesson 9.8, and try classifying the soil based on the relative amounts of different sized rock fragments. Students then do a practical to measure the volume of air in a soil sample. Finally, students test soil pH for several samples, and suggest crops that might grow well in the samples.

Activities

- Students return to their apparatus set up from lesson 9.8, and follow the guidance on part B of **worksheet 9.8.1** to try classifying the soil based on the relative amounts of different sized rock fragments. Students will not be able to make firm classifications based on their findings; rather, the results give some indication of whether the soil is sandy, clay, or loam.
- Students measure the air content of a soil sample. **Worksheet 9.9.1** guides them through this activity.
- Students measure the pH of different soil samples and suggest crops that might grow well in each sample. **Worksheet 9.9.2** supports this activity.

Homework

Workbook page 59

Key words

pore, secondary source, minerals

Student book, pages 136–137

CD resources

- Worksheet 9.10.1
- 9.10 Stages of fossilisation illustrations

Objectives

- State what a fossil is
- Describe how fossils form
- Give examples showing what we can learn from the fossil record

Overview

This lesson is about fossils. It begins with an opportunity for students to share what they already know about fossils. It continues with a group activity, in which students work together to answer three key questions: What are fossils, and why do they form only rarely? How do fossils form? What have we learnt from fossils? There is then an optional activity in which students research recent fossil finds.

The six illustration from page 136 of the Student book is included on the CD-ROM in sequence. This could be used to show students how fossilisation occurs.

Activities

- Student pairs discuss what they already know about fossils. What are fossils? What type of rock are they found in? What have we learnt from fossils? Ask a few pairs to feed back.
- Divide students into groups of three. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 9.10.1**.

  Students doing the same question then get together in new groups of three or four. These are *expert groups*. Expert groups tackle the questions using information from the Student book, and plan how to teach their home groups what they have learnt.

  Students return to their home groups, and teach each other what they have learnt.
- Students remain in home groups. Ask them a few questions – perhaps to tackle as a group test – so as to check learning from the previous activity.

Extension

Students research recent fossil finds. Typing *fossils* into the news section of a search engine yields interesting articles.

Homework

Workbook page 60

Key words

fossil, preserved, remains, palaeontologist, fossil record

Student book, pages 138–139

CD resource
- Worksheet 9.11.1

Objective

- Describe how scientists have estimated the age of the Earth

Overview

The lesson begins with a short role play about William Thomson's ideas about the age of the Earth. Students are then introduced to sedimentary rock strata and their relative ages. Next, they learn about index fossils, and apply their new knowledge to create the strata in a cliff face – complete with fossils – and to compare their cliff face with that of another student. The lesson ends by telling students the modern best estimate of the age of the Earth.

Activities

- Ask students how old the Earth is. Note down their answers to refer to at the end of the lesson.
- Students read about William Thomson's ideas about the age of the Earth on page 138 of the Student book. In pairs, they perform quick role plays of a conversation between Thomson and a modern scientist – how do we now know that Thomson's estimate for the age of the Earth is incorrect?
- Explain that sedimentary rocks are laid down in layers called *strata*. Lower strata are older – they were formed first. Describe the work of William Smith, who recognised that rock strata of the same age contain the same fossils, and that certain fossils are only found in rock strata of certain ages.
- Student pairs create a poster of strata in a cliff face, complete with index fossils. They compare their posters to those of other students. **Worksheet 9.11.1** supports this activity.
- Tell students that the oldest rocks on Earth are 4 600 000 000 000 years old. This is the best estimate for the age of the Earth. How does this value compare to student estimates in the first activity?

Homework

Workbook page 61

Key words

strata, index fossil, radiometric dating

Student book, pages 140–141

CD resources
- Worksheet 9.12.1
- Worksheet 9.12.2

Objective

- Describe what fossils tell us about our human past

Overview

The lesson begins with an account of the find of the fossilised remains of a young girl in Ethiopia. Students then match evidence from the find to possible explanations. The lesson continues with an Internet research activity, in which students find out more about one of three fossil finds described in the student book – Toumaï, the Laetoli footprints, or *Homo floresiensis.* Finally, students share their findings with others.

Activities

- Show a video clip about the discovery of the fossilised remains of a young girl in Ethiopia – Selam. Alternatively, ask students to read about the fossil find on page 140 of the Student book.
  Excellent video clips can be found for searching for:
  Zeresenay Alemseged TED
  Zeresenay Alemseged National Geographic
  Zeresenay Alemseged Nature video
  It is recommended that you watch the video clips before the lesson to check their suitability for your students.
- Students match evidence from the fossilised remains of Selam to suitable explanations. **Worksheet 9.12.1** supports this activity.

  Students read about three further fossil finds on pages 140–141 of the Student book – Toumaï, the Laetoli footprints, and *Homo floresiensis*. They choose one of these finds to research on the Internet in greater detail, and include information about how evidence from the find supports explanations about the find. Some suitable web links are included on **worksheet 9.12.2**.

Homework

Workbook page 62

Key words

human, fossil, radiometric dating, ancestor, descendent

Student book, pages 144–145

CD resources
- Worksheet 10.1.1
- Worksheet 10.1.2
- Worksheet 10.1.3

Objectives
- Describe different types of force
- Understand the effects of forces on moving objects
- Describe how to measure forces

Overview
This lesson builds on the understanding of forces that students have gained at earlier. It will enable them to recall all the different types of forces, such as gravity, air resistance, and friction. The main idea is that forces enable us to explain what is happening to an object. To explain motion students need to be able to identify the forces acting on an object, and the direction in which they act. Forces are invisible so students need to be able to represent the forces acting on an object with an arrow, and to be able to label those arrows correctly. Students will be familiar with using a spring balance, or forcemeter, to measure forces. They should be aware that forces are measured in newtons.

Activities
- Ask students to identify the names of as many different types of force that they have met and below. They may not have met the electrostatic force. How do we know that there are forces acting? Explain that forces act on objects and we can represent them with arrows.
- Students revise what they know about forces using **Worksheet 10.1.1**.
- Students examine different situations where there are forces acting. For each one they identify the type of force and the direction in which it is acting and sketch diagrams to show those forces. They follow the instructions on **worksheet 10.1.2** and complete **worksheet 10.1.3**.
- Demonstrate using a spring balance to measure force. Show lifting an object to measure weight, and pulling an object to measure friction.
- Demonstrate how other forcemeters/bathroom scales can be used to measure force e.g. pushing against a wall against bathroom scales.
- Students make a table showing the different types of forcemeter and where you might use them.

Extension
Individually or in pairs students tackle question 4 on **worksheet 10.1.2**. This asks students to identify the link between the size of forces and the motion of the object, and to identify situations where this is happening.

Homework
Workbook page 63

Key words
force, gravitational force, weight, electrostatic force, attract, repel, magnetic force, friction, air resistance, water resistance, drag, thrust, upthrust, tension, spring balance, newtons

Student book, pages 146–147

CD resources
- Worksheet 10.2.1
- Worksheet 10.2.2
- Balanced and unbalanced forces presentation

Objectives

- Explain the difference between balanced and unbalanced forces
- Describe the effect of balanced forces
- Describe the effect of unbalanced forces

Overview

This lesson introduces the idea of balanced and unbalanced forces using the idea of a car moving and a tug of war. Most students will understand that forces can cancel out, and that if they do not cancel then the motion of objects will change. They explore these ideas in a tug of war activity with spring balances.

A more difficult idea is that an object moving with a steady speed can have balanced forces acting on it. A common misconception is that something needs a force acting on it to be moving at all, an idea that dates back to Aristotle over 2000 years ago. Students explore the idea of a friction-compensated slope shows that objects can move with a steady speed when there is a force of gravity acting on them but a force of friction is also acting, which cancels it out. Finally students add arrows to drawings of a rocket at different stages of its flight.

Activities

- Ask students to list some situations where objects are speeding up, slowing down, or moving with a steady speed. Ask them to add arrows to a picture of a car that is not moving, accelerating, decelerating, or moving with a steady speed. Introduce the idea of forces being ‘balanced’ or ‘unbalanced’.
- Students follow instructions in pairs to use two forcemeters to look at the effect of different size forces on the motion of an object using **worksheet 10.2.1**.
- Demonstrate the idea of balanced forces on a moving object with a trolley or toy car on a ramp. With the ramp flat push the car. Ask the students about the forces acting at each stage (when your finger is in contact with the car, when it is no longer in contact, when it has stopped). Bring out the effect of friction on the motion.
- Next, raise the ramp until friction is just compensated for. This time if you push the car it should move with a steady speed. There is just enough of the gravitational force to compensate for friction so it moves with a steady speed.
- Students draw diagrams showing the forces on the car when the ramp is steep, just compensating for friction, and horizontal.
- Show a picture of a rocket taking off. Ask students if there are any forces acting on it. How can they tell that there are forces acting on it when they cannot see them? Students complete **worksheet 10.2.2** by drawing arrows on the rocket at different stages of its flight and describing and explaining its motion.

Extension

Students calculate the size of the resultant forces in question 4 of **worksheet 10.2.1**.

Homework

Workbook page 64

Key words

balanced, unbalanced, accelerate, decelerate, resultant

Student book, pages 148–149

CD resources
- Worksheet 10.3.1
- Worksheet 10.3.2

Objectives
- Describe the effect of friction on moving objects
- Understand how to reduce friction
- Describe how friction can be useful

Overview
Students will be familiar with the effects of friction in their everyday lives, from shoes to slides. In this lesson they consider the causes of friction and its effects, and how it can be reduced. They consider the role of friction in enabling them to walk.

Activities
- Ask students to rub their hands together. Establish that there is friction between them and ask them what causes that friction. By looking carefully at the surface of their skin they can see the ridges, grooves, and mounds that get caught when they rub them together. This produces the resistance to motion of their hands so that they 'grip'.
- Ask students to make a table headed useful and unwanted friction. Use the example of a bicycle: the brakes work because of friction, but air resistance slows them down.
- Students investigate how different lubricants reduce friction. They pull a block along a surface with and without lubricants and measure the effect. **Worksheet 10.3.1** supports this activity.
- Ask students to link what they have learned about friction to how they are able to walk! It is a very simple question, but they may not have thought about the role of friction in walking. When is it easy to walk and when is it not easy? Use ideas about the microscopic reasons (shown on page 148 of the Student Book) for friction to explain the observations.
- Students make a model of a hovercraft and describe how this reduces friction using **worksheet 10.3.2**.

Extension
Repeat the activity but vary the height of the ramp.

Homework
Workbook page 65

Key words
friction, lubrication, lubricant

Student book, pages 150–151

CD resources

- Worksheet 10.4.1
- Worksheet 10.4.2
- Gravity on different planets presentation

Objectives

- Explain the link between gravity, mass, and weight
- Describe how your weight can be different on different planets

Overview

This lesson introduces ideas about weight and how it is different to mass. Students often find it difficult to distinguish between the two, so it is worth spending time talking about the use of the two words in everyday language to bring out the issue. The weight of an object is a measure of the gravitational force of the Earth on object, and the mass is a measure of how difficult it is to move it, or the amount of 'stuff' there is in it.

Talking about the gravitational force *of the Earth* on objects naturally leads into the idea that weight will be different on different planets.

Activities

- Ask students to guess the weight of bar of chocolate. They will usually give the answer in grams. It will say that on the wrapper! Next, they write down as many ways of measuring the weight of something that they can think of, for example, weighing scales, spring balance, etc. Ask what the weights would be, and again they will be in grams or kilograms.
- Establish that most weighing machines are effectively spring balances, so they are measuring a *force*, the force of the Earth on the object, and this is what we call weight, in newtons (N).
- Students find the weight of objects of different mass, and work out the link between them using **worksheet 10.4.1**.
- Prepare small boxes that are sealed and labelled with the names of the planets. In each box should be the amount of plasticine that gives the weight as it would feel if you took an object of the same mass to each of the planets. Use the weblink *http://www.exploratorium.edu/ronh/weight/* to work out the appropriate masses. Hand around the boxes for students to feel the difference in the weight.
- Establish from the results that the link between weight and mass on Earth is the number 10. Emphasize that this is the link between weight and mass on *Earth*, and therefore their weight might be different elsewhere, such as other planets or the Moon. Use the **worksheet 10.4.2** to consolidate their understanding.

Extension

Students complete questions 5, 6, and 7 on **worksheet 10.4.1**.

Suggest reasons why your weight is different on different planets as shown on **worksheet 10.4.2**.

Homework

Workbook page 66

Key words

gravity, weight, newtons, mass, kilograms, grams, matter, gravitational field, gravitational field strength

Student book, pages 152–153

CD resource

- Worksheet 10.5.1

Objectives

- Recognise scientific questions
- Describe how explanations are developed

Overview

In this lesson students are introduced to the role of creative thought in developing explanations. They learn about how different scientists can have the same explanation for a phenomenon at different times in history, but how evidence from predictions is important in confirming that explanation. Students learn about the idea of gravity, as described by Bhaskaracharya and Newton, and use ideas about gravity to plot a journey to the Moon. They use creative thought to think about how the mission would work given the relative strengths of the gravitational fields of the Earth and the Moon.

Activities

- Students read through the Student book pages 152–153 to find out about Bhaskaracharya and Newton and their ideas about how the gravitational pull of the Earth keeps the Moon in orbit.
- Introduce the idea of gravity getting weaker as you move away from a planet or moon and that gravity is weaker on less massive planets or moons. Explain how they are going to make a poster presentation about a journey to the Moon. They can use *http://www.nasa.gov/mission_pages/apollo/missions/apollo11.html* for information. **Worksheet 10.5.1** supports this activity.
- Groups present their 'Mission to the Moon' to the class. Elicit that the Earth's gravity will slow the rocket as it leaves the Earth, but will accelerate as it approaches the Moon. The rocket will need to slow down to land safely.
- Students vote on which group has produced the best explanation for each of the questions on the worksheet.
- If available, show a video clip from the film 'Apollo 13' where they are coming back to Earth and the astronauts say 'Isaac Newton is in the driving seat now'.
- Students draw a table of similarities between Bhaskaracharya and Newton's ideas and differences. Emphasise the role of evidence (the discovery of Neptune) as support for Newton's ideas.

Extension

Students investigate the Curiosity Mission to Mars and make a comparison with the Apollo Mission in a four page leaflet.

Homework

Workbook page 67

Key words

explanation, gravity, questions, Newton, Bhaskaracharya

Student book, pages 154–155

CD resources

- Worksheet 10.6.1
- Worksheet 10.6.2
- Air resistance presentation

Objectives

- Explain what affects air resistance
- Describe what is meant by terminal velocity
- Explain how and why the speed of a skydiver changes

Overview

Students will be very familiar with the idea of air resistance from Stage 6, and their everyday experience. In this lesson the practical activities establish the link between air resistance and the area of an object, and air resistance and speed.

It is important for students to think about the mechanism by which the air is exerting a force, which is explained by the collisions with the air molecules. This will help them to explain the observations of the effect of changing area and speed on the force of air resistance.

The idea that air resistance increases with speed (and so affects the motion of a falling object like a skydiver) can be linked back to balanced and unbalanced forces. When air resistance is equal to weight the object falls with a constant speed, called 'terminal velocity'. (The distinction between speed and velocity is not needed here). The forces are balanced.

Activities

- Demonstrate dropping sheets of paper in different ways:
  - two screwed up pieces
  - one screwed up and one flat piece
  - one held flat and one held vertically.

  Ask students why the fall at different rates, and establish the idea of air resistance.
- Discuss what exactly we mean by 'air resistance' and bring out the idea of collisions with air molecules. Students draw diagrams of the second case above showing the air molecules colliding with the paper. More collide with the flat piece than the screwed up piece.
- Students make parachutes of different areas and find how long each one takes to reach the ground. This activity could be made into a competition to find the parachute that takes the longest time to travel a set distance. **Worksheet 10.6.1** supports this activity.
- Show a video clip of the feather and hammer being dropped on the Moon or demonstrate in the classroom if a vacuum pump is available. See *http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo_15_feather_drop.html* Discuss the difference between the Moon and the Earth in terms of gravitational field strength and atmosphere.
- Students consolidate what they have done by making a cartoon strip of a person jumping out of a plane. **Worksheet 10.6.2** supports this activity.

Homework

Workbook page 68

Key words

air resistance, streamlining, terminal velocity

Student book, pages 156–157

CD resources
- Worksheet 10.7.1
- Worksheet 10.7.2

Objective

- Understand how to plan an investigation to test an idea in science

Overview

In this lesson students plan an investigation into stopping distances. They revise what they learned about friction and gravity and apply it to a trolley going down a ramp. They consider all the factors that might affect the stopping distance, and then suggest ideas to test and question what to investigate. Their plan should include: considering all the variables, making a prediction, choosing apparatus, making a plan, and collecting evidence to present in a table. You may want the students to read the pages 156–157 of the Student book before planning their investigation, or they could complete their investigation and then review what they have done once they have read the book.

Activities

- Show photographs of different types of vehicle and ask students which would take the longest distance to stop if they were all travelling at the same speed.
- Remind the students of what they learned about friction and air resistance, and how they slow objects down. Demonstrate a trolley going down a ramp and show what is meant by 'stopping distance'. Explain that they are going to find out what affects the stopping distance.
- Discuss what scientists do when they want to investigate the link between variables in an investigation. Explain what we mean by variables (independent, dependent and control) and how scientists ensure that they are doing a fair test.
- Students consider the variables that would affect the stopping distance of a trolley and think about the questions that they could investigate.
- Students plan an investigation using **worksheet 10.7.1**. They may need further help to ensure that they do not change more than one variable at a time. Students can make their own plan or use the writing frame on **worksheet 10.7.2**. Students carry out the investigation and record their results in a table.
- Students report back to the class about what they found out. Alternatively they could make a poster that has their plan, results, and what they found out. Other groups look at the posters and write down one good thing and one thing that needs to be improved.
- Students look at the points that need to be improved and make a checklist ready for their next investigation.

Extension

Students use pages 226–7 of the Student book to decide which graph to use when plotting their results. They use pages 228–9 of the Student book to help them describe any link that their graph shows.

Homework

Workbook page 69

Key words

variables, evidence, plan, prediction, fair test

Student book, pages 160–161

CD resources

- Worksheet 11.1.1
- Worksheet 11.1.2
- Worksheet 11.1.3

Objectives

- Describe what light is
- Explain how shadows form
- Describe how a camera works

Overview

In this lesson students consider light as a way of transferring energy. They investigate how shadows are formed and how to explain their size and shape using the idea that light travels in straight lines.

Activities

- Ask students to think of as many different things that give out light as they can. Introduce the idea of luminous and non-luminous sources. Students will be less clear about what light actually is. At this stage we consider that it is a wave that transfers energy.
- Demonstrate that light travels in straight lines with a laser and chalk dust, if available.
- Students use a ball on a piece of string and a light source to investigate the size and shape of shadows using **worksheets 11.1.1** and **11.1.2**. Discuss the results of the experiments and bring out the effect of having a point or an extended source in terms of the type of shadow that is produced. Remind students of ideas about an umbra and penumbra that they learnt earlier.
- Students further explore light travelling in straight lines by using a pinhole camera to form and image of the filament of a lamp using **worksheet 11.1.3**. A method for making a simple pinhole camera from a box, some greaseproof paper and some foil can be found online. *http://www.nuffieldfoundation.org/practical-physics/pinhole-camera-and-lens-camera*
- Alternatively, or as well as the practical, they construct a model of the rays of light forming an image in a camera using string. Students can draw a picture of a lamp on a piece of paper. They draw a picture of a pinhole camera on another piece of paper. If they use string from the top and bottom of the filament they can use the model to predict what will happen if they move the camera closer to the lamp, or further from it.
- They consolidate what they know by drawing ray diagrams showing how shadows and images in a pinhole camera are formed using **worksheet 11.1.2** and **11.1.3**.

Extension

Find out why cameras contain lenses.

Homework

Workbook page 70

Key words

light, light source, luminous, non-luminous, infrared radiation, thermal energy, shadow, umbra, penumbra, image, inverted

Student book, pages 162–163

CD resources

- Worksheet 11.2.1
- Worksheet 11.2.2
- Worksheet 11.2.3
- Worksheet 11.2.4
- Worksheet 11.2.5
- The eye presentation

Objectives

- Describe what happens when light travels from a source
- Explain how we see things

Overview

In this lesson students learn what happens to light when it interacts with objects and the words that we use to describe what happens. They investigate how materials absorb light, including things that appear to be transparent. They learn that we see objects because they emit light, or they reflect light, and why some objects look black and some objects look white.

Activities

- Introduce the idea of a light journey and what can happen to light after it has been emitted by a source. There are lots of words to describe the properties of materials and what happens to light on its journey. Students complete a matching exercise to test their understanding of the various words associated with the journey using **worksheet 11.2.1**.
- Show a light meter and introduce the unit of light intensity with some examples.
- Students investigate the absorption of light by different materials, including water using **worksheet 11.2.2** and **worksheet 11.2.3**.
- How do we see things? Discuss the difference between seeing luminous and non-luminous objects. Ask students to describe the light journey for luminous and non-luminous objects. Use **worksheet 11.2.4** to consolidate their knowledge.

Extension

Students look at the structure of the eye in the Student book page 163. They label the diagram of the eye on **worksheet 11.2.5**, and describe the similarities and differences between the eye and the camera.

Homework

Workbook page 71

Key words

source, detector, transmitted, reflected, absorbed, transparent, translucent, opaque, lux, luminous, non-luminous, eye, lens, cornea, retina, cones, rods, optic nerve

Student book, pages 164–165

CD resources
- Worksheet 11.3.1
- Worksheet 11.3.2

Objectives
- Know how fast light travels
- Understand how astronomers use the speed of light to describe distances

Overview
In this lesson students get a feel for the speed of light and how it can be used to measure distance. The distances in space are so large that it is much more convenient to use light time to measure them. This lesson will give them a sense of the scale of the Solar System and the galaxy, and the distance between galaxies. There is a significant mathematical content to this lesson and some students may need extra support.

Activities
- Show students pictures of the stars. Ask them to explain why looking at stars is like looking back in time. Elicit that it take light a certain amount of time to travel from the stars to our eyes. Discuss what would happen if the Sun 'went out'. The speed of light means that we would not know for about 8 minutes. Introduce light time in terms of light seconds, minutes, hours, and years. Link these ideas to the speed equation: distance = speed × time.
- Students calculate the distance to the planets of the Solar System in light time using **worksheet 11.3.1**, and work out the most appropriate unit of light time.
- Students make a scale model of the Milky Way using light time using **worksheet 11.3.2**. They use the dimensions of the Milky Way in light years to make a scale model showing the shape of the Milky Way and where the Solar System is in relation to the centre of the galaxy. They work out where Andromeda is in relation to the Milky Way using the same scale.
- Discuss the definition of the metre and how it is linked to the speed of light. The metre is no longer the length of a piece of metal kept in Paris, but relates to the wavelength of light.

Homework
Workbook page 72

Key words
speed of light, light year

Student book, pages 166–167

CD resources

- Worksheet 11.4.1
- Worksheet 11.4.2
- Worksheet 11.4.3
- Reflection presentation

Objectives

- Describe how an image in a plane mirror is formed
- Describe the differences between you and your image
- Explain why you see your image only in certain situations

Overview

Students will know that they see themselves when they look in a mirror. In this lesson they learn that an image is formed when they look in the mirror, and investigate mirror images. They investigate some examples of reflection in everyday life, and in magic tricks. Students often only associate reflection with mirrors rather than with any non-luminous object. In this lesson they learn that all surfaces reflect light to some extent, but that images are only formed in particularly smooth surfaces. This leads into an exploration of the law of reflection next lesson.

Activities

- Recap how we see things, and the words that the students have learnt to describe what happens on a light journey. Explain that this lesson will look at light being reflected. Ask how many objects in the room are reflecting light (anything that isn't giving out light).
- Students investigate their mirror image, and their reflection in other surfaces using **worksheet 11.4.1**. They consider how their mirror image is different and the same, and how different surfaces reflect in different ways leading to an understanding that you need a very smooth surface to produce an image. Discuss the idea of a real and virtual image and the difference between reflection from a smooth surface and diffuse reflection.
- Glass is an interesting material to investigate as it both reflects and transmits light. Students set up a magic trick (known as Pepper's Ghost) where they make it appear that a candle is burning in a glass of water using **worksheet 11.4.2**. They explain what they see from what they know about light transmission and reflection using a simple ray diagram.
- Letters and words appear differently in a mirror. Students work out which letters and words appear different, and how to write them so that they can be read in a mirror using **worksheet 11.4.3**.

Homework

Workbook page 73

Key words

plane mirror, image, real images, virtual images, laterally inverted, ray diagram, diffuse

Student book, pages 168–169

CD resources
- Worksheet 11.5.1
- Worksheet 11.5.2
- Worksheet 11.5.3
- Worksheet 11.5.4

Objectives

- State the law of reflection
- Use the law of reflection
- Describe how to make accurate measurements

Overview

In this lesson students investigate the law of reflection by taking measurements using a ray box and a mirror. They assess how well they have taken the measurements and think about things that they could do to improve the measurements. They use the law of reflection to predict what will happen in situations where there is more than one mirror, and this leads to a consideration of periscopes and kaleidoscopes. Students can make a periscope using two plane mirrors.

Activities

- Students set up the equipment to measure the angles of incidence and reflection using **worksheet 11.5.1**. They record their results on **worksheet 11.5.2** and consider how their results would be affected by small changes to the method or equipment. Discuss the results that different groups have achieved and highlight particularly effective methods for getting accurate and precise results.
- Students extend their investigation into mirrors by finding the number of images that they can see when there are two mirrors together at an angle using **worksheet 11.5.3**.
- Students are often not clear why we do not just measure the angles from the mirror to the incident and reflected rays. By trying to construct ray diagrams for rough and curved surfaces on **worksheet 11.5.4** they learn the reason why we use the normal in ray diagrams. Give students two plane mirrors, cardboard, scissors and glue and challenge them to make a periscope to look over a wall using the law of reflection.

Extension

Students should answer questions 4, 5, and 6 on **worksheet 11.5.3**.

Homework

Workbook page 74

Key words

incident ray, normal, angle of incidence, reflected ray, angle of reflection, law of reflection, periscope, kaleidoscope

Student book, pages 172–173

CD resources
- Worksheet 12.1.1
- Worksheet 12.1.2
- Worksheet 12.1.3
- Worksheet 12.1.4

Objectives
- Know the types of charge
- Explain why things become charged
- Explain the difference between conductors and insulators

Overview
This is the first of two lessons on electrostatic phenomena. In this lesson students are introduced to the idea of charging things up and the idea of positive and negative charge. Students investigate how charged objects attract or repel each other, and use the idea of charge to explain some everyday phenomena. They consider why electrostatic phenomena occur with insulators but not conductors. As some of the experiments are described in the book ensure that students do not look at the book until the end of the lesson.

Activities
- Students experiment with trying to stick a balloon to the wall by rubbing it on their clothes and putting it against the wall. If there are different types of surface in the room then they can see if it works for all surfaces or just some. They write down their explanation in the box on **worksheet 12.1.1**. They will review that explanation at the end of the lesson and see how their ideas have changed.
- Explain how atoms are made of tiny, subatomic particles. Describe the structure and explain why atoms are neutral. If available show an animation that shows the electrons, protons, and neutrons in different atoms such as: *http://www.colorado.edu/physics/2000/applets/a2.html* Students show what they know about the structure of the atom using **worksheet 12.1.2**.
- Rub a rod with a cloth. Talk through the movement of electrons to or from the rod producing an excess of charge. Demonstrate attraction/repulsion of charged rods as described on page 172 of the Student book or let students experiment with it in the series of practicals.
- Students explore a range of electrostatic phenomena using **worksheet 12.1.3** and record their results on **worksheet 12.1.4**.
- Finally students return to their explanation of the balloon experiment at the start of the lesson and evaluate what they wrote. Then they write an explanation that uses ideas that they have learned in the lesson.

Extension
Students can investigate the history of electrostatics and find out the origin of the word ‘electric’.

