INTERNATIONAL SECONDARY SCIENCE 2
TEACHER PACK

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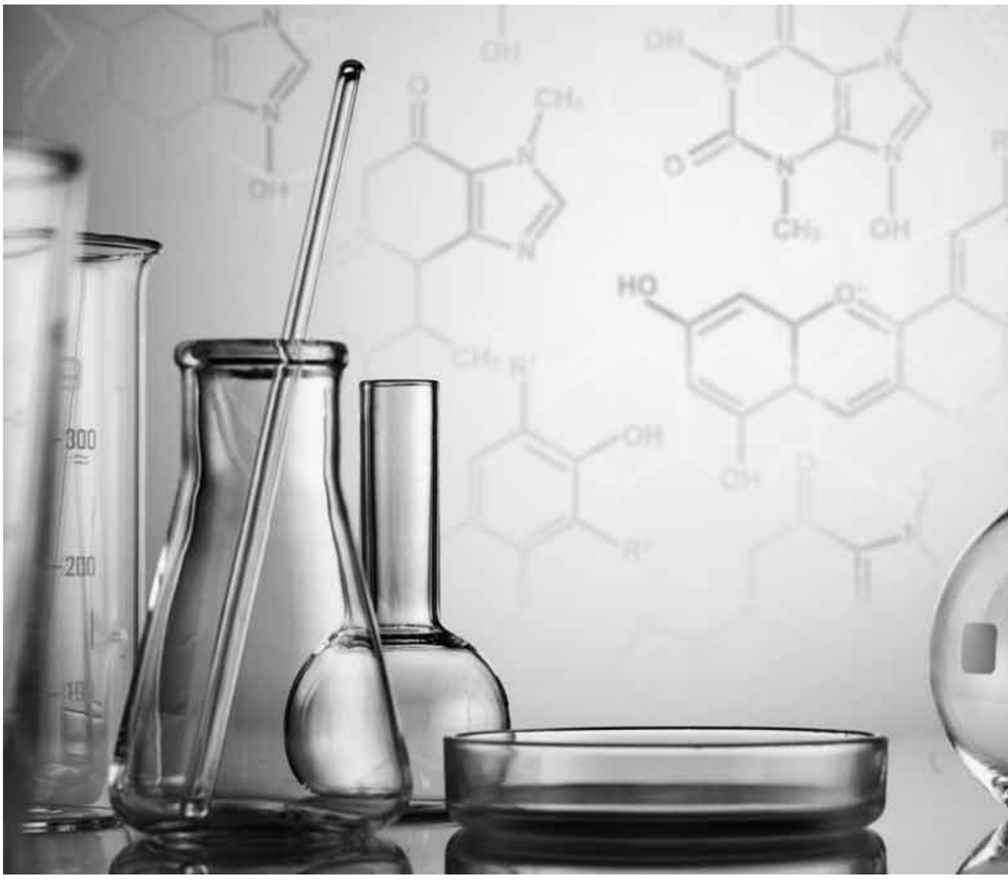

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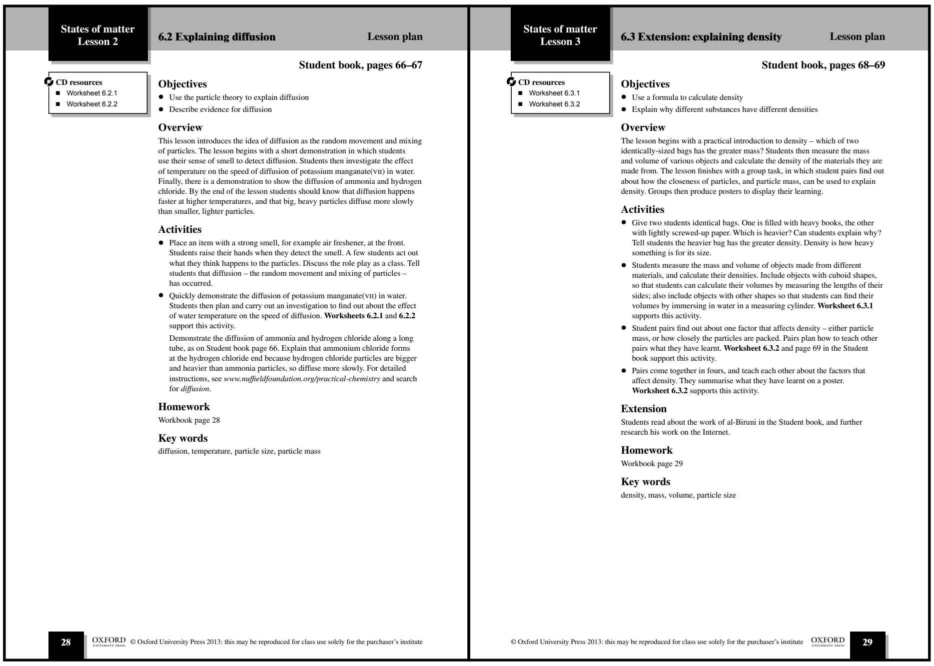
How to use your Teacher Pack

Welcome to your **International Secondary Science 2** 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.



States of matter Lesson 2

6.2 Explaining diffusion — Lesson plan

Student book, pages 66–67

CD resources
- Worksheet 6.2.1
- Worksheet 6.2.2

Objectives
- Use the particle theory to explain diffusion
- Describe evidence for diffusion

Overview

This lesson introduces the idea of diffusion as the random movement and mixing of particles. The lesson begins with a short demonstration in which students use their sense of smell to detect diffusion. Students then investigate the effect of temperature on the speed of diffusion of potassium manganate(VII) in water. Finally, there is a demonstration to show the diffusion of ammonia and hydrogen chloride. By the end of the lesson students should know that diffusion happens faster at higher temperatures, and that big, heavy particles diffuse more slowly than smaller, lighter particles.

Activities
- Place an item with a strong smell, for example air freshener, at the front. Students raise their hands when they detect the smell. A few students act out what they think happens to the particles. Discuss the role play as a class. Tell students that diffusion – the random movement and mixing of particles – has occurred.
- Quickly demonstrate the diffusion of potassium manganate(VII) in water. Students then plan and carry out an investigation to find out about the effect of water temperature on the speed of diffusion. **Worksheets 6.2.1** and **6.2.2** support this activity.

  Demonstrate the diffusion of ammonia and hydrogen chloride along a long tube, as on Student book page 66. Explain that ammonium chloride forms at the hydrogen chloride end because hydrogen chloride particles are bigger and heavier than ammonia particles, so diffuse more slowly. For detailed instructions, see *www.nuffieldfoundation.org/practical-chemistry* and search for *diffusion*.

Homework

Workbook page 28

Key words

diffusion, temperature, particle size, particle mass

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States of matter Lesson 3

6.3 Extension: explaining density — Lesson plan

Student book, pages 68–69

CD resources
- Worksheet 6.3.1
- Worksheet 6.3.2

Objectives
- Use a formula to calculate density
- Explain why different substances have different densities

Overview

The lesson begins with a practical introduction to density – which of two identically-sized bags has the greater mass? Students then measure the mass and volume of various objects and calculate the density of the materials they are made from. The lesson finishes with a group task, in which student pairs find out about how the closeness of particles, and particle mass, can be used to explain density. Groups then produce posters to display their learning.

Activities
- Give two students identical bags. One is filled with heavy books, the other with lightly screwed-up paper. Which is heavier? Can students explain why? Tell students the heavier bag has the greater density. Density is how heavy something is for its size.
- Students measure the mass and volume of objects made from different materials, and calculate their densities. Include objects with cuboid shapes, so that students can calculate their volumes by measuring the lengths of their sides; also include objects with other shapes so that students can find their volumes by immersing in water in a measuring cylinder. **Worksheet 6.3.1** supports this activity.
- Student pairs find out about one factor that affects density – either particle mass, or how closely the particles are packed. Pairs plan how to teach other pairs what they have learnt. **Worksheet 6.3.2** and page 69 in the Student book support this activity.
- Pairs come together in fours, and teach each other about the factors that affect density. They summarise what they have learnt on a poster. **Worksheet 6.3.2** supports this activity.

Extension

Students read about the work of al-Biruni in the Student book, and further research his work on the Internet.

Homework

Workbook page 29

Key words

density, mass, volume, particle size

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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 resources
- Spreadsheet 1.1.1
- Spreadsheet 1.1.2
- Worksheet 1.1.3
- Spreadsheet 1.1.4
- Spreadsheet 1.1.5
- Worksheet 1.1.6

Objective

- Investigate the variation between individuals

Overview

This lesson introduces the idea that individuals vary. Students learn that we each have a different combination of features and that it is not just our appearance that varies.

Activities

- To introduce the idea of variation, give students PTC taste test papers to taste. Have a bin to hand and water available for those who can taste it – it will either taste very bitter or be completely tasteless.
- Introduce the term variation to describe the differences between individuals and show students other differences by asking whether: their left arm is on top when they fold their arms; they have a widow's peak, free ear lobes, dimples, and eyes that are not blue. **Spreadsheet 1.1.1** illustrates these features and could be used to record students' responses. They could use **worksheet 1.1.3** to record their own features. **Spreadsheet 1.1.2** could be displayed to demonstrate how to do this. Stress that their personal profile only compared six features, but we have thousands of different features and most of these are hidden. The combination of features we possess makes each of us unique.
- Read pages 2–3 of the Student book and stress that all the features students have been looking at show discontinuous variation. Other features show continuous variation or are unique to each person.
- To demonstrate continuous variation, get students to line up in order of height. Highlight the fact that their heights can take any value. Volunteers could use tape measures taped to the wall to measure everyone's height in cm. These could be used to construct a frequency chart using **spreadsheet 1.1.4**.
- Students could examine their fingerprints using a magnifying glass. Then use **spreadsheet 1.1.5** to classify them as loops, arches, or whorls and produce a frequency chart.

Extension

Students use **worksheet 1.1.6** to draw a frequency chart for a continuous variable.

Homework

Workbook page 1

Key words

variation, discontinuous variation, frequency chart, category, continuous variation, range, biometrics

1.2 Extension: Causes of variation

Student book, pages 4–5

CD resources
- Worksheet 1.2.1
- Worksheet 1.2.2
- Worksheet 1.2.3

Objective

- Understand why individuals are different

Overview

This lesson introduces the idea that we inherit genes from each parent. Genes influence our features by controlling our cells. Features influenced by single genes show discontinuous variation. There are only a few different options. The concept of environmental variation is also introduced. Students learn to distinguish features that are not influenced by the environment from inherited features. They should come to appreciate that the vast majority of our features result from the interplay of genes and environmental factors and display a continuous range of values.

Activities

- Student pairs discuss why we resemble our parents.
- Use page 4 of the Student book to explain that what we actually inherit from our parents are genes. These control our growth and development so they determine the features we inherit. There is a copy of every gene we inherited in the nucleus of all our cells.
- Have plants grown in the dark and plants grown in full sun on display. Tell students that the seeds were planted at the same time and came from the same parent so they should have similar genes. Introduce the term 'environmental variation' to describe the differences between them. Students should appreciate that genes are not only things that influence growth and development.
- Stress that identical twins inherit exactly the same genes so their differences can only be caused by differences in their environments.
- Students read page 4–5 of the Student book to learn more about environmental variation.
- Groups sort the cards from **worksheets 1.2.1** and **1.2.2** into those that are inherited (cards 1, 2, 4, 5, 13), those determined only by the environment (cards 8, 15), and the rest that result from the interplay of genes and the environment.

Extension

Students review the work on pages 4–5 of the Student book by completing **worksheet 1.2.3**.

Homework

Workbook page 2

Key words

genes, inherited variation, environmental variation

Student book, pages 6–7

CD resources
- Worksheet 1.3.1
- Worksheet 1.3.2
- Worksheet 1.3.3
- Worksheet 1.3.4

Objective

- Understand what is meant by a species

Overview

This lesson introduces the definition of a species and the use of two-part Latin names.

Activities

- Challenge groups to list an animal for every letter of the alphabet. There is an illustrated A–Z of animals on Blogjam (search Google for Blogjam's Amazing A–Z of Animals). Another possible list is: antelope, bear, cheetah, dog, elephant, fox, giraffe, hippopotamus, iguana, jaguar, koala, lion, meerkat, newt, orang-utan (a type of ape), panda, quokka (similar to a kangaroo), rhinoceros, snake, tiger, urutu (a type of snake), viper (another type of snake), wolf, Xantus's hummingbird, yak (similar to a cow), zebra. Establish that each type of plant or animal is a species. Scientists estimate that there are at least 3 million species.
- Use page 6 of the Student book to point out that it is often hard to tell whether two animals belong to the same species. If they can breed and produce fertile offspring, they are members of the same species. (This is a grey area because artificial insemination allows some animals that don't normally breed to produce fertile offspring.)
- Pairs use the picture cards from **worksheets 1.3.1** and **1.3.2** to match fertile and infertile offspring with their parents and see which parents belong to different species. Same species – Boxer and Dalmatian; Persian and Siamese; pig and wild boar. Different species – lion and tiger; donkey and horse; zebra and horse.
- Students learn how species are named by reading pages 6–7 of the Student book. **Worksheet 1.3.3** supports this activity.

Extension

Students deduce whether the two clouded leopards shown on **worksheet 1.3.4** belong to different species. The expected answers are: 1. They have similar tail and body lengths, cloud markings, and teeth. They have different coloured coats, their cloud markings are a different size and colour, and they have at least 40 different genes. 2. They are different species because their genes are so different. 3. Scientists do classify them as different species. They share the same first name because they are closely related.

Homework

Workbook page 3

Key words

species, hybrid, infertile, Latin

Student book, pages 8–9

CD resources

- Worksheet 1.4.1
- Worksheet 1.4.2
- Worksheet 1.4.3
- Worksheet 1.4.4
- Worksheet 1.4.5
- Worksheet 1.4.6

Objective

- Understand what classification involves, and classify invertebrates into their major groups

Overview

This lesson introduces classification. Students will learn to distinguish vertebrates from invertebrates and practise putting invertebrates into smaller subgroups.

Activities

- Use page 8 of the Student book to introduce the idea that animals are classified to make it easier to name them, and to store what we know about them. They separate into two major groups: those with backbones and those without.
- Stress that although they are usually very small, invertebrates vastly outnumber vertebrates in number of different species, number of individual animals, and total mass of living things. Most invertebrate species are arthropods. Like vertebrates, they have a skeleton, but it is on the outside – and this only works well for small animals. Short videos of most types of invertebrate are available as free downloads from the ARKive website. Choose the 'Explore' tab, then under 'Species groups' choose from the 'Invertebrates' options.
- Students classify the 24 arthropod images from **worksheet 1.4.3** into the subgroups shown on **worksheet 1.4.2**. **Worksheet 1.4.1** provides full instructions. (Note that the last part of the classification can only be done effectively if **worksheet 1.4.3** is printed out in colour.) The correct groups are: **other arthropods** – 4 crab, 14 millipede, 19 spider, 21 shrimp, and 23 mite; **other insects** – 1 ant, 2 flea, 6 butterfly, 8 fly, 11 cockroach, 15 water boatman, 16 wasp, and 18 dragonfly; **other beetles** – 3 water beetle, 9 stag beetle, 17 goliath beetle, and 24 wood-eating beetle; **other ladybirds** – 7 unspotted ladybird, 5 striped ladybird, and 20 brown ladybird; **other spotted ladybirds** – 10 water ladybird, 12 14-spotted ladybird, and 22 11-spotted ladybird; **7-spotted ladybirds** – 13 7-spotted ladybird.

Extension

- Ask each student to research one of the eight different invertebrate subgroups on **worksheets 1.4.4** and **1.4.5** using the internet. These are labelled A–H in order of difficulty. The biggest group in terms of numbers of individuals is the nematodes. These have been left out deliberately because many are parasites and students are likely to come across some disturbing images if they use nematode or roundworm as a search term on the internet.
- Groups of students could summarise the information about each group on **worksheet 1.4.6**, using the arthropod and insect boxes as examples. Stress that all the other invertebrate groups have further subdivisions, not just the arthropods. We are concentrating on the arthropods because they have many more species than any of the other groups.

Homework

Workbook page 4

Key words

classification, vertebrates, invertebrates, arthropods, molluscs, echinoderms, cnidarians, annelids, nematodes, flatworms, insects, arachnids, crustaceans, myriapods, beetles, ladybirds

Student book, pages 10–11

CD resources
- Worksheet 1.5.1
- Worksheet 1.5.2
- Worksheet 1.5.3
- Worksheet 1.5.4
- Worksheet 1.5.5
- Worksheet 1.5.6

Objective

- Classify vertebrates into their major groups

Overview

Students learn what is different about the main vertebrate groups, practise vertebrate classification, and predict what features an animal from a particular group will have.

Activities

- Label tables around the room with the names of the vertebrate groups. Give each student a vertebrate card from **worksheets 1.5.**1 and **1.5.2** and ask them to find the right table for their animal. Then give groups time to check that their animals belong together. The cards for each vertebrate group are labelled A–F in order of difficulty; the reptiles and amphibians are the hardest to classify. Groups should find they have missing or duplicate letters if students have not identified the correct group for their vertebrate.
- Emphasise that all the animal cards show vertebrates. These animals all have backbones to protect their spinal cords. If any vertebrate animal skeletons are available, they could be put on display.
- Stress that each vertebrate group has distinct features. Ask groups of students to identify the features that apply to their animals. These are shown on **worksheets 1.5.3** and **1.5.4** and could be called out one at a time. They are: for mammals – give birth to live young, produce milk, hair; for birds – wings, feathers, shelled eggs; for reptiles – dry skin, hard scales, waterproof eggs; for amphibians – moist skin, larvae have gills; for fish – soft scales, adults have gills, eggs laid in water, fins.
- Ask if students have pets, and how much these pets eat. They should appreciate that mammals and birds need more food than fish, amphibians, and reptiles. Explain that one of the reasons for this is that mammals and birds keep their body temperature constant – they are warm blooded. The other groups are cold blooded, but can warm themselves up by lying in the sun.
- Give students a chance to claim a warm blooded or cold blooded card for their group. A volunteer from each group could then use the animal cards and feature cards to create an instant poster to leave on display. Students could complete the summary on **worksheet 1.5.5** using a tick or a cross in each box.
- Students should read pages 10–11 of the Student book and complete the summary on **worksheet 1.5.6**.

Extension

If the internet is available, students could practise classifying vertebrates using a classification animation like the one on the Science NetLinks website: http://sciencenetlinks.com/interactives/class.html or try the ‘Animal hit’ game on the KScience website (choose ‘animations’; ‘Animal hit’ is under Biology).

Homework

Workbook page 5

Key words

fish, amphibians, reptiles, birds, mammals

1.6 Classification of plants

Student book, pages 12–13

CD resources
- Worksheet 1.6.1
- Worksheet 1.6.2

Objective
- Classify plants into their major groups

Overview
Students learn about the major groups of plants and practise plant classification.

Activities
- Show students a selection of objects made from plants and ask what they have in common, e.g. a mat, nuts, compost, rope, milk, wood, charcoal, oil, chocolate. There are about 300 000 species of plant and one in five of them provide useful products. As with animals, we need to classify them so we can give each species a unique two-part Latin name.
- Give groups of students sets of plant cards from **worksheet 1.6.1**. They should sort the cards into groups with similar features.
- Use page 12 of the Student book to show the four main groups of plants. Ideally, have grass, a fern, moss, a conifer branch, and a flowering pot plant on display for comparison. Students could complete **worksheet 1.6.2** to summarise the differences between them.

Extension
Students read page 13 of the Student book to learn why algae are not classed as plants, even though they can make their own food. This extension section also explains the origin of the binomial system of classification.

Homework
Workbook page 6

Key words
flowering plants, conifers, ferns, mosses, spores, algae

Student book, pages 16–17

CD resources
- Worksheet 2.1.1
- Worksheet 2.1.2

Objectives
- Describe the role of the skeleton
- Understand why joints are needed

Overview
Students learn the roles of the skeleton and joints, compare their own elbow and shoulder joints, and examine the bones and joints in a chicken wing.

Health and safety
Warn students to keep all the chicken parts and used scissors in the dissecting tray.

The dissected material and any disposable towels used should be tipped into a large plastic bag for disposal at the end of the session. The dissecting tray and scissors need to be sterilized. Warn students to wash their hands after handling the chicken.

Activities
- Student pairs discuss what they know about their skeleton. What is it made of? What holds it together? Why do we need it? Use page 16 of the Student book to show the skeleton's role and its main bones and joints.
- Ask students to hold their arms out at shoulder level with their palms facing each other, then bend and straighten one arm. Explain that the elbow joint is a hinge joint because it works like a door hinge. Ask them to draw the largest possible circle in the air to demonstrate that their shoulder joint allows much more movement.
- Explain that hinges need to be oiled to keep them turning freely and use page 17 of the Student book to show why joints move so smoothly.
- Student pairs dissect a chicken wing to locate muscle, bone, tendon, ligament, and cartilage and describe their appearance and function. **Worksheet 2.1.1** supports this activity.

  Typical observations are: muscle – springy, pale brown, moves bones; bone – hard, white, provides strength and support; tendon – very strong, white, doesn't stretch, attaches muscle to bone; ligament – strong, white, slightly stretchy, attaches bone to bone; cartilage – smooth, white, slippery, slightly squashy, protects ends of bones.

Extension
Students read page 17 of the Student book and then use the internet to research ankle sprains and shoulder dislocations. **Worksheet 2.1.2** supports this activity.

Homework
Workbook page 7

Key words
skeleton, organs, skull, backbone, vertebrae, spinal cord, rib, joint, ball-and-socket joint, hinge joint, cartilage, synovial fluid, ligaments, sprain, dislocate, arthritis

Student book, pages 18–19

CD resources
- Worksheet 2.2.1
- Worksheet 2.2.2
- Worksheet 2.2.3
- Worksheet 2.2.4
- Worksheet 2.2.5

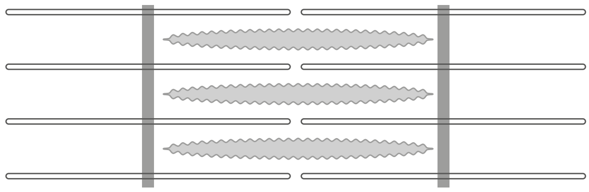
Objectives
- Understand why muscles are arranged in pairs
- Predict what will happen when a given muscle contracts

Overview
Students use models to explain how pairs of antagonistic muscles move our arms and legs.

Health and safety
Students must wash their hands after handling meat.

Activities
- Student pairs use models to investigate how we bend and straighten our arms. **Worksheet 2.2.1** supports this activity.
- Students read page 18 of the Student book and investigate their own arm movements. **Worksheet 2.2.2** supports this activity.

Extension
- Students examine images of muscles under the microscope. Then they observe the structures seen in muscles at higher magnification and deduce how they contract. Students should produce a diagram like the one below to show how muscle fibres slide together. **Worksheet 2.2.3** supports this activity.



- Students read page 19 of the Student book to learn about robotic exoskeletons. Groups of five or six select character cards from **worksheet 2.2.4**. They consider what benefits the technology offers for their character and what drawbacks there are, and complete their character's section of **worksheet 2.2.5**. Then they take turns to explain their ideas to the rest of the group and complete the sections for the remaining characters.

Homework
Workbook page 8

Key words
muscles, contract, antagonistic, tendons

Student book, pages 20–21

CD resources
- Worksheet 2.3.1
- Worksheet 2.3.2
- Worksheet 2.3.3

Objectives

- Recognise the nervous, digestive, and respiratory systems
- Describe what these organ systems do

Overview

Organs and organ systems are identified in the human body.

Activities

- Use a model torso, or page 20 of the Student book, to name and locate the human organs and discuss their functions. Students could label each organ on **worksheet 2.3.1**. Starting at the top the labels are: brain, lungs, heart, liver, kidneys, intestines.
- Groups use the pages 20–21 of the Student book to prepare posters about the nervous system, respiratory system, or digestive system. Students within each group should work on different organ systems. They can then take turns to teach the rest of the group about the organ system they have been allocated. They could take images from the internet or use the body outline on **worksheet 2.3.2** to create their posters.
- Students sort the organs on **worksheet 2.3.3** into four groups and place them under the correct headings. The expected answers are: nervous system – brain, spinal cord, nerves, and sense organs; skeletal system – bones, ligaments, and tendons; respiratory system – lungs; digestive system – mouth, stomach, small intestine, and large intestine.

Extension

Give students an example of an action relevant to their interests, such as running towards a ball and kicking it into the goal. Then ask them to explain which organ systems help them to do this, and how.

Homework

Workbook page 9

Key words

organs, specialised, systems, skeletal system, muscular system, nervous system, circulatory system, respiratory system, digestive system, sense organs, respiration, gas exchange, glucose, small intestine, starch, digestion

Student book, pages 22–23

CD resources
- Worksheet 2.4.2

Objective
- Recognise the circulatory system and describe what it does

Overview
Students learn about the role of the heart and use the idea of respiration to explain why every cell needs a good blood supply.

Activities
- Listen to a recording of a beating heart to introduce the lesson.
- Students observe blood vessels in the whites of each other's eyes. These are veins. They should see other veins in on the back of their hands or in their wrists. Explain that the heart sends blood to every tissue in arteries and takes it back in veins. The arteries aren't visible but you can feel them in places where they pass over a bone.
- Show students how to feel the pulse in their wrist using the middle finger of the opposite hand. Explain that their heart squeezes out blood each time it beats. The pulse is the pressure caused by each heartbeat. If stethoscopes are available students could listen to their own heartbeat.
- Show students pieces of rubber tube to represent arteries and veins (a wide thick-walled tube represents an artery; a wide thin-walled tube represents a vein; thin transparent micro-irrigation distribution tubing represents a capillary.) Explain that blood is under pressure in arteries and spurts out if they are damaged. Blood travels more slowly in veins. There are more than 100 000 km of blood vessels in your body and most of this length is taken up by 40 billion microscopic capillaries.
- Use page 22 of the Student book to introduce the idea of a double circulation. If space is available students could role play carrying oxygen from the lungs other parts of the body. Four students represent the heart. Pairs stand side by side but facing in opposite directions in the middle of the room. They each make an arch for students to pass through. Two students represent lungs at one end of the room – give them a stack of oxygen cards from **worksheet 2.4.2**. Two students stand at the other end of the room to represent other parts of the body. They need a stack of carbon dioxide cards from **worksheet 2.4.2**. The rest of the students represent the blood; they walk around two loops – one between the heart and the lungs and one between the heart and the rest of the body. This is easier to organise if you mark the route on the floor with chalk or string, and demonstrate first with two students. They walk fast but in single file as they leave the heart, and walk slowly but side by side on the way back. Students take oxygen cards as they pass the lungs and swap them for carbon dioxide cards as they pass the rest of the body.

Extension
Students use the internet to find out what a stroke is and what causes it.

Homework
Workbook page 10

Key words
heart, arteries, veins, capillaries

Student book, pages 24–25

CD resource
- Worksheet 2.5.1

Objective

- Recognise that many scientists study the human body

Overview

Students will already be familiar with doctors and nurses. This lesson makes them aware of other possible careers in healthcare and gives them an opportunity to present their ideas to other students.

Activities

- Students discuss why scientists study the human body. Possible suggestions are: to find out how our bodies work; to find cures for diseases; to replace damaged body parts; to improve athletic performance.
- Groups use the pages 24–25 of the Student book, and the internet, to prepare presentations about one of these careers: sports scientist, neuroscientist, prosthetic limb developer, haematologist, dietician, or optometrist. **Worksheet 2.5.1** supports this activity.
- Each group presents their career to the rest of the class and individuals complete the summary on **worksheet 2.5.1**.

Extension

Students could use the internet to find other careers in health care. The American Medical Association's website is a good starting point. Choose 'education' and then 'careers in health care' from the menu bar.

Homework

Workbook page 11

Key words

sports scientist, neuroscientist, prosthetic limb developer, haematologist, dietician, optometrist

Student book, pages 26–27

CD resources
- Worksheet 2.6.1
- Worksheet 2.6.2
- Worksheet 2.6.3
- Worksheet 2.6.4
- Worksheet 2.6.5

Objective
- Recognise that lives can be extended by replacing faulty organs

Overview
Students explore the economic, ethical, social, or cultural aspects of developments in transplant technology.

Activities
- Use page 26 of the Student book to introduce the use of transplants to save lives.
- Groups of six take part in a structured debate on the proposal that students below the age of 18 should be allowed to donate one of their kidneys. Each student takes one set of opinion cards from **worksheets 2.6.1** and **2.6.2**. They take turns to read the opinions on their cards to the rest of the group. The group then decides whether it supports or opposes the proposal. Once all the cards have been read out, groups decide whether they are for or against the proposal and explain which arguments convinced them. **Worksheet 2.6.3** supports this activity.
- Students read pages 26–27 of the Student book, and complete **worksheet 2.6.4**, to learn how a patient's own tissues can be used to grow new organs.
- Students link advantages and disadvantages to four different transplant techniques using **worksheet 2.6.5**. The correct answers are: 1 with A, E, and F; 2 with B, F, and G; 3 with A, B, C, and H; 4 with A, B, C, D, and H.

Extension
Students could write a report on the outcome of their debate. They should say whether students below the age of 18 should be allowed to donate one of their kidneys. They then list the main arguments they used to support their decision.

Homework
Workbook page 12

Key words
transplant, rejected, kidneys, urine, scaffold

Student book, pages 30–31

CD resources
- Worksheet 3.1.1
- Worksheet 3.1.2
- Worksheet 3.1.3

Objectives
- List the nutrients in food
- Understand why each nutrient is needed

Overview
Students analyse common foods and learn what the nutrients they contain are used for.

Safety
Eye protection must be worn when testing foods and no food samples should be tasted.

Activities
- Show students a selection of foods. Ask them what nutrients the foods contain, and how our bodies use them.
- Use page 30 of the Student book to remind students that there are two types of carbohydrate and review the differences between glucose and starch.
- Students test a selection of foods carbohydrates to see if they contain glucose or starch. **Worksheet 3.1.1** supports this activity.
- Read the sections of the Student book about proteins and fats and demonstrate how to test for these. Students select foods they expect to contain these nutrients and collect evidence to support their ideas. **Worksheet 3.1.2** supports this activity.
- Use page 31 of the Student book to introduce the roles of vitamins, minerals, and fibre. Stress that specialised equipment is needed to test foods for vitamins and minerals because the quantities in food are so small.
- Students use their own results and secondary evidence from the Student book or the internet to add foods to the correct part of the Venn diagram on **worksheet 3.1.3**.

Extension
Students could test a range of foods with mixed ingredients to identify the main nutrients they contain.

Homework
Workbook page 13

Key words
nutrients, protein, fat, minerals, carbohydrate, amino acids, vitamins, fibre, constipation

Student book, pages 32–33

CD resources
- Worksheet 3.2.1
- Worksheet 3.2.2
- Spreadsheet 3.2.3

Objectives
- Understand how scientists can measure the energy content of food
- Work out which variables must be changed, controlled, and measured

Overview
Students plan and carry out an investigation to compare the amounts of energy in two foods.

Safety
Warn students to wear eye protection and be careful with the food spikes and hot glassware. Avoid burning snacks containing nuts in case any students are allergic to them.

Activities
- Use page 32 of the Student book to introduce the idea that we can compare the energy in foods by burning them and collecting the heat released.
- Demonstrate how to use a Bunsen burner to set light to a piece of food and then hold it under a boiling tube of water to show the heat released as it burns. Students could be asked to suggest variables that need to be controlled to compare foods fairly. A suitable sample of food to burn is a 1 cm^2 piece of potato crisp. Stress the importance of choosing sensible values for controlled variables, such as the volume of water heated. Explain that we can check these by carrying out preliminary tests and then change them if we need to.
- Groups plan how to carry out the experiment using **worksheet 3.2.1** as a guide. **Worksheet 3.2.2** provides a table for less able students.
- Compare students' results and discuss possible improvements they could make to their methods.

Extension
- Read page 33 of the Student book to see how the method could be improved to take account of the mass of food burned. Students could weigh the food before and after burning it and express their results as temperature rises per gram of food burned. **Spreadsheet 3.2.3** could be used to automate the calculations and allow students to collaborate to check that their results are reliable.

Homework
Workbook page 14

Student book, pages 34–35

CD resources
- Worksheet 3.3.1
- Worksheet 3.3.2

Objective
- Understand what a balanced diet is

Overview
Students use the concept of a balanced diet to assess the quality of their diets.

Activities
- Use pages 34–35 of the Student book to introduce the definition of a balanced diet – a diet that contains the right amounts of all the nutrients your cells need to function properly.
- Students complete **worksheet 3.3.1** to see how much our energy needs can vary.
- Ask students to write down everything they ate on the previous day and estimate how close they came to having a balanced diet. **Worksheet 3.3.2** structures this activity.

Extension
- Prepare a poster to explain why everyone needs to eat some fats, but not too many.

Homework
Workbook page 15

Key word
malnutrition

Student book, pages 36–37

CD resource
- Worksheet 3.4.1

Objectives

- Recall some of the main roles of specific vitamins and minerals
- Discuss the importance of collecting evidence, developing explanations, and using creative thinking

Overview

Students learn how the causes of deficiency diseases were discovered.

Activities

- Use pages 36–37 of the Student book to introduce deficiency diseases.
- Students use cards from page 2 of **worksheet 3.4.1** to complete the flow chart on page 1. Each possible flow chart shows how scientists discovered the cause of one deficiency disease: scurvy, beri-beri, or rickets. Students record each sequence in the table on page 3 of the worksheet. The expected answers are: scurvy – A, L, I, E K; beri-beri – B, M, G, N, F; rickets – C, J, H, D, O.

Extension

- Allocate different vitamins and minerals to different students. They use the internet to collect data for a poster to show the recommended daily intake of their vitamin or mineral and the amounts present in common foods.

Homework

Workbook page 16

Key words

scurvy, beri-beri, night blindness, rickets, deficiency diseases, kwashiorkor, anaemia

Student book, pages 38–39

CD resources
- Spreadsheet 3.5.1
- Worksheet 3.5.2

Objective
- Understand why people don't always have balanced diets

Overview
Students discuss why people don't always eat a healthy diet and what we can do to change this situation.

Activities
- Ask students to write down their favourite food. It must be a single item, not a whole meal. Then discuss our inherited taste for sweet, fatty foods or foods with a high salt content. Do their choices reflect this or have they learned to prefer other foods?
- Show page 1 of **spreadsheet 3.5.1** and ask students to remember when they last ate a new type of fruit, vegetable, or meat – a food they hadn't tried before. What made them try it? Was it one of these: convenience, a desire for a healthy balanced diet, advertising, what their parents provided, or what a friend ate? One person from each group could collect the reasons from each person in their group and enter them into the class database on page 2 of the spreadsheet. A pie chart should automatically plot as the responses are added and page 3 summarises the students' responses.
- Discuss the growing problem of obesity and the need to change people's diets in the future. Students read page 38 of the Student book and complete **worksheet 3.5.2**.

Extension
- Students read page 39 of the Student book and recommend three foods that should be fortified, what should be added to them, and what problems their plan would overcome.

Homework
Workbook page 17

Key words
obese, fortified

Student book, pages 42–43

CD resources
- Worksheet 4.1.1
- Worksheet 4.1.2

Objective

- Construct food chains and webs and explain what they show

Overview

Students build on the understanding of food chains developed in lesson 4.2, and the term trophic level is introduced.

Activities

- Students read page 42 of the Student book to review their prior learning about the transfer of energy from producers to consumers.
- Pairs construct a simple food web using the feeding relationships on **worksheet 4.1.1**.
- Students read page 43 of the Student book. This introduces the term trophic level to describe an organism's position in a food chain, and shows that animals can feed at more than one trophic level.
- Students complete **worksheet 4.1.2** to practise assigning animals to trophic levels.

Extension

- Students could practise assigning the correct trophic level to the organisms in a range of food webs printed from internet.

Homework

Workbook page 18

Key words

primary consumers, secondary consumers, tertiary consumers, population, trophic level

Student book, pages 44–45

CD resources
- Worksheet 4.2.1
- Spreadsheet 4.2.2

Objective

- Model energy flow through food chains

Overview

Students practise representing feeding relationships as pyramids of number and pyramids of biomass, and learn why energy is lost at each trophic level.

Activities

- There are rarely more than five cheetahs per 1000 square kilometres of the African countryside. Ask students to explain why the animal needs so much space. They should appreciate that a cheetah needs to eat a lot of herbivores (impala) and these need to cover large areas of grassland to find food.
- Use page 44 of the Student book to introduce the idea that a pyramid of numbers is better for showing the numbers of each organism in a food chain. Emphasise that they are only really pyramid shapes if the biggest organism is at the end of the food chain.
- Read the 'passing on energy' section from page 44 of the Student book. Check that students recognise that energy escapes when organisms release energy from food, and when they produce waste products.
- Students use **worksheet 4.2.1** and **spreadsheet 4.2.2** to compare pyramids of number and biomass for the same food chains. Then complete the questions on page 45 of the student book.
- Check students' understanding by asking which sort of pyramid: (a) shows that small numbers of predators need large numbers of prey? – pyramid of numbers; (b) always looks like a pyramid? – pyramid of biomass; (c) cannot be drawn to scale if one of the species in it is very small or very large? – pyramid of numbers; (d) shows the biomass present in each trophic level – pyramid of biomass.

Extension

- Students complete the extension question on **worksheet 4.2.1**.

Homework

Workbook page 19

Key words

pyramid of numbers, pyramid of biomass

Student book, pages 46–47

CD resources
- Worksheet 4.3.1
- Worksheet 4.3.2
- Worksheet 4.3.3

Objective

- Explain the role of decomposers

Overview

Students learn more about the role of decomposers in the context of mangrove forests.

Activities

- Use page 46 of the Student book to introduce the recycling of minerals by decomposers.
- One place where there are large numbers of decomposers is a mangrove forest. The video clip 'Born of mud' on the BBC Nature website (www.bbc.co.uk/nature/adaptations/Detritivore#p00n0zxz) could be used to introduce mangrove forests.
- Pairs use the cards from **worksheet 4.3.1** to construct carbon cycles for herbivore and decomposer food chains. **Worksheet 4.3.2** structures the activity.
- Students read page 47 of the Student book and complete the questions.

Extension

- Students read about the importance of mangroves on page 47 of the Student book. Then use the information on **worksheet 4.3.3** to prepare a presentation to the rest of the class. It should explain why mangrove forests are important and why they need protection.
- Students could complete the summary questions on **interactive 4.3.4.**

Homework

Workbook page 20

Key words

decomposers, biodiversity

Student book, pages 48–49

CD resources
- Spreadsheet 4.4.1
- Worksheet 4.4.2
- PowerPoint 4.4.3
- Worksheet 4.4.4

Objective
- Describe factors affecting the sizes of populations

Overview
Students consider the factors that control population size.

Activities
- **Spreadsheet 4.4.1** can be used to remind students how populations are affected when the food supply or predator numbers change.
- Students use **worksheet 4.4.2** to compare human population growth with the growth curve seen when reindeer were taken to a small island in the Arctic.
- Use page 48 of the Student book to introduce the idea that if an animal has no predators its population will continue to rise until it is suddenly cut back by disease, pollution, or food shortages.
- Discuss the predictions about human population growth on page 190 of the Student book.
- Use **PowerPoint 4.4.3** to introduce the idea that populations can be controlled by predators. The PowerPoint builds a typical predator/prey graph step by step.
- Students read page 49 of the Student book and complete **worksheet 4.4.4** to reinforce their understanding of the graph.

Extension
- In many parts of the world carnivores such as wolves have been killed to protect herbivores. Students should prepare a presentation to explain why that might not be a good idea.

Homework
Workbook page 21

Key words
population, biodiversity, interdependent

Student book, pages 50–51

CD resource
- Worksheet 4.5.1

Objective
- Describe factors affecting the sizes of populations

Overview
Students learn how an invasive species can destroy existing food webs.

Activities
- Remove the brown tree snake card from the cards on **worksheet 4.5.1** and ask students to make a food web with the others on a large sheet of paper.
- Ask students to add the brown tree snake to their food webs and work out what effect it will have on the animals and plants in the original food web. They should appreciate that the bird population will fall as the snakes destroy their eggs. Then the spider population will increase because their predators are removed.
- Students read pages 50–51 of the Student book to see what has happened already on the island and what the long-term consequences may be.

Extension
- Students use the internet to produce posters about invasive plants and animals in their own country.

Homework
Workbook page 22

Key word
invasive species

Student book, pages 52–53

CD resources
- Worksheet 4.6.1
- Worksheet 4.6.2
- Worksheet 4.6.3

Objective
- Explain why biodiversity is important

Preparation
- Have images available of six different ecosystems: a tropical rainforest, savannah, woodland, tundra, farmland used for a single crop, and highlands covered with heather. These could be displayed during the lesson for reference.

Overview
Students learn where most biodiversity is found and what can be done to preserve it.

Activities
- Student pairs use the ecosystem cards from **worksheet 4.6.1** to assign biodiversity scores to a range of ecosystems and then locate them on the world map on **worksheet 4.6.2**. This should allow them to decide what affects the biodiversity of an ecosystem. Key points they should be able to draw out are that: biodiversity shows a lot of variation; hot, wet ecosystems close to the equator have high biodiversities; ecosystems far from the equator tend to have a lower biodiversity.
- Use **worksheet 4.6.3** to look for a correlation between the biodiversity of an ecosystem and its productivity.
- Students read page 52 of the Student book to review the importance of tropical rainforests.
- Students read page 53 of the Student book to learn how we can help to preserve plant and animal biodiversity.

Extension
- The video clip *Kew's Millennium Seed Bank – conserve our biodiversity* argues why we should save seeds and *Saving the planet's biodiversity – Millennium Seed Bank project* shows how they are preserved (Kew Gardens videos, both available on YouTube).

Homework
Workbook page 23

Key words
biodiversity, community, ecosystem, inbreeding

Student book, pages 56–57

CD resources

- Worksheet 5.1.1
- Worksheet 5.1.2
- Worksheet 5.1.3

Objective

- Recognise each part of the alimentary canal and explain its role in digestion

Overview

Students model what happens to food as it travels through the digestive system.