Homework
Workbook page 75

Key words
electrostatic, charge, repelled, attracted, positive charge, negative charge, nucleus, neutral, neutralise, conductor, insulator

Student book, pages 174–175

CD resource
- Worksheet 12.2.1

Objectives

- Describe how electrostatics can dangerous
- Explain how the risk of damage from electrostatic phenomena can be reduced

Overview

In this lesson students consolidate what they have learned about charge by considering the risks of the build-up of charge. They learn that when charges move through a material it produces a current. This can cause a heating effect that produces the sparks that we see as lightning. Students learn about how lightning conductors work and produce a poster about safety in thunderstorms and a leaflet about how the risk of sparks in everyday situations can be reduced.

Activities

- Demonstrate the Van der Graaf generator. Charge the dome and throw small pieces of paper at the dome or blow bubbles at it. Ask students to explain the observations using the idea of charge. Demonstrate how sparks are produced by bringing another earthed sphere close to the dome. Explain that the charge is moving through the air, that it is a current that is heating up the air, just like it heats up the filament of a lamp. Alternatively show a suitable video clip from the Internet.
- Ask students to choose where the safest place would be in a thunderstorm. Demonstrate with the Van der Graaf generator that points produce sparks more easily than blunt surfaces. Elicit that tall buildings and trees are more likely to be hit by lightning. Ask whether it is safer to lie flat or stand up in a storm. Discuss ways of reducing the risk of being hit by lightning.
- Explain how lightning conductors work and what is meant by earthing.
- Students read page 174 of the Student book and produce a poster that explains what lightning is and what people should do to reduce the risk of being hit by lightning. They should include information about what happens if you are hit by lightning and why, and how lightning conductors provide a path for the charges to be earthed.
- There are lots of examples of places where charge can build up in everyday life. Students use **worksheet 12.2.1** to plan a leaflet that explains how risks can be reduced.

Extension

Students find out about how lightning conductors were developed.

Homework

Workbook page 76

Key words

spark, current, lightning conductor, earth, earthing

Student book, pages 176–177

CD resources
- Worksheet 12.3.1
- Worksheet 12.3.2
- Worksheet 12.3.3

Objective

- Describe how touch screens and digital cameras work

Overview

In this lesson students learn how touch screens on phones and computers work. They learn about how charge is stored in a capacitor and how that can be used to detect the position or motion of your finger on a screen. They learn about charge-coupled devices as devices that become charged when light (or other radiation) falls on them. The charge stored depends on the intensity of the radiation, and the colour, and this is used to produce an image that can be viewed on a computer. They learn about pixels and how they relate to the CCDs, which links to what they learned about light.

Activities

- Demonstrate a touch screen, or show a video of a touch screen being used. Ask students to think about how the screen works. Give the class the hint that it is to do with charge and ask groups work on the 'solution'. Discuss the possible options.
- Introduce the idea of a capacitor. Demonstrate a capacitor this animation: *http://phet.colorado.edu/en/simulation/capacitor-lab*. Use the animation to show that you can charge up a capacitor and disconnect it. Use the animation to show how charge is stored on two plates, and that putting a dielectric between the plates increases the charge between the plates.
- Students research how touch screens work using the information in the student book and sites such as *http://computer.howstuffworks.com/touch-screens.htm*. They produce a poster using **worksheet 12.3.1**. Each poster should have a section that explains how charge is important in the operation of the touch screen. Make sure that students concentrate on capacitive rather than resistive screens.
- Demonstrate a solar cell generating a voltage when light shines on it. Explain that when the light hits the solar cell it produces a charge and this is what the voltmeter is showing. This is what happens in a digital camera. Show pictures of a CCD device and explain what is meant by a pixel. Show a digital image in a suitable image processing software, and demonstrate how you 'see' pixels if you continue to zoom in.
- Students investigate digital cameras with **worksheet 12.3.2**. They consider how the activity relates to taking, uploading, and displaying images and video using **worksheet 12.3.3**. The numbers represent the charge stored (in a CCD you need to use three numbers, one for red, one for green, and one for blue, from which you can make any colour). It takes time to measure the charge on each pixel, so that is why there is a delay. Elicit that you need more pixels to make a better picture, but this produces limitations on how many images you can store, and how long it takes to send. This also explains the size of video files compared to single images, and why it takes so much longer to download them.
- If available show the size of different types of file stored on a computer. Even storing a blank document takes space!

Extension

Students have met gravitational, magnetic, and now electric fields. Students research all three types of field and write a 'Guide to Fields'.

Homework

Workbook page 77

Key words

capacitor, dielectric, charge-coupled device (CCD), pixel

Student book, pages 178–179

CD resources
- Worksheet 12.4.1
- Worksheet 12.4.2
- Worksheet 12.4.3
- Worksheet 12.4.4

Objectives

- Describe how to draw components in circuits diagrams
- Explain how to test whether something conducts electricity

Overview

This is the first lesson on electric circuits, and in this lesson students revise what they have learned earlier. They consider the safety aspects of working with components in electric circuits and make a safety leaflet or poster. They revise what they know about circuit symbols and how to represent circuits using circuit diagrams. They work out the circuit diagrams for a variety of different circuits. Finally they use a simple circuit to work out which materials are conductors and which are insulators. Do not allow students to look at the Student book before this lesson.

Activities

- Explain to students that throughout the next few lessons they will be building and testing a variety of electrical circuits. Ask students what they think they will have to do in order to stay safe during these experiments. Students make a safety poster with illustrations using **worksheet 12.4.1**.
- Students use **worksheet 12.4.2** to fill in the names of circuit symbols next to their pictures.
- Make up five different circuits like the ones on **worksheet 12.4.3**. They are:

  Circuit **1:** 1 single bulb, single switch, completed with wires

  Circuit **2:** identical to circuit 1 but with one connecting wire removed

  Circuit **3:** two bulbs, no switches

  Circuit **4:** identical to circuit 3 but with an additional wire producing a short circuit (parallel connection)

  Circuit **5:** three bulbs, two switches.

  Put them around the room and make sure that they are clearly labelled 1–5. Students go to each of the circuits and draw a diagram of the circuit using circuit symbols. They swap their diagrams with other groups. Each group marks the diagrams using **worksheet 12.4.3** and comments on the quality of the diagram (drawn with a pencil and ruler, no gaps). They explain how to make the circuit work if it does not work.
- Remind students about what they learned in lesson 12.4 about charge and sparks. Students design a circuit to test whether something conducts electricity. They use their circuit to investigate a range of different objects, including graphite (use a pencil sharpened at both ends but check that the graphite is not broken), using **worksheet 12.4.4**.
- Discuss the findings of the experiment, and the fact that graphite (carbon) is a non-metal that conducts electricity. Elicit that there is a range of conductivity – even air conducts if enough charge is built up.

Extension

Students use the Internet to find out why some materials do not conduct electricity very well.

Homework

Workbook page 78

Key words

electric circuits, components, circuit symbols, battery, terminal, cell

Student book, pages 180–181

CD resources
- Worksheet 12.5.1
- Worksheet 12.5.2

Objectives

- Describe what an electric current is and how we measure it
- Describe what is meant by a series circuit

Overview

Students learn that electrons moving through a wire constitutes an electric current. They learn how to measure the current flowing in a circuit using an ammeter. They learn that a circuit with only one loop is called a series circuit, and learn how to construct series circuits They learn about the disadvantages of series circuits. This leads into the next lesson on parallel circuits. At this stage they are learning about *what* happens in the circuit. When they have learned about models for circuits in lesson 12.7 they will consider reasons *why* current and brightness varies as it does in lessons 12.8 and 12.9.

Activities

- Remind students of what they learned about conductors and insulators. Explain that metals are good conductors because they contain lots of loosely bound electrons that can move through the wire. Show a suitable animation e.g. *http://www.schoolphysics.co.uk/animations/Electron_motion/index.html* and *http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc*. The latter can be used in subsequent lessons to consolidate what they have learned. Emphasise that the charges are already in the wires and do not come out of the battery.
- Demonstrate how to construct a simple series circuit containing a bulb, lamp, wires, single cell, and a switch. Explain that one type of circuit is called a 'series' circuit. This is where components occur one after another in a loop. Highlight that all components are connected in a single loop, one after the other in a series.
- Explain that we measure the flow of electrons per second, or the current, using an ammeter. Demonstrate how to connect up an ammeter in a circuit. Students measure the current at different places in a series circuit using **worksheet 12.5.1**. Elicit in discussion that the current is the same everywhere. Students may think that the current is used up, or comes out of the battery. Discuss what happens when you unscrew a bulb (or a bulb breaks) or short circuit a bulb.
- Use **worksheet 12.5.2** to stimulate discussion on limitations of series circuits. Students need the key ideas of reduced power to components and vulnerability to component failure. They write down the problems in each situation on the sheet.

Extension

- Students find out who discovered the electron, and how they did it. They make a poster explaining what they have found out.
- Using **worksheet 12.5.1** students try to explain why the brightness of the bulbs diminishes.

Homework

Workbook page 79

Key words

charge, electrons, atom, Ampere, amps, milliamps, ammeter, series

Student book, pages 182–183

CD resources
- Worksheet 12.6.1
- Worksheet 12.6.2

Objective

- Describe the differences between series and parallel circuits

Overview

This lesson builds on what students learned about series circuits last lesson. They learn that circuits with more than one loop are parallel circuits and they learn how to build parallel circuits. They measure the current in different branches of a parallel circuit and consider why parallel circuits are useful. In lesson 12.8 and 12.9 they will consider how the type and arrangement of components affects the current in a circuit and use models from lesson 12.7 to explain what is happening.

Activities

- Ask students to recall what they learned about series circuits last lesson, and in particular the disadvantages of series circuits. Elicit that adding more bulbs makes them dimmer, and they all go out if one breaks. Explain that there is an alternative type of circuit called a parallel circuit.
- What does parallel mean? Show examples of parallel lines, gymnastic bars, and parallelograms. Explain that a parallel circuit contains more than one loop, and that each loop is independent of the other.
- Demonstrate how to make the parallel circuit with two bulbs and two switches. Arrange the wires to highlight the parallel portions of the loops and ensure that the switches are within the parallel loops of the circuit to allow independent control of bulbs.
- Ask students draw the parallel circuit they have seen and use two different colours to identify the two parallel regions of the circuit. To help with this students can look at the first two diagrams on page 176. The first diagram is how parallel circuits are usually connected, but this is identical to the second, which is easier for students to understand.
- Students then construct the parallel circuit using **worksheet 12.6.1**. Ask them to compare brightness of bulbs in each branch (identical) and what happens when a single switch is turned off (individual control). Students expand their circuit by adding a switch in the circuit before the parallel branch split (gives over-riding control over both branches) and record the effect of this.
- Students expand their circuit by increasing the number of parallel chains and record the effect of this on bulb brightness.
- Discuss the benefits of parallel circuits: full power supplied to each branch of the circuit; individual controls can be used; breaks in one branch do not affect the other branches.
- Students draw circuits for dealing with particular situations: house lighting (two rooms, separate branches); a battery torch (simple series); upstairs and downstairs lighting that can be switched on at either end; and two bulbs that can be switched on individually or both together with a master switch using **worksheet 12.6.2**. Ask students to feed back solutions to their problems. Use these answers to highlight the greater versatility of parallel circuits.

Extension

Students complete the Extension activity of **worksheet 12.6.2**.

Homework

Workbook page 80

Key word

parallel circuit

Student book, pages 184–185

CD resources
- Worksheet 12.7.1
- Worksheet 12.7.2

Objectives

- Explain why scientists use models
- Describe some models for electric circuits

Overview

In this lesson students learn about models that can be used when discussing how electric circuits work. They start by thinking about models in other topics that they have used so far and why we use them. Then they are introduced to the rope model and use it to explain what is happening in a circuit. They learn how to use other models involving people carrying things or trucks carrying coal or food. Finally they criticise each model and work out the pros and cons of using each model. They will use these models in subsequent lessons to explain the behaviour of components in a circuit.

Activities

- Ask students to think of two models that they have used in science (model of the Solar System, or the Milky Way, or the atom). Ask them to explain *why* we use those models (to show things that are too big or too small to see to scale). Explain that scientists use other kinds of models to predict or explain, for example computer models, mathematical models.
- Discuss with students why it can be difficult to work out what is happening in circuits (cannot see the charges flowing). Explain that they are going to learn about the models that you can use to predict or explain what was happening in an electric circuit.
- Students use the rope model in pairs to model an electric circuit. They work out how to model cells, current, components, and ammeters using **worksheet 12.7.1**.
- In discussion afterwards ask groups of four to report back and give one good point and one bad point about the model.
- Use the class to demonstrate the 'sweet' or 'people' model. This is one of many examples of a 'donation' model. Nominate one student to be the bulb and another to be a battery. Give the person who is going to be the battery a bowl of sweets. The rest of the students in the group all stand in a circle so that they are very close to each other. The person who is the battery should stand at one point in the circle, but just outside the line of students, and the person who is the bulb should stand opposite the battery. When you say 'Go' the students start to walk and the 'battery' should give the students a sweet as they walk past. When the students get to the 'bulb' they give their sweet to the bulb who throws it (onto the table). Discuss the model with the students and ask how you could extend the model to add another bulb, add an ammeter, make a parallel circuit.
- Discuss the pros and cons, particularly the problem of a delay before the 'energy' gets to the 'lamp', and fact that the people need to know how many lamps are in the circuit.
- Students evaluate each model for the pros and cons using **worksheet 12.7.2** using what they have learned and check their findings with the Student book.

Homework

Workbook page 81

Key word

model

Student book, pages 186–187

CD resources
- Worksheet 12.8.1
- Worksheet 12.8.2

Objective

- Understand how components affect the current in series and parallel circuits

Overview

This lesson consolidates a lot of the work of the previous four lessons. Students explore how the current in a circuit changes with the types and arrangements of components in a circuit. They learn about resistance as the property of a component that determines the current in a circuit that contained it and a cell. They use the models that they learned about last lesson to explain the measurements of current in the circuit. Students keep the voltage the same in all of their circuits. They will learn about voltage and the effect of changing the voltage in the next lesson.

Activities

- Remind students of the models that they used last lesson. Ask them to consider these models when they are asked to explain what they are seeing in the experiments.
- Construct a circuit with a single cell and a single bulb. Ask students to describe the brightness of the bulb. Explain that this is the 'normal' brightness and that they can use this as a standard for comparisons using the terminology of more, or less, than 'normal' brightness.
- Students make series circuits and test them using **worksheet 12.8.1**. Students gradually increase the number of bulbs in the series circuit (as equipment levels allow) and take note of the decreasing brightness and decreasing current. Students explain what they have seen. Encourage them to use the rope model. Introduce the idea of resistance. Explain that it is the push of the battery and the resistance of the component that determines the current. The rope model explains that particularly well.
- Remind students how to measure the current in different branches in a parallel circuit. Make sure that students are clear about where to put the ammeter to measure the current in each branch and the total current (next to the battery).
- Students investigate the resistance of different components using **worksheet 12.8.2**. In the second experiment students investigate the effect of putting different components in different branches of a parallel circuit. They consider explanations for the values of current that they have measured. In discussions after the experiments ask groups to explain the results of the experiments. Encourage them to use the rope model to explain their observations.

Homework

Workbook page 82

Key words

normal brightness, resistance

Student book, pages 188–189

CD resources
- Worksheet 12.9.1
- Worksheet 12.9.2
- Worksheet 12.9.3

Objective

- Understand what is meant by voltage

Overview

Students may have intuitively come to realise that the voltage is linked to the energy stored in the battery, and here they learn about the link between energy, voltage, and charge. In this lesson students learn how to measure voltage with a voltmeter. They measure the voltage across components in series and parallel circuits and explain their readings using one of the models that they have considered in previous lessons. They learn what is inside a battery, and this will be preparation for next lesson when they complete an investigation into making batteries. Finally they consolidate what they have learnt about current and voltage in parallel circuits by making a game of snap involving circuits.

Activities

- Show a variety of different batteries (cells) of different sizes and shapes and voltages. Establish that the physical size of a battery or cell is not a measure of the energy stored by connecting up two circuits with batteries of different sizes with the same voltage lighting identical bulbs.
- Demonstrate how to connect up a voltmeter and use it to measure the voltage across a cell. Explain that voltage is measured with volts and is a measure of the energy transferred by the charges and the push of the cell or battery.
- Students investigate the voltage across components in series and parallel circuits using **worksheet 12.9.1**. In discussion establish that the energy is effectively shared between the two bulbs in series, and this is linked to the brightness of the bulbs decreasing as more are added in series. Ask students to decide which of the models that they have learned about best helps to explain these observations. Establish that the voltage across each of the branches in a parallel circuit is the same, because each loop is effectively independent of the others. Again discuss which of the models best helps to explain this.
- Remind students about the chemical energy stored in a cell. Show a diagram of the inside of a cell to show that it contains chemicals. Explain that there are metal electrodes and acid in a simple battery. Explain that they will be making batteries next lesson.
- Students consolidate what they have learned by making a game where they have to match circuits where the meter readings are the same. **Worksheet 12.9.2** supports this activity. This is quite a substantial activity, so could be shortened, or used for revision later. **Worksheet 12.9.3** could be used as an alternative.

Extension

Students research the origins of the first battery and the scientists involved in making them. They make a poster that shows a timeline of the history of the battery.

Homework

Workbook page 83

Key words

voltage, volts, voltmeter

Student book, pages 190–191

CD resources
- Worksheet 12.10.1
- Worksheet 12.10.2

Objectives

- Select ideas that can be investigated
- Plan an investigation

Overview

In this lesson students consider the different kinds of questions that you can ask and ideas that can be tested with practical work. They select an idea to test in relation to fruit batteries and complete an investigation. They write up their investigation to show what they have done and found out. They are then paired with someone who has done a different investigation and they critique the reports that they have written. Finally, students consider how scientists ensure that their conclusions are accurate and consider the importance of results being reproduced by other scientists. Students could use the information in the Student book in their planning, or alternatively draft a plan and check it against the plan in the Student book.

Activities

- Remind students of what they learned last lesson about voltage. Demonstrate how to make a fruit battery. Take a piece of acidic fruit and put two different pieces of metal in it and show that a voltage is produced.
- Ask student to think of three ideas that they could test about the fruit battery. Show them the range of apparatus that they could use (see **worksheet 12.10.1**). Elicit that there are lots of different types of question, and that students would need to do an experiment or investigation to answer them. Highlight the difference between answering a question 'do all fruits produce a voltage?' to testing a hypothesis 'Does the voltage depend on the acidity of the fruit?'.
- Students plan and carry out an investigation into fruit batteries using **worksheet 12.10.1**. They should conduct the necessary preliminary work to ensure that their investigation will work and write up their investigation as a formal report.
- Pair students with someone who has done a different investigation. Explain that scientists review each other's work and feedback on it. Students read each other's reports and complete **worksheet 12.10.2** to give feedback. Students read each other's feedback and discuss it.
- Discuss how scientists ensure that what they have found out is accurate. Distinguish between repeatability (the scientist repeating the experiment to check the results) and reproducibility (other scientists conducting the same experiment to check that the results are accurate).
- Match groups who have conducted the *same* experiment together and ask them to discuss how they went about their experiment and what they found out. Each group reports back their conclusions to the class.

Homework

Workbook page 84

Key words

resistance, questions, preliminary work, planning

Student book, pages 192–193

CD resources

- Worksheet 12.11.1
- Worksheet 12.11.2
- Worksheet 12.11.3

Objectives

- Understand the difference between energy and power
- Be able to calculate power

Overview

In this lesson students learn about the equation for power, and how power is different to energy. They practice using the equation and develop a sense that more powerful means that more energy is transferred in a shorter time. They investigate the power of electrical items and recognise that items that heat things up are generally more powerful than things that produce sound or light.

They learn about the link between the power of an appliance, the time for which you use it and the cost in terms of what is paid for on an electricity bill. Finally they compare LEDs and CFLs and make a leaflet for the general public that describes the differences and compares the costs.

Activities

- Show students lamps that have different powers, e.g. a 60 W and a 100 W lamp. It would be helpful to have available a range of different types of lamp (incandescent, CFL, and LED). Elicit that some bulbs look brighter than others, and get students to think about the light energy being produced. Explain that it is not about the total amount of energy but the energy per second that means that the light is brighter.
- If available use a mains joulemeter to show more energy per second is transferred by the higher power lamp. Explain the difference between energy and power, that power is the rate at which energy is transferred. Introduce the units of power, the watt, and the kilowatt.
- Show students the panel/plate on an electrical appliance that shows the power of the appliance. Show students a range of appliances (or pictures of them) and ask them to rank them in order – highest to lowest power. Students look at each appliance to work out the power (or pictures) and put them in order. **Worksheet 12.11.1** supports this activity.
- Students practise using the equation for power using **worksheet 12.11.2**.
- Remind students about what they learnt about efficiency in lesson 2.5. Show a Sankey diagram of a energy saving light bulb. In groups students prepare an explanation about why less efficient appliances cost more to run. Make sure that they use the terms 'power' and 'energy' correctly.
- Students use **worksheet 12.11.3** to compare the cost of LEDs and energy saving light bulbs and then make a leaflet that informs the general public about the differences, pros and cons, and costs.

Homework

Workbook page 85

Key words

mains supply, power, watts, kilowatts, filament, light emitting diode (LED), efficient, kilowatt-hour (kWh)

Student book, pages 196–197

CD resources
- Worksheet 13.1.1
- Worksheet 13.1.2
- Worksheet 13.1.3

Objectives

- Know the types of objects that can be seen in the night sky
- Understand how we see different types of objects

Overview

In this lesson students start to think about the objects beyond the Earth, Sun, and Moon system that they have considered at primary level. They begin to build up an understanding of the types of objects that they can see and their positions relative to the Earth.

Activities

- Ask students to name all the things that they have seen in the night sky. Prompt them with pictures of all of the objects discussed in the Student book on pages 196–197.
- Students make a wall display of the night sky. Give groups one of the objects, or types of object, that they can see. Students research the object to produce a fact file using information from the Student book and **worksheet 13.1.1**. They should display those facts next to their object on the display.
- Each group uses the wall display to make an information leaflet for Stage 6 students that helps them to identify what they can see in the night sky.
- Student read an article about satellites on **worksheet 13.1.2** and complete a table about their uses using **worksheet 13.1.3**.
- Ask students to write a question that they have about space, prompted by something that they have learned this lesson, and make a display that can be revisited at the end of the topic.
- Students design a night sky diary that then can keep during the course of the topic, or beyond. They should, if possible, make sure that they sketch the appearance of stars/constellations for lesson 13.4, and the Moon for lesson 13.6.

Homework

Workbook page 86

Key words

stars, planets, dwarf planets, exoplanets, orbit, Earth, moon, natural satellite, comet, meteor, meteorite, artificial satellite, Global Positioning Satellite (GPS)

Student book, pages 198–199

CD resource

- Worksheet 13.2.1

Objectives

- Explain why the Sun appears to move across the sky
- Explain why we have day and night

Overview

Students build on what they have learned earlier by thinking about the direction of sunrise and sunset. They link this to the spinning Earth and the way that the Sun moves in the sky. They link the spinning of the Earth on its axis to the appearance of the Sun in the sky. They extend this idea to a consideration of how stars look in the sky, and how this depends on the direction that they are looking.

Activities

- Ask students to list the observations that they have made about where the Sun is in the sky. Discuss how people thousands of years ago would have explained these observations.
- Use a model globe of the Earth with a model mountain stuck on it to show how scientists/astronomers argued that the Earth is round nearly 2000 years ago. Rotate the globe towards the students so that the mountain 'appears' over the horizon as if it is growing. Place the mountain on a flat surface to show that you would be able to see it all the time if the Earth were flat– it might just look smaller from a distance.
- Recap day and night. Use a globe and a light source to represent the Sun and the Earth.
- Discuss possible explanations for the observation that the Sun rises in the East and sets in the West. Revisit the demonstration of the Earth/Sun to explain.
- Students investigate how the length of a shadow changes with the height of a lamp on the desk. Ensure that they can safely adjust the height of the lamp. **Worksheet 13.2.1** supports this activity.
- Show an appropriate animation that shows how the Earth is spinning and how the Sun appears to move across the sky. Alternatively use Stellarium software which can be downloaded free from **www.stellarium.org** to highlight the changes in height of the Sun at different locations. Once loaded on a computer, press 1 (one) to see the menu. Set the location and the date (it might be useful to compare June to December). You can tilt the view by using the cursor keys, and so get more sky in view. Press play in the bottom right-hand corner of the screen, where you can also speed up and slow down the time to watch the Sun rise and set and its progression across the sky. You can use the other program, SkyMotionApplet from lesson 13.4 to show them that you get circles (click Tracks) if you look north in the Northern Hemisphere, and south from the Southern Hemisphere. Discuss how (or if) this proves that the Earth is spinning on its axis.

Extension

Students complete the extension section of **worksheet 13.2.1**.

Homework

Workbook page 87

Key words

space, day, night, axis

Student book, pages 200–201

CD resources
- Worksheet 13.3.1
- Worksheet 13.3.2

Objectives
- Describe the how the height of the Sun in the sky changes over the year
- Explain why there are seasons in different parts of the world

Overview
Students build on what they have learned earlier to work out why there are seasons, and why the seasons in some parts of the world are very different to the seasons in other parts of the world. They build on what they have learned about the tilt of the Earth's axis to explain the difference in day length, temperature, and the maximum height of the Sun in the sky.

Activities
- Discuss how temperature and day length changes during the year, and ask if the answer to the question would be different if they lived in a different country.
- Students model summer and winter in the different hemispheres using **worksheet 13.3.1** as a guide. They demonstrate that when it is summer in the Northern hemisphere it receives more hours of sunlight than the Southern hemisphere, and vice versa. They estimate the hours of daylight at different times in the year. Depending on your location ask students to use their globes to find out one of the following: What is summer like at the South Pole? What is winter like at the North Pole? What are the day lengths in equatorial countries?
- Students feed back their answers and discuss explanations using their globes.
- Students complete **worksheet 13.3.2** to show how season change as the Earth orbits the Sun. Students identify the seasons and fill in hours of daylight using information from the graph on page 200 of the Student book, then describe the temperatures (e.g. hot/cold, not actual temperatures).
- If available use strips of heat-sensitive tape attached to a globe together with a lamp to show how the temperature changes during different seasons in different parts of the world. Alternatively set up the practical shown in the extension question on page 88 of the Workbook. You will need two trays of sand, two long thermometers, and two desk lamps. If you vary the angle that the lamp is to the sand you will see different temperatures on the thermometers. Discuss how the angle affects the temperature in the summer and the winter as well as the hours of sunlight.
- Students write a story about what they would see around them during the year if they lived in a very different part of the world.

Homework
Workbook page 88

Key words
year, seasons, Pole, Northern Hemisphere, Southern Hemisphere

Student book, pages 202–203

CD resources
- Worksheet 13.4.1
- Worksheet 13.4.2
- Worksheet 13.4.3

Objectives

- Explain why the stars appear to move in circles during the night
- Describe how the night sky changes over the year

Overview

In the previous two lessons students have learned about the impact of the tilt of the Earth's axis on the appearance of the Sun. In this lesson students consider the motion of stars, and learn about some of the constellations that they see in the night sky. They use what they know about the movement of the Earth around the Sun to explain why what they see changes over the year.

Activities

- Use Stellarium (see lesson 13.2) to demonstrate the stars in the sky and how they appear to move during the night. Demonstrate that what you see depends on which direction you are looking and your location on the planet. Use an applet such as *http://physics.weber.edu/schroeder/sky/SkyMotionApplet.html* to demonstrate this idea. Check the box 'Trails' to produce images such as those on page 202 of the Student book. If available students can use this applet themselves to find out how the appearance of the stars change.
- Demonstrate that you see different stars at different times of the year using the software described above or using pictures. Introduce the idea of constellations and discuss why we have the constellations that we do. Emphasize that the patterns themselves have no scientific meaning but are a useful way of working out where you are. Demonstrate how you can find north or south using Ursa Major or the Southern Cross. Demonstrate you see different stars if you live in the Southern Hemisphere than if you live in the Northern Hemisphere.
- Demonstrate that it is impossible to judge how bright a star is from looking at it. Use a bright light source, such as a bulb, and a less bright source, such as a candle. If the bright source is further away, it can look of a similar brightness to the weaker light source.
- Students make a model of a constellation using **worksheet 13.4.1**. They work out that the stars in a constellation may not be close to each other at all and that we happen to view the group of stars as forming a pattern because of our viewpoint. You can demonstrate what the constellations look like using Stellarium. Information about the distances to stars in various constellations can be found on **worksheet 13.4.2**.
- Students summarize what they have learned about stars by writing a leaflet 'A guide to the stars'.