Activities

- Use a long coil of rubber tubing to introduce the idea that the alimentary canal (gut) is like a long tube. It is divided into different sections with different roles and curled up inside us.
- Students use **worksheet 5.1.1** to estimate the length of their alimentary canals.
- Use pages 56–57 of the Student book to introduce the parts of the gut and what they do.
- Use six volunteers to help model what happens in each part of the gut. The cards on **worksheet 5.1.2** show each volunteer how to introduce themselves and perform their part. They will need the following equipment:
  1. Large bowl labelled 'mouth', a high fibre cereal, scissors, pestle, water labelled 'saliva'
  2. Vinegar labelled 'stomach acid', coloured water labelled 'enzyme';
  3. Large bowl labelled 'small intestine', sodium hydrogencarbonate mixed with water and green food colour labelled 'bile', coloured water labeled enzyme;
  4. Large sponge, disposable gloves, bucket labelled 'blood' containing red water
  5. Large sieve, bowl labelled 'large intestine'
  6. Plastic bag labelled 'rectum', disposable gloves, bucket
- Students prepare flow charts to show what happens to starch and fibre as they pass through the gut. **Worksheet 5.1.3** supports this activity.

Extension

Students could use the internet to find out what goes wrong when people suffer from coeliac disease.

Homework

Workbook page 24

Key words

gut, alimentary canal, rectum, mechanical digestion, enzyme, chemical digestion, peristalsis, small intestine, pancreas, large intestine, anus

Student book, pages 58–59

CD resources
- Worksheet 5.2.1
- Worksheet 5.2.2
- Worksheet 5.2.3

Objective
- Understand the function of enzymes

Health and safety
- Powdered enzymes can cause allergic reactions. Avoid getting any on your skin or in your eyes. Wash liquid enzyme off straight away with plenty of water and mix enzymes with plenty of water before pouring them away.

Overview
Students learn more about enzymes and model the way starch is broken into glucose and carried to cells all over the body.

Activities
- Ask students to hold a piece of bread in their mouths for as long as they can without swallowing. They should notice that it begins to taste sweeter as the enzyme in saliva digests it to glucose.
- Use a model starch molecule to remind students that starch is a large molecule made of lots of glucose molecules joined together. The model can be made by sticking lots of glucose molecules made from **worksheet 5.2.1** together. Explain that starch has to be broken down into separate glucose molecules to pass through the wall of the gut.
- Divide the students into groups to role-play digestion and the fate of the glucose produced. The groups are: enzymes, villi in the small intestine, blood plasma, and cells. Use cards from **worksheet 5.2.2** to give each group a role in breaking down the model starch molecule and using the glucose produced.
- Read pages 58–59 of the Student book to learn what is different about the molecules in starch, proteins, and fats, and how bile aids digestion. The role of bile could be demonstrated by using green washing-up liquid to make vegetable oil and water mix.
- Groups demonstrate the digestion of starch following the instructions on **worksheet 5.2.3**. A 1% solution of alpha amylase should give results in a suitable time but it should be checked in advance.

Extension
- Students could explore the effect of temperature on the time taken for amylase to digest starch.

Homework
Workbook page 25

Key words
catalysts, biological catalysts, carbohydrase, protease, lipase, large surface area, bile, gall bladder, emulsifies, denatured, optimum pH

Student book, pages 60–61

CD resource
- Worksheet 5.3.1

Objectives
- Understand how enzymes function
- Give some examples of the uses of enzymes

Overview
Students demonstrate the action of an enzyme and learn why different enzymes are needed for different reactions.

Health and safety
Students must take care when handling hydrogen peroxide. Hands must be washed after touching liver.

Activities
- Students add liver to hydrogen peroxide to show how effective the enzyme is. **Worksheet 5.3.1** supports this activity.
- Students read pages 60–61 of the Student book, to learn how enzymes like the ones involved in digestion are used in food production.
- Use the KScience animation (choose Animations from the main KScience website menu, then the Enzymes animation) to emphasise that enzymes can make small molecules join together as well as break molecules down, and to show why each reaction needs a different enzyme.

Extension
- Students could build Plasticine models and use them to explain what enzymes are and how they work.

Homework
Workbook page 26

Key word
active site

Student book, pages 64–65

CD resources
- Worksheet 6.1.1

Objectives

- Describe and explain the properties of substances in their solid, liquid, and gas states
- Identify changes of state

Overview

This lesson revises and reinforces the content of International Secondary Science 1 lessons 6.1, 6.2, and 6.4. Its primary purpose is to use the particle model to explain differences in the properties of a substance in their three states. Students will also revisit particle explanations of changes of state. The main task in this lesson is a group activity, in which students work together to answer four key questions. Student groups then create posters to demonstrate what they have learnt.

Activities

- Display samples of water in its solid, liquid, and gas states (as ice, liquid water, and steam). Briefly elicit some differences between the properties of water in its different states.
- Divide students into groups of four. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 6.1.1.**

  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 to demonstrate what they have learnt (or reminded themselves) about the states of matter and changes of state.
- Home groups show their posters to one other group. The other group peer assesses. Part 5 of **worksheet 6.1.1** supports this activity.

Homework

Workbook page 27

Key words

solid, liquid, gas, particle arrangement, particle theory, condensation, freezing, melting, evaporation, boiling

Student book, pages 66–67

CD resources

- Worksheet 6.2.1
- Worksheet 6.2.2

Objectives

- Use the particle theory to explain diffusion
- Describe evidence for diffusion

Overview

This lesson introduces the idea of diffusion as the random movement and mixing of particles. The lesson begins with a short demonstration in which students use their sense of smell to detect diffusion. Students then investigate the effect of temperature on the speed of diffusion of potassium manganate(VII) in water. Finally, there is a demonstration to show the diffusion of ammonia and hydrogen chloride. By the end of the lesson students should know that diffusion happens faster at higher temperatures, and that big, heavy particles diffuse more slowly than smaller, lighter particles.

Activities

- Place an item with a strong smell, for example air freshener, at the front. Students raise their hands when they detect the smell. A few students act out what they think happens to the particles. Discuss the role play as a class. Tell students that diffusion – the random movement and mixing of particles – has occurred.
- Quickly demonstrate the diffusion of potassium manganate(VII) in water. Students then plan and carry out an investigation to find out about the effect of water temperature on the speed of diffusion. **Worksheets 6.2.1** and **6.2.2** support this activity.

  Demonstrate the diffusion of ammonia and hydrogen chloride along a long tube, as on Student book page 66. Explain that ammonium chloride forms at the hydrogen chloride end because hydrogen chloride particles are bigger and heavier than ammonia particles, so diffuse more slowly. For detailed instructions, see *www.nuffieldfoundation.org/practical-chemistry* and search for *diffusion*.

Homework

Workbook page 28

Key words

diffusion, temperature, particle size, particle mass

Student book, pages 68–69

CD resources
- Worksheet 6.3.1
- Worksheet 6.3.2

Objectives

- Use a formula to calculate density
- Explain why different substances have different densities

Overview

The lesson begins with a practical introduction to density – which of two identically-sized bags has the greater mass? Students then measure the mass and volume of various objects and calculate the density of the materials they are made from. The lesson finishes with a group task, in which student pairs find out about how the closeness of particles, and particle mass, can be used to explain density. Groups then produce posters to display their learning.

Activities

- Give two students identical bags. One is filled with heavy books, the other with lightly screwed-up paper. Which is heavier? Can students explain why? Tell students the heavier bag has the greater density. Density is how heavy something is for its size.
- Students measure the mass and volume of objects made from different materials, and calculate their densities. Include objects with cuboid shapes, so that students can calculate their volumes by measuring the lengths of their sides; also include objects with other shapes so that students can find their volumes by immersing in water in a measuring cylinder. **Worksheet 6.3.1** supports this activity.
- Student pairs find out about one factor that affects density – either particle mass, or how closely the particles are packed. Pairs plan how to teach other pairs what they have learnt. **Worksheet 6.3.2** and page 69 in the Student book support this activity.
- Pairs come together in fours, and teach each other about the factors that affect density. They summarise what they have learnt on a poster. **Worksheet 6.3.2** supports this activity.

Extension

Students read about the work of al-Biruni in the Student book, and further research his work on the Internet.

Homework

Workbook page 29

Key words

density, mass, volume, particle size

Student book, pages 70–71

CD resources
- Worksheet 6.4.1
- Worksheet 6.4.2

Objectives
- Explain what causes gas pressure
- Explain air pressure and its effect on boiling point
- Explain how temperature affects gas pressure

Overview
This lesson explains gas pressure in terms of colliding particles. It begins by looking at a balloon – why does it get bigger when inflated? What are the particles doing? Then follow it with a fascinating demonstration, in which air pressure pushes a hard-boiled egg into a conical flask. The **egg in a bottle animation** is available on the YouTube. Students then do the collapsing can experiment, and use ideas about particles to explain their observations. The lesson concludes by returning to the balloon – why does it get smaller when cooled in a fridge?

Activities
- Blow up a balloon. Ask why it gets bigger. Explain that air particles move inside it rapidly in all directions. They collide with the rubber and exert a force on it. The force per unit area is pressure. If possible, put the balloon in a fridge. Students predict how it will change. Part A of **worksheet 6.4.1** supports this activity.
- Demonstrate how air pressure pushes an egg into a flask: in a conical flask, heat 2 cm depth of water to boiling. Turn off the Bunsen burner. Place a hard-boiled egg (shell removed) in the neck of the flask. When the water vapour condenses, the gas pressure outside is greater than that inside. The egg drops into the flask. Part B of **worksheet 6.4.1** supports this activity.
- Students do the collapsing can experiment, and use ideas about particles to explain it. **Worksheet 6.4.2** supports this activity. The answer to question 1 is D, A, E, B, F, C.
- Return to the balloon in the fridge. How has it changed? Explain that it is smaller because the cooler air particles inside it move more slowly. They collide with each other, and the inside of the bottle, less often. The pressure inside has decreased. Part C of **worksheet 6.4.1** supports this activity.

Extension
Students use the Student book to find out about air pressure, and to explain why air pressure affects the boiling temperature of water.

Homework
Workbook page 30

Key words
collide, pressure, air pressure

Student book, pages 72–73

CD resources
- Worksheet 6.5.1
- Worksheet 6.5.2

Objective

- Understand how scientists use questions, evidence, and creative thought to develop explanations

Overview

This lesson, on ideas and evidence, focuses on the work of Robert Boyle and Robert Hooke in developing an explanation about the Torricelli barometer. It begins with a look at empirical questions – what are they? Can students write their own? This builds on the first activity of lesson 1.3 in International Secondary Science 1.

Student groups then create short plays to describe the work of Boyle and Hooke, and to show how they created their explanation. The process of developing explanations is described in lesson 1.3 in International Secondary Science 1, but this is the first time the role of creative thinking has been made explicit.

Activities

- Explain that scientific questions, also called empirical questions, are ones that evidence will help to answer. Student pairs make up some empirical questions of their own. Discuss some of these as a class.
- Students read about the work of Robert Boyle and Robert Hooke, making sure they fully understand the process of developing explanations that is given on page 73 of the Student book.
- In groups of four, students create short plays/dramas to describe the work of Boyle and Hooke, and to show how they developed their explanation. **Worksheets 6.5.1** and **6.5.2** support this activity.
- Student groups perform their plays to the class, and members of the audience suggest improvements.

Extension

Students use the Internet to find out more about the work of Boyle, Hooke, or Torricelli.

Homework

Workbook page 31

Key words

empirical question, creative thinking, prediction

Student book, pages 74–75

CD resources

- Worksheet 6.6.1
- Worksheet 6.6.2

Objectives

Understand how to:

- plan an investigation
- obtain and present evidence
- consider evidence

Overview

In this lesson students plan and carry out an investigation to investigate the relationship between gas volume and temperature. They obtain evidence, and present it on a line graph. The lesson continues with a discussion about the evidence obtained. Does all the data fit the pattern, or are some of them anomalous? Finally, students are reminded of the term *correlation* (introduced in 6.2).

An alternative investigation (the one described in the Student book) that could be tackled during this lesson is described here *www.nuffieldfoundation.org/practical-physics/thermal-expansion-air-charles-law*. However, the capillary tubing required is difficult to obtain.

Activities

- Refer back to the balloon of lesson 6.5. What happened to its volume when it cooled? Elicit that as temperature decreased, so did the volume.
- Take the apparatus shown on **worksheet 6.6.1**. Hold the flask in your hands to warm the air inside it. Show that oil moves up the tube as the air expands.
- Students plan a quantitative investigation based on the demonstration in the previous activity. They do the investigation and present the evidence on line graphs. **Worksheet 6.6.1** and **6.6.2** support this activity.
- Ask if any student has results that do not fit the pattern – these are anomalous. Discuss what to do about these results – ignore them? Repeat the investigation? Read page 75 of the Student book.
- Use the Student book graphs to reinforce the meaning of the term *correlation*. Read page 75 of the Student book.

Homework

Workbook page 32

Key words

correlation, anomalous, trend, pattern

Student book, pages 78–79

CD resources

- Worksheet 7.1.1
- Worksheet 7.1.2

Objectives

- Explain what an element is
- Explain what an atom is
- Understand the importance of questions, evidence, and creative thought in developing explanations

Overview

In this lesson, students are reminded about elements. They then learn about atoms, and make posters to display what they know about elements and their atoms. Students then look at the development of ideas about atoms. Having read the section in the Student book, they create dramas to highlight the use of creative thought and evidence in developing explanations about atoms.

Activities

- Student pairs discuss what they know about atoms. What are they made up of? Has anyone heard of atoms? If possible, show students toy bricks and use them to model atoms, as shown on page 78 of the Student book.
- Students follow the guidance, and use information from page 78 of the Student book, to make posters to display their knowledge about atoms and elements. **Worksheet 7.1.1** supports this activity.
- Students read about the development of ideas about atoms in the Student book. In groups of at least four they create dramas to describe how early philosophers and scientists used creative thought and evidence in developing explanations about atoms. **Worksheet 7.1.2** supports this activity.
- Student groups perform their plays to the class, and members of the audience suggest improvements.

Extension

Students use the Internet to find out more about any of the philosophers or scientists in mentioned in the lesson.

Homework

Workbook page 33

Key words

atom, element, ideas, evidence

Student book, pages 80–81

CD resources
- Worksheet 7.2.1
- Worksheet 7.2.2

Objectives

- Know the chemical symbols of the first twenty elements of the periodic table
- Understand why scientists use chemical symbols for elements

Overview

This lesson introduces chemical symbols. To start, students suggest reasons for elements having symbols. They then practise writing chemical symbols correctly, before playing games using element symbol and name cards. Students then use the periodic table to help them make up quiz questions about element names and chemical symbols. Finally, students swap with others and answer the quiz questions.

Activities

- Tell students that each element has its own chemical symbol. Ask student pairs to suggest why, and elicit that they are shorter to write and internationally understood. Read page 80 of the Student book.
- Students practise writing chemical symbols correctly by listing the first 20 elements and their symbols. Emphasise the correct use of lower and upper case letters. Read page 81 of the Student book.
- Students play games with the element name and symbol cards on **worksheets 7.2.1** and **7.2.2**, including memory and snap:
  - For memory, spread out the cards, face down, on the table. The first player turns over two cards. If they are a pair (element and symbol) the player keeps them and has another turn. If they are not a pair, the next player has a turn.
  - For snap, deal out the cards. Hold them face down. Players take turns to quickly turn over one card. When players spot a pair, they shout *snap*. First person to shout wins the pile.
- Students make up quiz questions on element names and chemical symbols, for example *Name four elements whose symbols start with S; name two elements named after countries*. Students swap quizzes and answer questions. Read page 81 of the Student book.

Homework

Workbook page 34

Key words

chemical symbol, element, periodic table

Student book, pages 82–83

CD resource
- Worksheet 7.3.1

Objective

- Understand some factors that influenced when elements were discovered

Overview

This lesson is about the discovery of elements, focusing on factors that influenced when different elements were first found. The lesson begins with an opportunity for students to speculate about which elements were discovered earliest. It continues with a group activity, in which students work together to find out about the elements discovered in different time periods. Student groups then create posters to summarise and display what they have learnt.

Activities

- Student pairs speculate about which elements were discovered earliest. Why do they think these elements were first found so long ago?
- Divide students into groups of four. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 7.3.1**.

  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 their home groups. They create posters or dramas to show what they have learnt about the discovery of elements.
- Home groups present their posters or dramas to one other group. The other group peer assesses. The final part of **worksheet 7.3.1** supports this activity.

Extension

Use the Internet to find out more about the discovery of particular elements. See *www.rsc.org/periodic-table* and *www.webelements.com*

Homework

Workbook page 35

Key words

elements, explanation, discovery, periodic table

Student book, pages 84–85

CD resources
- Worksheet 7.4.1
- Worksheet 7.4.2
- Worksheet 7.4.3
- Worksheet 7.4.4

Objective

- Explain how scientists asked questions, collected evidence, and thought creatively to develop the periodic table.

Overview

This lesson tells the story of one of the most important developments in chemistry – the discovery of the periodic table. Like lesson 7.1, it takes the form of group dramas. This time, though, students create television programmes to take viewers through the stages in some detail. Role cards are provided. The lesson finishes with a look at the development of theories in general, and a consideration of how the creation of the periodic table fits with this model.

Activities

- In groups of six, students read the guidance for the drama activity on **worksheet 7.4.1**, and clarify the task if necessary. They allocate individual roles.
- Students use their role cards to create and practise their group dramas. **Worksheets 7.4.2** and **7.4.3** support this activity.
- Student groups perform their dramas. Others use the peer assessment grid on **worksheet 7.4.4** to evaluate each one.
- Lead a description and discussion of the flow diagram on page 85 of the Student book showing how theories are created. Ask students to consider how the creation of the periodic table fits with this model.

Extension

Students use the Internet to find out more about any of the scientists in this lesson.

Homework

Workbook page 36

Key words

empirical question, evidence, explanation

Student book, pages 86–87

CD resource
- Worksheet 7.5.1

Objective
- Practise interpreting secondary data

Overview
This lesson is an opportunity for students to practise interpreting secondary data. It begins with a reminder about primary and secondary sources. Students then plot melting point data for three groups of the periodic table. They describe patterns in the data, and compare the patterns for the three groups. Students then examine interpretations of density data made by others, and decide which interpretation is better. The lesson ends with a look at a pie chart – can students interpret this successfully?

Activities
- Remind students that primary data is that which they collect themselves, by making their own observations or measurements. Secondary data is data from others. Students may obtain secondary data from text books, data books, the Internet, or other students.
- Students follow the guidance on **worksheet 7.5.1** to draw bar charts to display the melting points of the elements of Groups 1, 7, and 0. They describe patterns in the data, and compare the patterns for the three groups. Do not allow students to look at pages 86–87 of the Student book during this activity.
- Students look at the density data in the table on page 87 of the Student book. They discuss the two interpretations given in the book, and decide which is better. A few groups justify their choice to the class.
- Students look at the pie chart on page 87 of the Student book. They answer questions 1 and 2 to practise interpreting data from pie charts.

Homework
Workbook page 37

Key words
group, secondary source, secondary data, patterns

Student book, pages 88–89

CD resources
- Worksheet 7.6.1

Objectives

- Describe differences between metals and non-metals
- Explain differences between metals and non-metals

Overview

This lesson begins with a reminder about the properties of typical metal and non-metal elements, covered in lessons 2.2 and 2.3. Students then look at models or diagrams of atom arrangements in typical metals and non-metals. The lesson continues with a group activity in which students work together to use atom arrangements to explain metal and non-metal properties. Finally, students check their learning by answering the questions in the Student book.

Activities

- Display samples of metal and non-metal elements. Non-metals could include carbon (as charcoal), sulfur, and sealed jars labelled *oxygen*, *nitrogen*, and *hydrogen*. Elicit differences in the properties of typical metals and non-metals. Students should refer to the table on page 88 of the Student book.
- Use models to show the atom arrangements in typical metal and non-metal elements, or display the diagrams on page 89 of the Student book.
- Divide students into groups of four. Within each group, allocate one pair to do each question on the **worksheet 7.6.1**. These pairs are called *sub-groups*.

  Sub-groups tackle the questions using information from page 89 of the Student book, and plan how to teach the rest of their group what they have learnt.

  Within each group, sub-groups teach each other what they have learnt.
- To check their learning, students answer the questions on page 89 of the Student book.

Homework

Workbook page 38

Key words

molecule, metal, non-metal, properties, atom arrangement

Student book, pages 90–91

CD resources
- Worksheet 7.7.1
- Worksheet 7.7.2

Objectives

- Understand what a compound is
- Give examples of compounds and state how their properties are different from the properties of their elements

Overview

This lesson introduces compounds. It begins with a demonstration to show that the properties of a compound are very different from those of the elements it is made up of. Students then explore the properties of iron, sulfur, and iron sulfide, and note their differences. Finally, students use models to show that compounds are made up of atoms of more than one element, strongly joined together. At this stage, to avoid misconceptions, it is best to model only simple molecular compounds.

Activities

- If possible, display three substances – sodium, chlorine (in a gas jar), and sodium chloride (as table salt). Tell students that sodium chloride is made up of two elements, sodium and chlorine. Sodium chloride is an example of a compound. Give a second example of a compound, calcium phosphate. Use page 90 of the Student book to describe how the properties of the compound are different from the properties of the elements it is made up of.
- Students do two practicals to explore the properties of iron, sulfur, and iron sulfide. **Worksheet 7.7.1** and **7.7.2** support this activity.
- Use models to show that compounds are made up of atoms of more than one element, strongly joined together. Suitable examples include carbon monoxide, carbon dioxide, and water. If possible, allow students to make models using toy bricks or molecular model kits.

Extension

Students use the Internet to research differences in properties between compounds and the elements they are made up of.