Extension

Students put the stages of the lifecycle of a large and small star in order using **worksheet 13.4.3**. Students read page 203 about the lifecycle of a star and use the information to make a 'flick book' to demonstrate the lifecycle of a large or a small star.

Homework

Workbook page 89

Key words

sun, star, constellation, lifecycle, nebula, main sequence, red giant, white dwarf, black dwarf, red supergiant, supernova, neutron star, black hole

Student book, pages 204–205

CD resources
- Worksheet 13.5.1
- Worksheet 13.5.2
- Worksheet 13.5.3
- Worksheet 13.5.4

Objectives

- Describe the planets in our Solar System
- Know the order of the planets, and where the asteroid belt is

Overview

In this lesson students learn about the size and scale of the Solar System. They build a model to learn about the relative distances from the Sun to each of the planets.

Activities

- Students complete a quiz on the Solar System using **worksheet 13.5.1**.
- Students work in pairs using a set of the Solar System cards from **worksheet 13.5.2**.

  Students can:

  a Use the information to organise cards in order of distance from the Sun and work out the meaning of inner and outer planets.

  b Play Top Trumps. The aim of the game is to collect all the cards in the pack. Shuffle the cards and deal them all out. Player 1 looks at their top card, picks a category and reads it out to player 2 (e.g. distance from Sun). The player with the highest number in that category wins the card and puts it, with their own, to the back of their hand. The winner then reads a category from the next card. The game continues until one player holds all the cards.
- Discuss the distances to different planets. Explain that it is difficult to draw the Solar System to scale because of the great distances involved. Give a sense of the distances – from your town to the next town/city is x km, from the capital of your country to the next is y km, from Earth to the Moon is 384 400 km, from Earth to the Sun is about 150 million km.
- Students then build a scale model of the Solar System with modelling clay or pictures for the Sun and planets using **worksheet 13.5.3** as a guide. Each model will need about 5 metres of floor or wall space, so arrange groups and space accordingly.
- Students plot a graph of the distances to the planets using **worksheet 13.5.4**.
- Set them the task of describing the Solar System in 50 words or fewer. They read each other's work and assess it.

Extension

Students find out how scientists find out the data that is on the cards.

Homework

Workbook page 90

Key words

Solar System, inner planets, outer planets, asteroid belt, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, dwarf planet, Pluto, astronomer

Student book, pages 206–207

CD resources
- Worksheet 13.6.1
- Worksheet 13.6.2
- Worksheet 13.6.3
- Worksheet 13.6.4

Objectives

- Describe the phases of the Moon
- Explain why we see phases of the Moon and eclipses

Overview

In this lesson students learn about the Moon and its position in relation to the Earth. They are introduced to the different phases of the Moon and eclipses and how to model how phases and eclipses happen. This work links to the work that they did in lesson 13.1 about the night sky, and work from Stage 6 on shadows.

Activities

- Ask students what they know about the Moon. They can refer to the diary of the night sky that they have been keeping. Elicit the idea that the Moon is Earth's satellite and takes 28 days to orbit the Earth. Then ask them to draw as many phases of the Moon as they can.
- Explain that we see the Moon because sunlight is reflected off its surface. We see it differently depending on where it is in its orbit: new Moon, waxing crescent, first quarter, waxing gibbous, full Moon, waning gibbous, last quarter, waning crescent, and new Moon. (Waxing is getting bigger, waning smaller.)
- Students model the phases of the Moon using a half-black ping-pong ball. Talk about what the model represents (front wall = Sun, turning on the spot with the ball held out = the Moon's orbit around Earth, the view of the ball as it orbits = view of the Moon we get from Earth). **Worksheet 13.6.1** supports this activity.
- Students use **worksheet 13.6.2** to consolidate ideas about the phases of the Moon. They write a short evaluation of the model, e.g. it is a good model because the ping-pong ball is round like the Moon and you can see the phases. It is not a good model because the Moon is not held out by a giant arm! The Earth (= person) does not spin on its axis the same way that the real Earth would. In reality the same part of the Moon is always facing the Earth and the shadow moves across the surface – in this model the shadow is fixed and it appears to move by turning the Moon. Students could suggest improvements to the model.
- Show a video clip of a solar eclipse e.g. from *http://www.nasa.gov/* and search for *eclipse*. Ask students to try to explain what is happening.
- Students model solar and lunar eclipses with a lamp and two balls. **Worksheet 13.6.3** supports this activity. They draw diagrams to show how solar and lunar eclipses are formed. Discuss the diagrams and show a suitable animation showing the formation of solar and lunar eclipses. If available show a photo or diagram of a solar eclipse as seen from space. Discuss the tilt of the Moon's orbit, and how this relates to how frequently we see eclipses. Discuss the difference between phases (different views of the Moon that is lit in the same way) and eclipses (shadows).
- Students use **worksheet 13.6.4** to consolidate what they have learned about phases and eclipses.

Homework

Workbook page 91

Key words

phases of the Moon, new Moon, First Quarter, full moon, Last Quarter, gibbous, crescent, waxing, waning. solar eclipse, total eclipse, partial eclipse, umbra, penumbra, lunar eclipse, the 'dark' side of the Moon

Student book, pages 208–209

CD resources
- Worksheet 13.7.1
- Worksheet 13.7.2

Objectives
- Describe how scientific explanations are developed
- Understand the importance of evidence

Overview
This is the first of three lessons about questions, evidence, and explanation. The emphasis is on the way scientific explanations are developed set in the context of the development of the model of the Solar System. The first two lessons look at the impact of technology (the telescope) on the transition from the geocentric to the heliocentric model of the Solar System. Students produce a television programme to demonstrate how and why the explanation of the observation of the motion of the Sun and planets changed.

Activities
- Students imagine what it would have been like for people looking up into the night sky. Ask them for some of the natural conclusions that people might have made based on what they could see.
- Introduce the difference between a story, or a myth, and a scientific explanation. There are some myths about the Sun, Moon, and Solar System here: *http://www.windows2universe.org/mythology/mythology.html*. Discuss the idea that scientific explanations explain and predict, and are based on evidence from observation or experiments.
- Students prepare a television programme that charts the change from the geocentric to the heliocentric models using **worksheet 13.7.1**. This guides them through the structure of their programme and what should be included. In this lesson they should concentrate on familiarising themselves with both models and preparing the sections where they explain the nature of each model, and the evidence for it.
- Provide materials for them to make geocentric/heliocentric models e.g. poster paper, balls, string, card.
- There is an activity for making a telescope in the classroom in the next lesson, but that could be done here so that students understand how it works, and can decide what to include in their programmes.
- At the end of the lesson each group should write out a draft schedule for their programme that shows what each member of the group will do, or fill in the storyboard on **worksheet 13.7.2**.

Extension
Use the Internet to find out more about the motion of the planets (retrograde motion) and include a model in your programme.

Homework
Workbook page 92

Key words
question, explanation, evidence, model, geocentric model

Student book, pages 210–211

CD resources

- Worksheet 13.8.1
- Worksheet 13.8.2
- Worksheet 13.8.3

Objective

- Describe how new evidence can be used to develop different explanations

Overview

In this lesson students consider the impact of the telescope, and construct a telescope similar to Galileo's telescope. They finish their programmes and rehearse them. Depending on resources they could use a video camera to record their programme, and swap videos for another group to review, or they could present to the whole class. In either case another group or the rest of the class should complete a peer review sheet. In the discussion bring out the importance of evidence in changing the ideas that people had, but that, despite the evidence, it still took time for a new idea to be accepted.

Activities

- Introduce the idea that technology can have a major impact on scientific explanations. The telescope has made a huge impact, not only in Galileo's time but also in figuring out the structure of the Universe since Galileo's time. Students make a simple telescope using the instructions on **worksheet 13.8.1**. This activity may be better placed in lesson 13.7, so that student can decide how to use it in their presentations. Provide thin convex lenses with a focal length of 50–100 cm, and a thin lens with a focal length of 5–10 cm. 100 cm and 5 cm work best.
- If available use a commercial telescope to project sunspots on a piece of card. Under **no** circumstances use a telescope to look at the Sun, or allow students to do so. A risk assessment must be completed. Read instructions for showing sunspots here: *http://solar-center.stanford.edu/observe/*
- Students read over their storyboards or plans from last lesson.
- Group members each prepare the script for their section of the programme. The narrator works out how to link the scripts together (if they are using one).
- Each group rehearses what they are going to present.
- If resources allow, students could tape their programme and share their programmes with another group. They assess each other's work using **worksheet 13.8.2**. Alternatively each group presents to the rest of the class who peer assess them using **worksheet 13.8.3**.
- Discuss the role of evidence in the development of the model, and draw out how it was preferable for the Greeks to adapt their model to fit (using epicycles) rather than say that it was wrong.
- Each group produces a flow chart that summarises what they have learnt about how models develop using the words: question, evidence, explanation.

Extension

Use the Internet to find out more about the development of the telescope and how it was used to see phases of Venus.

Homework

Workbook page 93

Key words

telescope, heliocentric model, sunspots

Student book, pages 212–213

CD resources
- Worksheet 13.9.1
- Worksheet 13.9.2
- Worksheet 13.9.3

Objective

- Describe how ideas about the motion of the stars and the planets developed in India, Africa, and Islamic countries

Overview

In this lesson students consider how astronomers and scientists in India, Africa, and Islamic countries developed explanations about the world around them. They complete a group activity to learn about the science that was done in each region. As part of the activity they consider how the science fits in chronologically with the development of the model of the Solar System that they have studied in the previous two lessons. Finally they consider the role of communication, or problems with it, in the development of ideas, and how that has changed and the impact on how scientists work today.

Activities

- Students play a matching game for the geocentric and heliocentric models of the Solar System using **worksheet 13.9.1**. They cut up the cards and place them face down. Each student takes it in turns to pick two cards. If they match (are about the same model) the student keeps them. If not they return them. The winning student is the one with the most cards.
- Ask students where astronomers lived in ancient times. Establish that there were people making measurements of the sky and developing explanations all over the world.
- Introduce the 'expert group' activity. Divide the class into groups of three. These are their *home groups*. In each group they decide who is going to answer questions about each of the regions of science. They meet with others who have been given the same questions and work out how to teach the others. These are the *expert groups.* They return to their home groups to teach each other, and remain there to make a poster about what they have learned. **Worksheet 13.9.2** supports this activity.
- Students should lay their posters out on the desk. Groups should circulate around the posters with stickers and write one positive thing about the poster, and one thing that could be improved on stickers and stick it on a piece of paper next to the poster.
- Give out the cards from the start of the lesson and give students extra cards to make a timeline of ideas about the Solar System, stars, and gravity. Blank cards can be found on **worksheet 13.9.3**.
- Each group should think of three reasons why the same ideas appeared in different places at different times. They feed those ideas back to the class and they can be collated. Elicit that communication is the issue, and that problems with language or geography could be significant problems. Discuss whether the same problems exist today and whether someone with a very new idea would have that idea accepted.

Homework

Workbook page 94

Key word

communication

Student book, pages 214–215

CD resources
- Worksheet 13.10.1
- Worksheet 13.10.2
- Worksheet 13.10.3

Objective

- Describe what is outside our Solar System

Overview

In this lesson students learn about the place of our Solar System in the Universe. They develop an understanding of the Solar System as part of a galaxy, the Milky Way, that is one of millions of galaxies in the Universe. This is an example of how scientists produce explanations based on observational evidence alone: no-one can or ever will leave the Solar System to travel through interstellar space. Emphasize that the models and images are constructed and that we will not be able to look back and take a photograph of the Solar System from somewhere beyond it. Students have learned about distances in space in 11.3 on the speed of light. Some students could use light years in their leaflets to give an idea of scale.

Activities

- Give out 10 shuffled cards with the name of the planets, the asteroid belt, and Pluto. Get the students to line up in the correct order or give groups a set of cards to put in order starting with the Sun. Ask students what is outside the orbit of Pluto. Remind students that there are planets around other stars called exoplanets so those stars must be a great distance from our star. Cards can be found on **worksheet 13.10.1**.
- Introduce the Solar System, other stars and solar systems, galaxy, Universe order. Students read page 214 of the Student book to learn about the Kuiper Belt, Oort Cloud, and our nearest star. Show a suitable animation such as one based on the *Powers of Ten* at *http://www.powersof10.com/* or this one: *http://apod.nasa.gov/apod/ap100120.html* to give an idea of scale.
- They complete **worksheet 13.10.2** to work out the order of objects in the galaxy.
- Students estimate the number of stars in the night sky using **worksheet 13.10.3** or other image of the night sky. Discuss the fact that most of the stars that they see are in the Milky Way, and some of the fuzzy objects are galaxies.
- Students write a 'Guide to the Universe' leaflet for the general public that explains what would happen if they travelled in a spacecraft away from the Earth. This could draw on what they have learned throughout this topic on space.

Homework

Workbook page 95

Key words

Milky Way, Andromeda, interstellar space, Kuiper belt, Oort cloud, Proxima Centauri, galaxy, black hole, Universe, Hubble Space Telescope, infinite

Student book, pages 216–217

CD resources

- Worksheet 13.11.1
- Worksheet 13.11.2

Objectives

- Know the difference between primary and secondary sources of data
- Name some secondary sources
- How to use information from secondary sources to answer questions

Overview

In this lesson students learn the difference between primary and secondary sources of data. They interpret data about the planets of the Solar System. They compare the need to be able to repeat the results of an experiment, and for the results of an experiment to be reproduced by other people, to the need to confirm secondary data by looking at data from a range of sources.

Activities

- Ask students to recall an experiment that they have done this year where they collected data that they put in a table. Show them the cards with information about the planets of the Solar System from lesson 13.5 and ask them where that data has come from. Explain the difference between primary and secondary data.
- Students use the cards about the planets and **worksheet 13.11.1** to investigate the link between distance from the Sun and temperature, and distance from the Sun and year length.
- Students read pages 216–217 of the Student book and discuss the conclusions that you can draw from the data shown. They answer questions 3 and 4.
- Students work out how you can ensure that your primary and secondary data is reliable using **worksheet 13.11.2**. Groups present their ideas and the class votes on the best ideas.

Extension

Students find at least five websites that contain information on the cards (temperature, distance from the Sun, day length, year length, and diameter) and draw a table comparing the data. Discuss any differences.

Students could plot graphs of the data collected on **worksheet 13.11.1** and discuss how the graphs provide additional information about the links between the variables.

Homework

Workbook page 96

Key words

data, primary source, secondary source

Student book, pages 218–219

CD resources

- Worksheet 13.12.1
- Worksheet 13.12.2
- Worksheet 13.12.3
- Worksheet 13.12.4

Objective

- Describe how scientists think that the Universe started

Overview

In this lesson students learn about the Big Bang theory and how it can be modelled. They learn about the timescale over which the Universe has existed. One of the key messages is the relatively short time that human beings have been on Earth in comparison to when the Earth was formed. This lesson includes making a timeline and some students may need support with the mathematical elements.

Activities

- Show a photo from the Hubble Space telescope that shows the most distant galaxies that have been observed such as: *http://apod.nasa.gov/apod/ap121014.html*. Explain that the galaxies shown in the picture are 13 billion light years away. Elicit that we are seeing the galaxies not as they are now, but how they looked 13 billion years ago.
- Introduce the idea that the galaxies that we observe are all moving away from us, and that we can model this with a balloon. Students use the balloon activity to work out that more distant galaxies are moving away faster using **worksheet 13.12.1**. They will need to do the activity in pairs. Demonstrate how to use the string to measure the distances on the curved surface of the balloon.
- Students use the cards to sort out the order of events since the Big Bang using **worksheet 13.12.2**. Then they make a timeline using **worksheet 13.12.3**.
- Students consolidate their knowledge by putting the events in order with the appropriate timescale using **worksheet 13.12.4**. These cards could be used to make a display or be stuck in their books.
- Students revisit the questions that they used to make a display in lesson 13.1 and review the extent their questions have been answered. This discussion could be used to consolidate ideas about the sorts of questions that science can and cannot answer. Student could plan how to find out the answers to those questions that have not been answered given what they know about primary and secondary data.

Homework

Workbook page 97

Key words

Big Bang, atom

1 Plants

1.1 Leaves, stems, and roots

1 Roots spread out for two reasons: to hold the plant firmly and to absorb more water and minerals from the soil.

2 Broad, thin leaves can absorb plenty of sunlight for making food.

3 The tubes in the stem allow the plant to transport food and water.

4 Desert plants' swollen stems allow them to store water, which keeps them alive until it rains again.

1.2 Questions, evidence, and explanations

1 Van Helmont observed that the tree he planted gained 73 kg but the soil it was growing in only lost a few grams. He thought that if the plant took food from the soil, the loss from the soil should equal the plant's gain in mass.

2 Van Helmont thought that plants must be made of water, because they won't grow without it.

3 Woodward's results don't support van Helmont's explanation. Woodward's plants grew more in water with soil than in pure water. If plants needed only water, both sets of plants would have grown by the same amount.

4 Plants take something they need for growth from the soil, in very small quantities.

5 Malpighi thought that plants make food in their leaves and transport it to other parts of the plant.

6 Malpighi did not have strong evidence. He should have repeated his experiment more than once and tested other plants. He did not have enough evidence to show that the plant stopped growing because it had no leaves.

7 Trees are made of water, a gas from the air, and small amounts of material from the soil. Van Helmont proved that most of the material trees are made from does not come from the soil – they only take in water. Woodward showed that they do take small amounts of material from soil. Malphigi showed that seedlings cannot grow without leaves. Hales found that they take in a gas from the air.

1.3 Review

1a Plants take in light energy from the Sun.

b Any two differences, e.g. the leaves are different shapes and different sizes.

c Any two similarities, e.g. they are all thin, flat, and green, have tubes (veins) running through them, or are attached to stems.

2a The leaf reduced the light meter reading from 100 to 50.

b The leaf blocked or absorbed some of the light.

3 Any two points from: Plants on Mars would receive less sunlight because Mars is further away from the Sun than Earth is. This would make it harder for plants to get the energy they need to make their own food. This means that plants probably wouldn't grow as well on Mars as on Earth.

4a The average mass of leaves was the same (0.22 g).

b The average width of leaves in dim light was twice as big as (accept bigger than) the average width of leaves in bright light.

c In dim light, leaves need to be wider to collect enough light energy.

5a The trees planted close together (10 per m^2) grew 50 cm more than those planted far apart (1 per m^2).

b Trees planted close together grow taller because other plants are blocking their light. Growing taller increases their chances of getting enough light.

6a The plant with green leaves grew 12 cm in 1 month. The plant with white and green leaves grew 6 cm in 1 month.

b Food is required for growth so the plant with green leaves made more food.

c Kazim's evidence does support his explanation. If leaves contain more of the green substance they can absorb more light energy and make more food.

7a The amount of radioactive sugar in the leaves decreased and the amount in the tomato fruit increased.

b Yes. Roots must take food from the leaves. They cannot make their own food because they don't absorb light.

8a The roots of the plants receiving 100 cm^3 of water a day grew 20 cm but the roots of the plants receiving 500 cm^3 grew only 10 cm. The roots of the plants receiving less water grew twice as long (accept longer).

b Longer roots help plants collect more water from deeper soil.

9a The total crop growth has decreased over 5 years from 24 to 11 tonnes; it decreased more rapidly in later years.

b The farmer could plant the same crop in a different field with fresh soil. All the other conditions that affect plant growth, such as light, amount of rain, and temperature, should be the same in both fields. If a bigger crop grows in the new field, it would support the explanation.

2 Plants and Photosynthesis

2.1 Photosynthesis

1 Animals depend on plants for oxygen and for the food they use as a source of energy and building materials.

2 Carbon dioxide enters a leaf through stomata on its underside and diffuses to the the chloroplasts in its cells. Water is carried from roots to leaves, through xylem vessels in the veins, and then diffuses into every cell.

3 If seedlings are kept in the dark they produce tall, weak shoots and tiny yellow leaves and they only survive for a few days. If part of a leaf is covered it does not make starch.

4 Test 1 shows that plants can only make their own food in the green parts of leaves.

5 Test 3 shows that plants can only make their own food if they have carbon dioxide around their leaves.

6 On a sunny day the amount of oxygen in the air around sugar cane should increase as more oxygen is produced by photosynthesis (than the plant uses for respiration).

2.2 Preliminary tests

1 Does the colour of light affect the rate of photosynthesis (the time a leaf disc takes to collect enough oxygen to make it rise)?

2 Salma thinks that green light is no good for photosynthesis because plants are green. This shows that they absorb red and blue light but reflect greeen.

3 Students should produce a diagram of the apparatus shown on page 160 of the Student book.

4 Leaf discs sink when the air is sucked out of them. As they photosynthesise, oxygen builds up in the discs and they start to float again. The faster the rate of photosynthesis, the less time they take to float.

5 Preliminary tests check that the method works and the controlled variables have suitable values.

6 The light from each filter might have a different intensity. There could be other variables she did not control.

2.3 Plant growth

1 Minerals are added to the water used in hydroponic systems.

2 Plants take the elements nitrogen, potassium, phosphorus, and magnesium from minerals.

3 Purple leaves and few roots show a plant is short of phosphorus.

4 A plant that is short of potassium has poor flower and fruit growth, and older leaves wilt and lose their colour.

5 Plants can't grow properly without nitrogen because they use it to make proteins to build new cells.

6 Plant one group of rice plants in normal soil and another group in soil that is short of magnesium. Make sure both groups receive the same conditions of other minerals, light, water, temperature, and carbon dioxide. Compare the appearance of the groups after 2 weeks (any suitable time).

2.4 Phytoextraction

1 Some metals need to be removed from soil or water because they are toxic.

2 Hyperaccumulators can absorb a lot of metal and it doesn't harm them.

3 To remove metals from soil, grow hyperaccumulators, harvest the plants, and burn them to trap the metal in a small amount of ash. Repeat until the soil is clean.

4 Plant the ferns (hyperaccumulators) along river banks to take poisonous arsenic from the water.

2.5 Flowers

1 Students should draw stamens and a carpel like those in the insect-pollinated flower shown on page 166 of the Student book and a second set like those in the wind-pollinated flower shown on page 167 of the Student book.

2 Insect-pollinated flowers have brightly coloured petals and produce nectar to attract the insects. In wind-pollinated flowers, the anthers hang down to catch the wind and the stigmas are feathery to catch pollen.

3 Wind-pollinated flowers produce smaller, lighter pollen.

4 Flowers can make self-pollination difficult by producing their male and female gametes at different times.

5 Pollination occurs when pollen lands on the stigma. Fertilisation occurs (after a pollen tube grows down to the ovule) when the nucleus of the male gamete fuses with the egg cell nucleus.

2.6 Seed dispersal

1 Seeds germinate when they have water, a suitable temperature, and oxygen.

2 Seedlings have a better chance of survival if they grow a long way from their parent plant, because this reduces competition between plants of the same species.

3 Students should produce three diagrams: a small fruit, with either wings or a parachute, that could be carried by the wind; a large floating fruit, with air inside it, that could be carried by water; and fruit with a sticky coat of hooks that could be carried by animals.

2.7 Review

1 A water (minerals).
B carbon dioxide.
C light.
D glucose (starch).
E oxygen.

2 a and c are correct.

3a The grams of plant biomass produced increased as the carbon dioxide percentage in the air increased.

b Carbon dioxide + water → glucose + oxygen

c Carbon dioxide is essential for photosynthesis but there is very little in the air. When more is provided, the rate of photosynthesis increases.

d To increase reliability the tests (measurements) should be repeated.

4a Any one from: the volume; the temperature.

b Any one from: the number of leaves; the sizes of the leaves; the length of the seedling.

c Nitrogen.

d To make proteins.

e The leaves of plants grown without magnesium would be white, yellow, or paler.

5a B

b E

c F

d C

e D

f A

6 Any two from the following:
Insect-pollinated flowers have brightly coloured petals.
Insect-pollinated flowers have nectaries/produce nectar to attract the insects.
Wind-pollinated flowers have anthers that hang down to catch the wind.
Wind-pollinated flowers have feathery stigmas to catch pollen.
Wind-pollinated flowers produce smaller, lighter pollen.

7a The concentration of the sugar solution the pollen was placed in.

b 80%

c Repeat the test.

8a A, E

b B

c C, F

d D

3 Cells and organisms

3.1 The characteristics of living things

1 M – movement; R – respiration (reproduction) S – sensitivity; G – growth; R – reproduction (respiration); E – excretion; N – nutrition.

2 Plants make their own nutrients from water and carbon dioxide using light energy. Animals get their nutrients by eating plants and other animals.

3 Animals need to move around so that they can find enough food to eat. Plants make their own food and so they do not need to move around.

4 The seeds use nutrients stored inside them to respire. Respiration produces carbon dioxide and releases energy. Some of the energy is released as heat.

5 Students' answers need to show awareness of the seven life processes and suggest ways to test for them. For example: gently touch the flatworm to see if it moves and is sensitive to touch; make repeat observations/measurements to test whether it moves/grows/reproduces; look for evidence of excretory products such as faeces and urine; keep it in a closed container and test whether it removes oxygen from the air for respiration or adds carbon dioxide.

3.2 Microbes

1 Bacteria, fungi, protozoa, algae.

2 Algae photosynthesise to make their own food, like plants do.

3 Many protozoa resemble tiny animals because they eat other micro-organisms. (Protozoa can also take in nutrients from their surroundings.)

4 Bacteria are best seen using an electron microscope. They are very small but electron microscopes allow us to magnify things up to 1 million times.

5 Viruses are not living things because they do not carry out the seven characteristics of living things. They can only reproduce inside other living things.

3.3 Louis Pasteur

1 The process is called pasteurisation.

2 Bacteria use sugar from milk for respiration and make lactic acid as a waste product. The lactic acid causes milk to turn sour.

3 Pasteurised milk lasts longer because it contains fewer micro-organisms and these produce less lactic acid.

4 Warm, damp conditions are ideal for the growth of micro-organisms. The leaves shrink because micro-organisms are using nutrients from the leaves for respiration.

5 Enough sugar and oxygen need to be added to the fermenter to allow the yeast to respire.

3.4 Testing predictions

1 The rotten meat 'spontaneously generated' the maggots – they were created by the rotting meat.

2a Both pieces of meat would spontaneously generate maggots as they rotted.

b Pasteur would predict that only the meat in the open jar would rot, as micro-organisms from the air were able to reach it and break it down.

3 If nutrients ran into the S-shaped tube, the micro-organisms would be able to reach them. They could use the nutrients to respire and the liquid would turn cloudy.

4 The crushed grapes would ferment. The yeast on the skin of the grapes would now be in contact with the grape juice and could ferment it. If the juice was extracted from inside the grape, the yeast on the grape skin would not be present so no fermentation would occur.

5 You could stop a mixture of yeast, sugar, and water fermenting by boiling it to destroy the yeast.

6 A mixture of sugar and water turns cloudy if micro-organisms grow in it.

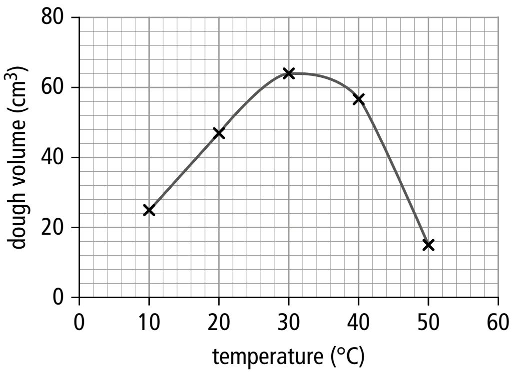
3.5 Useful micro-organisms

1 Yeasts are used to make bread soft and spongy.

2 *Lactobacillus* bacteria are used to make yoghurt.

3 The yeast increases the dough volume from 10 cm^3 to 69 cm^3 (by 59 cm^3).

4 Students should plot a line graph and join the points with a smooth curve.



Between 10 and 30 °C, the dough volume increases as the temperature rises. Between 30 and 50 °C, the dough volume decreases as the temperature rises.

5 The pH of milk drops from from 6 to 4.2 when it is fermented for three days.

6 Many fungi and bacteria are involved in its production, releasing a mixture of chemicals as they ferment the cocoa. The length of time the microbes are left to ferment will affect how much of each chemical is produced and affect the taste of the chocolate. If it is left too long, fungi can ruin its flavour.

3.6 Planning investigations

1 Finding the best conditions for the growth of each micro-organism allows scientists to obtain the maximum amount of product in a given time, which makes the process more efficient.

2 One from: the mass of sugar (nutrients); the number of other yeast present; the pH.

3 Students should produce a diagram of the student's apparatus and describe the measurements needed.
Tomas – test tubes of yeast/sugar solution covered by balloons: measure the diameter of the balloon after a set time.

Sam – flask of yeast/sugar solution connected to a gas syringe: measure the volume of carbon dioxide produced after one hour.

Maria – test tubes of yeast/sugar solution: measure the depth of the bubble layer after a set time.

Grace – flask of of yeast/sugar solution with a delivery tube dipping into a test tube of water: count how many bubbles escape in one minute.

Moses – flask of of yeast/sugar solution with a delivery tube dipping into a test tube of limewater: measure how long it takes for the limewater to go cloudy.

4 All students need to control the mass of yeast, mass (and type) of sugar, volume of water, amount of stirring, and the apparatus used.

5 Evidence A: Sam; evidence B: Tomas; evidence C: Maria.

6 40 °C

7 Sam's method – it allows the volume of carbon dioxide to be measured most accurately.

3.7 Harmful micro-organisms

1

Micro-organisms	Diseases caused	How they get into the body
fungi	ringworm, athlete's foot	direct contact
protozoa	malaria, sleeping sickness, leishmaniasis	from an insect bite (vector)
bacteria	typhoid, food poisoning	consuming contaminated food or drink

2 Two diseases caused by viruses are: colds/flu, caught by breathing in virus particles; hepatitis C, caught from contaminated needles.

3 Ringworm: Avoid head to head contact, or sharing brushes and combs.
Typhoid: Always wash your hands before eating. Only eat food that has been cooked thoroughly. Only drink bottled water or water which has been boiled and then cooled.

Malaria: Use mosquito repellent, take malaria prevention tablets, sleep under a mosquito net.

Hepatitis C: Always use sterile needles when injecting or taking blood. (Avoid having a tattoo or body piercing.)

3.8 Plant and animal cells

1 Students should draw a simple animal cell diagram with the nucleus, cytoplasm, and cell membrane labelled.

2 Students should label: A – chloroplast; B – nucleus; C – vacuole; D – cytoplasm; E – cell membrane; F – cell wall.

3 Chloroplasts (chlorophyll).

4, 5

Part of cell	Function	Plant, animal, both?
nucleus	contains genes, which control the cell	both
cytoplasm	where most of the cell's chemical reactions take place	both
cell membrane	controls what enters and leaves the cell	both
chloroplast	captures the light energy used to make food	plant
cell wall	keeps the cell firm when the vacuole pushes against it	plant
vacuole	helps to support the cell by pushing against the cell wall	plant

6 If the plant is not watered, the cell vacuoles shrink and do not push against the cell wall. The cells lose their firmness so the plant is unable to stand up straight.

3.9 Specialised cells

1 Students should draw each cell and explain why it is good at its job.
Red blood cell – small and round: small and flexible to squeeze through narrow blood vessels; no nucleus/packed full of haemoglobin to carry oxygen.

Muscle cell – long and thin: full of fibres that allow them to contract (shorten) to pull on bones and cause movement.

Fat cell – large and round: full of fat to act as a food store; good insulator to keep you warm.

Bone cell – small with thin strands pointing in every direction: produce fibres to attract minerals and form bone.

Root hair cell – rectangular with one long, thin extension: provide a large surface area to speed the absorption of water and minerals.

2 Students should draw each cell and describe where it would be found.
A – skin cell; covering the body.

B – nerve cell; in the nervous system.

C – cilliated cell; in the lungs.

3.10 Nerves

1 Students should draw and label a long thin nerve cell with end plates in contact with one or more long thin muscle cells.

2 It is hard to see individual cells because billions are packed together in the brain and each cell has thousands of connections to other cells.

3 Light-detecting cells contain molecules that change shape when light hits them. Sound-detecting cells contain hairs which vibrate when they detect a sound. Both changes make the cells release chemicals which make nerves send electrical messages to the brain.

4 Molecules in your light-detecting cells change shape as they detect light from the car → these cells release chemicals → nerve cells detect the chemicals and send an electrical signal to your brain → your brain interprets the signals → new electrical signals pass along nerve cells to the muscles in your leg → these nerve cells release chemicals → your muscle cells detect the chemicals and contract → you jump out of the way.

3.11 Tissues and organs

1 From smallest to largest: cell, tissue, organ, organ system.

2 Tissues contain one type of cell. Organs contain more than one sort of tissue.

3 Students should name one of the following.
Connective tissues; they hold other tissues together.
Blood tissues; bring food(glucose) and oxygen.

4a Tissues that make the heart beat – nervous tissue, muscle tissue.

b Tissues that give the inside of the heart its required features – tough tendon tissue, smooth lining tissue.

c Tissue that protects the heart muscle – fatty tissue.

5 Four tissues are visible in the root: xylem; phloem; connective tissue; root hairs. The xylem carries water and soluble minerals up from the roots. The phloem carries nutrients such as sugar.

6 Muscle tissue with long thin cells that can contract to cause movement.
Bone tissue with cells that attract minerals to build a solid support.

Nervous tissue with cells that carry electrical signals to allow the hand and arm to move or sense things they touch.

Blood tissue to carry oxygen and nutrients to other cells.

Fat tissue to reduce heat loss from (insulate) the arm and protect other tissues from damage.

Connective tissue to hold the other tissues together.

3.12 Review

1 Students' answers need to show awareness of up to three of the seven life processes and suggest ways to test for them. For example: gently touch it/make a sound/shine light on it to see if it is sensitive and responds by moving; make repeat observations/measurements to test whether it grows/reproduces; look for evidence of excretory products in the water around it; keep it in a closed container and test whether it removes oxygen from the water for respiration or adds carbon dioxide.

2a A bacterium.
B virus particle.
C fungus.

b A and C are living.

3a Micro-organism (bacteria/fungus).

b Micro-organisms remove dead plants and animals and their wastes; this returns minerals in the organic waste to the soil/can be reused by plants.

4a Bacteria obtain energy by converting the sugar in milk to lactic acid; which reduces the pH of the milk/gives yoghurt its flavour.

b Students' answers need to include two from: number of bacteria added; volume of milk added; type of milk.

c She can test the pH of the mixture. When the yoghurt is ready, the pH should be 4.5.

d 32–34 °C

5a The dough with the yeast added increased in height from 12 mm to 42 mm (by 30 mm); the dough without yeast did not change.

b Yeast uses the sugar in the flour for respiration and produces carbon dioxide gas as a byproduct of this reaction. (The bubbles of carbon dioxide cause the dough to increase in volume.)

c One from: add more yeast/sugar; warm the mixture.

6a Food is heated for long enough to kill most of the micro-organisms present whilst preserving the flavour.

b It increases the time milk stays fresh. Fewer micro-organisms are present so it takes longer for them convert the sugar in milk to lactic acid and turn it sour.

7a An open bottle would allow micro-organisms in from the air. These would use the sugars in fruit juice for respiration and spoil it.

b Carbon dioxide.

c Fermentation is faster at a higher temperature.

d After 8–10 days.

8a Chloroplasts carry out photosynthesis to make food for the plant, which it respires to release energy.

b The cell membrane controls what enters and leaves the cell.

c The cell wall keeps the cells firm when their vacuoles are filled with water.

d The nucleus controls the activity of the cell.

9a A influenza/flu/cold; B malaria; C food poisoning/typhoid.

b A through the air in droplets from coughs/sneezes which can be breathed in.
B by vectors/mosquitoes which transfer the protozoa to new victims when they bite.
C by consuming food or drink contaminated by bacteria from faeces.

10a When the soil mineral content is low, there are more root hair cells per mm and the average root hair length is (400 mm) longer than in soil with high mineral content.

b Root hair cells increase the surface area of the roots; so plants can take up water and minerals more quickly.

11a Organ because it contains several different tissues working together.

b Tissue because most of its cells are the same.

c Cell because it has a nucleus and cytoplasm.

d Tissue because it contains more than one muscle cell/fibre.

4 Living things in their environment

4.1 Habitats

1 Kangaroo rats – desert; sloths – rainforest; llamas – mountains.

2 Students' answers should name three animals, give a brief description of their habitats, and list two or three adaptations that help each animal survive in its habitat, e.g. antelopes; African savannah, which is grassland with widely spaced trees; eyes near the sides of their head to spot predators; long, thin legs for speed; tan-coloured coats for camouflage.

4.2 Food chains

1 Any one from: acacia tree → giraffe → lion; acacia tree/grass → impala → cheetah/leopard; grass → zebra → lion. The giraffe/impala/zebra should be labelled herbivore. The lion/cheetah/leopard should be labelled carnivore.

2 Any one from: acacia tree → giraffe → lion; acacia tree/grass → impala → cheetah/leopard; grass → zebra → lion. The giraffe/impala/zebra should be labelled prey. The lion/cheetah/leopard should be labelled predator.

3 Any one from: acacia tree → giraffe → lion; acacia tree/grass → impala → cheetah/leopard; grass → zebra → lion. The acacia tree/grass should be labelled producer. All the animals should be labelled consumer.

4 The arrows represent the direction of energy flow from producers to top predators.
5 A prey animal such as the impala uses some of the energy it gets from the producers it eats to build muscles and fat. When a predator such as a lion eats the prey, the energy passes to them.
6 The Sun provides the energy producers need to make their own food, so it also keeps consumers alive.
7 The herbivores will have less food; their numbers could decrease if they starve, move away, or die faster than they reproduce.
8 The number of herbivores would increase, as they have fewer predators hunting them. The number of plants would decrease, as the larger number of herbivores will eat more plants.
9 Students should produce a valid Antarctic food chain, e.g. phytoplankton → krill → fish → penguin/sea bird.

4.3 Feeding ourselves

1 Food chains can be disrupted by habitat destruction (which removes producers); pollution (which can kill plants or animals); invasive species (which compete with the plants and animals in existing food chains).
2 We can get more food without damaging other food chains by growing more food on the same amount of land, e.g. by growing algae in tanks to produce fuel and food for animals, so we have more space to grow food crops; by building tall greenhouses that take up less land.
3 Fertilisers increase crop growth by supplying minerals to plants, but they kill fish if too much runs into rivers. Herbicides kill weeds to stop them competing with crops for nutrients, but they also destroy wild plants. Insecticides kill the pests that eat crops, but they also kill beneficial insects such as bees.
4 Students should give an example of an animal that has been affected by human activities, e.g. in India, mercury is released by burning coal in power plants. Rain carries the mercury into lakes, rivers, and the sea. Krill take in the mercury, which builds up inside them. Small fish eat many krill and sharks eat many small fish. Sharks can accumulate enough mercury to poison them so their numbers have dropped.

4.4 Changing the planet

1 Our atmosphere lets us breathe, allows plants to make food, shields us from harmful ultraviolet radiation, and keeps the Earth at an ideal temperature for life. Changing our atmosphere could damage life on Earth.
2 Negative: fridges and spray cans released CFCs into the atmosphere which destroyed ozone/caused a hole to appear in the ozone layer. Positive: governments banned the use of CFCs in all products and over time the ozone layer should recover.
3 Negative: burning fuels containing sulfur releases an acidic gas that produces acid rain, which damages trees and aquatic life. Positive: scientists can now remove the sulfur from fuels before they burn them and neutralise any acidic gases released to prevent acid rain from forming.
4 Carbon dioxide acts like a greenhouse. It allows sunlight to enter and heat the ground but stops some of the heat from the ground escaping. If carbon dioxide levels continue to rise, more heat will be trapped in the Earth's atmosphere, causing the temperature of the Earth to rise. This will damage habitats and the organisms that inhabit them.
5 Any two from: cut down fewer trees/plant more trees to take in more carbon dioxide; burn less fossil fuel to cut the release of carbon dioxide into the atmosphere.
6 Clouds reduce the amount of sunlight reaching the Earth, and mirrors reflect sunlight away from the Earth; less sunlight reaching the Earth means there is less heat to be trapped by carbon dioxide.

4.5 Preventing extinction

1 Extinction is caused by animals dying faster than they can reproduce due to: pollution of rivers; killing by poachers; destruction of habitats to clear land for farming or for building homes.
2 Wildlife sanctuaries protect endangered animals from poachers as the animals there are guarded.
3 Students should describe a habitat, name a plant or animal under threat, and suggest how the organisms living there could be protected, e.g. the rainforests of the southern Western Ghats in India are being destroyed by humans to provide space to grow crops and build homes. This endangers the Bengal tiger and the deer and antelope it feeds on. Bengal tigers are also endangered due to poaching. These animals could be protected by building wildlife sanctuaries and protecting the animals from poachers. National parks could be set up in the area to protect some of the remaining habitat. A captive breeding programme could be set up to increase the number of Bengal tigers in zoos, before releasing them back into the wild.
4 Breeding species in captivity allows the number of individuals of that species to increase in a protected environment. These animals can be reintroduced into the wild once their numbers have increased enough.

4.6 Obtaining energy

1 Non-renewable energy sources cannot be replaced

once they run out. Renewable sources of energy are constantly replaced.

2 Non-renewable – coal, oil, gas. Renewable – any three from: solar energy; biofuels; wind; moving water; geothermal energy.

3 Geothermal energy.

4a Solar energy/biofuels.

b Solar energy.

c Geothermal energy.

d Moving water (hydroelectric power).

e Wind energy.

4.7 Growing fuels

1 Biodiesel comes from plant oils. Bioethanol comes from sugar cane.

2 Petrol releases carbon dioxide when it burns but biofuels could be carbon neutral, which would reduce pollution; petrol is non-renewable because it is made from oil, but biofuels are renewable.

3 Plants release carbon dioxide when they burn, but when crops are replanted, they take in the carbon dioxide that was released into the atmosphere. So biofuels should not increase the amount of carbon dioxide in the atmosphere.

4 Land is cleared to make space to grow biofuels/oil palms by starting fires which release large quantities of carbon dioxide into the atmosphere, and not enough oil palms are grown to take in all the carbon dioxide that was released. It also takes more energy to convert plant material into biofuels than it does to convert oil to petrol and most of the energy needed for this is obtained by burning fossil fuels.

5 Fungi make enzymes that can break down the plant cell walls. This allows more of a plant's biomass to be turned into sugar and fermented to make bioethanol.

6 Students should give one advantage and one disadvantage of each fuel.
Bioethanol advantages: cheaper to produce in warm countries; could be carbon neutral; could be made from waste plant material.

Bioethanol disadvantages: uses fungal enzymes which are expensive; yields are low if fungal enzymes are not used.

Biodiesel advantages: algae grow quickly; they could use up the carbon dioxide produced by power stations to reduce pollution; photobioreactors can be set up anywhere in the world without taking up much space.

Biodiesel disdvantages: a lot of space is required to grow the algae in water; algae could be contaminated by other micro-organisms; photobioreactors are expensive.

4.8 Review

1a Any two from: the fennec fox has larger ears than the arctic fox; the fennec fox is sand coloured whilst the arctic fox is white; the fennec fox is thinner than the arctic fox; the arctic fox has thicker fur than the fennec fox.

b The arctic fox has thicker fat to reduce heat loss.

c Any two from: the fennec fox would lose too much heat from its large ears; it would not be camouflaged/its predators would easily spot it; its fur/fat layer is too thin so it would lose too much heat.

2a Any one from each category: carnivore – lizard/hawk; herbivore – insect; producer – cactus; consumer– insect, lizard, hawk; predator – lizard, hawk; prey – insect, lizard.

b A rise in the number of foxes would cause the lizard population to reduce, as the foxes will need more food. This means less food is available for the hawk so it will raise fewer offspring successfully.

c If all the lizards died, the insect population would increase, as they would have fewer predators. The cactus population would then decrease as there would be more insects to eat them.

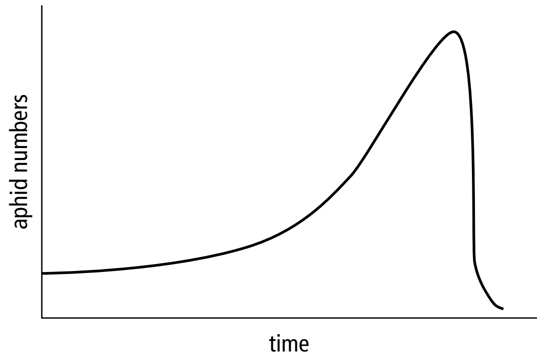
3 Any two from: they have long roots near the surface with lots of root hair cells to increase their surface area so they can take water quickly when it rains; their spines deter herbivores; having spines instead of leaves cuts their surface area and reduces water loss; they store water in their swollen stems.

4a Any two from: the population fell slowly between 1900 and 1960 (from 320 000 to 275 000); the population fell rapidly between 1970 and 2010 (to 10 000); since 2010 the population has fallen more slowly.

b Between 1960 and 1980 their rainforest habitats were destroyed more rapidly to make room for crops/to provide timber.

c One from: people have become more aware of habitat destruction; the orang-utans' habitats have been protected; they have been moved to sanctuaries.

5a



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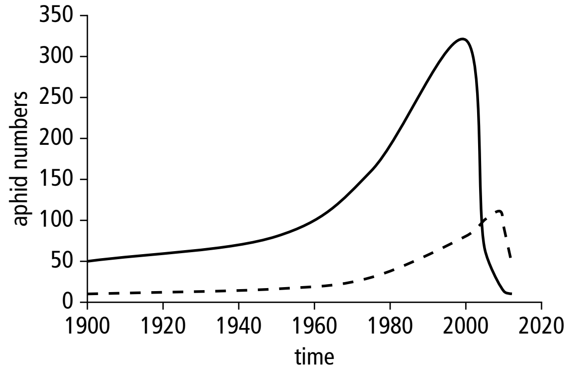


Any two from:

A graph showing the ladybird population is always lower than the aphid population; the graph has a similar shape to the aphid graph; the graph peaks later.

c One from: there was not enough wheat left so the aphids starved/stopped reproducing; ladybirds ate them faster than they could reproduce.

6a Timmy controlled the seed type, the volume of water given each day and the amount of light they received.

b The plant receiving acid rain grew 5.5 cm less than the plant given pure water, so acidic rain restricts plant growth; *or* acid rain causes leaves to turn brown and reduces photosynthesis/growth.

7a The carbon dioxide concentration increased from 315 to 380 ppm (by 65 ppm) between 1960 and 2000.

b Increased burning of fossil fuels, releasing more carbon dioxide; increased deforestation reducing the amount of carbon dioxide taken up by plants.

8a The average temperatures in the Arctic and the rest of the world have increased from 1950 to 2000. The temperature has increased much more (by 1.25 °C) in the Arctic than in the rest of the world (0.5 °C).

b The ice will melt faster each year.

c Polar bears cannot catch seals in open water, so as the ice melts sooner, they will catch fewer seals.

9a 86%

b This figure will decrease in the future because fossil fuels are running out, so we need to use more renewable sources of energy.

c Any four from: geothermal energy; moving water; wind energy; solar energy; biofuels.

d Renewable energy sources do not release carbon dioxide, or are carbon neutral. This means that they won't add carbon dioxide to the atmosphere. Carbon dioxide causes global warming/reducing the amount of carbon dioxide released decreases global warming.

10a The more ozone there is in the atmosphere the less harmful ultraviolet radiation reaches Antarctica; the amount of ozone in the atmosphere fluctuates but has shown an overall drop.

b The ozone layer absorbs ultraviolet radiation; so it reduces the amount that reaches the Earth.

c Any one from: ultraviolet light can damage plants; ultraviolet light can cause skin cancer in humans.

5 Adaptation and survival

5.1 Adaptation

1 An adaptation is a characteristic (physical feature or behaviour) that helps an organism survive.

2a Any two of the following: forward-facing eyes; sharp teeth; camouflage; streamlined shape.

b Any two of the following: forward-facing eyes; sharp beak; streamlined shape; strong claws.

c Any two of the following: eyes on the front of their heads to judge distances; large ears; good sense of smell; grasping feet; long arms.

d Any two of the following: eyes on the sides of their heads; large ears; good sense of smell; camouflage; speed; living in herds.

e Any two of the following: forward-facing eyes; sharp teeth; sharp claws; speed; streamlined shape; camouflage; hunting in packs.

5.2 Extreme adaptations

1 Students should produce a labelled drawing of a desert plant with at least two of these adaptations: long horizontal roots; a very long vertical root; thick stems; small fleshy leaves; spines or waxy coatings.

2 Small animals survive without drinking because they store fat, stay underground during the day, extract water from food, avoid sweating, and produce concentrated urine.

3 Arctic animals conserve heat because they have rounded bodies and thick layers of fat and fur. Most are large but smaller animals burrow under the snow.

4 In milder winters, when there is less snow, fewer lemmings survive because there is nothing to burrow under and no protection from icy winds.

5.3 Survival

1 Many plant species move towards the poles as the climate warms because their seeds survive in cooler places.
2 Climate change could affect our food supply because the world's three main crops – maize, wheat, and rice – are not adapted to hot, dry conditions.
3 Global warming has reduced the number of seals that polar bears catch because the ice they hunt from melts earlier.
4 Between 1990 and 2000, adelie penguin numbers dropped and chinstrap penguin numbers rose.
5 Adelie penguins find it harder to catch their food when there is less ice.
6 Adelies breed later because there is more snow now and they wait until the snow has melted.
7 Adelie chicks have less chance of survival because small chicks lose their heat more quickly and have smaller food stores.

5.4 Sampling techniques

1 To estimate the size of a rabbit population scientists could: set traps; mark the animals they capture; release them; capture another sample; calculate what fraction of the second sample is marked; divide the number marked at the start by this fraction.
2 To estimate the number of plants on 1000 m^2 of land: place 10 or more 1 m^2 quadrats in random positions over the land; count the plants in each quadrat; calculate the average number of plants per quadrat; multiply by 1000 to estimate the total population.
3 Students should sketch a pitfall trap like the one at the top of page 179 of the Student book. They should state that it is designed to catch any invertebrates that run along the ground.
4 The percentage plant cover increases as the distance from the tree increases.
5 Trees stop light reaching the ground, so few plants can grow near trees.

5.5 Studying the natural world

1 Ecologists study animals in their environments by: direct observation; studying their tracks; using automatic cameras; using electronic tags.
2a Automatic cameras could show how a lioness brings up her cubs.
b Electronic tags, studying their tracks, or direct observation could be used to study the migration of wildebeest.
c Automatic cameras or studying their tracks could be used to study shy mammals in a tropical rainforest.
d Electronic tags could be used to study whale migration.
e The number of arctic foxes in a habitat could be studied by observing their tracks.
3 Studying animal faeces can show which animals are present and what they eat.
4 Long-term observations of a group of animals can show how they behave and what their social lives are like.

5.6 Review

1 A – desert; B – rainforest; C – grassland; D – arctic region.
2 Any three from: forward-facing eyes; sharp beak; streamlined shape for speed; strong claws.
3a Fox A is camouflaged against soil in summer and snow in winter.
b Fox B has large ears to cool its blood.
4 The long root collects water from deep underground. The swollen leaves store water.
5 Wide feet stop the camel sinking in loose sand and the polar bear sinking in loose snow.
6 Any two from the following:
The long root collects water from deep underground.
The surface roots collects water when it rains.
The chemical prevents other plants from competing with it for water.
7 Decorator crabs cover their shells with corals, sea anemones, seaweeds, and sponges to camouflage themselves from predators.
8a The average beak length increases as the temperature of the environment increases.
b Birds can increase heat loss by having a longer beak in warmer climates or reduce heat loss in cold climates by having a shorter beak.
9a Plant B is better adapted to the dim light under the tree.
b Any one from: collect data around other trees; repeat the investigation.
10a The minimum area of sea ice in the Arctic dropped by 4.7 millions of m^2.
b Narwhals could be endangered if the sea ice disappears because they will not be able to feed under sea ice where their predators can't catch them.
11a Seema threw the quadrat over her shoulder so that it would land in a random position.
b The total number of poisonous plants growing in the square of grass is the average number in one quadrat multiplied by the total area (50 m^2), which is 100.
c She could repeat the test in more positions.
12a There were fewer attacks on the model snakes with triangular heads than the model snakes with flat heads.
b The grass snakes deter predators by making themselves look more like dangerous vipers.
13 100 fish.

6 States of matter

6.1 The particle theory of matter

1

	solid	**liquid**	**gas**
How close are the particles?	Touching	Touching	Not touching
Are the particles in a pattern?	Regular pattern	No regular pattern	No regular pattern
How do the particles move?	Particles don't move – they vibrate on the spot	Particles move around, in and out of each other	Particles move very fast in all directions
How strongly do the particles attract each other?	Strongly attracted	Strongly attracted	Very weakly attracted

2 When you press a solid metal hard, the shape does not change because the particles are already touching so they cannot get closer together.

3 In the solid and liquid states the particles are touching and cannot get any closer. In the gas state, the particles are not touching so they can be compressed (squashed together).

6.2 Boiling, evaporating, and condensing

1 condensation

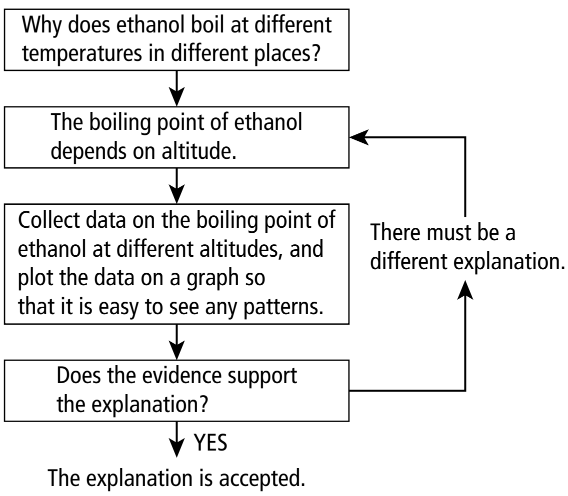
2 The particles move faster and spread out.

3 nitrogen

4 Heat the metal using an electric heater. When the temperature stops rising, the scientist has found the boiling point.

6.3 Questions, evidence, and explanations

1 Collect data for the boiling points of other liquids (e.g. ethanol) at different altitudes.



2 Given the new evidence, Rabia can now consider her previous knowledge about what boiling is. Rabia can conclude that at a higher altitude, for a given volume, less energy (heat) is required to reach boiling point.

6.4 Melting, freezing, and subliming

1 melting

2 Particles stop moving around, arrange themselves in a regular pattern and vibrate on the spot.

3 Jati could heat the sample until it melts whilst measuring the temperature. If the substance melts at the same temperature it is pure. If the substance melts over a range of temperatures it is a mixture.

6.5 Energy and changes of state

1 The forces between the particles get weaker when a liquid becomes a gas.

2 When particles evaporate, some of the faster-moving particles have enough energy to overcome the forces holding the particles together and they can break free from the surface of the liquid.

3 Gold. Substances with higher boiling points have stronger forces between the particles and require more energy to separate the particles.

6.6 Using particle theory to explain dissolving

1 **Dissolve:** When the particles of a solid randomly mix with the particles of a liquid to form a random arrangement.
Solution: A mixture of solute dissolved in a solvent.
Solvent: A liquid in which a solute can dissolve.
Solute: A substance that can dissolve in a solvent.
Solubility: The mass of a substance that can dissolve in 100 g of water.

2 Find the mass of the water and the container. Find the mass of the salt. Dissolve the salt in the water. Find the mass of the solution. The mass should be the total of the water, salt, and container.