Homework

Workbook page 39

Key words

compound, atom, element

Student book, pages 92–93

CD resources
- Worksheet 7.8.1
- Worksheet 7.8.2

Objective

- Understand the stages involved in an enquiry

Overview

The lesson starts with a demonstration to show that, when iron is heated in air, the mass increases since iron joins with oxygen to make a compound. Students then do their own investigations into the mass change when magnesium burns in oxygen. They compare their results with those of other groups, and suggest improvements to the investigation.

Activities

- Demonstrate the investigation shown in the Student book, emphasising the investigation stages described in the book. Full details of the investigation are given at *www.nuffieldfoundation.org/practical-chemistry/combustion-iron-wool*
- Students investigate the mass change involved in the combustion reaction of magnesium. **Worksheet 7.8.1** and **7.8.2** give guidance on selecting ideas to test, controlling risk, making a prediction, making measurements, obtaining evidence, doing simple calculations, and making a conclusion.
- Gather together results from all groups. Student pairs speculate on reasons for the different values obtained, and suggest improvements to the investigation.

Homework

Workbook page 40

Key words

hazard, risk

7.9 Naming compounds and writing formulae

Student book, pages 94–95

CD resource
- Worksheet 7.9.1

Objectives

- Name compounds
- Write and interpret formulae

Overview

In this lesson students learn how to name compounds, and how to write and interpret formulae. The lesson begins with an introduction to the idea that names give clues about the elements that make up a compound. For example, a name ending in *–ate* shows that the compound includes oxygen atoms. Students then use models to help them understand how to name compounds made up of atoms of non-metal elements only. Finally, students learn how to write formulae. They practise writing and interpreting formulae for molecular elements, and compounds.

Activities

- Show students four compounds – sodium chloride, copper oxide, copper sulfate, and copper carbonate. They guess which elements make up the compounds. Explain that compounds whose names end in *–ide* include atoms of just one non-metal; compounds whose names end in *–ate* include atoms of oxygen and another non-metal. Students do the questions on Part A of **worksheet 7.9.1**.
- Display molecular models of compounds made up of atoms of non-metals only, including carbon monoxide, carbon dioxide, sulfur dioxide, and sulfur trioxide. Explain how the compounds are named. Students do Part B of **worksheet 7.9.1** on naming compounds.
- Students make models of the elements or compounds shown in the first table on page 95 of the Student book. They then do Part C of **worksheet 7.9.1** on writing and interpreting formulae.

Homework

Workbook page 41

Key words

formula, compounds, chemical symbols

Student book, pages 96–97

CD resources
- Worksheet 7.10.1
- Worksheet 7.10.2
- Worksheet 7.10.3

Objectives

- Name some common oxides and hydroxides
- Describe one difference in the properties of metal oxides and non-metal oxides

Overview

In this lesson students explore the properties of oxides of metals and non-metals, and find out that non-metal oxides are acidic and metal oxides are basic. Students also learn that some metal hydroxides dissolve in water to make alkaline solutions. The lesson continues with a look at the formulae of common oxides and hydroxides. Finally, students use the Student book or the Internet to research the properties and uses of some common oxides, hydroxides, sulfates, and carbonates, and create posters to communicate what they have found out.

Activities

- Display samples of three oxides – magnesium oxide, calcium oxide, and copper oxide. Students speculate what they have in common. They do a practical using **worksheet 7.10.1** to find out that they are bases – they neutralise acids, and if they dissolve in water the solution will be alkaline. Students also measure the pH of sodium hydroxide solution, and learn that it is alkaline.
- Students follow the guidance on **worksheet 7.10.2** to find out that non-metal oxides are acidic.
- Students write formulae for oxides and hydroxides. Part A of **worksheet 7.10.3** supports this activity.
- Students use the Student book or the Internet to research the properties and uses of some oxides, hydroxides, sulfates, and carbonate. They create posters to communicate what they have found out. Part B of **worksheet 7.10.3** supports this activity.

Homework

Workbook page 42

Key words

oxide, bases, hydroxide, sulfate, carbonate

Student book, pages 98–99

CD resources
- Worksheet 7.11.1
- Worksheet 7.11.2

Objective

- Plan investigations, present evidence, and consider the evidence

Overview

This lesson focuses on enquiry skills. Through part-planning and carrying out an investigation to find the percentage by mass of salt in sea water, students practise the skills of selecting ideas to test, controlling risk, taking accurate measurements, using equipment correctly, making simple calculations, and making a conclusion.

If sea water is not available, make a substitute by dissolving about 35 g of sodium chloride in 1 dm^3 (one litre) of tap water. The investigation gives better results, and is safer, if the solution is heated to remove most water, but then left in a warm, dry place for the remaining water to evaporate slowly.

Activities

- Display some table salt (sodium chloride). Elicit that the salt is sodium chloride, $NaCl$. We obtain most of it from sea water or rock salt. Pairs discuss how much salt is in the sea.
- Ask how we could find the percentage by mass of salt in sea water. Elicit that we could take a known mass of seawater, evaporate the water, and find the mass of solute remaining. Most – but not all – the solute is sodium chloride.
- Students plan and do an investigation to find the percentage by mass of salt in sea water. **Worksheets 7.11.1** and **7.11.2** support this activity.
- Gather results from all groups. Students speculate on reasons for differences, and suggest improvements to the investigation.

Extension

Students use the Internet to find out more about salts in the oceans, and their different total concentration in different regions. This web page is a useful starting point:

www.seafriends.org.nz/oceano/seawater.htm#salinity

Homework

Workbook page 43

Key words

chloride, meniscus

Student book, pages 100–101

CD resource
- Worksheet 7.12.1

Objective

- Understand the differences between elements, mixtures, and compounds

Overview

This lesson introduces mixtures. It starts with a discussion about familiar mixtures, for example sea water, air, and fruit juice. How are mixtures different from compounds? Students then plan and do a practical to separate salt from rock salt. Some groups then justify their choice of separation techniques to the class. The lesson concludes with an opportunity for students to check their learning by answering the Student book questions.

If rock salt is not available, make a substitute by mixing sand, table salt, and a few small stones. It is safer to perform the evaporation stage by heating the salt solution to remove most of the water, and then leaving in a warm, dry place for the remaining water to evaporate slowly.

Activities

- Tell students that sea water, air, and fruit juice are all mixtures. A mixture may contain elements, compounds, or both. The substances in a mixture are not chemically joined together. Elicit further differences between mixtures and compounds. The table on page 101 of the Student book summarises the differences between mixtures and compounds.
- Students plan and do a practical to separate salt from rock salt. This practical experiment will review what they know about mixtures from Primary level. They list the stages they use – and the reason for each stage – on **worksheet 7.12.1**. The best order for the processes listed is dissolving, filtering, evaporating.
- Students display their samples of salt. A few groups tell the rest of the class what they did, and why. They can base what they say on their completed planning sheets.
- Students check their understanding by answering the questions on page 117 of the Student book.

Homework

Workbook page 44

Key words

mixture, elements, compounds, ratio

Student book, pages 102–103

CD resource

- Worksheet 7.13.1

Objective

- Describe how to separate mixtures by decanting and filtering

Overview

This lesson focuses on two separation techniques – filtering and decanting. The focus of the lesson is different from that in the Student book, which concentrates on enquiry methods.

The lesson starts with a brief demonstration of decanting, in which cooking oil is separated from a mixture with water. Students then plan presentations and demonstrations for primary school students on decanting and filtering. Their presentations should include explanations of why each technique works. The lesson finishes with performances of the presentations, and a peer assessment for each group. *The activities on this page review the work on* Separating Mixtures *that students will have done as part of the Cambridge Primary curriculum framework.*

Activities

- Show students a mixture of recently-shaken cooking oil and water. Pairs discuss how to separate the mixture. Elicit that the process of decanting can be used, and demonstrate this.
- Students follow the guidance to plan presentations for primary school students on filtering and decanting. The presentations should include demonstrations, and explanations of why each technique works. **Worksheet 7.13.1** supports this activity.
- Student groups present their presentation to one other group. The other group peer assesses using the criteria on the final part of **worksheet 7.13.1**.

Homework

Workbook page 45

Key words

decant, filter, filtration

Student book, pages 104–105

CD resources
- Worksheet 7.14.1
- Worksheet 7.14.2

Objective

- Understand how evaporation and distillation separate liquids and solids from solutions

Overview

This lesson continues the theme of separating mixtures, started in lesson 6.12. It begins with a brief reminder about separating salt from its solution in water by evaporation. It continues with a demonstration of distillation, in which a solvent is separated from its solution by evaporation and condensation. Students then do a simple distillation procedure themselves. The lesson finishes with a brief mention of one of the first scientists to use distillation, Jabir ibn Hayyan. This lesson reviews some material that students will have covered as part of the Primary Science curriculum framework. Encourage students to think about how the different properties of materials affect how mixtures can be separated. *The activities on this page review the work on* Separating Mixtures *that students will have done as part of the Cambridge Primary curriculum framework.*

Activities

- Show students some seawater. Ask if they would like to drink it. Remind them that they can obtain salt from sea water by evaporation, but how can they obtain pure water? The next activity shows how.
- Use the apparatus shown on the **worksheet 7.14.1** to demonstrate obtaining pure water from a mixture of ink and water by distillation. This mixture has been chosen since it is easy to see that ink-free water is produced. Students label the diagram on the worksheet. Tell students that a version of distillation is used in desalination, to produce pure water from sea water on a large scale in places with low rainfall.
- Students follow the guidance on **worksheet 7.14.2** to obtain pure water from ink solution.
- Tell students that Jabir ibn Hayyan was one of the first scientists to use distillation. He lived in the Middle East from 721–815.

Extension

Students use the Internet to find out more about Jabir's work on distillation.

Homework

Workbook page 46

Key words

evaporation, distillation

Student book, pages 106–107

CD resource
- Worksheet 7.15.1

Objective

- Explain how fractional distillation separates mixtures of liquids with different boiling points

Overview

This extension lesson introduces the technique of fractional distillation as a way of separating mixtures of liquids with different boiling points. It begins with a simple demonstration of the fractional distillation of a crude oil substitute. It continues with student explanations – what is fractional distillation, and how does it work?

Activities

- Ask students about vehicle fuels. Where do diesel and petrol come from? Elicit that both come from crude oil. Crude oil is a mixture of compounds. Elicit that the compounds can be separated by distillation.
- Demonstrate the simple fractional distillation of a crude oil substitute. Use the apparatus, and follow the procedure, shown on **worksheet 7.15.1**. Demonstrate the viscosity and flammability of the fractions, and ask students to identify trends in these properties.
- Students read about fractional distillation on pages 106–07 of the Student book. In pairs they plan illustrated talks in which they use ideas about changes of state to explain how fractional distillation works. Their talks could draw on one of two examples – the fractional distillation of an ethanol/water mixture, or of crude oil.
- Student pairs give their talks to other pairs, and suggest improvements.

Homework

Workbook page 47

Key words

fractional distillation, crude oil, fractionating column

Student book, pages 108–109

CD resources
- Worksheet 7.16.1
- Worksheet 7.16.2

Objectives

- Understand how chromatography separates mixtures
- Give examples of uses of chromatography

Overview

This lesson shows how chromatography can be used to separate mixtures of dyes from pens and leaves. It begins with a scene-setter – how can you tell whether green marks on a criminal's T-shirt are from grass, spinach, or cassava leaves? To solve this problem, students first try out the technique of chromatography to separate the dyes from ink samples. They then plan and do an investigation in which they use chromatography to answer the question posed at the start of the lesson.

Activities

- Display a piece of cloth with green stains on it. Tell students that police need to know whether the stains are from grass, spinach, or cassava leaves. Set the challenge – students will use chromatography to identify the source of the green stains.
- Students follow the guidance on **worksheet 7.16.1** to experience chromatography by making chromatograms of ink samples, ideally from felt-tip pens.
- Students plan and do an investigation to identify the source of the green stains introduced in activity 1. Discuss the results as a class – how sure can you be that the conclusions are correct? **Worksheet 7.16.2** supports this activity – each group needs a strip of chromatography paper with a spot of spinach on the pencil line.
- Students read about some uses of chromatography, focusing on the study on cassava described on page 109 of the Student book.

Homework

Workbook page 48

Key words

chromatography, chromatogram, empirical question, evidence, explanation

7.17 Extension: separating metals from their ores

Student book, pages 110–111

CD resource
- Worksheet 7.17.1

Objectives
- Describe how to separate metals from ores
- Calculate the mass of metal obtained from an ore sample

Overview
In this lesson students use ideas about separation techniques to explain how tin is extracted from its ore. The main activity is a group activity, in which students work together to answer three questions about the extraction of tin from its ore: How does tin exist naturally, and where is it found? How is tin oxide separated from the substances it is mixed with in its ore? What chemical reaction is used to obtain tin from tin oxide, and how is this tin separated from the impurities it is mixed with? Student groups then create posters to demonstrate what they have learnt.

Activities
- Use the Student book to help explain how gold is obtained by panning. Point out that this technique only works for metals that exist naturally as elements on their own. The extraction of other metals – such as tin – requires a greater number of steps.
- Divide students into groups of three. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 7.17.1**.

  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 page 110 of 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 to demonstrate what they have learnt about extracting tin from its ore.
- Home groups present their posters to one other group. The other group peer assesses. Part 5 of **worksheet 7.17.1** supports this activity.

Homework
Workbook page 49

Key words
ore, panning, filtration, tin

Student book, pages 112–113

CD resource
- Worksheet 7.18.1

Objective

- Name the main elements in living things

Overview

This lesson is about the elements of life. It begins with a look at the human body – what are the main elements in us? Where do they come from? Students create posters to address these questions. Students then find out about iodine deficiency. They create radio or television programmes to describe an iodine deficiency disease, and to tell others about a study in which scientists researched the impact of action taken to prevent iodine deficiency diseases in Tanzania.

Activities

- Ask students to guess the main elements that make up their own bodies. Use information from page 112 of the Student book to give the answer. Pairs produce posters to show the main elements in a human body, and also to show where they come from.
- Students read about iodine deficiency in the Student book. In groups of four, they use **worksheet 7.18.1** to help them create a radio or television programme to tell others about iodine deficiency, and about the Tanzanian study described in the Student book.
- Student groups perform their programmes to at least one other group. The listening/viewing groups evaluate the programmes according to the criteria at the bottom of the **worksheet 7.18.1**.

Extension

Use the Internet to research one other deficiency disease.

Homework

Workbook page 50

Key words

vitamin, mineral, inverse correlation, deficiency

Student book, pages 116–117

CD resources
- Worksheet 8.1.1
- Worksheet 8.1.2
- Worksheet 8.1.3

Objectives

- Know what chemical reactions are
- Know how to recognise chemical reactions

Overview

The lesson starts with two short demonstrations to introduce the idea of chemical reactions. Students then carry out their own reactions, and notice signs that may indicate that a reaction is occurring. They then burn magnesium in air, and are introduced to the terms *reactant* and *product*.

Activities

- Demonstrate frying an egg. Then demonstrate another chemical reaction – add one spatula of potassium thiocyanate to about 50 cm^3 of water to dissolve, followed by a few drops of 0.1 mol/dm^3 iron(III) chloride. Deep red iron thiocyanate forms.
- Students follow the guidance on **worksheets 8.1.1** and **8.1.2** to carry out their own chemical reactions.
- Lead a discussion to elicit some signs of chemical reactions, including temperature changes, sounds, smells, and flames. Then define chemical reactions as changes which create new substances and cannot be reversed. Read page 116 of the Student book. **Worksheet 8.1.2** supports this activity.
- Demonstrate burning magnesium in air. Students should observe the experiment carefully. Introduce the terms *combustion, reactant,* and *product*. **Worksheet 8.1.3** supports this activity.

Extension

Students do further research about burning reactions, including finding interesting examples.

Homework

Workbook page 51

Key words

reactants, products, combustion, burning

Student book, pages 118–119

CD resources
- Worksheet 8.2.1
- Worksheet 8.2.2
- Worksheet 8.2.3

Objective

- Write word equations to represent chemical reactions

Overview

The purpose of this lesson is for students to learn how to write word equations to represent chemical reactions simply. During the lesson, students carry out five chemical reactions. They record their observations. Having been told the names of the reactants and products, students write word equations for each of their reactions.

During the lesson, emphasise that the meaning of the arrow in chemical equations is different from the meaning of the equals sign in maths. Also make clear that you cannot guess the names of products of reactions.

Activities

- On the board, write a sentence to describe a chemical reaction, for example *magnesium reacts with oxygen from the air to make one product, magnesium oxide*. Tell students they can summarise the reaction using just four words by writing a word equation.
- Students follow the guidance on **worksheets 8.2.1** and **8.2.2** to carry out five chemical reactions and record their observations.
- As a class, discuss the observations of the chemical reactions. Give the names of the reactants and products for each reaction. Students then write word equations for each reaction. The products are: 1 – iron oxide; 2 – iron hydroxide and sodium chloride; 3 – sodium ethanoate, carbon dioxide, and water; 4 – zinc chloride and hydrogen; 5 – copper sulfate and water. **Worksheet 8.2.3** supports this activity.
- Students complete the questions on Part 3 of **worksheet 8.2.3** to practise writing word equations.

Homework

Workbook page 52

Key words

word equation, neutralisation, salt, reaction

Student book, pages 120–121

CD resource

- Worksheet 8.3.1

Objectives

- Understand what corrosion is
- Know how to prevent iron corroding

Overview

This lesson is about corrosion. It begins with an opportunity for students to share what they already know about rusting and corrosion. It continues with a group activity, in which students work together to answer three key questions: What makes iron corrode? Why is the corrosion of iron – and other metals – a problem? How can iron corrosion be prevented? Student groups then create posters to summarise and display what they have learnt.

Activities

- Student pairs discuss what they already know about corrosion, including the rusting of iron. A few pairs feedback.
- Divide students into groups of three. These are *home groups*. Within home groups, each student is allocated one question from **worksheet 8.3.1**.

  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 pages 120-21 of 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 to show what they have learnt about corrosion.
- Home groups present their posters to one other group. The other group peer assesses using the grid at the bottom of **worksheet 8.3.1**.

Extension

Students do further research about burning reactions, including finding interesting examples.

Homework

Workbook page 53

Key words

corrosion, rusting

Student book, pages 122–123

CD resources
- Worksheet 8.4.1
- Worksheet 8.4.2

Objective

- Reinforce the stages of doing an investigation

Overview

This lesson continues the work on corrosion started in lesson 8.3. It is designed to reinforce the stages in planning and carrying out an investigation. Students spend the lesson planning and setting up their investigation, and predicting results. They will need to examine the results of their investigation, and consider the evidence obtained, one week later.

Possible investigation questions are given in the Student book. The Workbook also gives an example of a suitable investigation.

Activities

- Tell students that they will today plan and set up an investigation about corrosion. Discuss what they can remember about this topic from lesson 8.3.
- Students follow the guidance on **worksheet 8.4.1** and **8.4.2** to plan and set up an investigation. Encourage them to read carefully pages 122–23 in the Student book – and, if possible, page 54 of the Workbook – to help inform their choice of investigation question.
- Finish the lesson by discussing students' predictions. How confident are they in these?

Extension

Students use the Internet to further research some implications of corrosion. *www.corrosion.org* has some interesting videos about the topic.

Homework

Workbook page 54

Key words

questions, evidence, secondary sources

Student book, pages 124–125

CD resources
- Worksheet 8.5.1
- Worksheet 8.5.2

Objective

- Know how to use chemical reactions to identify metal elements in compounds

Overview

In this extension lesson, students witness the flame colours made by compounds of different elements. They are introduced to two applications of this phenomenon – identifying unknown compounds, and making fireworks. Students then observe the coloured precipitates formed when sodium hydroxide solution is added to different metal salts. They write word equations for the reactions observed, and find out how this method can be used to identify compounds.

Activities

- If possible, show a video clip of fireworks. Suitable clips can be found by searching the Internet for *firework video*.
- Students follow the guidance on **worksheet 8.5.1** to perform flame tests on salts of the following metals: lithium, sodium, potassium, calcium, and barium. As a class, discuss how flame tests can be used to help identify unknown compounds.
- Students follow the guidance on **worksheet 8.5.2** to make precipitates of metal hydroxides. As a class, discuss how this method can be used to help identify unknown compounds.
- Students write word equations for the precipitation reactions they have observed. Students should complete the questions on **worksheet 8.5.2**.

Homework

Workbook page 55

Key words

flame test, precipitate

Student book, pages 128–129

CD resource
- Worksheet 9.1.1

Objective

- Explain the difference between exothermic and endothermic reactions

Overview

This lesson introduces exothermic and endothermic reactions. It begins with a brief demonstration to illustrate an exothermic reaction (burning) and an endothermic change (melting). Through this activity, students are introduced to the terms *exothermic* and *endothermic*. The main part of the lesson is taken up by a practical activity in which students classify four reactions as exothermic or endothermic. They will return to some of these changes in greater detail in future lessons.

Activities

- **Practical activity:** Burn a piece of paper or wood. Through discussion, point out that a chemical reaction is taking place. The reaction releases heat. It is an exothermic change.

  Then place an ice cube on a student's hand. It melts, and the hand feels cold. Tell students that melting ice takes heat from the hand. Melting is an endothermic change.
- **Practical activity:** Students follow the instructions on the **worksheet 9.1.1** to perform four reactions, and classify each change as exothermic or endothermic. Emphasise that, for changes involving solutions:
  - In an exothermic change, the temperature initially increases. This is because the heat released is first used to heat the solution. The heat is then released to the surroundings.
  - In an endothermic change, the temperature initially decreases. This is because the heat needed for the change is taken from the solution, so its temperature decreases. The solution then takes in energy from the surroundings.