3 Add 1 g of salt to 100 g of water and mix until dissolved. Repeat until the salt will not dissolve. Repeat the experiment to check the result.

4 **a** Lithium chloride
b Sodium chloride
c Approximately 73–4 grams per 100g of water.

6.7 Planning an investigation

1 A variable is a quality or characteristic that can change.

2 To ensure that her investigation is a fair test.

3 Zahra could add 5 g of salt to 100 cm^3 and stir at different speeds e.g. 1 rotation per second, timing how long it takes for the salt to dissolve.
Variables: speed of stirring, water temperature, water volume, mass of salt, size of salt grains.
Variable to change: speed of stirring.
Variable to observe: time for salt to dissolve.
Apparatus: measuring cylinder, beaker, laboratory thermometer, electronic balance (for

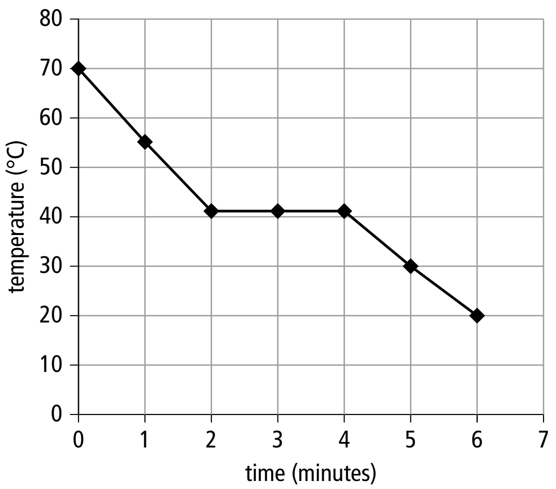
accuracy) OR balance with weights (reliability of electricity), stirring rod, stopwatch.

6.8 Presenting evidence

1 A variable whose values are words or certain numerical values.
2 To look for patterns in her results.
3 Continuous data is best shown on a line graph.
4 A bar chart as the variable he is changing (the substance) is discrete.

6.9 Review

1a Particles do not move around, but vibrate whilst touching each other.
b In ice the particles are arranged in a regular pattern, in water the particles are arranged randomly.
2a C
b D
c melting
3a In gases, the particles do not touch each other, they move around very quickly and there are weak forces of attraction between the particles.
b As the particles in gases are not touching they can be compressed (pushed closer together).
4 The particles get further apart.
5a increases
b decreases
c decreases
6 Top to bottom: C, B, and A
7a krypton
b krypton
c chlorine and krypton
d iodine and osmium
e liquid, gas
f boiling
8a liquid
b melting
9a C
b A
10a time
b temperature
c



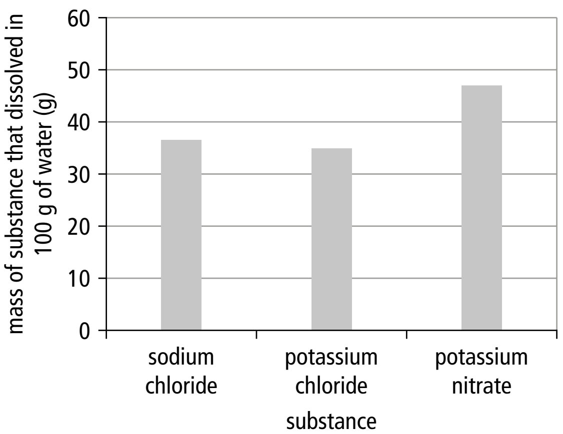
d freezing point = 42 °C

e Particles slow down, move less, and arrange themselves into a regular pattern and vibrate in the same place.
11a i temperature of water
ii mass of potassium chloride that dissolves
iii volume of water
amount of stirring
b Yes, the graph shows that as the temperature increases, the mass of potassium chloride that dissolves increases.

12a

Substance tested	Mass of substance that dissolved in 100 g of water (g)
Sodium chloride	36
Potassium chloride	34
Potassium nitrate	47

b



c The variable that is being changed (substance tested) is discrete.
d (electric or weighted) balance, thermometer, beaker, stirring rod,

7 Material properties

7.1 Introducing elements

1 A substance that cannot be split into anything simpler.
2 Metals and non metals
3 **Metals:** any elements to the left of the red line.
Non-metals: any elements to the right of the red line. Hydrogen is also a non-metal.
4 Any two of the following: conduct electricity, solid at room temperature, shiny, conduct heat, strong, hard, heavy, malleable, ductile.

7.2 Metal elements

1 High melting and boiling points, shiny, sonorous, conductors of heat and electricity, strong, hard, dense (high density), malleable, ductile.
2 Shiny, strong, malleable, ductile.
3 Strong, malleable, hard.

7.3 Non-metal elements

1 Low boiling and melting points, not shiny (dull), brittle, cannot conduct electricity.

2 Dull, brittle, and cannot conduct electricity.

3

Diamond	Graphite
Particles arranged in crystals	Particles arranged in layers
Hard	Soft
Does not conduct electricity	Conducts electricity

7.4 Making conclusions from data

1 iron

2 X, non-metal: not shiny, does not conduct electricity, low melting and boiling points.
Y, EITHER metal: shiny and silver, conducts electricity OR non-metal: low melting and boiling points.

Z, metal: shiny and silver, conducts electricity and has high melting and boiling points.

3 As the force applied increases, the extension of the spring increases.

4 Most metals have melting points above 1000 °C. Lithium and sodium (both Group 1 metals) have melting points of below 200 °C.

7.5 Metal alloys

1 A mixture of metals.

2 The composition of pure aluminium is 100% aluminium. Aluminium alloy 7075 contains 90% aluminium. Pure aluminium has a lower density, is less hard, and is weaker than the aluminium alloy 7075.

3 Low carbon steel is used to build bridges, buildings, and objects that need to be strong. Low carbon steel is strong and easily shaped (malleable).

Manganese steel is used for mining equipment and railway points. It needs to be strong, hard, and be used with large forces. Manganese steel is hard and tough.

Stainless steel is used for knives and forks, and surgical instruments. It need to be able to be used and washed several times. Stainless steel does not rust.

4 See the "particles in iron" and "particles in steel" diagrams (page 101). The particles in iron are arranged in layers and the particles can slide over each other easily making iron soft and weak. In steel, the particles of the other elements are mixed with the iron particles. This mixture stops the iron particles from being able to slide over each other in layers, making steel harder and stronger than pure iron.

7.6 Material properties

1 Cotton is soft, flexible, and allows air through small holes making it comfortable to wear.

2 Sisal is used to make rope because it is strong when pulled.

3 Flexible, strong, waterproof, tough.

7.7 Polmers

1 Polymers are substances that have very long particles.

2 Any six from: poly(ethene), poly(propene), poly(chloroethene) / poly(vinyl chloride) / (PVC), cotton, silk, wool, wood.

3 It is difficult to break up the particles.

4 PVC is used for underground water pipes, insulation on electric cables, and for waterproof clothes. PVC is waterproof and flexible which makes it suitable for bending and covering objects whilst keeping them dry (or keeping water in).

7.8 Review

1a It melts at 1063 °C.

b It is good conductor of electricity. It is a good conductor of heat.

c It melts at 1063 °C (to make it harder to make forgeries) and/or it is always shiny.

d It melts at 1063 °C. It is good conductor of electricity.

2a C

b A: is green, does not conduct electricity, and has a low melting point.
D: is dull yellow, does not conduct electricity, and has a low melting point.

3a a good conductor of heat

b a good conductor of electricity

c sonorous

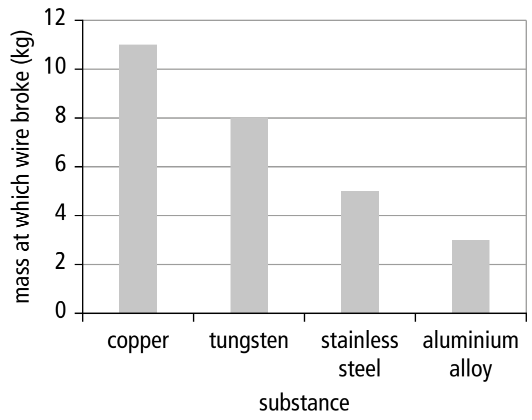
d strong

4a Substance and weights added.

b Length of wire, same equipment used, e.g. same hangers, weights, clamp stand, etc.

c **i** copper

ii



5a waterproof, transparent

b waterproof, flexible

c waterproof, flexible, and strong

d waterproof, strong

e absorbent

6a Poly(propene) does not rot and is stronger than manila fibre.

b Manila is obtained from a plant whereas poly(propene) is made from oil, which is harder to get.

c i 54–55 kN

ii 35–36 mm

iii As the diameter of the manila rope increases, the breaking strength increases at an increasing rate.

iv 30 mm manila rope

7a wood

b concrete

c Wood conducts heat the least, so a house would heat up less in the sun, keeping it cool inside.

d Limestone is stronger than wood.

8a The data (about the substance) is discrete and is best compared in a bar chart.

b Tin, magnesium & platinum, zinc, aluminium, gold, copper.

8 Material changes

8.1 Acids and alkalis

1 Hydrochloric acid, ascorbic acid, omega-3 fatty acids, ethanoic acid (vinegar), methanoic acid, sulfuric acid, nitric acid.

2 Sodium hydroxide is extremely corrosive, it can cause skin to blister, or blind someone if it gets into their eyes. Use eye protection and make sure not to get it on your skin.

3 Acids taste sour. Alkalis feel soapy.

4a Oceania

b 53%

8.2 The pH scale and indicators

1 Acidic: red. Alkali: blue or purple.

2 alkaline

3 pH 4 is more acidic

4 A white bowl or plate, a glass with white paper behind. An observer can view the colour clearly if the solution is placed in front of a white background.

8.3 Neutralisation

1 Neutralisation is the cancelling out of an acid by an alkali, or of an alkali by an acid.

2 acid

3 acid

8.4 Planning investigations and collecting evidence

1 Kim keeps the variables the same to ensure a fair test.

2 Measuring cylinders measure smaller differences than beakers (they are more accurate).

3 More logical, scientific, clear, less vague than others.

8.5 Review

1 less than, more than, equal to

2a Top to bottom: acidic, acidic, acidic, alkaline

b Indigestion medicine.

c Sweat, cola drink, or orange juice.

3a Top: red, bottom: blue.

b Red at start, (green at 100 cm^3) blue at end.

4a The extra acid comes out in urine, lowering the pH.

b The pH of the urine increases as extra alkali comes out in the urine.

c There would be more alkali in her urine, increasing the pH of her urine and lowering the pH of her blood.

5a cassava

b pineapple and cassava

c The farmer could try growing any of the crops.

d i maize and cassava

ii Acid to lower the soil pH.

6a beaker

b funnel and conical flask

c test tube

7a 6.0

b The acidity increased.

c Trout, salmon, eel, frog, snail, mayfly.

d frog

e The pH must have increased.

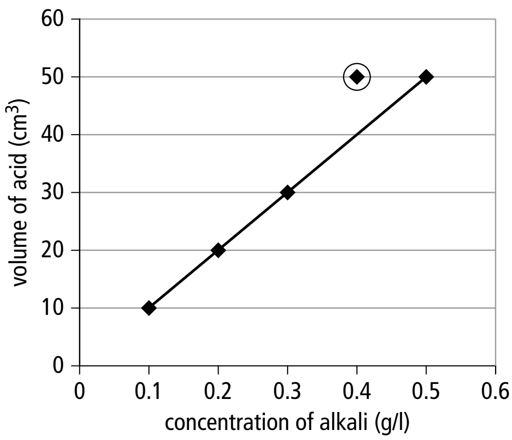
f i Mayflies cannot live in pH 5.0.

ii Yes, the pH had increased to 6.0 which mayflies can live in.

8a Measuring cylinders are more accurate as they can measure smaller amounts.

b Top to bottom: concentration of alkali, volume of acid, concentration of acid, volume of alkali, type of indicator.

c i–iii



9 The Earth

9.1 The structure of the Earth

1 Inner core, outer core, mantle, crust.

2 Ships sink as they go over the horizon. Aristotle's observations of the Earth's shadow on the Moon.
3 Shockwave patterns produced by earthquakes support the theory that the Earth has a solid inner core.

9.2 Igneous rocks
1 Hard, durable, non-porous.
2 Substances that exist naturally as crystals.
3 Granite is a mixture of minerals that are different colours.
4 Basalt cools quicker than granite, so the crystals have less time to form.

9.3 Sedimentary rocks
1 Sandstone, claystone, mudstone, limestone.
2 Claystone has tiny grains and it is easy to mould wet clay into different shapes.
Sandstone is a hard sedimentary rock making it a good building material.
3 Use a hand lens and water:
Look at it with a hand lens – she could see separate grains with spaces between them. If she puts water on the rock, it will absorb the water. If she submerges it in a beaker, bubbles will appear from the air inside the rock. If it is a sedimentary rock she will be able to scratch it.
4 Porous – due to small spaces between the grains within the rock.
Soft (relative to igneous) as the grains are held together less strongly than the crystals in igneous rocks.

9.4 Sedimentary rock formation
1 Water: pebbles can be transported along a river bed.
Wind: grains of sand can be transported.
Gravity: rocks and sediment can be moved by rock falls and landslides.
2 Weathering is the breakdown of rock into sediments.
3 Physical weathering: freeze-thaw weathering from water freezing in cracks, expanding and (after many repetitions) causing the rock to break.

Chemical weathering: acidic rain falling onto rocks can create new substances.

Biological weathering: tree roots can grow into rock cracks, slowly breaking the rock. Lichens make chemicals that break down rock.

9.5 Metamorphic rocks
1 Marble, slate, gneiss.
2 Metamorphic rocks are formed when rocks are changed by high temperatures or pressures.
3 Metamorphic rocks have interlocking crystals with no air spaces, so they cannot absorb water.
4 Use a hand lens – sedimentary rocks have separate grains, metamorphic rocks have crystals. Drop some water onto the rock – sedimentary rocks will absorb it, metamorphic rocks will not.

9.6 Questions, evidence, and explanations: the rock cycle
1 Scientists ask a question, make observations and collect evidence, describe the evidence, consider the evidence and suggest an explanation.
2 Rocks under the Earth's surface can (at any point) be forced upwards to make mountains, a process known as uplift.
3 Erosion wears down rocks into sediment. The sediment is transported into a lake, river, or sea, where it is deposited at the bottom. Over a long period of time this will turn into sedimentary rock. Under the Earth's crust, the high temperatures and pressures may turn sedimentary rock (and igneous rock) into metamorphic rock. Some rocks sink lower and are hot enough to melt into magma. Some magma is forced out of volcanoes, solidifying and forming igneous rocks.

9.7 Using science to explain predictions: volcanoes
1 To ensure people can evacuate to safety in time.
2 To look for patterns to help make predictions about whether or not the volcano could erupt.
3 Gases such as sulfur dioxide escape from magma, the more gas there is suggests that the closer the magma is to the surface.

9.8 Soil
1 Rock fragments, air, water, humus.
2 Add water to the soil and shake. Allow the mixture to separate.
3 In clay soil, 40% of the rock fragments are clay, in sandy soil, most of the fragments are sand. Sandy soil feels gritty whilst clay soil feels sticky when wet and hard when dry. Sandy soil drains much faster than clay soil.
4 Sandy soil – the volume of water collected in 30 minutes was larger than the volume collected for the clay soil. Sandy soil drains quicker because the rock fragments are larger and there are more spaces for the water to drain through quickly.

9.9 More about soil
1 iron
2 Place 100 cm^3 of soil into a measuring cylinder, add water until it reaches 200 cm^3. Stir until there are no more bubbles. The difference between the volumes is the volume of air in the soil sample.
3 $200\ cm^3 - 180\ cm^3 = 20\ cm^3$

9.10 Fossils
1 Most dead animals and plants are eaten or rot. Fossils will only form if the animal is buried quickly.
2 An animal dies. It is buried in mud or sand. Bacteria slowly break down the soft parts of the body, leaving the skeleton. Mud or sand above the skeleton starts to become rock. Mineral-rich

underground water seeps into tiny spaces in the skeleton, replacing the original minerals in the skeleton and creating a hard copy of the skeleton. When the soft rock is eroded, the fossil is exposed.

3 Students can choose any example on page 71 and do their own research on the find.

9.11 Estimating the age of the Earth

1 4 600 000 000 years old

2 Thomson assumed that the Earth formed as a liquid making his assumptions incorrect.

3 Index fossils are specific to the geological time period, so scientists can identify the age of the rock based on the fossils found within them.

9.12 Human fossils

1 Fossilised snails found nearby showed that the river Selam lived near flowed into a lake with sandy beaches.

2 The scientists used radiometric dating to date the surrounding rocks.

3 Toumaï's skull is not the same as modern gorillas, chimpanzees, or humans. Scientists cannot agree which species Toumaï is an ancestor of.

9.13 Review

1 Igneous, sedimentary, metamorphic.

2 Top to bottom: granite, sandstone, marble.

3a A, B

b A

c C, D

d A, B

e C, D

f A, B

4a V, W, X

b V

c X, there is marble (which is made from limestone) next to / below rock X.

d Under high temperatures and pressure.

e Y as it is the only igneous rock in the diagram.

5a 3

b Pumice has a low density (1), pumice contains bubbles (2).

c 3

d **i** I put it on water and it floated.
ii So it must have a low density.

6a hand lens

b B

c C

d Junaid, fossils are not very common, so it is very likely that a piece of sedimentary rock would not contain fossils.

7a M

b M

c L

d L

8a soil sample

b the water level

c the amount of soil used, the level to which water is added

9a Top to bottom: crust, mantle, outer core, inner core.

b Top to bottom: solid, solid, solid, liquid.

10 c, b, a, e, d

10 Forces

10.1 Introduction to forces

1

Force	Changes the speed of the object	Changes its direction
Gravity acting on a falling apple	✔	
Friction acting on a car going around a corner at a steady speed		✔
Friction when a car brakes in a straight line	✔	

2 People on the other side of the Earth do not fall off because the force of gravity acts towards the centre of the Earth, wherever you are.

3 Three of the following: friction, air resistance, gravity, thrust.

4 Pull – force of attraction.
Push – force of repulsion.

5a One of the following contact forces: friction, air resistance, water resistance, upthrust, thrust, tension.

b One of the following non-contact forces: gravity, electrostatic force, gravitational force.

10.2 Balanced forces

1 unbalanced

2 balanced

3a balanced

b unbalanced

c unbalanced

4 Alom – if a car is moving at a steady speed, then the resultant force would be zero and no resultant force would be acting on the car. A resultant force would only be acting on the car if the forces acting on it are unbalanced, for example when the car is accelerating, decelerating, or changing direction.

10.3 Friction

1 The force of friction is caused by the uneven surfaces of the objects sliding over each other.

2 Using oil as lubrication reduces friction because a thin layer of oil it makes it easier for two uneven surfaces to slide over each other.

3a The thin layer of water between the blade of an ice skate and the ice acts as a lubricant and reduces the friction between the two surfaces. Therefore, the skater can move across the ice more easily.

b Ice skates have a jagged edge at the front that skaters use to stop. When the surface of the jagged edge slides over the ice the force of friction is greater and the skater slows down and stops.

4 It is important to remove the water from between a tyre and the road, so that there is enough friction for the tyres to grip the road.

10.4 Gravity

1 Mass is the amount of matter in an object. Weight is a force – it is the force of gravity acting on an object.

2 40 N

3 The mass of the astronaut on Mars is the same as the mass of the astronaut on Earth. Mass is the amount of matter in an object and does not change.

4a Gravitational force is like a magnetic force because it is a non-contact force that can attract objects.

b Magnetic forces can also repel, gravitational forces cannot. Gravitational force is dependent on mass, magnetic force are not normally.

5 72 kg × 4 N/kg = 288 N

10.5 Questions, evidence, and explanations

1 Bhaskaracharya could not do any experiments to test his ideas because it was not possible to perform experiments on the Moon or the planets by changing or controlling variables. It is only possible to make observations.

2 Newton knew a force was acting on the Moon because it had to keep changing direction to stay in orbit around the Earth. An object only changes direction if a force is acting on it.

3 Any sensible reason, for example: you cannot feel the Earth moving and the Sun moves through the sky; the Sun does not touch the Earth, so how can it exert a force on the Earth; the orbiting of the Earth had been traditionally explained in a different way, people believed this instead of Newton or Bhaskaracharya; they had done no experiments to prove their ideas.

4 Any sensible reason, for example: you cannot feel the Earth moving and the Moon moves through the sky; the Earth does not touch the Moon, so how can it exert a force on the Moon; the orbiting of the Moon had been traditionally explained in a different way, people believed this instead of Newton or Bhaskaracharya; they had done no experiments to prove their ideas.

5 You need less fuel to return to the Earth from the Moon, because the Earth's gravity is stronger than the Moon's. A spacecraft would be pulled more towards the Earth than the Moon.

10.6 Air resistance

1a A car is 'streamlined' when it has been designed to reduce the effect of air resistance.

b A lorry travelling fast would experience more air resistance than a streamlined car travelling slowly because it will have a greater surface area that is in contact with the air, and also it will be pushing more air out of the way as it is travelling faster.

2 Missing words in order: unbalanced, balanced, unbalanced, balanced, balanced.

3 A tennis ball and cricket ball will hit the ground at the same time, even though the cricket ball is heavier, because they are the same size and experience the same amount of air resistance. If there is an equal amount, or no, air resistance, all objects fall at the same rate.

10.7 Planning investigations

1

Equipment	Why Kasini needed it
a large measuring cylinder	To fill with water and drop different shapes of clay into.
modelling clay	To make into different shapes, with the same mass, in order to test how the shape of an object affects resistance.
a stopwatch	To time the objects as they fall through the water.
a balance	To measure the clay, so that the same mass is used for each shape.
a measuring jug	To measure the amount of water in the cylinder to ensure the same amount of water is used each time.

2 It is important to only change one variable at a time, so that you can see what effect that variable is having on what you are measuring. If you change more than one variable, you do not know which one is causing any differences.

3 Kasini could use more water, repeat her measurements and take an average, or use timing gates.

4 units of measurement

5 Any suitable answer – it is important that Kasini uses the same stop-clock and type of clay for all of the experiments as changing them could have an effect, but Kasini is likely to be completing all of the tests at the same time using the same equipment and therefore using the same stop clock and clay.

10.8 Review

1 Balanced forces are equal and acting in opposite directions. Unbalanced forces are not the same size.

	Forces are balanced	Forces are unbalanced
The object is not moving.	✔	
There is only one force acting on the object.		✔
The object is accelerating.		✔
The two forces are the same size but in opposite directions.	✔	
The object is slowing down.		✔
The two forces are different sizes, but in opposite directions.		✔
The object is moving at a steady speed in a straight line.	✔	

2a The motorcycle and the child sitting on a swing.

b The child sitting on the swing and trampoline.

c The motorcycle. Some of the forces acting on the submarine are balanced, but some are unbalanced.

3a Accelerating downhill: gravity, air resistance, friction

b Diagram should have an arrow point forwards labelled thrust and one pointing back labelled air resistance and friction. The arrows should be the same length and start on the cyclist.

4 A car moves forward when the force when the forces acting forwards are greater or equal to the forces acting against the direction of motion, drag. Air resistance is one of the drag forces, it is caused when the car collides with air particles. Thrust is the force that acts forwards, it is provided by the engine. A streamlined car is designed to experience less air resistance, this means to travel at a steady speed it also needs less thrust. The car will use less fuel if it has to generate less thrust.

5 B and C.

6 The ball went a lot further because both the force of gravity and the air resistance are lower on the Moon. The force of gravity is lower, so the ball will travel further before it falls back to the surface. The Moon has a very thin atmosphere, so there are fewer particles in the air. This means the air resistance is lower and so the ball can travel further for the same thrust.

7a lubrication

b drag

c thrust

8a true

b false

c true

d false

9a Both Newton and Bhaskaracharya wondered why the Moon went around the Earth.

b They both worked out that there was a force that attracted the Moon to the Earth.

c The discovery of Neptune proved that Newton's prediction, and so his explanation, was correct.

d Albert Einstein and Edwin Hubble both developed Newton and Bhaskaracharya's explanations.

11 Light

11.1 What is light?

1 Candle and lightbulb.

2 A shadow can tell you whether the light sources are small or large and spread out.

3a The image will get larger and sharper.

b The image would be brighter because more light is getting into the camera.

11.2 How do we see things?

1 Light is emitted by objects that give out light. Light is transmitted when it passes through an object.

2 The Moon is non-luminous. It does not generate light, we can only see it by light from the Sun reflected off its surface.

3 It is harder to see dark coloured cats at night than light coloured cats because most of the light that shines on them is absorbed, so less is reflected for our eyes to detect. Light-coloured cats reflect more light and so are easier to see.

4

	Eye	Pinhole camera
hole to let the light in	pupil	pinhole
where the image is formed	retina	screen

5 The eye is not light a camera because it has different types of cells that are specialised for seeing in dim light or bright light and colour.

11.3 The speed of light

1 Distances in space are so large that it is not practical to use kilometres to measure them.

2a 8 light minutes × 9.3 = 74.4 light minutes
b 74.4 light minutes = 4464 light seconds. Distance to Saturn = 4464 × 300 000 000 = 1 339 200 000 km. Time in an aeroplane = 1 339 200 000 km / 900 km/h = 1 488 000 hours or 62 000 days.
3 The light from the stars takes so long to reach us that we are not seeing the star how it looks now, but how it looked several minutes, days or years ago.
4 The closest distance is when Earth is directly between the Sun and Mars and the two planets are close together. The furthest the planets could be apart is when the Earth is on the opposite side of the Sun to Mars.
5 A metal bar would change length with temperature.

11.4 Reflection
1 A, H, I, M, O, T, U, V, W, X, Y
2 left eye
3 The word 'ambulance' is laterally inverted on the front of an ambulance because people in cars in front of the ambulance will see it in their rear-view mirrors. It needs to be laterally inverted so that they can read it. Most people behind the ambulance will be looking at it directly, not in mirrors, and so the word does not need to be inverted.
4a Shiny metal reflects light well, so you can see your face in it like you would in a mirror.
b Smooth and shiny surfaces reflects light in a regular way, so you can sometimes see a reflection in them.
c A painted white wall is relatively rough, the light is not reflected in a regular way so it is not possible to see your reflection.

11.5 Making measurements: the law of reflection
1 They drew two dots on the paper to measure their results. They make sure the ray hits the mirror where the normal is drawn.
2 They could repeat each measurement 3 times and use the average.
3 Each angle of incidence and reflection is 45 °.
4a 90 ° – 30 ° = 60 °
b The angle of reflection is equal to the angle of incidence = 60 °.

11.6 Review
1a luminous
b opaque
c inverted
d umbra
e non-luminous
2a reflected
b absorbed
c translucent, transparent
d reflected
e opaque
f transparent
3 b
4 A, C, F
5 b, c, e
6a C
b A
c B

12 Electricity

12.1 Electrostatic phenomena
1 An atom is neutral because it contains the same number of positively-charged protons as negatively-charged electrons.
2a negative
b positive
c Attract because a charged polythene rod becomes negatively-charged.
3 Metal is a conductor, it becomes charged but because metal is a conductor the extra electrons flow through the metal and your hand to the earth.
4 She is not correct – the rod repel when they have similar charges which are the same across the whole of the rod, two negatively-charged rods would repel whichever ends or you placed next to each other.

12.2 Dangers of electrostatic phenomena
1 Lightning is a spark of negative charge as it travels to Earth.
2 Earthing is the process of connecting something to the Earth by a conductor, so that charge can flow through the conductor to Earth and prevent a dangerous build-up of negative charge.
3 An engineer's wristband acts as an earth as it conducts any build-up of charge away from components they may be working on. If the charge was not conducted away, then it could flow through the components and damage them.
4a No
b A plastic handle is an insulator. She gets a shock from the metal handle because the charge that she has built up by walking across the carpet sparks through her hand to door handle to Earth.

12.3 Digital sensors
1 If the dielectric wasn't made out of an insulator, the charges would not remain separate and the electrons would flow onto the positive plate.
2 A CCD is like a touch screen because it works by storing charge. When you touch a touch screen or when light hits a CCD the charge changes. The difference in charge in different areas lets you use a touchscreen or capture an image.
3 A pixel is a small dot called a picture element.