Homework

Workbook page 56

Key words

fuel, exothermic, endothermic

Student book, pages 130–131

CD resources
- Worksheet 9.2.1
- Worksheet 9.2.2

Objective

- Consider how to plan an investigation, obtain evidence, and draw conclusions

Overview

In this lesson, students plan and carry out an investigation to compare the heat released on burning by different fuels. They will plan the investigation themselves. This includes carrying out preliminary work to decide the volume of water to use.

Students then consider their evidence and approach. What is their conclusion? How could they improve their method? What changes could they make to reduce error and improve reliability?

You may need to emphasise that temperature is not the same as heat. The temperature increase of the water is an indication of the heat released by the burning fuel. The greater the temperature increase of the water, the more heat is released by the burning fuel.

Activities

- Introduce students to fuels as materials that burn to release useful heat. Ask students to suggest examples of fuels.
- Display a range of substances that can be used as fuels, for example methanol, ethanol, propan-1-ol, butan-1-ol. Point out that of these fuels, only ethanol is used on a large scale. Students follow the guidance on **worksheet 9.2.1** to plan an investigation to find out which fuel releases most heat on burning. The level of teacher guidance required will depend on students' previous planning experience.
- **Practical activity:** Students follow the guidance on **worksheet 9.2.2** to carry out their investigation, and consider their evidence and approach. Tasks include writing a conclusion, and considering how to reduce error and increase reliability.

Homework

Workbook page 57

Key words

reliable, error, preliminary work

Student book, pages 132–133

CD resource
- Worksheet 9.3.1

Objective

- Consider the advantages and disadvantages of vehicle fuels

Overview

Students begin by listing all the different vehicle fuels they can think of, and outlining their advantages and disadvantages. They then read about three different vehicle fuels. In groups they create, perform, and evaluate a radio or television programme to tell people about these fuels.

Finally, there is an optional activity to research other fuels – perhaps ones that are used locally – and produce a poster about them.

Activities

- In pairs, students list all the different vehicle fuels they can think of, and outline what they know about their advantages and disadvantages.
- Students read pages 132–33 in the Student book about three different vehicle fuels – diesel, hydrogen, and ethanol. In groups of four, they use **worksheet 9.3.1** to help them create a radio or television programme to tell others how these fuels are produced, and about their benefits and disadvantages.
- Student groups perform their programmes to at least one other group. The listening/viewing groups evaluate the programmes according to the criteria at the bottom of **worksheet 9.3.1**.

Extension

Use the Internet to research one or more other fuels – perhaps ones which are used locally – and produce a poster about how they are obtained, and their advantages and disadvantages. A suitable starting point is *www. afdc.energy.gov/fuels/*

Homework

Workbook page 58

Key words

fuels, greenhouse gas, combustion

Student book, pages 134–135

CD resources
- Worksheet 9.4.1
- Worksheet 9.4.2

Objective

- Describe how to measure the heat released when food burns

Overview

The lesson begins with a discussion about the different amounts of energy provided by different foods. Students then measure the temperature increase of a fixed volume of water caused by burning different foods. They calculate the amount of heat transferred to the water by each food, and compare their results to published energy values for these foods. Student values are likely to be lower than published values, since much heat is transferred to the apparatus and surroundings in their investigation.

Activities

- As a class, discuss foods that provide different amounts of energy. For example, fatty foods provide more energy than green leafy vegetables. Of course, foods with low energy values may still be nutritious.
- Students design and carry out an investigation to compare the heat released on burning different foods. **Worksheet 9.4.1** guides them through the planning process.
- Students follow the guidance on **worksheet 9.4.2** to calculate the amount of energy transferred as heat to the water on burning each food. They use food packets, or the Internet, to find published energy values for these foods. They suggest reasons for differences. The reasons might include the fact that, in the investigation, heat is transferred to the apparatus and surroundings as well as to the water.

Homework

Workbook page 59

Key words

heat, energy, burning

9.5 Enquiry: investigating endothermic changes

Student book, pages 136–137

CD resources
- Worksheet 9.5.1
- Worksheet 9.5.2

Objective

- Plan how to investigate an endothermic process

Overview

The lesson begins with a demonstration to illustrate the cooling that occurs when ammonium nitrate dissolves in water.

Students then plan and carry out an investigation to answer one of three scientific questions about the heat released or taken in when solutes dissolve.

If time allows, students discuss their findings with a group who answered a different investigation question.

Activities

- Demonstrate the process described on page 136 of the Student book in which ammonium nitrate dissolves in water, causing a small amount of water under the flask to freeze. The ice formed sticks the flask to a small block of wood.
- **Practical activity:** Students plan and carry out an investigation to answer one of the three questions below. **Worksheet 9.5.1** supports this activity.
  - For a solute that dissolves endothermically, does the mass of solute affect the amount of heat taken in?
    (use from 0.5 g to 3.0 g of ammonium chloride in 10 cm^3 of water)
  - For a solute that dissolves endothermically, does the volume of solvent affect the amount of heat taken in?
    (use 1.5 g of ammonium chloride in 5–15 cm^3 water)
  - Which solutes take in or release the most heat when they dissolve in water?
    (solutes listed on activity sheet; use 1 spatula measure of each solid in 25 cm^3 water)
- Student groups discuss their results with others who have tackled a different question. They question each other about their planning, and about how they obtained and considered their evidence. **Worksheet 9.5.2** supports this activity.

Homework

Workbook page 60

Key words

endothermic, enquiry, variable, evidence

Student book, pages 140–141

CD resources

- Worksheet 10.1.1
- Worksheet 10.1.2
- Worksheet 10.1.3
- Stretching a string presentation

Objectives

- Describe what happens when you stretch a spring
- Explain what is meant by tension
- Explain the elastic limit
- Explain why things float or sink

Overview

This is a two-part lesson. In the first part students stretch an spring to find the elastic limit. This links to what they learned about forcemeters in Book 1, and links to an experiment collecting data about elastic bands next lesson. In the second part they take a mass on a spring balance and suspend the mass in different liquids to measure upthrust. Finally, they look at different objects that float and sink and relate that to upthrust and weight. They will need the results of their spring investigation for next lesson on presenting results.

Activities

- Show student pictures of ropes or wires in a variety of places: bungees, suspension bridges, circus acts. Ask them for the name of the force that is acting in the wire or cord. Remind students about why we use a forcemeter to measure force. Elicit (or show students) that forcemeters contain springs.
- Discuss what is meant by the extension of a spring. Demonstrate how to measure extension. Students complete a short experiment to find the elastic limit of a spring by loading it using **worksheet 10.1.1**. Tell them the maximum number of 100 g masses that they should use. It should take the spring over the elastic limit but not break the spring. This means that the spring will be permanently extended when they unload it. (Eye protection is important.)
- Ask students to deduce the elastic limit from their results. Elicit that springs stretched beyond their elastic limit do not return to their original length.
- Discuss the use of springs in forcemeters and scales. Elicit that the same thing (proportionality) happens in compression as in tension.
- Elicit that the force that supports floating objects is called upthrust. Students complete a short experiment into the upthrust of some liquids using **worksheet 10.1.2**.
- Discuss the link between the upthrust and the weight in terms of floating and sinking, and link this to Archimedes Principle. Practical examples include supertankers and ferries.
- Students make boats out of plasticine that float on water and explain why the same amount of plasticine in a ball does not float. They will need to use Archimedes principle.
- Finally, ask students what would happen to the weight of a bag of water when you lower it into a bowl of water. (It doesn’t change because the upthrust and weight are the same).

Extension

Students calculate the decrease in length of the spring from the first activity if the mass was in each liquid. **Worksheet 10.1.3** supports this activity.

Homework

Workbook page 61

Key words

tension, elastic, plastic, proportional, elastic limit, permanently extended, upthrust, Archimedes Principle

Student book, pages 142–143

CD resource

- Worksheet 10.2.1

Objectives

- Describe how to present results in tables
- Describe how to draw line graphs
- Explain what is meant by continuous variables

Overview

In this lesson, students consider how to present the data that they collected in an experiment about stretching an elastic band. They can choose between using a line graph or a bar chart, and produce a line graph. They write conclusions for their experiments based on the graphs that they have drawn, and consider what they should do about any results that do not fit the pattern on the graph.

Activities

- Ask students to think of a situation where it is very important to know the elastic limit of a spring. Show the same pictures that you used at the start of the previous lesson and discuss the fact that you need to know when materials will extend permanently or break. Add ideas about weight limits for trampolines as shown in the Student book.
- Students consider how they could display the data for the extension of a spring when weights are added to it that they collected last lesson.
- Discuss the types of graph that you can plot and why. Students can use the reference section of the book to look at the different graphs and charts.
- Students plot an appropriate graph (line graph) of their results.
- They use the graph to find the elastic limit, and compare the value with the one that they worked out from their data alone.
- Students compare the graphs that they have drawn and discuss what to do about any anomalous points.
- Students use the data on **worksheet 10.2.1** to plot an appropriate graphs or chart (bar chart). They consider other variables and explain which graphs could be plotted.

Extension

Students consider and explain the links between variables by doing question 10 on **worksheet 10.2.1**.

Homework

Workbook page 62

Key words

discrete, categoric, continuous, line graph, bar chart, anomalous result

Student book, pages 144–145

CD resources

- Worksheet 10.3.1
- Worksheet 10.3.2
- Worksheet 10.3.3
- Circular motion presentation

Objective

- Explain why some objects move in circles

Overview

This lesson provides an introduction to circular motion. It explains that a force is necessary to change the direction of motion of an object to keep it moving in a circle. The name of that force is the centripetal force, but it must be provided by a physical force such as gravity, tension, or friction. There are a wide range of situations that provide examples of circular motion, such as planets and satellites in orbit, and going round a corner in a car.

The activities provide an opportunity to show that the force brings about a change in the *direction* of motion of an object and not its speed. This lesson prepares students for a further study of centripetal force at IGCSE level and O level.

Activities

- A dramatic example of circular motion is to swing a bucket on a rope in a vertical circle without spilling a drop. It is much safer to do this outside. Take care that the string will not break. Alternatively, show a video of this happening. Discuss that fact that the bucket goes around in a circle because of the tension in the string.
- Students investigate circular motion by swinging a small object on a piece of string using **worksheet 10.3.1**. They change the mass of the object, length of string, and the speed to find the effect on the centripetal force.
- Discuss what they have found out in the practical. Elicit that the force depends on the speed and the mass, and that a bigger force is needed to keep objects moving in circle of smaller radius.
- Students discuss in pairs the different situations where they know that something is moving in a circle. They work out which physical force is keeping them moving in a circle. Each pair feeds back one of their ideas. This should cover the range of physical forces: gravity, friction, tension are the most common.
- Satellites in orbits are kept there by the force of gravity. Students investigate the difference between different types of satellites and their uses, and link it to what they have learned in the experiments. **Worksheet 10.3.2** supports this activity.
- Students could research a particular satellite and present their findings on a poster. **Worksheet 10.3.3** supports this activity.

Extension

Ask students to complete question 2 of **worksheet 10.3.2**.

Homework

Workbook page 63

Key words

centripetal force, tangent, artificial satellites, orbit, gravity

Student book, pages 148–149

CD resources
- Worksheet 11.1.1
- Worksheet 11.1.2

Objectives

- Describe where we get our energy from
- Know the unit of energy

Overview

This introductory lesson focuses on the need for food or fuel to be able to do things like move, or make a car move. Students learn about the energy content of food in joules and kilojoules. They consider how much food is needed to do certain activities. They link the energy stored in food to the energy stored in fuels. In the next lesson students will link the energy stored in fuels and food as originating from the Sun.

Activities

- Ask students to list as many activities as they can that they do each week, and then to put them in order of those requiring the most energy to those requiring the least energy. Elicit that your body needs energy just to keep the body warm and for breathing. Ask them where this energy comes from.
- Introduce the idea of energy in food being measured in joules or kilojoules. Use a balance to measure the smallest piece of chocolate that will register (0.01 g is equivalent to approx. 2000 J), and use this to demonstrate why we use kJ rather than J. If appropriate discuss the link with calories/kilocalories. 1 cal = 1 kilocalorie = 4.2 kJ.
- Students complete an investigation into the energy content of food by measuring the temperature rise of a certain volume of water when a fuel is burnt using **worksheet 11.1.1**. They evaluate the investigation.
- Students work out how long they would have to complete different activities to ‘burn off’ the energy in food using **worksheet 11.1.2**.
- Introduce fossil fuels as energy stores like food. Discuss the similarities between fossil fuels and food and how they are used.

Homework

Workbook page 64

Key words

energy, fuels, joule, kilojoule, coal, oil

Student book, pages 150–151

CD resource
- Worksheet 11.2.1

Objectives

- Understand why the energy in food comes from the Sun
- Describe some methods of generating electricity using the Sun's energy

Overview

In this lesson students learn that the Sun is the source of the energy in all the food that we eat. They examine energy resources that are used to produce electricity, such as wind, wave, hydroelectricity, and fossil fuels and how they can be linked to the Sun. As an extension to this work students consider geothermal energy and tidal power, which are not connected to the Sun.

Activities

- In this lesson groups of students take responsibility for a section of a wall display that shows how the Sun important for the production of food, fuels, and energy sources that are used to produce electricity. Divide the class into groups. Each group prepares their section of the display using **worksheet 11.2.1**. Students can be encouraged to use simple materials to make the display three-dimensional.
- Take a section of wall and fix a large yellow Sun to the centre. Each of the groups will produce their section of the display.
- When they have done that they use the display to complete a table summarising the information.
- Alternatively, students could present their food, fuel, or energy source to the rest of the class during which the class complete the table. When this has been done they complete the display.

Extension

Allocate tidal power and geothermal energy to two groups. Make a separate display for these energy sources, and have students make a separate table to emphasise that the source of the energy is not the Sun.

Homework

Workbook page 65

Key words

photosynthesis, fossil fuels, crude oil, hydroelectricity, solar cells, solar panels

Student book, pages 152–153

CD resource
- Worksheet 11.3.1

Objectives

- Name the different types of energy
- Give examples of processes that involve the different types of energy

Overview

Students will not have met types of energy before, but will be familiar with everyday concepts of energy, such as heat (thermal energy), light, and sound. In this lesson they learn about the different types of energy that are involved in many everyday familiar energy transfers. They will consider energy transfers and energy transfer diagrams in the next lesson. The main aim of this lesson is to differentiate between energy stores and methods of transferring energy. The underlying principle here is that of the conservation of energy, to be considered in lesson 11.5. Energy types are a way of keeping track of energy because it can always be accounted for.

Activities

- Ask students to list the types of energy that they have met before. Students compare lists in pairs/groups to produce a ‘master list’.
- Introduce the idea of ‘stores’ of energy and ‘ways of transferring energy from one place to another’. Students should be encouraged to see light, sound, and electrical energy as ways that energy is transferred from one place to the next. Discuss the difference between ‘thermal energy’ and ‘heat’. We heat things up, and this increases their thermal energy.
- Students design a card game based on the energy types using **worksheet 11.3.1**. They make cards that illustrate places where you would see objects with the different types of energy, for example, a battery = chemical energy.
- Students play their game then swap with another group and play that game.
- Students draw a table for all of the energy types and write down as many examples for each one that they can think of based on the games that they have played.

Extension

Students find out about nuclear fusion, nuclear fission, and burning. They make a poster that explains the difference between them.

Homework

Workbook page 66

Key words

potential energy, store of energy, chemical energy, chemical potential energy, gravitational potential energy, elastic potential energy, thermal energy, heat, electrical energy, light energy, sound energy, nuclear energy, nuclear fusion, chemical reaction, burning, combustion, hydrogen, uranium, nuclear fission

Student book, pages 154–155

CD resources
- Worksheet 11.4.1
- Worksheet 11.4.2

Objectives

- Understand how energy transfers are shown in diagrams
- Be able to construct energy transfer diagrams

Overview

Students build on what they have learned about the different types of energy by considering energy transfers. They complete an activity where they draw energy transfer diagrams for a wide range of energy transfers. They consider where the energy is actually going, in preparation for next lesson on the conservation of energy. They consolidate their knowledge by completing a card sort to identify various energy transfers.

Activities

- Recap all the different energy types by asking students to write down as many different types of energy that they can remember in 30 seconds.
- Introduce the idea of an energy transfer diagram by thinking about a torch. Show a torch (or similar) and ask what energy transfers are taking place. Students may start with electrical energy. Elicit that the torch would not work without the battery, a store of chemical energy. Draw the energy transfer diagram for a torch.
- Students complete a circus of activities where they identify the energy types and draw an energy transfer diagram for each situation using **worksheet 11.4.1**.
- Discuss the processes and devices in the circus. Students will have a strong sense of what is 'useful' and what is not, and this will be explored in the next lesson. Elicit that energy is transferred in a device (like a solar cell) or a process (like a trolley rolling down a ramp). Students consider the start and end point of each process. Which store has less energy and which has more? This work will be referred to in the lesson on the conservation of energy. Elicit that sometimes it is clear what the energy transfers are, and sometimes it is not.
- Students complete a card sort of various processes in pairs using **worksheet 11.4.2**. One student uses the cards to make a diagram and the other student guesses the device or process. There are empty boxes to use different energy types (e.g. GPE or KE) and a different process.

Homework

Workbook page 67

Key words

energy transfer, energy transfer diagram

Student book, pages 156–157

CD resources
- Worksheet 11.5.1
- Worksheet 11.5.2
- Wasted energy presentation

Objectives

- Know the law of conservation of energy
- Explain how the law applies to different situations

Overview

Students are introduced to the idea of energy as an amount that we can keep track of, a bit like money. By considering the energy transfers that they have previously studied they differentiate between 'useful' and 'wasted' energy and learn what is meant by efficiency. They learn the law of conservation of energy, and how that applies to the energy transfers that they have been investigating. They look at two different ways of modelling energy and use the models to describe some energy transfers. Finally they discuss the fact that a lot of the 'wasted energy' is in the form of thermal energy and how that can be incorporated into their models.

Activities

- Using the cards from the previous lesson students pick two of the devices/processes and identify the useful and the wasted energy. Compare groups' choices. Discuss the use of the word 'wasted', rather than energy that has 'gone' or been 'lost'. Emphasise that energy is something that we can keep track of and that this is a very important principle in physics called the law of conservation of energy.
- Introduce the idea that sometimes the wasted energy and useful energy can be the same type, but in different places, for example a kettle heats the water and the air around it.
- Student use two models for energy: coloured liquid and 'money'. Demonstrate the first process (a torch) in the following way. Take a beaker and a yellow and blue label. Write 'battery' on the blue label and 'chemical energy' on the yellow label. Fix both labels to the beaker with a rubber band. Label another beaker with light energy/surroundings, and another with thermal energy/surroundings. Fill the chemical energy beaker with coloured liquid and pour some into the light energy beaker and the rest into the thermal energy beaker. Discuss how the model shows that energy cannot be created or destroyed. Students continue with the modelling using **worksheet 11.5.1**.
- Discuss how the students used the coins/counters to model the torch. Bring out similarities/differences between the models.
- Discuss what we mean by 'efficient'. Ask if is possible to say how efficient the devices were. Elicit that to work out how efficient something is we need to know how much of the original energy is wasted. Students complete **worksheet 11.5.2** to compare three types of light bulb and think about how to incorporate wasted energy into each model.

Extension

Students compare and contrast the models for a range of processes and produce a table of the pros and cons of using each model.

Homework

Workbook page 68

Key words

useful energy, wasted energy, efficient

Student book, pages 158–159

CD resources

- Worksheet 11.6.1
- Worksheet 11.6.2

Objectives

- Explain what is meant by gravitational potential energy
- Explain what is meant by kinetic energy
- Describe situations which involve gravitational potential energy and kinetic energy

Overview

In this lesson students use the law of conservation of energy to interpret situations where there is a transfer of energy between gravitational potential energy and kinetic energy. They build a model of a cliff railway and work out the masses that you need to move one of the trains and how that relates to friction. Finally they investigate the link between the height that a ball is dropped from and the size of a crater.

Activities

- Start by demonstrating a very large pendulum. Suspend a football or other large ball by a piece of string from the ceiling. Stand against the wall and pull the ball back until it touches your forehead. Ask the students what they think will happen if you let go. Let go and discuss what happens in terms of GPE and KE. Link the fact that the ball will not come back further (and hit you) to the law of conservation of energy. Elicit that the 'wasted' energy here is due to the air heating up.
- Show photographs or a diagram of the funicular railway at Palani in Tamil Nadu, India. Students model cliff railway, and account for the fact that you need to use a bigger force due to the friction in the system. **Worksheet 11.6.1** supports this activity.
- Students investigate the transferral of gravitational potential energy to kinetic energy of a ball that then produces a crater. They evaluate the investigation and think what else could be investigated. **Worksheet 11.6.2** supports this activity.
- Students present their results and produce a plan to investigate another factor (type of ball, sand, etc.) They review each other's plans and evaluate them in terms of whether they would produce reliable results.