4a Diagram showing field lines of two positive charges being repelled away from each other.
b The diagram is similar to the magnetic fields of two similar poles close together.

12.4 electric circuits
1a Appropriate circuit diagrams using the correct symbols.
b B
c Circuit A needs another connecting wire. Circuit C need one of the cells to be turned around.
2 Conductors: iron, copper, carbon as graphite. Insulators: wood, carbon as diamond, paper.
3 The wires are covered in plastic because it is an insulator. This stops people getting shocks from bare wires.

12.5 Current: what is it and how can we measure it?
1 Current is the flow of charge rather than the amount – it is a measure of how many electrons are flowing per second.
2a charge, second
b high, charge
c broken
3 One switch controls the whole of a series circuit – when it is open the circuit is broken.
4a 0.5 A
b Current is not used up in an electric circuit so the current will measure the same either side of the lamp.
5 Current is a measure of flow of charge, it is the same all the way around the circuit as it is not used up around the circuit.

12.6 Parallel circuits
1 In a series circuit there is only one loop. In a parallel circuit there is more than one loop.
2 The lamps in a house are connected in parallel, so that they can all be controlled by their own switches. In a series circuit one switch would turn all the lamps off or on at once.
3a X and Z
b Yes, they will all be the same brightness.
c A switch to turn all the lights on and off it should be placed before the first branch of the circuit to lamp X.
4a No, they are different because a different amount of current is flowing through each branch.
b 0.2 A + 0.3 A = 0.5 A

12.7 Models for electric circuits
1 In the rope model, a flat battery is represented by person X not moving the rope around the circle.

In the factory or people model, a flat battery is represented by a shut factory or by a person holding an empty pot.

In the water circuit model, a flat battery is represented by a broken or stopped pump or a circuit with no water.
2a To represent a parallel circuit using a rope model use two ropes both controlled at the same time by X, but one going past Y and the other past a third person Z.
b The currents in the branches of a parallel circuit because the charge that flows out of the battery is divided between the branches.
3 An ammeter would be represented by a person counting the number of people walking past with sweets in a certain time.
4 The water represents the flow of charge, electrons, around the circuit.
5 Any suitable answers, e.g.: To put a switch in the truck model, she could use traffic lights or a swing bridge that moves to break the circuit.
To put a switch in the rope model, the knot could be untied or a person could stand and stop the rope moving.

12.8 How components affect the circuit
1a C
b B
2a circuit X
b circuit X
c two cells in X = one cell in Y
3 Narrower pipes
4a The rope model explain this by having two ropes coming from the battery to represent the current flowing down the two branches of the circuit. One rope goes down each branch.
b The current can only pass down one of the loops, it divides when it reaches the split which is like splitting at a junction.

12.9 Voltage
1 6 cells
2 Ammeters have no effect on the current, but a voltmeter connected in series would use some of the voltage and change the measurement.
3 The voltage that the battery supplies is used up by the components in a circuit. It is divided between the components so the voltage across all of the components will be the same as the voltage of the battery.
4a 6 V – 2 V = 4 V
b The current will be the same because the lamp and buzzer are in a series circuit.
5 The charge is not used up, but the energy need to push the charge around the circuit will be used up.

12.10 Selecting ideas to test circuits
1 It is easier to take a precise reading from a digital ammeter.

2a Change: thickness of wire, Measure: resistance, Control: voltage, length of wire, material of wire

b She might find it difficult to get different thicknesses of wire in the same material. The differences may be small and difficult to measure.

3 The wire will get hot when the current is flowing, so they used a heatproof mat. They should also avoid touching the wire when the battery is connected and only connect it for a short amount of time.

4a Katie can draw a line graph because thickness of wire is a continuous variable. Sue cannot draw a line graph because she is testing the material of the wire which is a categoric variable.

b

Material	Current (A)

12.11 Energy and power

1 2000 W

2 Power = energy/time = 1200 J / 60 s = 20 W

3 LEDs use less power because they are more efficient than a CFL, but they are more expensive to produce.

4a Energy = power × time = 0.015k W × 10 h = 0.15 kWh

b Incandescent bulb = 10 × 0.6 = 6 rupees
CFL = 10 × 0.15 = 1.5 rupees
LED = 10 × 0.1 = 1 rupee

c You would save 5 rupees a month.

12.12 Review

1a neutral – has no overall charge

b charged – has an overall positive or negative charge

c charge – when a material has more positive protons or negative electrons it has a charge

d earthed – connected to the ground so that any charge can flow to the ground and not build up

e conductor – conducts charge and electrons away quickly

f insulator – does not conduct charge or electrons

2a charged

b insulator, charge, conductor

c charge

d conductor, charge, earthed

3 1 – C, 2 – D, 3 – B, 4 – A

4a cell

b series circuit

c switch

d parallel circuit

5a

Position of switch on the left	Position of switch on the right	Are the bulbs on or off?
1	2	on
1	4	off
3	2	off
3	4	on

b The circuit works because each switch does not have an on and off position, it is relative to the other switch. So if the circuit is connected by turning on one switch, changing the position of the other switch will break the circuit even though the position of the first switch has not changed.

6a Parallel circuit with two branches. Lamp A is in the circuit before it splits into branches. Then one branch containing only D. The second branch has B and C.

b Lamp A will be the brightest as all of the current will flow through it.

c Lamps B and C will be the dimmest because that branch of the circuit has the greatest resistance.

7a Lamps Y and Z are connected in series, but they are connected in parallel with lamp X.

b A_1 will show the lowest reading because it is on the branch with the least resistance.

c $A_3 = A_1 + A_2$

d Lamp X will be the brightest because the same voltage is passing along that branch, but there is only one component.

e **i** Lamps Y and Z would continue to shine.
ii Lamp Z would go out and Lamp X would
iii Lamp Y would go out and Lamp X would

8a diagram

b 3 V

c The voltage is shared equally between components in a circuit if they are identical.

9 C, A, D, B, E

10a The ammeter should be connected in series. The voltmeter should be connected in parallel with the buzzer.

b Corrected diagram with voltmeter connected in parallel with the buzzer and the ammeter in series.

13 The Earth and beyond

13.1 The night sky

1a Planets, exoplanets and comets.

b The Moon and artificial satellites.

2 Planets, artificial satellites, natural satellites.

3 A meteor is any piece of dust or rock that enters the Earth's atmosphere. A meteorite is a piece of rock that reaches the surface of the Earth.

4 Uranus and Neptune can only be seen with a telescope, so they are not called naked-eye planets.

13.2 Day and night

1a east

b west

c midday

2a At the start and end of the day, this is when the Sun is lowest in the sky.

b At midday because this is when the Sun is highest in the sky.

3 It is unlikely that the Sun is hidden behind clouds at night because when the Sun goes behind cloud during the day it does not get dark. The Sun appears to move as the Earth spins on its axis.

4 Foucault's pendulum needed a very heavy weight to keep it swinging for a long time, long enough to show the effects of the Earth spinning.

13.3 The seasons

1 Towards the Sun.

2 The days are longer, so the Sun warms the Earth for longer each day. Also, the Sun is higher in the sky so its rays fall over a smaller area, transferring their energy to a smaller area and heating the ground more.

3 The length of the shadow would be less in summer than in winter because the Sun is higher in the sky during the summer.

4a The length of a day changes over the year due to the tilt of the Earth's axis. The Earth is tilted towards the Sun during summer, and so has a longer day. It is more obvious further from the equator.

b **i** December

ii June

5 If the Earth's axis was not tilted, then day length and temperature would not vary throughout the year as they do now. There would be no seasons.

13.4 Stars

1 You cannot see stars during the day because the Sun is too bright. The light of the Sun is brighter than the light of the other stars.

2 A constellation is a collection of stars that make a pattern, like Cassiopeia or Ursa Major.

3 We see different stars in the summer and winter because the Earth is in different positions of its orbit around Earth. We can only see the stars that are in the opposite direction to the Sun, six months later these would not be visible as they would be the same direction as the Sun.

4 Most stars move as the Earth turns on its axis, so it was not possible for sailors to use them for navigation.

5 14 million years from birth – worked out using the diagram on page 59.

13.5 Our Solar System

1 Scientists think there could once have been life on Mars because there are features on the surface that suggest water once flowed there.

2a From largest to smallest: Jupiter, Saturn, Uranus, Neptune, Earth, Venus, Mars, Mercury.

b The Sun is roughly ten times bigger than Jupiter, the largest planet.

3a The inner planets are much smaller than the outer planets.

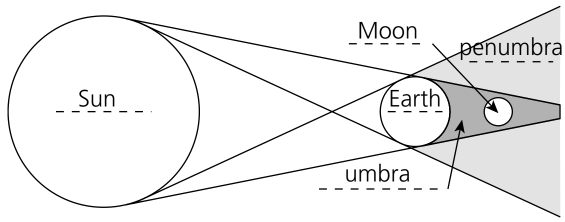
b The inner planets are made of rock, but the outer planets are made of hydrogen and helium gas – Neptune and Uranus both have a rocky centre.

4 Yes – the outer planets are further from the Sun and have to travel a greater distance to complete one orbit, a year.

13.6 The Moon

1 New moon, waxing crescent, first quarter, waxing gibbous, full moon, waning gibbous, last quarter, waning crescent.

2



3 If the orbit of the Moon was not tilted, we would not see a full Moon because the Earth would block the light from the Sun causing a lunar eclipse every month.

4a We only ever see once side of the Moon because the Moon completes one turn on its axis in the same amount of time it takes to orbit the Earth. This means that the same side of the Moon faces the Earth at all times.

5b It is possible to take a photograph of the dark side of the Moon because it isn't dark. We only call it the dark side of the Moon because it is never visible from Earth.

13.7 Explanations – the geocentric model

1 The invention of writing was important for the development of scientific explanation as people were able to write down measurements and look for patterns.

2 People found it easy to believe the geocentric model because from Earth it looked like the Sun, Moon, stars and other planets were all moving around the Earth, and it did not feel like the Earth was moving at all.

3 Ptolemy changed the geocentric model to explain the observations of planets that seemed to wander across the sky. He explained that the planets were making smaller circles as well as moving in a big circle around the Earth.

13.8 Explanation – the heliocentric model

1 In the geocentric model, the Earth is at the centre and all the stars, planets and the Sun orbit the Earth, in the heliocentric model the planets all orbit the Sun, which is at the centre of the model.

2 Galileo Galilei observed four moons orbiting Jupiter, this piece of evidence was important for overturning the geocentric model as it showed that not everything in the Universe orbited the Earth.

3 It was easier to explain the movement of the planets using the heliocentric model instead of using Ptolemy's explanation that they moved in smaller circles whilst orbiting the Earth.

13.9 Communicating ideas

1 Foucault proved that the Earth was spinning using a very large pendulum. It would have been possible for earlier astronomers to prove that the Earth was spinning if they had had the same idea.

2 Merkhets, telescopes, astrolabe, any other sensible answers not mentioned in the book.

3 It was important to develop new astronomical instruments in order to make new and more precise or accurate measurements.

4 If lots of astronomers came together in a new observatory they could share their ideas and observations and use them to develop new explanations together.

13.10 Beyond our Solar System

1 A galaxy is a collection of stars. A solar system is a group of planets and other objects that orbit one star. There could be millions of solar systems in a galaxy.

2 Missing words in order: Kuiper belt, Oort cloud, galaxy.

3 It is not possible to count all of the stars in the Milky Way because there are too many stars, there are billions and billions of stars in the Milky Way.

13.11 Using secondary sources

1 A primary source is data that you have collected yourself in a practical investigation, a field study or by making observations. A secondary source is data you have not collected yourself, such as information in a text book or on the Internet.

2 It is important to look at more than one secondary source to check that the data is reliable.

3 There is no link between day length and year length as planets with similar day lengths have very different year lengths.

4a Mercury

b Mars, Saturn and Neptune

c Jupiter and Venus

d Uranus

13.12 The origin of the Universe

1a Scientists think that the Universe is 13 700 million years old.

b The Solar System is 5000 million years old.

2 It is difficult to predict what will happen to the Universe as it depends on the mass of everything within it. It is not possible to measure the mass of all the objects in the Universe using the technology we have at the moment.

3 No – dinosaurs died out 65 million years ago, but humans did not exist then. Humans only appeared 0.5 million years ago.

13.13 Review

1 1 – C, 2 – A, 3 – D, 4 – B.

2 d

3a 3

b 1

c 2

d 5

e 4

4a Sun, Moon, star, comet, Venus

b You cannot put the objects in order because we do not know the size of all the object, for example the unnamed planet could be larger or smaller than Earth.

c Earth and Venus, because they are all inner planets in our Solar System.

d Star (not our Sun) because they are both stars.

5a 3 months

b 6 months

c 9 months

d 150 million km – 60 million km = 90 million km

e We see different stars at different times of year as we move around the Sun. We can only see stars that are in the opposite direction to the Sun, so the stars visible at position A would be hidden behind the Sun at position C.

6a axis, year

b south, north, shorter, longer

c larger, away from

7a A, B, C

b B, C, D, E

c D

d Foucault's pendulum.

8a The further from the Sun a planet is, the longer it's year is – this is because the orbit is larger.

b The further from the Sun, the lower a planet's orbital speed is.

c One year on Uranus is longer than one year on Earth because it is further from the Sun and so the distance it must travel to orbit the Sun, also it's orbital speed is lower than that of the Earth.

9a The scientist in Egypt might not be able to read the scientist in India's work because it is written in a different language, or the book might not have reached Egypt.

b For example, the Indian scientist Brahmagupta described the law of gravity 1000 years before Newton, but Newton did not know about him.

c It is easier to communicate internationally today using the Internet. Most work can be easily translated into several languages.

10a A primary source is data you have collected yourself in an investigation or by making observations. A secondary source is data that someone else has collected, it may be from a text book, or on the internet.

b secondary

c secondary

d primary

e The secondary data from a science book is likely to be the most reliable, but all data should be repeated or checked.

1 Plants

1.1 Leaves, stems, and roots

1 From top to bottom: flower, stem, leaf, root.

2 The missing words are: stems, leaves, flowers, reproduce, organ, minerals, food, leaves, water, minerals.

3 Leaf: absorbs light, makes food.
Stem: provides support.
Root: takes in water, takes in minerals, holds plant in place.
Flower: allows reproduction, produces seeds.

4 **a** Leaf. **b** Stem. **c** Root.

5 **a** F **b** T **c** F
Stems carry **water** from roots to leaves.
Every organ in a plant needs water.

E *Either* stores water to keep the plant alive between rain storms *or* carries out photosynthesis so the leaves become spines to conserve water and for defence.

1.2 Questions, evidence, and explanations

1 The missing words are: questions, answer, explanations, investigations, evidence, accepted.

2 Evidence: a growing plant takes in a lot of water. Explanation: plants are made from water.
Evidence: a growing plant gains more mass than soil loses. Explanation: plants do not get their food from the soil they grow in.
Evidence: seedlings stop growing if their leaves are cut off. Explanation: a plant's leaves make the food it needs.
Evidence: growing plants take a gas out of the air. Explanation: leaves use a gas from the air to make food.
Evidence: plants do not grow well in pure rainwater. Explanation: plants need small amounts of minerals to grow, and they get them from soil.
Evidence: leaves, stems, and roots have tubes running through them. Explanation: tubes carry water from roots to leaves and food from leaves to roots.

3a How does the number of leaves affect the growth of a plant?

b There is more extra growth when the number of leaves on the plant increases.

c More leaves make more food and this allows more growth.

Ea Take identical plants; give them different volumes of water each day; control every other variable; measure their height or mass after a specific time.

b Up to a certain point, plants grow more when they have more water. Then adding more water makes no difference because they cannot make any more food.

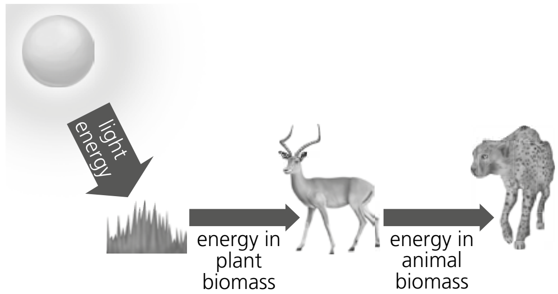
2 Plants and photosynthesis

2.1 Photosynthesis

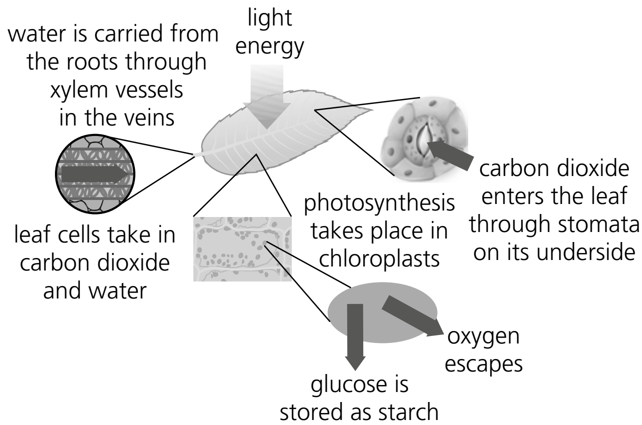
1 Equation as shown below.

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{absorbed by chloroplasts}]{\text{light energy}} \text{glucose} + \text{oxygen}$$

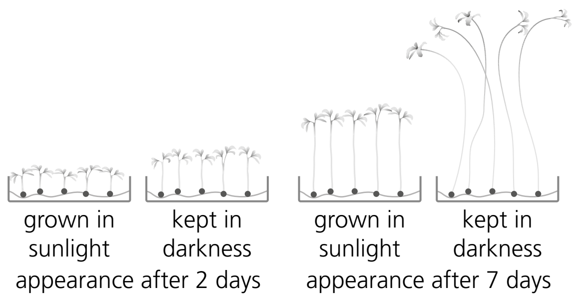
2 Labels added to the diagram as shown below.



3 Labels added to the diagram as shown below.



4 Cress seedlings added to the diagram as shown below.

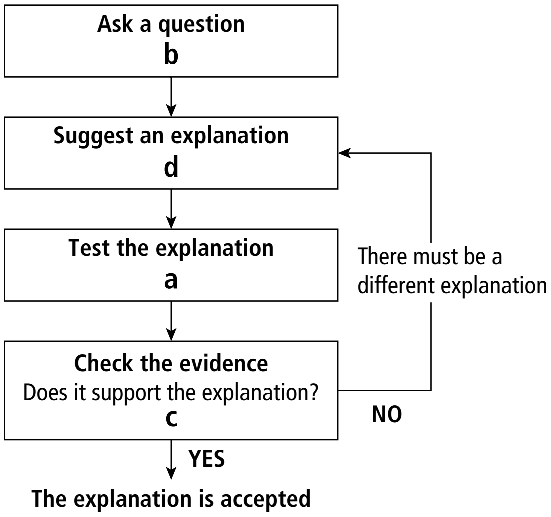


Ea Phloem tubes carry sugars around the plant. They take nutrients to cells that cannot make their own by photosynthesis.

b Aphids remove nutrients so they could make plants grow more slowly or produce fewer flowers or fruits.

2.2 Preliminary tests

1 Letters added to the diagram as shown below.



2 Lamp – produces white light.
Filter – removes every colour from light except one.
Syringe – removes the air from leaf discs.
Timer – to measure how long leaf discs take to rise.
Water – provides dissolved carbon dioxide for photosynthesis.

Ea Marc should move the lamp closer or use a brighter lamp because it will take him too long to collect results.

b If each test takes less time, Marc can repeat his measurements and check that he has reliable results.

c The light intensity under each filter must be the same. Marc could reduce the light intensity under the red filter by increasing its thickness, by moving the lamp further away, or by reducing the brightness of the lamp.

d These changes will make the measurements more valid by comparing the colours fairly.

2.3 Plant growth

1 The leaves should be coloured as follows.
Phosphorus deficiency: leaf is green in the centre and purple around the sides.
Potassium deficiency: leaf is green with brown edges.
Nitrogen deficiency: leaf is green around the edges with a yellow centre and tip.

2 Wondered what makes maize leaves turn yellow in some parts of the country – ask a question about something that has been observed.
Suggested that the plants might be short of magnesium because the green chlorophyll in chloroplasts contains magnesium – use creative thought to suggest a possible explanation.
Grew two lots of maize. Gave the control batch every mineral and the test batch every mineral except magnesium – collect evidence to test the possible explanation.
Compared the control and test batches of maize. The leaves only turn yellow in the test batch – check the evidence to see if it supports the suggested explanation.

3 The missing words are: proteins, chlorophyll, potassium, phosphorus.

Ea Mineral uptake increased with time for both aeroponics and hydroponics. The uptake when using aeroponics was more than twice as high as with hydroponics.

b Plants grown using hydroponics have their roots in water but plants grown using aeroponics have their roots in air. Sprays are used to keep them moist.

c Roots need oxygen for respiration to release energy. Some of this energy is used to take in minerals using active transport.

d Plants grown using hydroponics might grow more slowly, produce fewer flowers or fruits, or show signs of mineral deficiency like yellow, brown, or purple leaves.

2.4 Phytoextraction

1 Plants need metals to build their cells.
Only small amounts are needed.
Many metals are toxic in large quantities.
High metal concentrations prevent plant growth.
Hyperaccumulators can absorb a lot of metal.
Hyperaccumulators are used to clean soil.

2 Students should colour and label the diagram to show minerals from the soil moving into the plant's leaves.

3a Most of the arsenic accumulated in the plant's leaves.

b The ferns take in most arsenic between 6 and 7 weeks after planting, where the graph is steepest.

c The arsenic extracted from contaminated soil could be used to make solar panels.

2.5 Flowers

1 Clockwise from the top right the labels are: stigma, style, ovary, ovule, nectary, sepal, petal, filament, anther.

2a Ovary.

b Anther.

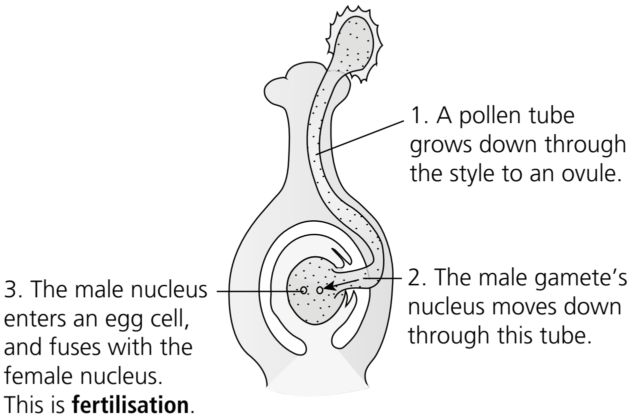
c Stigma.

d Style.

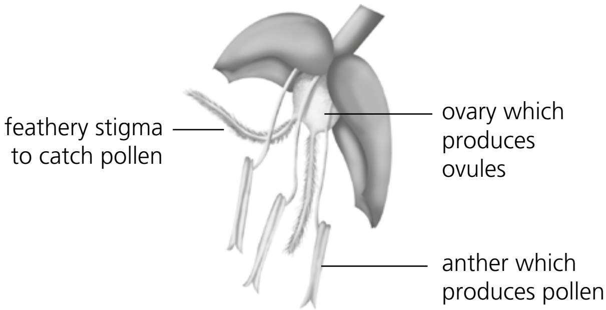
e Ovules.

f Ovary.

3 Labels added to the diagram as shown below.



4 Labels added to the diagram as shown below.



Ea Self-pollination occurs when pollen lands on the stigma in the same flower or a flower on the same plant. Cross-pollination takes place when pollen lands on the stigma of a flower on a different plant.

b Cross-pollination produces more variety because the male and female sex cells are produced by different plants and each plant contains a unique combination of genes.

2.6 Seed dispersal

1 The missing words are: exploding, animals, embryo, temperatures, water, germinate.

2 Reading from left to right:
Top row – wind, animals, animals.
Bottom row – water, exploding pods, wind.

3a A

b B

Ea The distance travelled is greater when the average mass of the seeds is lower.

b It is useful for seeds to be carried a long way because there is too much competition for light and water near the parent plant.

3 Cells and organisms

3.1 The characteristics of living things

1 Respiration – a chemical reaction that releases energy inside living things.
Sensitivity – the ability to detect chemicals, light, heat, pressure, or sound.
Excretion – the removal of waste products from a living thing.

2 The statements that apply to all living things are: a, b, d, e, f, g.

3 **a** i **b** iii **c** ii **d** ii **e** i

4 Any three from: they move by extending their stems and roots; they use respiration to release the energy they need to stay alive; they sense things in their surroundings, such as light; they increase in size during their lifetime; they produce offspring; they remove waste products from their bodies; they make nutrients.

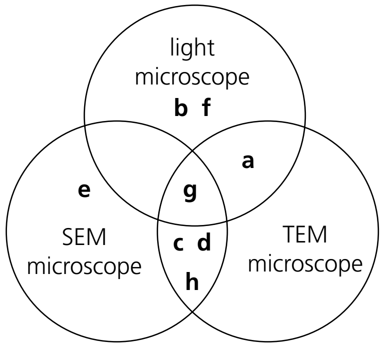
E Respiration would raise the temperature by releasing heat; respiration would remove oxygen and add carbon dioxide to the surroundings.

3.2 Microbes

1 **a** Fungus. **b** Bacteria.
c Protozoan. **d** Fungi (yeast).

2 **a** Fungus. **b** Bacteria.
c Yeast (fungi). **d** Protozoan. **e** Algae.

3 Venn diagram as shown:



Ea They reproduce.

b They do not show the seven characteristics of living things and they can only reproduce inside a living organism.

3.3 Louis Pasteur

1 Ferment – convert sugar into alcohol and carbon dioxide.
Alcohol – a chemical produced by yeast during respiration.
Pasteurisation – heating food or drink for long enough to destroy most of the micro-organisms it contains.
Organic matter – materials made by living things.
Lactic acid – a sour chemical some bacteria produce during respiration.

2 **a** Yeast. **b** Both. **c** Yeast.
d Bacteria. **e** Bacteria. **f** Both.

3 The correct order is: b, e, c, a, d.

Ea During the fermentation stage, yeast converts sugar from the plant material into alcohol.

b Bacteria need to be kept out of the fermenting mixture to prevent other products forming.

3.4 Testing predictions

1 Says: when yeast land in liquids full of nutrients

they grow and reproduce, and make them ferment – suggest an explanation.
Thinks: if I keep yeast out of a nutrient solution it will not go cloudy because it will not ferment – make a prediction.
Places nutrient solutions in flasks with S-shaped necks, and boils them to destroy any micro-organisms present: test the explanation.
Notices that nutrient solutions do not go cloudy in flasks with S-shaped necks – review the evidence.
Breaks the neck of one of the flasks and observes that the nutrient solution begins to ferment and turn cloudy – collect extra evidence.

2 The statements are: evidence, explanation, evidence, explanation, evidence, explanation, evidence, evidence, explanation.

Ea Put the same volume of fruit juice in two test tubes; add different amounts of yeast to each of them; keep them at the same temperature; measure the time it takes for bubbles to appear in each tube; repeat to check the results are reliable.

b Put the same volume of milk in two test tubes; add the same amount of bacteria to each of them; keep them at different temperatures; measure the pH at regular intervals; the one with the lowest pH produces lactic acid most quickly; repeat to check the results are reliable.

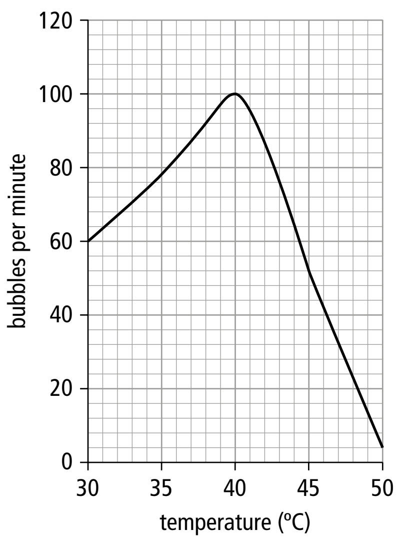
3.5 Useful micro-organisms

1 The missing words are: dough, flour, yeast, respiration, carbon dioxide, soft.

2a Extra bacteria gave the milk a lower pH after 4 hours.

b Bacteria use the sugars for respiration and produce lactic acid as a waste product.