Homework

Workbook page 69

Key words

gravitational potential energy, kinetic energy

11.7 Storing energy – elastic potential energy

Student book, pages 160–161

CD resources
- Worksheet 11.7.1
- Worksheet 11.7.2

Objectives

- Explain how the store of elastic potential energy can change
- Describe situations where the store of elastic potential energy increases or decreases

Overview

In this lesson students learn how energy is stored when materials are deformed, and that the energy can be recovered when it returns to its original shape. They link what they have learned about the conservation of energy to a situation involving a ball bouncing.

Activities

- Start by demonstrating a variety of activities and ask students what they have in common. For example, putting a mass on a spring and taking the mass off, a wind up toy, blowing up a balloon and letting it go, flicking an elastic band. Elicit that there is a spring inside the toy, and that there is an energy change from energy stored to kinetic energy. The springs or rubber change shape or extend and the more that they are extended the more energy is stored. Introduce the idea of elastic potential energy.
- Demonstrate bouncing a ball. Ask students to work out the energy transfer diagram.
- Students complete an investigation into bouncing balls and plot a graph of their results. They present the results to the class and describe the link that they have found using the language of 'the bigger the … the bigger the …' **Worksheet 11.7.1** supports this activity.
- Students consolidate what they have found out by designing and making a catapult to launch a marble to hit a target. Students learn how to calibrate their catapult so that they can hit a target on the floor. When they have finished tell them the distance that they have to put the target from the catapult. All groups have a single chance to hit the target. The winning group receives a prize. **Worksheet 11.7.2** supports this activity.

Extension

Students work out the percentage of energy 'wasted' for a sequence of bounces. They extend the investigation to look at the energy absorbing properties of different surfaces.

Homework

Workbook page 70

Key words

elastic potential energy (EPE), deform, elastic

Student book, pages 162–163

CD resources
- Worksheet 11.8.1
- Worksheet 11.8.2

Objectives

- Recognise that there are lots of ways to find out the answers to questions in science
- Understand how to decide on a question to investigate

Overview

This is the first of two lessons where students learn about the type of questions that science can answer and the different ways in which they can be investigated. In the first lesson they consider questions that can be answered by doing practical work and in the second lesson they learn about a range of other methods. The context of the two lessons is providing food and fuel for an island community. You could use a real example, or make up a fictitious island.

Activities

- Introduce the island, real or fictitious, and explain that they are going to consider the energy needs of the islanders. Ask the students to come up with three questions that they could ask about the food and fuel that the islanders use or need. Hint that the islanders need to choose which foods to grow, and that there are certain fuels that might be there, and others that they could grow. Bring all the questions together and ask the students to divide the questions into those that can be investigated practically by doing an experiment, and those that cannot. Leave the second category for next lesson.
- Students choose one of the questions to investigate and plan and do an experiment to answer it. **Worksheet 11.8.2** has some ideas that they could use if there are not enough practical ideas suggested. You can amend this sheet depending on the resources available. **Worksheet 11.8.1** supports this activity.
- Students could all do the same experiment, or each group could answer a different question.
- Students could present the findings of their experiments to the rest of the class.

Homework

Workbook page 71

Key words

questions, explanations, practical investigation, prediction

Student book, pages 164–165

CD resource
- Worksheet 11.9.1
- Worksheet 11.9.2

Objectives

- Recognise that there are lots of ways to find out the answers to questions in science
- Understand how to decide on a question to investigate

Overview

This is the second of two lessons about the types of question that can be asked and how they can be investigated using science. Students also consider questions that science can't answer. They use the other questions that they thought of in the previous lesson and use the Student book to work out others.

Activities

- Display the questions from the previous lesson that were not appropriate for a practical investigation. Discuss why not with the students and whether they are questions that science can answer at all. Introduce the idea that science can only answer questions where data can be collected, or a scientific explanation can be used.
- Students read the Student book to learn about the other ways that scientists can answer questions. Different groups are allocated different methods. They select the questions that can be investigated by that method.
- They consider those and other questions that can be investigated using their method, and produce a wall display to illustrate the method using **worksheet 11.9.1**. **Worksheet 11.9.2** provides some additional ideas that the students could use.
- All the groups put their displays on the wall.

Homework

Workbook page 72

Key words

observations, models, field study

11.10 Extension: Energy calculations and Sankey diagrams

Student book, pages 166–167

CD resources
- Worksheet 11.10.1
- Worksheet 11.10.2
- Worksheet 11.10.3
- Sankey diagrams presentation

Objectives

- Be able to do calculations that involve energy
- Use Sankey diagrams to show processes that involve energy

Overview

In this lesson students learn how to calculate efficiency and learn that efficient machines waste less energy than less efficient machines. They learn how to represent energy transfers with Sankey diagrams and how to construct diagrams so that they represent a process quantitatively.

Activities

- Remind students of the models that they used for energy in lesson 10.5 and the idea of 'useful' and 'wasted' energy. Introduce the idea of efficiency in terms of a process or device where there is less wasted energy, or where less energy is used to produce the same useful energy.
- Introduce the equation for efficiency and students practice calculations of efficiency using **worksheet 11.10.1**.
- Demonstrate the energy needed to light a low energy light bulb and an incandescent light bulb for 10 seconds using a mains joulemeter. If they have the same power they should appear to be equally bright to the students but the low energy light bulb should require less energy. Students work out how much energy is transferred as light given the information in the Student book on page 166–67.
- Introduce the idea of a Sankey diagram with reference to the light bulbs and explain how to construct a Sankey diagram. Students construct Sankey diagrams for the processes for which they found the efficiency using **worksheet 11.10.2**. They also model the processes using coloured water, coins, or dice.
- Students can look at more complicated Sankey diagram, for example of a power station. They suggest ways of making the power station more efficient (e.g. by using the thermal energy to heat homes). **Worksheet 11.10.3** supports this activity.

Homework

Workbook page 73

Key words

efficiency, Sankey diagram

Student book, pages 170–171

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

Objectives
- Know how to calculate speed
- Explain what is meant by average speed

Overview
In this lesson students are introduced to the equation for measuring speed. They learn how to calculate speed and to consider the units with which you can measure speed. To appreciate the difference between (instantaneous) speed and average speed they make a balloon rocket and measure the total time that it takes to travel a certain distance.

Activities
- Show pictures of animals and vehicles and ask students to rank them in terms of speed on **worksheet 12.1.1**. Students discuss what the speed of each might be in pairs, and rank them. In the discussion afterwards bring out that concept of a certain distance in a certain time. Introduce the equation, and all the units that speed can be measured in. Ask students to complete the calculations on **worksheet 12.1.2**. This is a good opportunity to discuss how best to set out calculations (as shown in the Student book). Students should be encouraged to develop good habits that will help them now and in later examinations.
- Discuss how the speed of a car changes during a journey. We can talk about the speed at certain moment (like the number on the speedometer) or the average speed. Define average speed and discuss how it is different from 'steady speed'.
- Introduce the balloon activity. Students complete the activity using **worksheet 12.1.3**. You will need to suspend long pieces of string across the room for this activity, and assist students when they are putting their balloon racers on the string. An alternative to this activity would be for students to time each other walking different distances and then calculate their average speeds.
- Students consolidate their learning by completing further calculations on **worksheet 12.1.4**.

Extension
Ask students to complete questions 7, 8, and 9 on **worksheet 12.1.2**.

Ask students to complete question 5 on **worksheet 12.1.4**.

Homework
Workbook page 74

Key words
speed, metres per second, kilometres per hour, steady speed, average speed

Student book, pages 172–173

CD resources
- Worksheet 12.2.1
- Worksheet 12.2.2

Objectives
- Explain the difference between accuracy and precision
- Define reaction time
- Know how to measure time precisely

Overview
This lesson introduces the ideas of precision and accuracy. A lot of the issues around precision of measurements that students make with a stopwatch are a result of reaction time. Students do an experiment to measure their reaction time. Students learn that when a higher level of precision is needed you can use timing gates or remote sensors that are linked to datalogging equipment. They compare measurements made in this way with measurements made with stop-clocks.

Activities
- Recap what was learned in lesson 12.1 by asking students the difference between speed, average speed, and instantaneous speed.
- How good were they at timing their balloon? Introduce the idea of reaction time and discuss how reaction time affects measurements that they can take. Introduce the activity to measure reaction time.
- Students complete an activity to measure their reaction time using **worksheet 12.2.1**. They can compare their reaction times with others in the class and discuss what factors might affect reaction time (tiredness, age, distractions).
- Students measure the time it takes a ball to roll down a ramp manually and automatically. **Worksheet 12.2.2** supports this activity.
- Students make a table comparing the pros and cons of using a stop-clock and timing gates.

Extension
Students can research the technology that enables the sprint races in the Olympics to be timed to a thousandth of a second.

Homework
Workbook page 75

Key words
precision, accuracy, reaction time, timing gates

Student book, pages 174–175

CD resources

- Worksheet 12.3.1
- Worksheet 12.3.2
- Distance-time graphs presentation

Objective

- Describe how a distance–time graph tells a story

Overview

This lesson introduces the idea that a distance-time graph can be used to tell a story. The total distance travelled in a certain time tells us the average speed and it would be difficult to write down the speed at every moment of a journey. Students complete an experiment to find the time it takes to travel different distances and use the reading to plot a graph. They work out how to draw distance-time graphs for different types of motion and how to interpret distance-time graphs in terms of relating the gradient of the graph to the speed of the object. Finally they link this lesson back to what they know about calculating speed using the equation that they learned in lesson 12.1.

Activities

- Ask students to think about walking to school, or out to see their friends after school. How could they describe that journey in terms of how far they went and how long it took them? Introduce the idea of showing those things on a distance-time graph.
- Students complete an activity that produces data to draw a distance-time graph using **worksheet 12.3.1**. They draw the graph and interpret it using **worksheet 12.3.2**. This asks them to work out from the graph where the ball is moving fastest and slowest.
- Discuss the shapes of the graphs and elicit that the slope of the graph tells you the speed.

Extension

Students complete questions 8 and 9 on **worksheet 12.3.2**.

Homework

Workbook page 76

Key words

distance-time graph, average speed

Student book, pages 176–177

CD resources
- Worksheet 12.4.1
- Worksheet 12.4.2
- Worksheet 12.4.3

Objectives

- Describe how to calculate acceleration
- Explain what is meant by deceleration
- Explain how speed-time graphs tell a story

Overview

This lesson introduces the idea of acceleration as changing speed, and how to calculate it. Students learn the difference between positive and negative acceleration and how that links to the motion of the object. They learn how to interpret speed–time graphs and to make calculations from those graphs.

Activities

- Show pictures of a car, a motorcycle, and a plane or find a suitable video online. Ask the students which one is the 'fastest'. Students discuss in pairs and report back. Elicit that there is a difference between speed and how fast the speed increases (acceleration). The motorcycle will accelerate more than the plane if both were on a runway, but the plane will end up fastest.
- Introduce the equation for calculating acceleration, and the units. Emphasise that the 'metres per second squared' is actually better thought of as '(metres per second) per second'. Students complete an activity using the equation on **worksheet 12.4.1**.
- Students complete an investigation into the motion of a toy car on a ramp using a motion sensor and a datalogger. They interpret the graph produced by the datalogger using **worksheet 12.4.2**.
- If data-logging equipment is not available students can use the data on **worksheet 12.4.3** to plot some graphs and answer questions relating to those graphs.

Homework

Workbook page 77

Key words

acceleration, deceleration, terminal velocity

Student book, pages 178–179

CD resources
- Worksheet 12.5.1
- Worksheet 12.5.2
- Worksheet 12.5.3
- Worksheet 12.5.4
- Presenting data – graphs presentation

Objectives

- Present results in tables, charts, and graphs
- Explain what a continuous variable is

Overview

This lesson looks at the presentation and analysis of data. Students consider pie charts, bar charts, and line graphs as ways of communicating with graphs and charts. They learn that it is appropriate to use line graphs when the variables are continuous.

Activities

- The first part of the lesson focuses on pie charts and bar charts. Show some examples of bar charts and pie charts, and demonstrate that we use these charts to show information that is categoric (names etc.) or discrete (can only have integer values).
- Students work with data from the Formula 1 2012 season on **worksheet 12.5.1** to present it in the most appropriate way. They can decide on their own way of showing the data, or use ideas on **worksheet 12.5.2** to structure their work. They present their charts to the rest of the class.
- The second part of the lesson is a chance to develop their understanding of line graphs. Ask them what they think is important if you are going to be a successful Formula 1 driver. Elicit age and experience might be factors. Give them more data about the drivers on **worksheet 12.5.3** and ask them to plot line graphs to find out if there is a link. The graphs show a distinct outlier (anomalous result) (Michael Schumacher). This should prompt a discussion about what to do with anomalous results in experiments.
- Consolidate with list of things to plot and students decide whether to plot line graphs or bar charts using **worksheet 12.5.4**.

Homework

Workbook page 78

Key words

categoric, discrete, continuous, bar chart, pie chart, line graph, variable

Student book, pages 180–181

CD resources
- Worksheet 12.6.1
- Worksheet 12.6.2
- Worksheet 12.6.3
- Worksheet 12.6.4

Objective

- Be able to talk about the importance of questions, evidence, and explanations.

Overview

In this lesson students learn about how scientists can be very creative when they want to answer questions. They learn about how you can do ‘thought’ experiments as well as actual experiments, and that this is very helpful when it is difficult or impossible to produce conditions that you are discussing. They do an actual experiment about falling objects and then think up a thought experiment that they could use to reach the same conclusion. This work builds on what they learned about gravity and air resistance in International Secondary Science 1. They read about Galileo in the Student book and work out a cartoon strip of picture book to explain to younger students that you do not need a force to keep something moving (at a steady speed). This is a misconception that many students (and adults!) have about moving objects.

Activities

- Ask students to imagine being a very, very long way away from the Earth or any other planet. Ask them what has happened to their mass (nothing) and their weight. Elicit that weight only has a meaning if they are near a planet or moon, or another massive body.
- Explain that this is a very simple example of a ‘thought experiment’. Explain that they are going to answer the question ‘do heavier things fall faster’ in two ways. First they will do an experiment to see if they can answer the question – provide students with a range of balls including balls of similar size but different masses e.g. cricket ball and tennis ball. **Worksheet 12.6.1** supports this activity.
- If available, demonstrate two objects of different mass falling in a vacuum or show the video of dropping the hammer and feather on the Moon from the NASA website. Search for *hammer and feather* on this website: *http://www.nasa.gov/home/index.html*
- Students work out a way of finding the answer to the question without doing the experiment. **Worksheet 12.6.2** supports this activity. **Worksheet 12.6.3** also supports this activity, but provides hints to support students.
- Students read about Galileo’s thought experiment on pages 180–181 of the Student book. They then design a cartoon book to explain to students of primary level why you do not need a force on an object for it to move. **Worksheet 12.6.4** supports this activity.

Extension

Ask students to answer questions 4 and 5 on the **worksheet 12.6.1**.

Homework

Workbook page 79

Keywords

questions, evidence, explanations, thought experiments, creative thinking, inertia

Student book, pages 184–185

CD resources
- Worksheet 13.1.1
- Worksheet 13.1.2
- Worksheet 13.1.3

Objectives

- Explain what we see when light is refracted
- Explain why light is refracted

Overview

In this lesson students investigate what happens at the boundary between air and water. They investigate two situations where light is refracted and learn about the difference between real and apparent depth. They learn about refraction and how it can be used to explain phenomena, and this will be developed when they take measurements of light travelling through glass blocks next lesson.

Activities

- Students investigate a pencil in a beaker of water and a coin trick in **Worksheet 13.1.1**. Discuss what they saw and introduce the idea of light being refracted at a boundary. Show a diagram of the angle of incidence and the angle of refraction. Discuss the pencil experiment to demonstrate that light travelling along the normal is not refracted.
- Students use **worksheet 13.1.2** to explain why the pencil looks bent. They construct a diagram to show what happens to the coin when you pour water in the cup, and apply what they know to situations involving fishing by considering how birds dive for fish.
- Discuss why light might behave in this way. If available show waves being refracted in a ripple tank. Otherwise show a suitable animation or video. It is important that students see the waves being refracted. It is obvious that they slow down. Use page 185 in the Student book to show that light is refracted because it slows down. Students can act out the soldiers marching in a role play. Draw a boundary line on the ground, clap at equal intervals, and get them to march towards the boundary. As soon as they cross the line they walk heel to toe instead. There should be a noticeable change in direction when they do this.
- Students complete an exercise based on the soldiers to show how the direction changes on **worksheet 13.1.3**.
- Demonstrate a small beaker of cooking oil being lowered into in a larger beaker of cooking oil. Ask the students to explain the observation that it seems to disappear. This experiment can also be done with Pyrex test tube full of glycerol in a beaker of glycerol.

Extension

Explain the cooking oil demonstration in terms of refractive index.

Homework

Workbook page 80

Key words

refraction, angle of incidence, angle of refraction, real and apparent depth, density, refractive index

Student book, pages 186–187

CD resources
- Worksheet 13.2.1
- Worksheet 13.2.2
- Worksheet 13.2.3
- Worksheet 13.2.4
- Refraction presentation
- Total internal reflection presentation

Objectives

- Use scientific knowledge to explain predictions
- Describe what happens when light goes through a glass block
- Explain total internal reflection

Overview

In this lesson students carry out an investigation into the behaviour of light as it is refracted and totally internally reflected. They learn that it is important to justify a prediction that you make in an investigation using scientific knowledge. By taking careful measurements they see how light behaves at the boundary between glass and air, and link what they have found to everyday uses of prisms and optical fibres.

Activities

- Recap what students learnt last lesson, possibly by repeating the demonstration from the end of the lesson.
- Students take measurements of the angles inside and outside a block of glass to learn about how light is refracted. They can plan and carry out an investigation themselves using **worksheet 13.2.1** or complete a more structured task using the alternative practical on **worksheet 13.2.2** and **13.2.3**. Bring out in discussion the fact that the angles outside the block are parallel and elicit that this is because the change in speed is the same each time.
- Students look at how light behaves when it meets the glass/air boundary from inside and measure the critical angle in **worksheet 13.2.4**.
- Discuss total internal reflection and its uses. Show a suitable image or video of an endoscope seeing inside, for example, the stomach. Discuss the pros and cons of using this type of instrument such as keyhole surgery.

Extension

Students research Snell's Law and use it to work out the refractive index of the block. They can then work out the speed of light in the block using the equation on page 186 of the Student book.

Homework

Workbook page 81

Key words

critical angle, total internal reflection, optical fibre, endoscope

Student book, pages 188–189

CD resources

- Worksheet 13.3.1
- Worksheet 13.3.2
- Dispersion presentation

Objectives

- Explain how a spectrum of light is produced
- Explain why we see rainbows

Overview

Students will be familiar with the spectrum of white light from rainbows and coloured patterns on materials, but may not appreciate that it is connected to refraction. In this lesson they produce a spectrum and learn how it links to the refraction of different colours of light by different amounts. They link what they have learned to work out how rainbows are produced.

Activities

- Show a picture of a rainbow formed over a waterfall and in the sky. Ask students how it is formed. Explain that scientists call it a spectrum and we can produce one using a prism.
- Students produce a spectrum on a screen using a prism and **worksheet 13.3.1**. In the discussion bring out the fact that most people can only see six colours and cannot usually distinguish indigo. It is possible that Newton added a seventh colour because he believed (superstitiously) that there had to be seven colours.
- Discuss how students used the second prism to recombine the spectrum. Demonstrate the spinning disc of colours to reinforce the idea that all the colours combined make white light.
- How is a rainbow formed? Students use the information on page 125 of the Student book to make a poster showing how the prism experiment is linked to how a rainbow is formed.
- Elicit the fact that explaining refraction means using the idea that different colours are refracted by different amount. Discuss the different wavelengths (and frequencies) of the different colours.
- Students use **worksheet 13.3.2** to explain the formation of the spectrum using the ideas from previous lessons.

Homework

Workbook page 82

Key words

refract, prism, spectrum, dispersion, rainbow

Student book, pages 190–191

CD resources
- Worksheet 13.4.1
- Worksheet 13.4.2
- Worksheet 13.4.3

Objectives

- Explain what happens when you mix light of different colours together
- Explain how filters work

Overview

In this lesson students learn about the primary and secondary colours of light. They begin by working out what a colour filter does to light, and that it does not 'add' colour but actually subtracts all the colours except the colour that it is. This links to what they will learn about coloured materials in the next lesson. Students work out that you can make secondary colours (or any colour) from primary colours and that colour displays need only contain pixels of three colours as all the colours that you want can be made from red, green, and blue.

Activities

- Show pictures of coloured floodlights or a concert with coloured lights. Ask how the coloured beams of light are produced.
- Students experiment with coloured filters using **worksheet 13.4.1**. By looking through combinations of filters they work out that filters *subtract* light by absorbing some colours and transmitting others. This links back to lesson 13.2.
- Student use filters to produce three beams of coloured light and investigate what happens when they overlap. **Worksheet 13.4.2** supports this activity. Discuss the results and emphasise that this is colour *addition*. All colours can be made from the three primary colours, which is why computer screens and television screens have picture elements in three colours.
- Students consolidate what they know using **worksheet 13.4.3**.

Extension

Ask students to complete questions 7 and 8 on **Worksheet 13.4.3**.

Homework

Workbook page 83

Key words

red, green, blue, cyan, magenta, green, primary colour, secondary colour, filter, transmitted, absorbed

Student book, pages 192–193

CD resources
- Worksheet 13.5.1
- Worksheet 13.5.2

Objectives

- Explain why coloured objects look coloured in white light
- Explain why coloured objects look different colours in different colours of light
- Describe how to present conclusions in appropriate ways

Overview

This lesson draws on what students have learned about colour in previous lessons and links to the how we see things in lesson 13.5. Students experiment with different coloured materials in different coloured lights and decide how to present the results of that experiment in the most effective way. They learn that coloured objects behave like coloured filters, and why mixing coloured paint is different to mixing coloured light.