Ea Graph as shown below.



b The number of bubbles per minute increases as the temperature increases until it reaches 40 °C, because yeast respire faster at higher temperatures. Above 40 °C, there are fewer bubbles per minute as the temperature increases because higher temperatures destroy the yeast.

3.6 Planning investigations

1 The missing words are: change, question, measure, effect, controlled, same.

2a The nutrient added.

b The diameter of the balloon.

c Any three from: quantity of yeast; mass of nutrient added; temperature of the water; the size/type of balloon; the size/shape of the flask.

d Carbon dioxide.

e Respiration (fermentation).

f Glucose.

Ea The temperature of the milk.

b The time the milk takes to reach pH 5.

c Flasks or test tubes to hold the milk and bacteria; a water bath to raise its temperature; a thermometer to check the temperature; a pH meter or universal indicator to check the pH; a clock/timer to measure the time; a measuring cylinder or pipette to measure out the milk and liquid holding the bacteria.

d Control the volume/type of milk and number/type of bacteria added.

e The time to reduce the pH to 5 would get less as the temperature increases, until it reaches about 40 °C, because bacteria respire faster at higher temperatures. Above 40 °C, the time will increase because higher temperatures will destroy bacteria.

3.7 Harmful micro-organisms

1 Athlete's foot – a fungus that grows on skin.
Typhoid – bacteria that infect the digestive system.
Malaria – protozoa injected into the bloodstream by mosquitoes.
Flu – a virus that infects your lungs.
Hepatitis – a virus that infects the liver.

2a Typhoid.

b Hepatitis.

c Athlete's foot.

d Malaria.

e Ringworm.

3 **a** F **b** F **c** T **d** F **e** T **f** T

4 Any two from: it is spread by mosquitoes that are difficult to destroy; it is present in many countries; the protozoa that cause it are difficult to destroy.

Ea Any three from: improve sewage treatment so that drinking water is never contaminated with faeces; make sure everyone can get clean drinking water; encourage people to wash their hands after using the toilet; encourage people who sell or prepare food not to work when they feel ill.

b People infected with hepatitis C can pass the virus to other people before they know they have it.

3.8 Plant and animal cells

1 The missing words are: cells, respiration, nutrients, repair, photosynthesis, nutrients.

2 **a** nucleus, **b** vacuole, **c** cytoplasm, **d** chloroplast, **e** cell membrane, **f** cell wall

3 Cell membrane – controls what enters or leaves the cell.
Chloroplast – absorbs light and allows photosynthesis.
Nucleus – controls the activities of the cell.
Cell wall – stops the cell bursting when its vacuole fills with water.
Cytoplasm – where most chemical reactions take place.

E Muscle cells would contain more mitochondria because they need to respire more to release more energy to cause movement.

3.9 Specialised cells

1 The missing words are: specialised, job, different, sizes, contents.

2 Red blood cell – contains haemoglobin to transport oxygen around the body.
Muscle cell – contains fibres which can make themselves shorter.
Fat cell – contains a large oil droplet which acts as an energy store.
Bone cell – produces fibres that attract minerals to make a rigid solid.
Root hair cell – has a long, thin side branch to absorb water and minerals.

3a Red blood cell.
b Fat cell.
c Muscle cell.

4 A red blood cell needs a large surface area so that it can deliver as much oxygen as possible to other cells in the body. A root hair cell has a large surface area so that it can collect water and nutrients from the soil more easily.

Ea Xylem cell.
b Phloem cell.
c Root hair cell.

3.10 Nerves

1 The missing words are: cells, electrical, sensory, ears, light-detecting, brain, images, electrical, muscles, movement.

2a Electrical.
b Chemical.

3 The nerve connected to bladder A releases a chemical signal. Some of the chemical signal stays in the liquid around the bladder. This makes bladder B contract.

4 The correct order is: b, d, a, e, c, f.

3.11 Tissues and organs

1 The missing words are: heart, tissues, cells, specialised, different.

2 Skin surface cell tissue – keep out micro-organisms.
Fatty tissue – stores energy and reduces heat loss through the skin.
Bone tissue – gives support and structure to limbs.
Muscle tissue – causes movement.
Blood tissue – brings nutrients and oxygen to other tissues.

3a Organ.
b Tissue.
c Organ system.
d Organ.
e Cell.

4 Any four tissues found in the neck and their functions, e.g. bone to support your head; muscle to pull on bones and turn your head; blood to carry nutrients and oxygen to your head; nerves to carry electrical signals to and from the brain; skin to keep out micro-organisms; connective tissue to join the rest together.

Ea Stems cells are controlled by growth factors made by other cells.
b Growth factors make different genes turn on in different cells. These genes make cells build different components and take on different shapes.

4 Living things in their environment

4.1 Habitats

1 **a** rainforest; **b** rainforest; **c** desert; **d** desert; **e** rainforest; **f** desert.

2a Antarctic
b Desert
c Rainforest.
d Antarctic and desert.
e Desert.
f Rainforest.
g Desert.

3 Any three from: thick fur, small ears or large rounded body – to reduce heat loss; wide feet to avoid sinking in snow or to help the bear to swim; sharp claws or teeth to help catch its prey.

E Students should draw an animal adapted to life in the desert, label its main adaptations, and explain why they are useful, e.g. wide feet to avoid sinking in the sand; sand coloured for camouflage; large body to avoid sudden temperature changes; burrows to avoid extreme temperatures; large fat stores to last between meals; gets all its water from its food; conserves water by not sweating and producing concentrated urine.

4.2 Food chains

1 Predator – hunts and eats other animals.
Prey – is hunted and eaten by other animals.
Consumer – eats other living things to obtain nutrients.
Producer – makes its own food.
Herbivore – eats only plants.
Carnivore – eats only animals.
Scavenger – eats only animals that have already been killed.

2a Maize.
b Mice.
c Snakes.
d The arrows show the direction in which energy is transferred.
e The maize harvest will increase because none of it will be eaten by mice.

3b Increases.
c Decreases.

E Herbivores use some of the energy in the leaves to build new tissues (muscles and fat). When carnivores eat herbivores, the energy in these tissues passes to them.

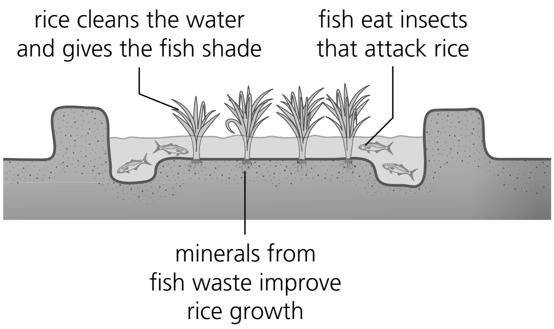
4.3 Feeding ourselves

1 The missing words are: chains, habitats, pollution, animals, chemicals.

2

Method used	**How it can increase the mass of food grown**	**How it can damage natural food chains**
use of fertilisers	supplies minerals	can kill fish
use of herbicides	stops weeds taking the crop's light, water and minerals	destroys wild plants
use of insecticides	stops insects eating the crop	destroys useful insects

3 Labelled diagram as shown below:



4 **a** N **b** P **c** N **d** P **e** P **f** P

E Algae can be used produce fuels and animal feeds so that more land is available to grow food.

4.4 Changing the planet

1 The missing words are: atmosphere, pollutants, ozone, ultraviolet, fuels, rainwater, warming.

2a Increase = 24 – 3 = 21 million square kilometres.
b Since the year 2000 the hole has shrunk by 24 – 18 = 6 million square kilometres.
c The use of CFCs, which destroy ozone, has been banned.

3a Sulfur dioxide and carbon dioxide.
b Any two from: take sulfur out of fuels before they are burned; neutralise acidic gases before they can escape; burn less coal/fuel.

Ea Carbon dioxide raises Earth's temperature by preventing some of its heat escaping.
b Any two from: global warming could be reversed by reducing the amount of carbon dioxide released; finding new ways to take carbon dioxide out of the atmosphere, or reflecting heat away from Earth using mirrors or clouds.

4.5 Preventing extinction

1 Conservation – preventing extinction.
Sanctuary – a place where species can be protected.
Captive breeding – breeding animals in zoos.

2a Remove its predators.
b Provide sanctuaries.
c Save its habitat.
d Captive breeding.

3a Jaguar numbers have fallen due to loss of habitat and hunting.
b The species could be conserved by saving its habitat or providing sanctuaries.

4a Goats reduced the tortoise's food supply.
b Tortoise numbers could be growing because the goats have been removed or they have found a new source of food.

E Leatherback turtles are endangered because: the beaches where they lay their eggs are being built on; humans eat their eggs and meat; they are accidently caught in fishing nets; climate change is raising sea levels and covering the beaches where they nest; the oceans are polluted with pieces of plastic which resemble jelly-fish from below and fill turtle stomachs; rising temperatures cause more females to hatch than males which could reduce the number that reproduce in future.
Conservation methods include: protecting nesting beaches; encouraging local people to protect the turtles and their nests; redesigning fishing nets so turtles can escape from them; finding their migration routes so these can be protected.

4.6 Obtaining energy

1 Biofuel – a fuel made by living things.
Geothermal energy – heat from hot rocks under the Earth's surface.
Solar cells – devices that use light to produce electricity.

Renewable energy – energy sources that are constantly replaced.

2 Replaced; constantly/continually.

3 **a** F **b** F **c** F **d** T
e T **f** F **g** T

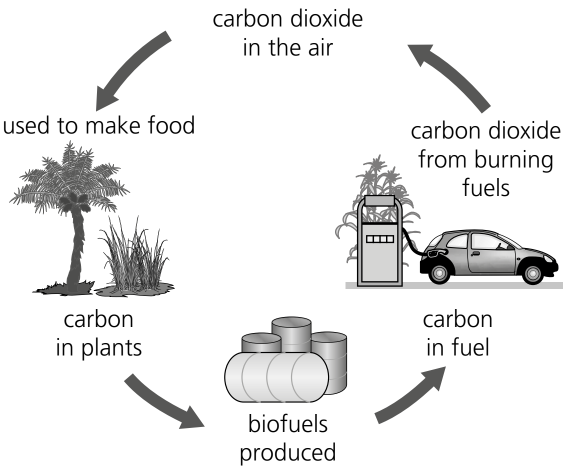
4a Solar cells.
b Geothermal energy.
c Biofuels.
d Wind power.
e Water power (hydroelectricity).
f Biofuels.

E Students should describe the renewable energy sources available in their own country. They could choose from: solar cells, biofuels, wind power, water power, or geothermal energy.

4.7 Growing fuels

1 The missing words are: renewable, plant oils, sugars.

2 Labels as shown below:



3 Extra carbon dioxide is released when fuels are burned to release the energy needed to convert plant material into biofuels and when trees are burned to clear land to grow plants for fuel.

4a Yeast.
b Fungi.
c Sugars.

5

Fuel	Advantages	Disadvantages
biodiesel from algal oil	grow fast oil can form 60% of algae's biomass can grow in contaminated water use up waste carbon dioxide don't use up valuable farmland could be grown anywhere	grow best in expensive photobioreactors
bioethanol from sugar cane	cheaper to produce in warmer countries	sugar can only form 20% of sugar cane's biomass expensive enzymes are needed to convert the rest of the plant into sugars

6 Students could include the following points: oil palms use up land which could be left as rainforest or used to grow food crops; clearing land to grow oil palms releases large amounts of carbon dioxide which contributes to global warming; algal oil could be produced in places where crops will not grow; the algae could use up the carbon dioxide released from power stations; algae grow fast so they could meet the demand for fuel.

5 Adaptation and survival

5.1 Adaptation

1 The missing words are: characteristics, survive, environment, features, behaviours, generations.

2a A prey animal.
b Both.
c A predator.
d Both.
e A prey animal.
f A prey animal.
g A prey animal.
h Both.

3a A
b B

4a Any two from: hiding during the day in hollow trees; feeding at night; exceptional hearing; good sense of smell.

b Any one from: long whiskers to feel their way along branches; exceptional hearing; good sense of smell.

E Students should have five images of animals with labels that highlight the adaptations that help them to find food or avoid predators.

5.2 Extreme adaptations

1 Long roots near the surface to catch occasional rain.
Swollen stems or leaves store water for months between rain storms.
Tiny leaves or spines prevent evaporation through stomata.
Long-lived seeds can survive for years until it rains.

2 The missing words are: slowly, rounded, surface area, insulator, air, fat, energy.

3 Animals A, D, and F should be circled.

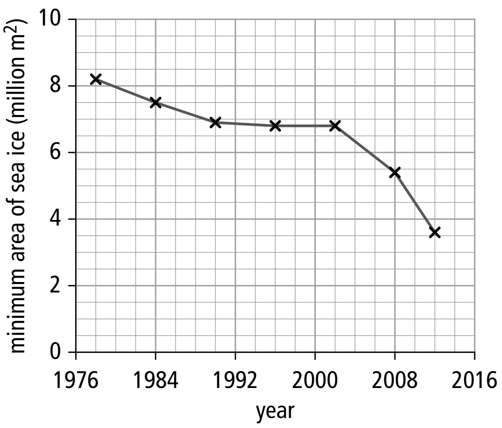
E For the tube worm, any two adaptations from: obtains nutrients from bacteria that live inside its cells; withstands high pressures; builds a tough tube around it for protection; contains haemoglobin to bind oxygen.

For the Pompeii worm: withstands high pressures; builds a tough tube around it for protection; covered with a thick layer of bacteria which help to protect it; secretes mucous which feeds the bacteria; withstands temperatures up to 80 °C; contains haemoglobin to bind oxygen.

5.3 Survival

1 Arrows pointing north should be added at A and D and arrows pointing south at B and C.

2a Graph as shown below.



b Polar bears catch seals when they surface at breathing holes in the ice, so they can only feed when the sea is covered in ice.

3a Decrease.

b Increase.

c Decrease.

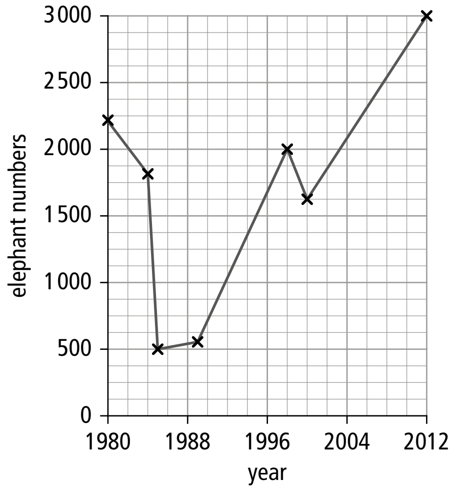
d Have no effect.

e Decrease.

5.4 Sampling techniques

1 The missing words are: species, estimate, sampling, quadrats, traps, calculated.

2 Graph as shown below.



a Elephant numbers dropped between 1980 and 1985 (from 2200 to 500). Since 1985, numbers have risen steadily and there were 3000 elephants in 2012. But the population fell by 400 between 1998 and 2000.

b The elephant population should continue to grow unless they run out of food and begin to starve. Sudden drops in the population occur when criminals kill them to steal their tusks.

E Number marked on day 1 = 15
Number caught on day 8 = 12
Number marked and recaptured = 3

Fraction recaptured $= \frac{3}{15} = \frac{1}{5}$

Estimated population $= 15 \div \frac{1}{5}$

$= 15 \times \frac{5}{1}$

$= 75$

5.5 Studying the natural world

1 The missing words are: live, eat, behave, tracks, faeces, cameras, tags.

2 Rhino – B, I.
Impala – A, H.
Cheetah – C, F.
Elephant – E, G.
Lion – D, J.

3 Scientists can learn about animal behaviour from automatic cameras.

4 Scientists can learn about animal migration routes using electronic tags.

E Students should have detailed notes about the behaviour of one animal. They should include: what it spends most time doing, what it notices, and how it responds.

6 States of matter

6.1 The Particle theory of matter

1 particles, identical, liquid, states, move around from place to place, weak

2a See the diagram of a solid on p14 of the Student book. All of the particles should be touching each other in a regular arrangement.

b Particles in a solid don't move around and vibrate on the spot.

3 More of the particles should be touching each other. Improved diagram should show the particles randomly arranged, as here, but with more of them touching each other.

4 Solids only – statements C, E, G
Gases only – statement H
Solids and liquids – statements F, I
Liquids and gases – statement B
Solids, liquids, and gases – statements A, D, J

E A piece of cake contains particles in both the solid state and the gas state. Most of the cake is in a solid state, but there are bubbles of air throughout the cake, which are in the gas state.

6.2 Boiling, evaporating, and condensing

1a F – Condensation is the change of state from gas to liquid.

b T

c F – When a substance changes state from liquid to gas, the forces of attraction between its particles get weaker.

d T

e F – When a substance condenses, the forces of attraction between its particles get stronger.

2a D

b B

c D and C

3

	True of evaporation only	True of boiling only	True of both evaporation and boiling
This involves a change of state from a substance in its liquid state.			✔
Particles leave the surface of the liquid only.	✔		
Bubbles of the substance in its gas state form throughout the liquid.		✔	
This can happen at any temperature.	✔		
During this change of state, the particles get further apart.			✔

6.3 Questions, evidence, and explanations

1 Top to bottom:
ask a question, suggest an explanation, test the explanation, check the evidence

2 Top to bottom:
Evidence, evidence, explanation, evidence, evidence, evidence, explanation

3a How does the amount of salt added to water affect the boiling temperature?

b The saltier the water, the higher the boiling temperature.

c Laura could add different amounts (1 g, 2 g etc.) of salt to a fixed volume of water (e.g. 100 cm^3) and measure the boiling temperature.

6.4 Melting, freezing, and subliming

1 solid, liquid, move out of, move around, are touching their neighbours.

2 From left to right:
Sloping part of graph on left – C; horizontal part of graph – A; sloping part of graph on right – B

3a sodium

b Sodium, lead, copper, manganese, iron, chromium.

c copper

4a **i** water

ii mercury

b Scale drawn with equal divisions from approximately −120 °C up to −360 °C.

c Melting and boiling points correctly marked on scale.

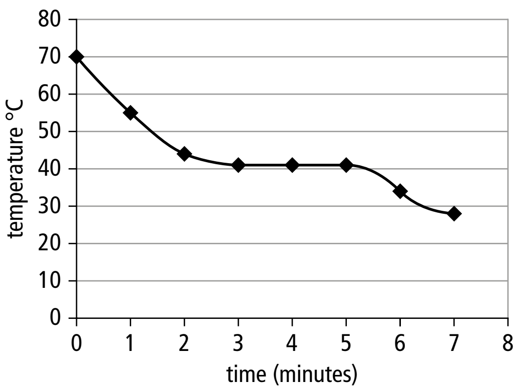
d **i** Chlorine is in the gas state, ethanol is in the liquid state.

ii mercury

6.5 Energy and changes of state

1 A, F, B, D, C, E

2a



b 41 °C

c **i** Label at the plateau (41 °C).

ii Label at the first part of the curve (0,70) to (2,44).

iii Label at the last part of the curve (6,34) to (7,28).

Ea It takes time for energy to leave the water, and go the water particles to arrange themselves into a pattern.

b Water particles in sweat take heat energy away from the body when they evaporate, cooling it down.

c The particles in water need energy (from heating) to overcome the forces holding them together.

6.6 Using particle theory to explain dissolving

1

Word	Meaning
solute	The process of adding a solid to a liquid so that you can no longer see separate pieces of solid.
solvent	A substance that is dissolved in a liquid.
solution	A substance is ________ in a liquid if it dissolves in the liquid.
dissolving	The mass of a substance that dissolves in 100 g of water.
soluble	A liquid in which another substance dissolves.
insoluble	A substance is ________ in a liquid if it does not dissolve in the liquid.
solubility	A mixture of a liquid and dissolved substance.

2 A

3 250 + 10 = 260 g

E

Student	Correct, incorrect, or partly correct
Kim	Partly correct: stirring makes the particles move faster, however if the solution is saturated, no more copper sulfate will dissolve.
Lyla	Correct: if no more copper sulfate will dissolve, they have made a saturated solution.
Mike	Correct: increasing the energy of the water would allow more copper sulfate to dissolve.
Nelson	Correct: you can use filter paper and a filter to remove any undissolved solids.
Peter	Incorrect: if the copper sulfate has dissolved, it cannot be removed by filtration.
Ryan	Correct: increasing the energy of the water would allow more copper sulfate to dissolve.
Sunan	Correct: using evaporation would cause copper sulfate crystals to grow if left long enough.

6.7 Planning an investigation

1a top to bottom: change, control, measure

b **i** measuring cylinder

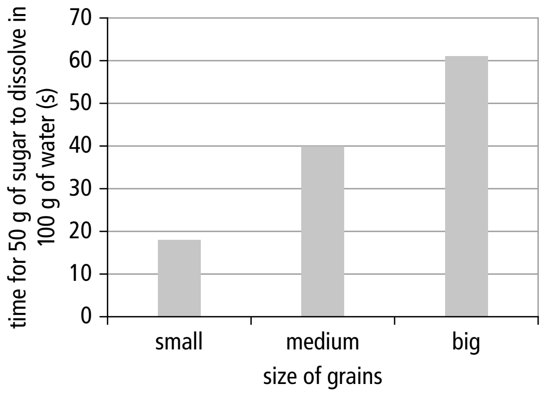
ii laboratory thermometer (not clinical)

c 58 cm^3

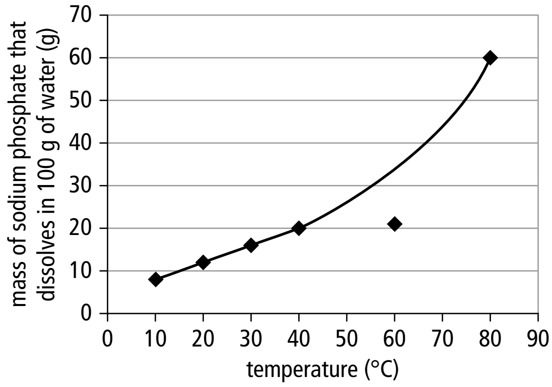
E Measure out 100 cm^3 of water and pour it into a beaker.
Measure the temperature of the water.
Add salt, 1g at a time, with stirring.
When no more will dissolve, write down the mass of the salt added.
Measure out a fresh sample of 100 cm^3 of water and pour it into a beaker.
Heat the water to 40 °C.
Add salt, 1 g at a time, with stirring
When no more will dissolve, write down the mass of the salt added.

6.8 Presenting evidence

1



2a



b iv

E

Temperature (°C)	Copper sulfate	Sodium carbonate	Potassium chloride

7 Material properties

7.1 Introducing elements

1a T
b F – An element is a substance that cannot be split up to make other substances.
c F – There are 92 elements that are found naturally on Earth.
d T
e T
2 gold, copper, iodine, oxygen, chlorine
3 metals: lithium, manganese, nickel, rhodium, tungsten, vanadium, yttrium
non-metals: oxygen, phosphorus, sulfur, xenon, zirconium
4a hydrogen and helium
b oxygen and silicon
c nitrogen
E Anything appropriates

7.2 Metal elements

1 Metal properties – sonorous, shiny, hard, high melting point, good conductor of heat, strong, good conductor of electricity, ductile, high density, malleable.
2 Water pipes – waterproof, high melting point, malleable
Bells – sonorous
Bicycle frames – shiny, hard, high melting point, strong, malleable
Electric cables – ductile, high melting point, good conductor of electricity, strong
Cooking pans – shiny, high melting point, good conductor of heat, strong
Coins – shiny, hard, high melting point, strong
3 A, C, and E are likely to be metals because they have high melting and boiling points, and high density values.
E4 Ways in which lithium, sodium, and potassium are like other metals – they are shiny, and good conductors of electricity.
Way in which lithium, sodium, and potassium are not like other metals – they are soft.

7.3 Non-metal elements

1 Typical metals tend to have high melting and boiling points, whilst typical non-metals have low melting and boiling points. Typical metals are good conductors of both electricity and heat and are shiny. Typical non-metals are poor conductors of electricity and heat and are usually dull looking.
2 C and E are non-metals.
3a Carbon (as diamond) does not conduct electricity.
b Its melting point is higher than 3500 °C and its boiling point is 4827 °C.
Ea Germanium is shiny.
b Germanium is brittle and has poor electrical conductivity.
c Yes, it has both metal and non-metal characteristics. If no, ensure the student has a valid point.

7.4 Making conclusions from data

1a D, F, C, A, E, B
b A, B, E
2a I, L, K, J, G, H
b G, H, J. All three have a high melting point, conduct electricity, and are shiny.
c K, this element cannot conduct electricity but is shiny and silver coloured.
Ea Metals conduct heat much better than non-metals
b The conclusions should say that elements with high thermal conductivity are often metals.

7.5 Metal alloys

1 Low density, stiff, hard, shiny, strong, is not damaged by air and water.
2 The best material for the job is the alloy in column C.
3 Benefits – better than aluminium alloy because it is harder, stronger when pulled, stiffer and has a greater fatigue strength.
Bar chart – name of material on X-axis; property name and units on Y-axis; Y-axis scale drawn with equal divisions.
Disadvantage compared with old aluminium alloy – the new alloy has a greater density. But the added strength of a bicycle made from the new alloy outweighs its extra mass.

7.6 Material properties

1 stiff, strong
2a good conductor of heat, rigid, waterproof
b poor conductor of heat, rigid
c good conductor of electricity, flexible
d poor conductor of heat, flexible
Ea To ensure that the material does not melt when the processors get hot.
b Copper has the highest thermal conductivity and has a high melting point.
c Copper is the most dense and would add weight to the computer.
d Aluminium alloy 6063 is the hardest material and isn't very dense.

7.7 Polymers

1 Buckets, bottles, plates, bags etc (anything reasonable).
2 long, difficult, flexible
3 Pipes: waterproof – prevents water from leaking out of the pipe.
Insulation: does not conduct electricity – protects the surrounding areas from electricity.

Waterproof clothes: waterproof, flexible – keeps the wearer dry and comfortable.
Roofing for houses: flexible, waterproof, does not catch fire easily – roofing needs to be protective, keeping the inhabitants dry and safe from fire.

4a Poly(butene) is suitable for making water pipes because it is not damaged by hot water.
b Poly(butene) is not used to transport water that has had chlorine added to it because it is damaged by chlorine and substances that contain chlorine.

8 Material changes

8.1 Acids and alkalis

1 Acidic substances: limes, lemons, vinegar, vitamin C, fish oils,
Alkaline substances: toothpaste, washing powder.
2 hydrochloric
sulfuric
nitric
sodium hydroxide
3a The last symbol.
b wear gloves and goggles
4a making other chemicals
b 14% is used for soap, detergents, and textiles.
c 7.14 million tonnes

8.2 The pH scale and indicators

1a T
b F – The pH of an alkaline solution is more than 7
c F – The more acidic a solution, the lower its pH.
d T
e T
f T
2 The unknown solution is alkaline. When indicator is added the colour is the same as for sodium hydroxide, which is known to be alkaline.
3 Make indicators from each of the species' petals in turn: add petals to water, heat the mixture, filter, and collect the filtrate.
Test each indicator in turn by adding a few drops to acidic, alkaline, and neutral solutions. If the colour of an indicator is different in two or more of the three solutions, then the species' petals make a suitable indicator.
Ea Solution A is more concentrated since a greater mass of sodium hydroxide is dissolved in the same volume of solution.
b She could dissolve any mass greater than 40 g.

8.3 Neutralisation

1 purple, alkaline, decreases, 7, neutralised, decreases, red
2a F – The lakes are neutralised by adding alkali.
b T
c F – The pH increases.
d T
e F – The pH stays the same, the concentration changes.
3 The last table. Students should plot a graph with points at (0, 1) and (20, 7).

8.4 Planning investigations and collecting evidence

1a By answering the question, the students will know the mass of limestone that will cause a certain change in pH.
b i mass of limestone
ii pH after adding limestone
iii volume of water, pH before adding limestone
c i 20 g of limestone since the pond will then have a neutral pH, and this is the minimum mass that will cause this pH change.
ii The volume of water in the pond.

9 The Earth

9.1 The structure of the Earth

1 Top to bottom: crust, mantle, outer core, inner core
2A C, M, I
B O
C I
D M
E C
F C
3 Ships appear to sink over the horizon, the shadow of the Earth on the Moon is round, the Earth appears round when viewed from Space.
4a B and C
b A and D

9.2 Igneous rocks

1 magma, solidifies, igneous, gabbro, granite, basalt, non-porous, hard
2 There are no gaps between the crystals for water to soak into.
3a Sample 1 – the crystals are different colours.
b Sample 2 – its crystals are biggest
4 Basalt is used for road surfaces because it has a rough surface when it has not been polished. Granite is used for hotel floors because it is hard and durable. Gabbro is used for making sculptures because it can be polished to look attractive.
E5 Gabbro is hard and durable.

9.3 Sedimentary rocks

1 Igneous: granite, basalt, gabbro, quartz
Sediment: limestone, sandstone, claystone, mudstone
Metamorphic: marble, slate, gneiss
2 transportation, deposition, compaction or cementation
3 (in any order)
a Sedimentary rocks are porous because they are made of grains with spaces between them.

b Sedimentary rocks are usually soft, this means that it is easy to scratch them.
c Igneous rocks are not porous because they are made of crystals with no space between them.
d Igneous rocks are usually hard, this means that, it is difficult to scratch them.
4a A
b B
c C – water soaked into the rock, but Marcello could not scratch it. The rock had both igneous and sedimentary properties.

E

Physical: freeze thaw weathering. Water gets into cracks in rocks and freezes at night. Over time the cracks grow and the rock breaks.

Chemical: acidic rainwater. The acidic rainwater dissolves the rocks.

Biological: tree roots and lichens can damage rocks. Tree roots grow through cracks, making them larger and breaking the rock apart. Lichens make chemicals that break down rocks.

9.4 Sedimentary rock formation

1a B because it is made of grains with spaces between them.
b A because it is made of interlocking crystals.
2a D, bubbles came out of the rocks demonstrating that the rock was porous (because there are air spaces between the grains in the rock).
b C, igneous rock is non-porous as there are no gaps between the grains.
3 Sandstone – hard – building material
Claystone – easily moulded when wet – making bricks and pottery
4 A, D, B, E, C
5 Limestone is made from sediments, if creatures have been trapped in the sediment before decomposing and breaking down, a mineralised form of the sea creature can be formed.
Ea Wind, water, gravity (through landslides).
b Deposition is when sediments stop moving and settle in layers
c In cementation, new minerals stick the sediments together whilst in compactation, the weight of the layers above squash the sediments together.

9.5 Metamorphic rocks

1 Marble, slate, and gneiss.
2a F – All sedimentary and igneous rocks can be changed into metamorphic rocks.
b F – Heat or high pressure (usually both) are needed to change an igneous or sedimentary rock to a metamorphic rock.
c T
d F – The rock does not get hot enough to melt.
e F – Technically, only heat or pressure are required but it is usually both.
f T
3 A – it is stripy.
4 Top to bottom:
Limestone: water will be absorbed, limestone is a sedimentary rock with gaps between the grains, allowing water to soak in.
Marble: water will not be absorbed, marble is made of tightly interlocking crystals with no gaps for the water.
Mudstone: water will be absorbed, mudstone is a sedimentary rock with gaps between the grains, allowing water to soak in.
Slate: water will not be absorbed, slate is made of tightly interlocking crystals with no gaps for the water.

E

The left hand fossil. As slate is a metamorphic rock, any fossils within the rock would have been distorted/squashed when the rock was transformed.

9.6 Questions, evidence, and explanations

1

What Jack does	Stage of developing an explanation
Writes down that: The size of salol crystals may depend on the temperature of the surface the liquid salol cools on.	Suggest an explanation
Places liquid salol on warm and cold pieces of glass, and observes the crystals that form.	Ask a question
Looks carefully at his crystals and thinks about whether what he wrote down was correct.	Test the explanation
Wonders what causes salol to form crystals of different sizes.	Check the evidence

2

Statement	Evidence	Explanation
If you look at a cliff face made up of sedimentary rocks, you may see different layers of rock.	✔	
There are no spaces between the crystals of an igneous rock.	✔	
Sedimentary rocks were formed when sediments were deposited. In different time periods, different types of sediment were deposited.		✔
Water does not soak into igneous rocks.	✔	
Fossils found in slate have distorted shapes.	✔	
Igneous rocks do not contain fossils.	✔	
Slate was formed when high pressures squashed mudstone.		✔
Igneous rocks are formed from liquid rock. The liquid rock is hot, and living things cannot survive in it.		✔

E

Ask a question: How is uplift involved in the formation of mountains?

Suggest an explanation: mountains are made of rocks that have been forced upwards by uplift.

Test the explanation: make observations of the rocks that mountains are made from, and similar kinds of rocks. Make a model of uplift.

Check the evidence: look carefully to see if the evidence shows that mountains could have been formed by uplift.

9.7 Using science to Explain predictions: volcanoes

1

Prediction	Scientific explanation
When the steepness of a volcano slope changes, the volcano may erupt.	This change may be caused by magma moving inside the volcano.
When there are more earth movements near a volcano, the volcano may erupt.	This change may be caused by magma moving upwards.
Magma often contains dissolved sulfur dioxide. When extra sulfur dioxide gas comes out of a volcano, the volcano may erupt.	This change may be caused by magma pushing up against surface rock.
When the surface temperature of a volcano changes, the volcano may erupt.	

2 Amisha: when rock cools quickly (e.g. when it comes into contact with water), the crystals form faster and are smaller.
Hakim: when rock cools slowly (e.g. underground near other heat sources), the crystals form slowly and are larger.
Gabir: rocks that are made up of separate grains have air spaces between the grains, allowing water to soak in.

3a Lisimba
b Muna
c Kibibi

9.8 Soil

1 Rock fragments – helps to give the soil its structure. Humus – a store of nutrients for microorganisms. Air – plants need this for respiration. Water – helps to give the soil its structure.

2a Humus
b 25%
c 10%

3a B
b D
c B
d D

E Add sand to the soil, since sand drains better than clay.

9.9 More about soil

1 pores, solid, less, more, loam

2 A, C, E, D, B
3a Hannah: 14 cm^3
Ruth: 36 cm^3
Rachel: 10 cm^3
b Ruth's
4a maize, spinach
b Maiba's and Chenzira's
c Acid to lower the pH between 6.0 and 7.0.

9.10 Fossils
1a Mikayla
b Jayden: No mention of preservation.
Kaden: Does not state what fossils are but only how they are preserved.
Leah: Fossils can be remains or traces of animals or plants.
2a A – 1; B – 4; C – 6; D – 2; E – 3; F – 5.
b A, D, E, B, F, C
E Fossils are very rare as most dead animals or plants are eaten or decomposed. The conditions for fossilisation are very specific.

9.11 Estimating the age of the Earth
1a E
b A
c D
d C or E
2a F – Each time period has its own index fossil, the same fossil can be found in different rock types from the same time period.
b F – Index fossils are only some of the organisms that lived in that time period. There would have been other organisms however they might not have been fossilised.
c T
d T
3 B – P; C – Q; D – R.

9.12 Human fossils
1a Lucy was quickly buried in ash from a volcano.
b Lucy has a smaller bone ratio than modern chimpanzees, but a larger bone ratio than modern humans suggesting that Lucy may have walked on two legs. Lucy's skull volume is smaller than the modern human but larger than the modern chimpanzee.
c Lucy has a smaller skull volume than modern humans but a larger skull volume than that of the modern chimpanzee. This suggests that Lucy was an organism that had evolved from chimpanzees and was an ancestor of modern humans.

10 Forces and motion

10.1 Introduction to forces
1 Correct answers in order: gravity, friction, air resistance, air resistance, gravity, upthrust.
2 The forces have been incorrectly labelled on the first diagram – drag is a combination of friction and air resistance that acts to slow down a moving object. Thrust is a force that acts in the direction that an object is moving, like a car.
To correctly label the diagram the up arrow should be upthrust, and the down arrow should be gravity.
3a Inside a spring balance is a spring. The extension of the spring is proportional to the amount of force applied. When a force is a applied, the spring stretches and the display shows how much force has been applied dependent on the spring's extension.
b tension
c Weight is a measure of force, and is measured in newtons. The bananas have a mass of 1 kg.
Ea

Contact forces	Non-contact forces
friction	weight
air resistance	electrostatic force
water resistance	magnetic force
thrust	
upthrust	
tension	

b Any suitable answer: for example when something is dropped into water.
c Any suitable answer: for example when a car drives from a road onto gravel.

10.2 Balanced forces
1a Incorrect word: balanced.
When a cyclist is decelerating uphill the forces on him are **unbalanced**.
b Incorrect word: cannot.
A cyclist **can** reach terminal velocity going downhill.
c Incorrect word: upthrust.
When friction and **air resistance** are equal to thrust the cyclist is moving at terminal velocity.
2 The box will **move to the left**.
The box will **not move**.
The box will **move to the left, more slowly than in the first case**.
To measure the forces on the block you would use a forcemeter.
3a T
b F – The forces on a rocket taking off are unbalanced.
c T
d F – All objects that accelerate have balanced forces acting on them.
Ea A resultant force is the single force that is equivalent to two or more forces acting on an object.
b From top to bottom: 0 N, 2400 N, – 100 N, 1200 N.
c A – continue moving at a steady speed;
B – accelerate; C – decelerate; D – accelerate.

10.3 Friction

1 Correct answers in order: newtons, in contact, lubrication, opposite to.

2 From top to bottom: large, large, small, large.

3

Friction …	… of friction.
It is difficult to walk on an icy pavement because …	… rely on friction to work.
Matches light because …	… there is not much friction.
Car brakes …	… always slows things down.

Ea wood, paper, sandpaper, carpet

b The mass of the block has increased, so he would need to lift the ramp higher.

10.4 Gravity

1 Both arrows should start on the people and point towards the centre of the Earth.

2a N

b The third result is incorrect – the correct weight would be 2.0 N.

3a D

b D

Ea

Mass of object on Earth	**Weight on Earth (N)**	**Mass of object on the Moon**	**Weight on the Moon (N)**	**Mass of object on the planet**	**Weight on the planet (N)**
50 g	0.5	50 g	0.08	50 g	2.5
500 g	5	500 g	0.8	500 g	25
2 kg	20	2 kg	3.2	2 kg	100
25 kg	250	25 kg	40	25 kg	1250

b 50 N/kg

c The gravitational field strength of the planet is greater than that of Earth, so it has a greater mass.

10.5 Questions, evidence, and explanation

1 Missing words in order: questions, observations, explanations, proof, ideas, evidence, explanations.

2a Newton thought there was a force acting on the Moon because it was constantly changing direction. An object can only change direction if a force acts on it.

b It was hard for people to believe because the Earth is not touching the Moon.

c From top to bottom: Make observations using space telescopes. Check the evidence supports the prediction

3a F – Evidence can support an explanation, but not prove it is true. The explanation may be wring or incomplete.

b T – It explained all observations at the time.

c T

d **F –** Scientist may look for a new explanation or improve the current one.

Ea The Earth cannot be falling down as there is no down in space, but it is being pulled towards the Sun.

b Bhaskaracharya and Newton both noticed that objects fall towards the Earth and that a force must be acting on them, and that it would also be acting on objects like the earth and the Moon.

c Bhaskaracharya could not test his ideas or make predictions, Newton was able to predict the existence of Neptune.

10.6 Air resistance

1 Missing words in order: friction, air resistance, balanced, friction, air resistance, air resistance, streamlined.

2 G, C, A, D, E, F, B

3a Birds take on a streamlined shape to dive into water and catch fish, to reduce the water resistance acting on them.

b Large parachutes slow you down more than small parachutes because they have a larger surface area and so experience more air resistance.

Ea Down arrow labelled gravity, up arrow labelled air resistance. On the Moon these arrows should be much smaller.

b In both speed increases to reach a terminal velocity and then travel at a constant speed until they reach the ground. The paper would fall slower on the Moon as there is almost no air resistance and less gravity.

c Objects fall at the same rate even if they are different masses. Any difference in speed on Earth is caused by air resistance, but on the Moon there is much less air resistance.

10.7 Planning investigations

1 Any suitable answers: How does the size of the mass affect the deflection?
Does the height of the books change the deflection?

2 I predict that the further apart the books are the greater the deflection will be.

3 Distance between the books, mass of object, type of card, height of books.

4 Equipment: books, cardboard, masses, ruler.

5 Plan of investigation:

6 A

Distance between the books	Deflection

E Any suitable answer: The student might have problems

11 Light

11.1 What is light?

1 Correct answers in order: straight, shadows, images, reflections, straight, travels.

2a Correct answers in order: closer to, away from, closer to.

b The shadow would be sharp as the torch is point light source.

3a A-C, A-E, C-E, D-E

b Light cannot travel in a straight line between them as there are buildings in the way.

Ea Light travels in a straight line from the top and bottom of the lamp to meet at the pinhole. From here it continues in a straight line to produce an inverted image.

b You would need to turn the lamp upside down, turning the camera would not affect the light and would still produce an inverted image.

11.2 How do we see things?

1 Completed sentences: You cannot see through opaque materials like concrete. You can see through transparent materials like glass. Light can get through translucent materials but you cannot see through them.

2a The reading is a measure of how much light is transmitted by the material.

b The reading is a measure of how much light the material is reflecting.

3a B

b C

c A

E

Part of the eye	Mainly transmitted	Mainly absorbed
pupil	✔	
cornea	✔	
rod cells		✔
lens	✔	
cone cells		✔
eyelid		✔

11.3 The speed of light

1a 1/100 000 of a second

b No, this is a too short amount of time to detect and respond to with the human eye.

c 300 000 km – the problem with doing this experiment is that they would not be able to see each other due to the distance and the curvature of the Earth.

2a It takes time for light to travel through space to Earth.

b 6.2 million km = 20.7 light seconds, 9.4 million km = 31.4 light seconds

c When Io is furthest from the Earth, the Earth is on the far side of the Sun from Jupiter and Io is on the far side of Jupiter from the Sun and Earth.

3 There is a range of values for Mars and Earth because as they orbit the Sun at different speeds they are at different points of their orbit and so distances between them change.

11.4 Reflection

1a F – The image you see in a mirror is a virtual image.

b F – if you look in a mirror your image looks as if left and right are swapped over.

c F – The reflection of light from a mirror is regular reflection.

d T

e F – your mirror image appears the same distance from the mirror as you.

2a

Things that are the same about you and your mirror image.	Things that are different about you and your mirror image.
Size, colours, up and down, distance from the mirror.	Left and right are reversed.

b 100 cm

Ea A beaker of water.

b The glass transmits and reflects light. Light from the beaker is transmitted and light from the candle is reflected to the same place making is appear as if the candle is burning underwater.

c Diagram with light transmitted through the glass in straight lines from a beaker.

d Replace the beaker with a lit candle.

11.5 Making measurements: the law of reflection

1a Measurement for the angle 40°.

b It is not in line with the other results.

c Through points for 0, 20, 60 and 80 degrees.

d They show that the angle of incidence is always the same as the angle of reflection.

e A white screen absorbs more light than a mirror, which means less is reflected.

2 Statement A – F, Statement B – T, Statement C – F, Statement D – T, Statement E – T

3 B

Ea Normal is at right angles to the surface.
b Reflected ray is same angle from the normal as the incidence ray.
c Draw another ray at any other point on the wall.
d Draw an appropriate normal and reflected ray.
e The reflection from a stone wall is not regular because the wall is uneven so you do not see a reflection.

12 Electricity

12.1 Electrostatic phenomena

1a positive, negative, electrons
b conductors iron
c insulators, plastic
2a positively charged
b The diagram shows more positive symbols.
c minus
d the paper will be attracted to the rod if it is negatively charged
e The paper has an opposing charge to the rod, so it will be attracted to the rod.

3a **i** positive
ii The paint will be attracted to the car.
iii It is cleaner and more efficient as the paint is attracted to the car and will not go everywhere.
b positive

12.2 Dangers of electrostatic phenomena

1a the process of connecting objects to the ground
b a flash of light you see when the air conducts electricity
c the flow of electric charge
d the probability of something happening and the consequences if it does
2a As the petrol moves through the nozzle electrons are transferred.
b A spark could ignite the petrol.
c The nozzle is earthed through the car.
d It will earth the nozzle allowing charge to flow away.
e Earthing the nozzle reduces the risk to drivers and cars of petrol igniting and exploding by conducting away the charge.
3a A lightning conductor will carry any charge from lightning to the ground avoiding damage to the building.
b If lightning strikes your car it will be conducted to the earth, but if you are outside and lightning strikes you it will harm you severely.
Ea Not normally, but if charge builds up in a cloud then air will conduct electricity.
b A vacuum is an insulator as there are no particles that can be charged or carry charge.
c It is very dangerous to be out in a thunderstorm because you could be struck by lightning, and the current would go through you to earth.

12.3 Digital sensors

1a Correctly labelled diagram has positive charge on the right and negative charge on the left with dielectric between the plates.
b electrons
c The charge would move from the left to right to become equal.
2 Correct answers in order: capacitor, plates, position, CCD, charge, pixel
3a B, E, A, D, C
b There is a delay whilst the charge is moved from the CCD and converted to a digital signal.
Ea An electric field is a field around a charge.
b It moves towards the charge plates.
c positive
d The size of the field is the same everywhere between the plates.

12.4 Electric circuits – what can you remember

1 Images in the left column are in order: cell, open switch, ammeter, lamp, battery, voltmeter, motor. Images in the right column are in order: ammeter, lamp, cell, voltmeter, motor, open switch, battery.
2

Conductors	Insulators
metal spoon, piece of graphite, aluminium foil, iron nail	wooden spoon, plastic spoon, paper cup, plastic bag

3a Metal conducts electricity and wires need to be able to conduct electricity.
b Plastic is an insulator so it covers wires to protect you from the current.
c The pins need to conduct electricity and metal is a conductor.
d The outside of a plug is made of plastic to protect you from the current.
Ea Students should leave a gap to connect the material, and connect the cell to the lamp.
b The air conduct electricity, such as lightning at very high currents and voltages.

12.5 Current: what is it and how can we measure it?

1

The current in a wire is …	… in ampere, or amps.
Inside a metal wire …	… the charge flowing per second.
There are 1000 milliamps …	… provides the push to make electrons in a wire move.
You measure current …	… in one amp.
The battery …	… there are lots of electrons that move.

2a B and C
b A – close the switch, D – reverse one of the cells, E – add a cell.

3a F
b F
c T
d F
4a 2 A
b 2 A
c The current flowing through the battery is 2 A.

12.6 Parallel circuits

1 Series circuit with a switch and bulb.
Parallel circuit with a switch before the circuit branches.
Parallel circuit with a switch before the circuit branches and in each branch.
2a C
b It is the only circuit where the lamps are not on separate branches of the circuit.
3a Correct answers in order: 0.2, 0.1, 1.1
b The current is different in the branches because they have different resistance.

12.7 Modelling electric circuits

1a Correct answers in order: water, cyclist, chain, back wheel, rate of water flow.
b Add a tap or valve.
c No cyclist to turn the pedals.
2 Any suitable answer: circuit 1 needs two different components, circuit two has cells incorrectly connected.
Ea Half the students go down the first branch and half down the second one. The lamp on the first branch gets all of the sweets for that branch, but on the second branch they are divided equally between the two.
b The person represent the battery hold two ropes, pulling them both round the circuit. Branch one has one person holding onto one of the ropes, branch two has two people holding onto the other rope.

12.8 How components affect current

1 Correct answers in order: dimmer, the same brightness, brighter, bigger, smaller, adds up.
2 A1, C1, D2 and D3.
E

	In B compared with A	**In C compared with A**
the brightness of the bulb or bulbs	twice as bright	the same
the reading on the voltmeter	twice as high	the same
the reading on the ammeter	twice as high	the same

12.9 Voltage

1 Missing words in order: voltage, energy, charges, charges, current, energy, current, volts, voltmeter.
2a 6 V
b 0 V
c 3 V
3a F
b T
c F
d T
e T
Ea Lamp A would switch on, the brightness of lamps B and C will not change.
b It will go from 0 v to 12 V.
c It will stay at 6 V.
d It will stay at 6 V
e It will increase.

12.10 Selecting ideas to test circuits

1 a and c
2 Independent variable: current, Dependent variable: temperature of the water. Variables to control, wire, voltage, room temperature time in the water. Students' own answers.

12.11 Energy and power

1a F – Lamp A is less powerful than lamp B.
b F – The first motor is more powerful.
c T
d F – They are the same power.
e F – There are 1000 watts in a kilowatt, there is only 1 watt in a watt.
2 Correct answers in order: 1000 W/1 kW, 500 W, 1 W, 800 W.
3a 10 kJ
b 6000 kJ
c 2 seconds
4a 0.8 kW
b 0.5 hours, 0.4 kWh
c 4 rupees

13 The Earth and beyond

13.1 The night sky

1 Orbits the Earth:
Does not give out light: A, C, D
Both: B, E
2a F – not all of the object we see in the night sky are in orbit around the Sun.
b F – some of the stars in the night sky are bigger than our Sun.
c T
d T – and Saturn.
e F – we can see manmade objects, like satellites.

3

	Comet	Meteor	Asteroid
Made of ice and dust	✔		
Made of rock		✔	✔
Called shooting stars		✔	
Visible in the night sky	✔	✔	
Burns up as it enters the atmosphere		✔	

Ea Comet Hale Bopp – 4497, Halley's Comet – 2062

b The larger the period of the comet the further it travels from the Sun.

c Comet Hale Bopp – its closest distance from the Sun is 0.9 compared to the Earth, which would be 1, if these are at a similar position relative to the Sun it would be very close to the Earth.

13.2 Day and night

1 Students should label the light side day, the dark side night, the central axis and north pole at the top, and south pole at the bottom.

2a A

b E

c B

d D

e C

f F

3a move, day

b spins, 24 hours, day

c day, night

d anticlockwise

Ea Jengo and Simba can use this model to explain day and night because the torch represent the Sun. As Jengo turns anticlockwise you will see the path of the torch move around the map as the rays of the Sun would move on the Earth's surface.

b Foucault's pendulum demonstrates that the Earth is spinning.

13.3 The seasons

1a orbit

b The Sun and the Earth are similar sizes, but the Sun is really a lot bigger than the Earth.

c

Position	Southern Hemisphere	Northern Hemisphere
A	Spring	autumn
B	Summer	winter
C	Autumn	spring
D	Winter	summer

2a summer, days, nights, high

b winter, nights, days, low

c warmer, longer, more, are not

3a Southern

b Sunrise is earlier in January than July, which means January must be summer, and this only happens in the southern hemisphere.

Ea A

b In the summer the Sun is directly overhead like in tray A, but in the winter its rays hit the Earth's surface at an angle like in tray B.

13.4 Stars

1a F – You see different stars at different times of year

b T

c F – Our star is not the brightest star, it is just the closest.

d F – The stars in a constellation can be different distances away.

2a The Earth spins on its axis throughout the night so the stars appear to move in circles.

b Sigma Octantis

c Polaris

d Sailors used the two pole stars to navigate because they did not move in the night sky.

3a A constellation is a pattern of stars noticed by humans.

b They are further away.

c All stars appear the same brightness because they are so far away the differences are not easily detectable to the human eye.

13.5 Our Solar System

1

	Correct?
All planets orbit the Sun.	✔
Pluto is an exoplanet.	
Dwarf planets do not orbit the Sun.	
Planets that are further from the Sun are colder than planets that are closer.	✔
All the inner planets are rocky.	✔
Asteroids orbit the Sun between Mars and Jupiter.	✔

2a diameter

b number of moons

c Distance from the Sun and time to orbit the Sun, because the further a planet is from the Sun the slower it moves and the further it has to travel to orbit the Sun once.

E An exoplanet is a planet that orbits a star other than our Sun.

i It is possible to think Pluto is a planet because it orbits the Sun.

ii It is possible to think that Pluto is not a planet because its orbit is not in the same plane as all of the other planets.

13.6 The Moon

1a F, A, B, G, H, E, C, D

b E and G

c H
d We only see the area of the Moon that is lit up and facing us, other parts are lit up by the Sun at the same time. For example in a new moon we see only a dark moon, the other side is lit by the Sun but we cannot see it.
2a From left to right: Sun, Earth, umbra, moon, penumbra.
b Lunar eclipse as the Moon is in darkness because the Earth is blocking the Sun's light.
c Student should draw a diagram like the one on p63 of the Student Book.

13.7 Explanations – geocentric model

1 Missing words in order: questions, stories, measurements, measurements, explanations, explanations, model.
2a Draw the Earth at the centre, planets and sun in orbit around the Earth.
b Beyond the furthest orbit.
c Everything in the night sky appeared to orbit around Earth.
3a Models are based on observations and measurements.
b The planets appeared to wander, their motion did not fit the model.
c Ptolemy added smaller epicycles to the orbits of the planets.
d Ptolemy's explanation was useful because it explained the movement of everything in the sky and could be used to make predictions.
Ea Greek astronomers did not have good enough equipment.
b Now astronomers have much better equipment, like telescopes.

13.8 Heliocentric model

1a The size also changes.
b B
c A – this model has a simpler explanation of the changing size of Venus over time.
2

	True for Copernicus	True for Galileo
wanted to talk about his ideas		✔
thought that the Sun was at the centre of the Solar System	✔	✔
used a telescope to make observations		✔

E Geocentric model: a, c
Heliocentric model: b, d, e

13.9 Communicating ideas

1a movement of the Sun and stars, and solar and lunar eclipses
b motion of the planets
c It was not easy to communicate when Aryabhata was alive, his ideas may not have been written down, or the writings were not taken to other countries or written down in other languages.
2a Measuring the position of the stars and planets in the sky.
b water clocks
c The Egyptians made measurements using water clocks and merkhets so their observations were more accurate than the drawings ancient people made. Ancient people created stories to explain what they could see, rather than making measurements and using them to create explanations.
Ea Communication was difficult then, ideas were not written down or were taken to other countries and written in other languages.
b Islamic astronomers may not have known about the heliocentric model.

13.10 Beyond our Solar System

1a E, A, D, C, G, F, B
b E
c You cannot travel beyond the edge of the Universe in a spaceship.
2a The different separations are within each other.
b Inside the solar system: G, A
Inside the Milky Way, but outside the solar system: E, C, D, H
Inside the Universe but outside the Milky way: B
F is difficult to place as it could be in both of the two outer circles.
c Planet could be added to all three circles, it would be difficult to place.
3a Count a small area of the crowd and multiply.
b Astronomers use the same method to count stars.

13.11 Using secondary sources

1

	Primary source	Secondary source
data from a book in a library		✔
data from measurements that you have made	✔	
data from a field study		✔
data on a website		✔
data from measurements that someone else has done and given to you		✔

2a secondary data
b The data indicates there is spiral galaxies are not brighter as one is less bright than the elliptical

galaxy, but this may have been affected by distance. There is only one elliptical galaxy listed, she needs more evidence.

c **i** Plot the graph from the table.

ii There is no clear link between distance and brightness.

iii Collect more data.

Ea Repeating measurements makes it easier to spot when an anomalous result has been recorded.

b It is important to check secondary data as the source could be incorrect.

13.12 The origin of the Universe

1a T

b F – The Earth is not at the centre of the Universe.

c F – When astronomers look at galaxies they are all moving away from us.

d F – The Solar System formed 5000 million years ago.

e T

2a Each centimetre will represent 140 million years, so he will find it difficult to draw from dinosaurs to today as they happened over a relatively short period of time and will be difficult to separate at that scale.

b It will be easier as each centimetre will represent 70 million years, but it will still be difficult to show when humans began to exist.

3a The student can draw galaxies on the elastic band and stretch it to show they are moving apart.

b If he holds one end and stretches the other, the galaxies at this end will move further away than those closer to the end he is holding.

c All of the galaxies astronomers observe display red shift, this means they are moving away from us.