Activities

- Recap what students learned in lesson 13.5 about how we see things. Elicit that light from an object has to enter our eyes.
- Students investigate what happens when you shine coloured light on different materials. Make sure that there is a wide range of available colours of material, with some mixed and some plain pieces. There are a large number of combinations and they will need to think carefully how to present the results. Discuss the results and elicit that coloured materials behave like filters. **Worksheet 13.5.1** supports this activity.
- Students may have learned about primary colours in terms of paint. This is often a source of confusion. Demonstrate mixing paint and that it gets darker. Discuss what is happening in terms of *subtraction*, and ask them to suggest why mixing red, blue, and green paint doesn't usually produce black. This could be extended to a discussion of why looking through red, green, and blue filters may not completely block out the light.
- Students consolidate what they have learned with **worksheet 13.5.2**.
- One of the questions is about making things 'disappear'. Ask students to make a poster in colour that will look different when viewed through a red, green, or blue filter. This could be a competition with a prize for the poster judged to be the best by the class.

Homework

Workbook page 84

Key words

reflect, absorb, light, colour, results, conclusions

Student book, pages 194–195

CD resources
- Worksheet 13.6.1
- Worksheet 13.6.2

Objectives

- Understand that there can be different explanations for the same observations
- Explain why some explanations are accepted and others are not
- Understand that explanations change as new observations are made

Overview

In this lesson students take part in a debate about whether light is a wave or a particle. They use the information in the Student book to argue for one side or the other, and illustrate their points with practical examples or models. The whole class is then introduced to a new piece of information (interference of light) and discuss how that changes their views. Finally they are introduced to the final piece of information (photoelectric effect) and discuss how both views of light are needed.

Activities

- Ask students 'what is light?' By now they may have built up an idea that light is a ray or beam, and will have been introduced to light as a wave. Discuss how ideas in science change because new experiments or data bring new evidence to light. This makes scientists change their ideas or explanations about the world.
- Students work in small groups. Half the groups work on Newton's particle idea and half work on Huygens wave idea. They read the pages 194–195 of the Student book and prepare for the debate using **worksheet 13.6.1**. Then all the wave groups meet to discuss how they will present their practical work and models, and the particle groups do the same.
- Have a debate where each side presents their view about what light is. Stop the debate and discuss which side is the most persuasive at this point.
- Show pictures of Young's slits experiment, or an animation e.g. *http://phet.colorado.edu/en/simulation/wave-interference*. Talk about how the light must be cancelling out. Discuss how this changes their view, and if the observation can be explained at all using particles.
- Introduce the idea of the photoelectric effect (simplified to explain the discharge of an electroscope) e.g. *http://phet.colorado.edu/en/simulation/photoelectric*. Discuss how this changes their view, and if the observation can be explained at all using waves.
- Students use **worksheet 13.6.2** to make a timeline of discovery about 'What is light?'

Extension

Students find out more about Thomas Young or Albert Einstein and how they did their experiments.

Homework

Workbook page 85

Key words

observations, explanation, particles, wave

Student book, pages 196–197

CD resources
- Worksheet 13.7.1
- Lasers presentation
- Light quiz

Objectives
- Describe how laser light is different from sunlight
- Describe some of the uses of lasers

Overview
In this lesson students learn about a different type of light to daylight, lasers. Start by demonstrating a laser beam and eliciting from the students how it is different to daylight. One use of lasers is to transfer information along optical fibres. Remnd students about how this works and return to lesson 13.7 on refraction if necessary.

Finally ask students to research other uses of lasers in groups, in particular medical uses, and to make presentation or poster about what they have found out.

Activities
- Demonstrate a laser and chalk dust (from lesson 13.1) if available, or show a picture of a laser beam. Ask students how laser light is different to visible light from a light bulb. Often they will say that lasers are more powerful than normal light. Introduce the idea that laser light is light of a particular frequency, and that lasers can have a range of powers depending on their use.
- Demonstrate light travelling down an optical fibre, or show a picture of it. Discuss how optical fibres have made a huge impact in medicine, but that they have other uses. Ask students to research the uses of optical fibres in groups.
- Divide up the different uses of lasers between groups. Each group prepares a presentation about how lasers are used in a particular situation and prepare a poster/PowerPoint presentation and a short talk for the rest of the class. **Worksheet 13.7.1** supports this activity. Student book pages 196–97 can be used by the group doing endoscopes. They should be encouraged to make models to illustrate their use.
- Students present their chosen use to the rest of the class.

Homework
Workbook page 86

Key words
laser, monochromatic

1 Variation and classification

1.1 Variation

1 Any five visible differences, e.g. skin colour, hair colour, height, body mass, eye colour.
2 Any five variables that can be tested, e.g. different ways of walking, voices, blood groups, fingerprints, iris patterns.
3 Features that show discontinuous variation, such as blood groups, can only take certain values. Those that show continuous variation, such as height, can take any value within a certain range.
4 Any three features that show continuous variation, e.g. height, body mass, foot length, arm or leg length.
5 On a frequency chart, the height of each bar shows the number of people in each category.
6 Everyone's fingerprint has a unique pattern of lines so fingerprints can be used to identify criminals.
7 Allow any choice as long as it is justified, e.g. an iris scanner would be best as iris patterns show more variety than fingerprints; they take longer to scan than fingerprints but this could be done easily whilst sitting at a computer; scanning fingerprints may be difficult if the keyboard or fingers are dirty. *Or* a fingerprint scanner would be best because they are cheaper and most computers don't need the very high security that iris scanners can provide.

1.2 Causes of variation

1 Any two from: hair colour; skin colour; eye colour.
2 Genes control cells and cells build your tissues and organs, so genes influence your features.
3 Any two from: eye colour; blood group; earlobe shape.
4 Environmental variation.
5 The lower leaves receive less sunlight.
6 No – a bonsai tree is only small because it does not get enough light, water, and minerals to grow bigger. The genes in its seeds could produce a full-sized tree if the plant gets enough light, water, and minerals.
7 Genes and the environment both influence skill at football, health, and body mass.

1.3 Species

1 Members of a species can breed with each other and produce offspring that are able to breed.
2 Members of a species do not always look similar, e.g. there are many breeds of dog/cat that look very different from each other.
3 Mules are not able to breed; they are infertile hybrids; the offspring of a horse and a donkey.
4 Breed the male and female wild cat together. Wait until their offspring reach reproductive age and see if they are able to produce offspring of their own. If they can, they are fertile. This means the male and female wild cat came from the same species.
5 We can't be sure how many species there are because we haven't found them all yet, and it is difficult to decide whether similar animals belong to the same or different species.
6 The first name *Panthera* is given as it is large cat that roars. The second name could be *albus*, which is white in Latin.

1.4 Classification

1 73%
2 There are far more invertebrate species (70%) than vertebrate species (3%).
3 Vertebrates have a backbone; invertebrates do not.
4 Arthropods make up 60% of all the species on Earth. Most arthropods are insects and one-third of all insects are beetles.
5 A spider: arachnid because it is an arthropod with eight legs.
B beetle: insect because it is an arthropod with six legs.
C snail: mollusc because it has a single muscular foot.
D worm: annelid because its body is divided into segents.
E millipede: myriapod because it is an arthropod with a long body divided into segments.
F stick insect:insect because it is an arthropod with six legs.
G shrimp: crustacean because it is an arthropod with with two pairs of antennae.
H crab: crustacean because it is an arthropod with two pairs of antennae.

1.5 Vertebrates

1 **a** Dolphins – mammals.
b Snakes – reptiles.
c Sea turtles – reptiles.
d Sea horses – fish.
e Penguins – birds.
f Whales – mammals.
g Komodo dragons – reptiles.
2 Typical mammalian features include being warm blooded, giving birth to live young which are fed on milk, having hair or fur.
3 Students could choose any two animals from different vertebrate groups, e.g. a crocodile is a reptile because it has dry, scaly skin and lays waterproof eggs on land. A pike is a fish because it has gills and fins and lays its eggs in water.
4 Students could choose any two land animals from different vertebrate groups, e.g. a panda is a mammal because it has fur, gives birth to

live young, produces milk to feed them, and is warm blooded. An anaconda is a reptile because it has dry, scaly skin, is cold blooded and lays waterproof eggs on land.

5 Mammals need more food than other vertebrate groups because they are warm blooded.
They need extra energy to keep their body temperature constant.

6 Whale – unlike most mammals they have very little body hair.
Bat – unlike most mammals they can fly.
Snake – unlike most reptiles they do not have legs.
Penguin – unlike most birds they cannot fly.

7 Olm – amphibian, but lives only in water and has gills.
Platypus – mammal, but lays eggs instead of giving birth to live young.
Caecilian – amphibian, but lives hidden in the ground instead of in water. They also give birth to live young, instead of laying eggs.
Armadillo – mammal, but has a low body temperature.

1.6 Classification of plants

1 Students should draw simplified diagrams of each of the four types of plant shown on page 79 of the Student book.

2 The diagrams should be labelled as follows: moss – no roots/veins; fern – reproduces using spores; conifer – reproduces using seeds made in cones; flowering plant – reproduces using seeds made in flowers.

3 Plant A: fern – reproduces using spores.
Plant B: conifer – reproduces using seeds made in cones.

Plant C: moss – no roots/veins.

Plant D: flowering plant – reproduces using seeds made in flowers.

4a Fern – grass and the flowering tree both produce flowers.

b Flowering tree – plants in the other two groups do not produce flowers.

c Grass – moss and fern produce spores and grow in damp, shady places.

d Moss – conifers and ferns have roots and veins in their stems to carry water and minerals up the plant.

e Algae – ferns and flowering plants both have roots, stems, and leaves

5 Moss.

6 The arrival of the gulls allowed flowering plants to grow as they deposited seeds from mainland that had passed through their digestive systems.

1.7 Review

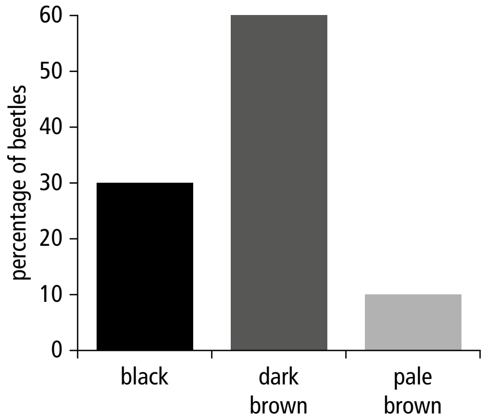
1a Green.

b Any feature than shows discontinuous variation, e.g. blood group, gender, shoe size, hair colour.

2a 38%

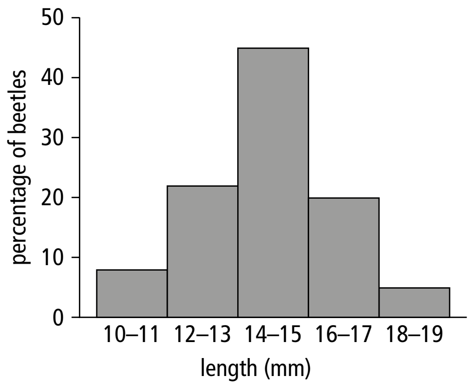
b Any two features that show discontinuous variation, e.g. height, body mass, foot length, limb length.

3



Axes labelled. All points correctly plotted.

4



Axes labelled. All points correctly plotted.

5a This indicates that the two bears are different species.

b This indicates that the two bears come from similar species.

c Species have different names in different languages; all scientists need to use the same name so that they can share information about each species.

6 Scientists could breed a male and a female cheetah from different parts of Africa. They could then attempt to breed their offspring to see if they are fertile. If the offspring are fertile, the male and female cheetah came from the same species.

7a Hybrid.

b Zeedonks have a female donkey as their mother and a male zebra as their father. The offspring of different species are always infertile.

8a B (octopus), C (beetle).

b They all have a backbone.

c A (snake), D (turtle).

d Any two from: dry, scaly skin; lay eggs on land; are cold blooded; breathe using lungs.

9a Cow – mammal.
b Dolphin – mammal.
c Penguin – bird.
d Frog – amphibian.
10a It has fur.
b It lays eggs.
11 Mammals are covered with hair or fur, give birth to live young, and feed their young on milk.
12 Annelid because it has a segmented body.
13 Flies are insects because they have six legs. Spiders have eight legs, so they are arachnids.
14a Invertebrate.
b Arthropod.
c Insect.
15 B (conifer).
16a Moss.
b Ferns.
c Conifers.

2 Humans

2.1 The human skeleton

1 Your skeleton protects vital organs such as the heart and lungs, helps to support your body, and allows you to move.
2 Your brain is protected by the solid bone in your skull. Your heart and lungs are protected by your rib cage.
3 Knee and elbow joints are hinge joints.
4 Hip and shoulder joints are ball-and-socket joints.
5 Knee joints are hinge joints which allow you to bend and straighten your legs. Hip joints are ball-and-socket joints which allow you to swing your legs round in many directions.
6 The diagram should show two bones held together by ligaments like the left-hand diagram at the bottom of page 14 in the Student book. Two features should be labelled: synovial fluid inside the joint and cartilage covering the ends of the bones.
7 **a** bone – hard, **b** cartilage – smooth, **c** ligaments – flexible.

2.2 Muscles and movement

1 Muscles are attached to bone. When they contract, they pull the bone.
2 Antagonistic muscles pull in opposite directions.
3 The muscle on the front of your arm (the biceps) feels firmer. To hold this position the biceps muscle must contract and the triceps muscle relax.
4 The muscle at the back of your leg (hamstrings) contracts to bend it. The muscle at the front of your leg (quadriceps) contracts to straighten it.
5 The strong cord is a tendon. It attaches muscle to bone so that the bone moves when the muscle contracts.
6 Messages from your brain tell muscles when to contract. These electrical messages are sent down nerves in your spinal cord to the smaller nerves that carry the message to each muscle fibre.

2.3 Organ systems

1 The nervous system controls how you respond to your surroundings.
2 Messages are sent along nerves from taste buds in your tongue to your brain. Your brain processes the information and decides how to react. Then your brain sends messages to the muscles in your mouth to make you to spit out the fruit.
3 The digestive system takes in glucose (nutrients).
4 Oxygen is needed for respiration, which produces the energy your body needs.
5 As blood passes through your lungs, it exchanges carbon dioxide for oxygen. This is gas exchange.
6 The digestive system breaks down food into smaller particles so that they can pass into the bloodstream. Food particles that cannot be digested are excreted in faeces.

2.4 The circulatory system

1 Harvey doubted Galen's ideas because he watched animals' hearts beating and pumping out massive amounts of blood – it could never be made that fast.
2 Ibn al-Nafis's discoveries were not known in Europe when he made them because nobody translated his work.
3 Three types of blood vessel are arteries, veins and capillaries.
4 Blood leaving the lungs returns to the heart, which pumps it around the body. This supplies cells with oxygen. After travelling around the body, the blood returns to the other side of the heart. The heart sends it back to the lungs to pick up oxygen, and the cycle repeats again.
5 Arteries carry blood away from your heart and veins carry it back to your heart.
6 If the heart stops beating, blood stops circulating. The delivery of oxygen and nutrients stops so tissues cannot carry out respiration. They do not get the energy they need to survive, so they die.

2.5 Studying the human body

1 Haematologist – they run tests on blood samples to look for the changes different types of illness cause.
2 Students should choose one from the following. Neuroscientist – they research brain diseases to find the best treatments to aid their recovery.

Dietitian – they advise patients how to improve their health and fitness by eating the right combination of nutrients.

3 Students should choose two from the following. Audiologist – they investigate hearing and balance disorders in patients. They perform tests to work out whether a patient has hearing loss and can find out how severe their deafness is.

Cardiologist – these are doctors who have specialised in assessing, diagnosing, and treating heart and circulatory problems.

Dermatologist – these doctors are involved in assessing and managing diseases involving the skin, hair, and nails.

Pathologist – these scientists study disease by examining tissue samples under a microscope. They also perform autopsies on people who have died to find out what killed them.

2.6 Extending lives

1 Not enough people opt to donate their organs for transplantation. Only patients whose heart stops working or whose brain is severely damaged are suitable donors. People who require a transplant are often very sick and cannot survive very long with their damaged organ.

2 A transplant patient's body recognises the donated organ is not theirs. Their body would reject (destroy) the donated organ if they did not take drugs to stop this happening.

3 Kidneys can be transplanted from living donors, as we each have two kidneys, but can survive with one. Hearts can only come from deceased donors, so it is harder to find enough hearts to transplant.

4 Becoming a living donor is risky.

5 Organs built from a person's own tissues are not rejected so the transplant patients don't need to take drugs and have less chance of suffering complications.

2.7 Review

1a Karis: respiratory system; Amarjit: cardiovascular system; Nadeen: nervous system; Ali: digestive system; Simon: skeletal system.

b Karis and Amarjit must be treated first. These patients are not getting enough oxygen to their tissues. Karis is struggling to breathe so won't be taking in enough air into her lungs. Amarjit has no pulse, which means that his blood is not circulating, so oxygen isn't being delivered to his cells. Without oxygen, these patients will die quickly because they cannot carry out respiration.

2a The ball and socket joint on the left lets a limb swing in every direction.The hinge joint on the right lets a limb (arm or leg) bend and straighten.

b Students should include two from the following. In both joints, the ends of bones are covered in cartilage to allow them to slide over each other smoothly.

Both joints contain synovial fluid to reduce friction.

Both joints use ligaments to hold the bones together.

3a The leg bends at the knee.

b Muscle B (quadriceps) contracts. Muscle A (hamstrings) relaxes.

c Muscles can only pull on bones. They cannot push. So pairs of muscles pull your leg in opposite directions.

4a C

b The heart belongs to the circulatory system.

c The circulatory system circulates blood to every part of the body (to supply the glucose and oxygen needed for respiration).

d A is the brain.

e The brain belongs to the nervous system.

5a As blood enters the lungs, it picks up more oxygen and gives up carbon dioxide. The carbon dioxide concentration in the blood drops by 10 units and the oxygen concentration increases by 40 units.

b Breathed out air contains more carbon dioxide and less oxygen.

c After leaving the lungs, blood travels back to the heart. The heart pumps it around the body (to every tissue) to deliver oxygen. Then it returns to the heart and is pumped back to the lungs to collect more oxygen.

d If patients cannot get enough oxygen, less respiration takes place in their tissues, and they release less energy.

6a Kevin is wrong.

b Respiration occurs in all your tissues. It is a chemical reaction that releases energy from glucose using oxygen. Gas exchange occurs in the lungs when oxygen from the air enters the blood and carbon dioxide passes from the blood to the air.

7 The ends of her fingers did not get enough oxygen for respiration. Their tissues died because they lacked energy.

8a As an adult's age increases, the recommended heart rate needed during exercise decreases.

b 92 beats per minute

c Muscles require more energy during exercise (in order to contract more quickly and strongly). To release this extra energy, they need a greater supply of oxygen (and glucose). This is achieved by increasing the heart rate so that blood is pumped around more quickly.

d Arteries carry blood away from the heart.

e The heart is a double pump because one side pumps blood through the lungs and the other pumps blood around the rest of the body.

f Veins return blood to the heart.

9a As age increases, the average reaction time also increases. (There is a large jump in the reaction times between the 25–34 age group and the 35–44 age group.)

b The driver's eyes sense light reflected from the scene of the accident. They send electrical messages to his brain. His brain interprets the messages and decides how to respond. It sends messages down the spinal cord and along smaller nerves to the muscle fibres in his leg to make his foot move and press down on the brake.

10a The athlete's blood glucose rises rapidly after drinking a glucose drink (up to around 188 mg/dm^3), then falls again. The athlete's blood glucose rises much more slowly after a meal (reaching a maximum of 120 mg/dm^3) and remains at this level for about an hour, before it returns to baseline levels.

b The digestive system breaks food down into smaller particles and absorbs these into the blood.

c The particles in the glucose drink are small enough to be absorbed into the blood. The meal contains larger particles that need to broken down in the digestive system before they can be absorbed.

11a Bones support your body; protect vital organs like your brain, heart, and lungs; and help you to move.

b The 10–19 age group break bones in their feet most often. The 60–69 age group break their hips most often.

c The 10–19 age group break bones in their lower leg 4 times more often than the 60–69 age group.

3 Diet

3.1 Food

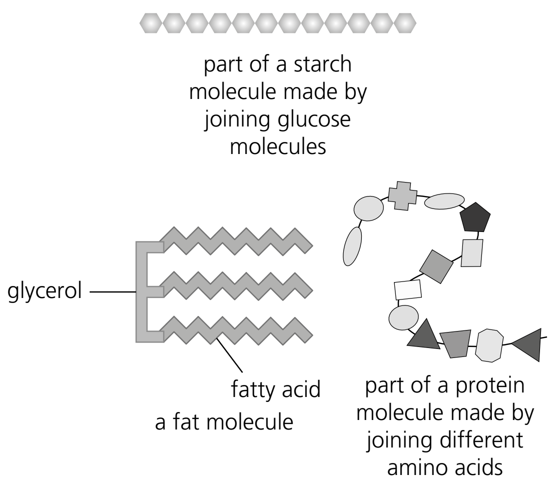
1 Nutrients provide materials for growth and repair; energy to keep your cells alive; and vital elements and compounds to maintain the chemical reactions in your cells.

2 Fat and protein are need to build new cells.

3 Carbohydrates and fat provide energy.

4 Vitamins help to maintain the chemical reactions in your cells

5



6

Nutrient	Foods that contain it
carbohydrate	wheat, rice, beans, potatoes, fruit, vegetables, chocolate, cakes
protein	fish, eggs, nuts, beans, milk products
fat	meat, fish, milk products, nuts, seeds
vitamin	fruit, vegetables, fish, dairy products
mineral	fish, milk products, fruit, vegetables

3.2 Managing variables

1 Measure 1 g of each food using an electronic balance. Measure 20 cm^3 (or a similar volume) of water into each of two boiling tubes (test tubes) and measure its starting temperature using a thermometer. Then burn each food underneath one tube of water and measure the end temperature. The food that causes the biggest temperature rise releases most energy per gram.

2 The volume of water heated: 20 cm^3; the mass of food burnt: 1 g; the distance between the burning food and the tube: 5 cm.

3 The results showed that the temperature of the water rose when the bread was burnt. They also showed that doubling the mass of food burnt doubled the temperature rise. This is evidence that the method works because burning twice as much food releases twice as much energy (the same amount of energy per gram).

4 Use a larger volume of water; burn a smaller mass of food.

5 Any two from the following:
Some of the energy released by the burning food could escape (heat the surrounding air instead of the water).
Some of the energy released heats the equipment, rather than the water.
Some energy is lost whilst Eniola sets light to the food.
The food may stop burning before all its energy has been released.

3.3 A balanced diet

1 You should eat more carbohydrates than other nutrients.

2 Each type of protein contains a different combination of amino acids, so we need to eat a variety of proteins to get all the amino acids we need.

3 Amino acids are small molecules that can be joined together to form the proteins needed to build and repair cells.

4 Fats contain fatty acids and some of these are essential for health. Fats also contain some essential vitamins.

5 Eating too many sweets can cause tooth decay and lead to obesity.

6 $\frac{40}{100} \times 8000\text{ kJ} \div 37\text{ kJ per g} = 86.5\text{ g}$

3.4 Deficiencies

1 Deficiency diseases are diseases that occur if you don't get enough of an essential nutrient.

2

Deficiency disease	Main symptoms	Missing nutrient
scurvy	bleeding gums swollen legs little energy	vitamin C
beri-beri	partial paralysis mental confusion	vitamin B1
night blindness	difficulty seeing in low light levels	vitamin A
rickets	softer bones that are more likely to break or bend	vitamin D calcium
kwashiorkor	muscle shrinkage swollen belly	protein
anaemia	tiredness	iron

3 Vitamin C is found in fruits and vegetables. Sailors could not take these on long voyages as they would rot. They are also expensive.

4 Lemon juice contains vitamin C (which prevents scurvy) but it is destroyed by boiling.

5 Vitamin D is made when skin is exposed to sunlight. Countries further from the equator get less sunshine so people there are more likely to have a vitamin D deficiency.

6 Casimir Funk fed different chemicals from rice skins to pigeons with (a similar disease to) beri-beri. One of the chemicals cured the pigeons so he concluded that this vitamin was deficient in the diet of those with beri-beri.

3.5 Choosing foods

1 Anyone whose body mass is much higher than average is considered obese.

2 Obesity increases the risk of having long-term health problems such as diabetes, cancer, high blood pressure, and heart disease. These could cost billions to treat in the future.

3 The average body mass is increasing in many countries because people rely more on takeaways and processed foods, which contain lots of sugar, salt, and saturated fat. People also do less exercise because they use more energy-saving machines and cars.

4 Any two from: stop TV companies from advertising sugary or fatty foods; stop schools providing sugary or fatty foods; change the layout of cities to make them better suited for walking and cycling; make sugary and fatty foods more expensive; educate people to avoid obesity.

5 Extra nutrients are added to foods like bread to make it easier for people to get the vitamins and minerals they require without having to alter their diet.

6 We can increase the amount of vitamins in crops by adding new genes to them.

3.6 Review

1a Rice.

b Chicken leg.

c Corn oil because it contains the highest amount of fat of the three foods, and fats release twice as much energy per gram as carbohydrates.

2a $\frac{50}{100} \times 100\text{ g} = 50\text{ g}$

b Cheese contains a higher percentage of fat (than other sources of protein).

c 25 – 10 = 15 g

3a Protein.

b B may not get enough protein in their diet.

4a Potato crisps because they have a higher fat content than crispbread, and fat releases twice as much energy per gram as carbohydrates.

b Measure out 1 g of each food and burn the food under a test tube (boiling tube) of water. Measure the temperature of the water before and after burning each food and calculate the temperature rise. If the prediction is correct, then burning the potato crisps will cause the biggest increase in temperature.

c Any two from: volume of water used; mass of food burnt; distance between burning food and water.

d Any one from the following:

Some of the energy released by the burning food could escape (heat the surrounding air instead of the water).

Some of the energy released heats the equipment, rather than the water.

Some energy is lost whilst the food is set alight.

The food may stop burning before all its energy has been released.

5a Her blood glucose levels.

b Her blood glucose levels are lowest before breakfast and will not be affected by food eaten earlier in the day.

c Any one from: the mass of each food type eaten; the amount of exercise done during the experiment; other foods or drinks consumed during this three-hour period.

d Any two from the following:
The sugary sweets caused a more rapid rise in blood glucose levels than the cereal.
The sugary sweets caused a higher peak in blood glucose levels than the cereal.
The sugary sweets caused a more rapid rise and fall in blood glucose.
The cereal caused raised blood glucose levels for longer.

e Any one from the following.
The starch in the cereal contains many glucose molecules joined together.
The starch must be broken down in the student's digestive system before these glucose molecules can enter the blood.
The glucose from the sugary sweets doesn't have to be broken down and can enter the blood straight away.

6a $\frac{10}{100} \times 12\,000 \text{ kJ} \div 16 \text{ kJ/g} = 75 \text{ g}$

b $36 \text{ g} \times 37 \text{ kJ/g} = 1332 \text{ kJ}$

c $1332 \text{ kJ} \div 12\,000 \text{ kJ} \times 100 = 11.1\%$

d A diet high in saturated fat increases your risk of developing heart disease.

e Oily fish contains a lot of unsaturated fat. A diet high in unsaturated fats reduces your risk of developing heart disease.

7a $75 \text{ mg} \div 25 \text{ mg/100 g} = 300 \text{ g}$

b Accept any combination which gives at least 0.9 mg of vitamin A, e.g. 100 g of carrots and 22 g of spinach; 200 g of spinach.

c It would be greatly reduced.

8a Vitamin A.

b Iron.

c Protein.

d Vitamin C.

9a Orla has bowed legs/the bones in her legs are curved.

b Any two from the following:
Rickets is caused by not getting enough vitamin D.
Your skin makes vitamin D when it receives direct sunlight.
Orla has developed rickets because she isn't getting enough sunlight.

10a The source of the acid.

b Whether each sailor's condition improved after one week.

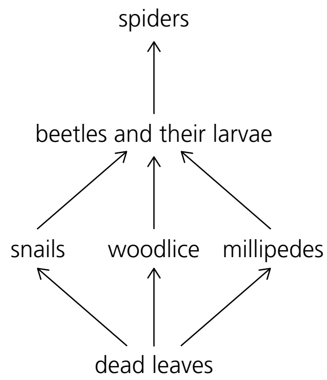
c No – some of the acids made their condition worse.

d The vitamin C in the citrus fruit cured the scurvy.

4 Energy flow

4.1 Food webs

1



2 The secondary consumers are beetles and their larvae.

3 Snails, woodlice, and millipedes make up the second trophic level.

4 The producers at the starts of food chains are plants (algae or phytoplankton).

5 The arrows in a food web represent the energy passed from producers to consumers.

4.2 Energy flow

1 Students should draw a pyramid composed of: a 15 cm wide block labelled acacia trees, a 2 cm wide block labelled giraffes, and 1 cm wide block labelled lion.

2 Students should draw a pyramid composed of, from the bottom upwards: a 5 cm wide block labelled acacia trees, a 10 cm block labelled impalas, and a 1 cm wide block labelled cheetahs.

3 Most of the energy in the food that impalas eat is used for respiration.

4 Students should draw a pyramid composed of, from the bottom upwards: a 200 mm wide block labelled acacia trees, a 15 mm wide block labelled giraffes, and 1.5 mm wide block labelled lion.

5 Students should draw a pyramid composed of, from the bottom upwards: a 100 mm wide block labelled grass plants, a 5 mm block labelled impalas, and a 0.5 mm wide block labelled cheetah.

6 Prey animals are present in the higher numbers.

7 Pyramids of biomass are always shaped like pyramids – the mass of producers is greater than the mass of herbivores, and the mass of herbivores is greater than the mass of carnivores.

8 Big carnivores such as lions need a large territory with plenty of vegetation to support a large number of prey animals.

4.3 Decomposers

1 Any two from: fungi and bacteria; invertebrates such as worms, slugs, snails, and fly larvae.

2 Most of the food chains in the mangroves depend on decomposers because most mangrove leaves are not eaten by herbivores. They fall into the water where they are decomposed.

3 Mangrove forests are important to local people because they provide building materials, fuel, medicines, and food, and the waters around them are rich fishing grounds.

4 Mangrove forests are important to the Earth as a whole because they produce new biomass as fast as tropical rainforests, and have a high biodiversity.

5 The carbon in rotting leaves can get back into the air when decomposers respire or when the animals that feed on them respire.

6 Decomposers allow life to continue by recycling the elements (minerals) that make up the bodies.

7 Phytoplankton grow faster in shallow coastal waters because rivers bring a constant supply of minerals to them.

4.4 Changing populations

1 The population of an animal species might suddenly increase if they move into a new environment, where there is plenty of food and no predators.

2 Three things that could reduce the population of an animal species are lack of food, disease, or pollution (or predators).

3 Populations stay small if their death rate the same as their birth rate.

4 Humans populations use energy and materials as well as food and water.

5 Sustainable development provides everything humans need without damaging the environment.

6 Animals are interdependent if one animal affects the survival of the other, such as a predator and its prey.

7 The numbers of caribou and wolves in the Arctic rise and fall in cycles because the animals are interdependent. Wolves eat caribou so the number of caribou drops. Then wolf numbers drop too because they have less food – they starve or raise fewer offspring. This gives the caribou a chance to breed and raise offspring. Then predator numbers increase and the cycle begins again.

8 Populations are more likely to stay the same size where there is more biodiversity because predators can eat several different prey species. If one disappears, they can eat something else.

4.5 Facing extinction

1 Invasive species are successful because they grow quickly, reproduce quickly, survive in a wide range of habitats, eat anything, or beat other species in the competition for food and spaces to live.

2 A species is more likely to become extinct if it is only found in a few places, reproduces very slowly, faces a new predator, or has its food supply reduced by a new competitor.

3 The number of tree snakes carried on rising when the bird population on Guam dropped because they swapped to eating other animals (lizards).

4 The number of spiders on Guam has risen because the tree snakes have eaten their predators (lizards and insect-eating birds).

5 Destroying the spiders could ruin the island because there would be fewer predators to control the insect population. Leaf-eating insects could destroy the island's vegetation.

6 The forests on Guam are likely to change in the future because many of Guam's tree seeds were dispersed by birds that are now extinct. The seeds can't grow successfully if they are not dispersed.

4.6 Maintaining biodiversity

1 An ecosystem has a high biodiversity if it contains many different species.

2 We should limit the amount of forest cleared for farming because farmland produces less biomass per m^2 and has a much lower biodiversity.

3 A rainforest can absorb more of the sunlight that reaches it than the crops on farmland can because it contains a mixture of plants that each need different growing conditions. Some absorb the dim light that the trees above them don't use.

4 It is useful to have many different varieties of each crop plant because a disease that affects one variety is unlikely to infect them all.

5 Animals can breed with other animals from other countries because their sperm can be frozen and flown around the world.

4.7 Review

1a Students should produce a sketch to illustrate the following food chain: plant → insect → lizard → fox.

b The number of lizards would increase if the foxes all died.

2a Any one from: squid; penguin; seal.

b Any one from: krill; squid; penguin.

c Krill.

d Penguin

e Krill.

f Phytoplankton

g Seal.

3a The number of offspring puffins can raise could fall because there are fewer prey for them to catch.

b Now there are fewer herrings, sharks have a bigger supply of zooplankton.

c If global warming reduces the biomass of phytoplankton in the oceans, populations will drop in the rest of the food web because there will less food (energy) available to feed them.

4a B

b A

c The biomass of secondary consumers is always lower than the biomass of primary consumers because primary consumers use most of the energy in their food for respiration. Only a small percentage is passed to the next trophic level.

5 Statements a, c, and d are true.

6a 2

b 3

c 4

d 1

7 The same area of land can feed more people if they eat cereals instead of meat because cereals occupy a lower trophic level. Energy is lost at each trophic level (through respiration) so the total biomass in higher trophic levels drops.

8a B

b D

c Where the population starts to drop because deaths exceed births.

d Any two from: pollution; disease; shortage of food; predators.

9a Decomposition.

b Decomposers.

c Any two from: bacteria; fungi; invertebrates such as worms, slugs, snails, and fly larvae.

d Decomposers release minerals from plant and animal wastes so they can be reused by plants. They also return carbon dioxide to the air.

10a B

b C

c D

d E

11a The zooplankton biomass could decrease between June and July because they have fewer phytoplankton to feed on.

b Any two from: lack of light (for photosynthesis); lack of carbon dioxide; lack of minerals; an unsuitable temperature.

5 Digestion

5.1 The digestive system

1 Most foods are made of complex molecules such as starch, fats, and proteins. These are too big to pass from your digestive system into your blood/cells. Digestion breaks them down into smaller molecules that your cells can take in.

2 Fibre passes through your digestive system without getting broken down. The route it takes is: gullet → stomach → small intestine → large intestine → rectum → anus.

3 Mechanical digestion uses your teeth to break solid food into smaller pieces that you can swallow. Chemical digestion uses enzymes to break large food molecules into smaller ones.

4 Saliva contains an enzyme that begins the breakdown of starch. It also makes food slippery so it is easier to swallow.

5 Food is mixed with acid in your stomach, to destroy microbes; it is also mixed with an enzyme to start protein digestion, and turned into a smooth paste.

6 Most large molecules are digested in the small intestine using enzymes made in the pancreas and the small intestine itself. Once broken down, these small molecules are absorbed into the bloodstream.

7 Small food molecules are absorbed by the walls of the small intestine and pass into the blood. The blood carries them to cells all over the body.

5.2 Enzymes

1 The term ‘biological’ means they are made by living cells. The term ‘catalysts’ means that they speed up the rate of chemical reactions.

2 Enzymes can only help molecules on the surfaces of food particles to break down. Chewing food breaks it into smaller pieces. This increases its surface area, so more of it can be broken down at once.

3 Fat molecules stick together in large globules. Bile emulsifies the fats in the small intestine. This breaks large fat droplets into smaller ones which mix with water. It increases the surface area of the fat so that enzymes can begin to break them down more rapidly.

4

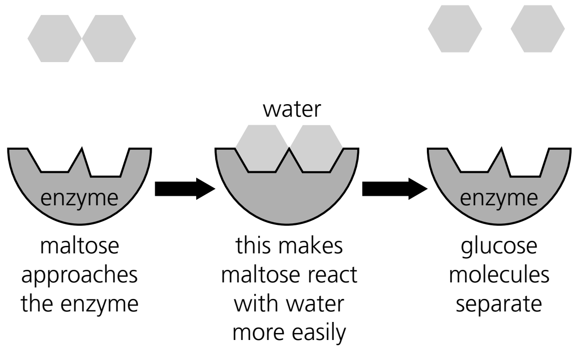
Nutrient	Enzyme used to digest it	Organ/s where digestion takes place
carbohydrate	carbohydrase (amylase)	mouth, small intestine
protein	protease	stomach, small intestine
fat	lipase	small intestine

5.3 Using enzymes

1

Type of enzyme	Use in food manufacture
carbohydrase	breaking down corn starch into a mixture of glucose and fructose for processed foods
protease	turning milk into cheese
lipase	flavouring cheese converting vegetable oils into butter or margarine adding omega-3 and omega-6 fatty acids to foods

2



3 Enzymes remain unchanged at the end of a reaction so the same enzyme molecule can be used again and again.

4 Each enzyme has a different active site which allows it to catalyse a specific reaction. By investigating the enzymes produced by different microbes we can find biological catalysts to speed up the reactions that make everything we need.

5.4 Review

1a E
b C
c B
d A
e F
2a Stomach.
b Gullet.
c Large intestine.
d Stomach.
e Mouth.
f Small intestine.
3a They grind and chew food into smaller pieces (mechanical digestion). This increases its surface area so enzymes can break down the large molecules in the food more easily.
b Saliva makes food slippery so it can pass more easily down your gullet. It also contains amylase to break down starch into smaller sugar molecules.
4 Glucose molecules are small so can pass directly into your blood and be taken straight to cells for respiration. Starch molecules must be broken down by enzymes in the mouth and small intestine before the glucose molecules are released and can be absorbed into your blood and this takes longer.
5a The small intestine.
b Any three from the following:
Undigested food (fibre) passes into your large intestine.
The large intestine absorbs water to make fibre more solid.
Fibre is stored in your rectum as part of your faeces.
Fibre is excreted from your anus as part of your faeces.

Bacteria in your large intestine use the fibre to make vitamins that your body cells need.

6a Large intestine and small intestine.
b Mouth, stomach, and small intestine.
7a B
b D
8a The indicator colour.
b The enzyme broke down the protein into amino acids, so the indicator did not turn lilac. Water cannot break down protein so the indicator turned lilac.
9a Glucose molecules are small enough to diffuse through the walls of the model gut and into the beaker.
b Starch molecules are too big to pass through the walls of the model gut. They would have to be broken down into glucose by enzymes first.
c The starch was broken down into glucose molecules by the amylase (enzyme/carbohydrase) in the saliva.
d Blood.
10a This is the normal human body temperature so the protease should work best at this temperature.
b Changed: type of protease – normal or boiled.
Observed: the appearance of the gelatin cube after 4 hours.
c Any two from: the temperature; the time it was left for; the size of the gelatin cubes; the volume of protease added.
d The protein that had normal pepsin added to it was completely digested. The boiled pepsin did not digest the protein at all. This is because boiling enzymes like pepsin causes them to denature so they cannot work.
e Any two from the following:
The table shows that it took more than twice as long to completely digest the gelatin when it was in a single cube.
This is because enzymes only work at the surface of a solid, and breaking the gelatin into tiny pieces increases its surface area.

This allows more large molecules to be broken down at once.

f The mouth.

6 States of matter

6.1 The states of matter revisited

1 As in the liquid state diagram on page 80. Particles must be touching with very little space between them. Particles must not be arranged in a regular pattern e.g. lines.

2 Oxygen particles move randomly, without touching. The particles spread out to fill the whole container.
3 In the solid state the oxygen particles are touching without spaces between the particles. In the gas state, the particles do not touch and have spaces between them, allowing them to be compressed (pushed) together.
4 In a solid, the particles are arranged in a closely packed, regular pattern. Particles vibrate on the spot. In a liquid, the particles are touching with small amounts of empty spaces between them. The particles are not arranged in a regular pattern and they move around.
5 Liquid

6.2 Explaining diffusion
1 Diffusion is the random movement and mixing of particles.
2 Temperature, size and mass of the particles, the states of the substances that are diffusing.
3 Warmer particles have more energy so they move faster.

6.3 Explaining density
1 Density is how heavy something is for its size. (Density depends on the mass of the particles and how closely packed the particles are)
2 Density = 20 ÷ 2 = 10 g/cm^3
3 Tungsten. The table on page 85 shows that generally, as the relative mass of the metal increases, the density of the metal increases.

6.4 Explaining gas pressure
1 Particles colliding with the walls of a container.
2 As Shahid increases the amount of air particles (by pumping) the pressure inside the tyre increases.
3 As the air particles warm up in the pan, the particles move further apart and move faster, colliding with the walls of the bottle more often. This increase in pressure leads to the plastic bottle expanding/bulging/getting bigger.
4 82–84 Pa
5 For water to boil, the pressure of the water vapour must be equal to the air pressure. In Addis Ababa, as the air pressure is lower (due to the high altitude), the vapour pressure needed for the water to boil is lower than in Asmara where the air pressure is higher.

6.5 Ideas and evidence
1 An empirical question is a scientific question that requires an experiment or making observations to answer it.
2 Suggest explanations, test their explanations, check their evidence, think creatively about possible explanations.
3 Scientists collect evidence and make observations to test their explanations and help develop them.
4 Try to think of a different explanation, double check the evidence.

6.6 Doing an investigation
1 To keep the investigation fair and ensure that he is only measuring the effects of the variable he is changing (temperature).
2 As the volume of the gas increases, the pressure of the gas decreases at a decreasing rate.
3 Marcos's experiment collects data from a larger range than Azibo's.

6.7 Review
1

Property	**Solid**	**Liquid**	**Gas**
Volume	**fixed volume**	fixed volume	**same as container**
Shape	**fixed shape**	**same as container**	same as container
Can it flow?	**no**	yes	**yes**
Can it be compressed?	**no**	**slightly**	yes

2a boiling
b (1.5, 48)
c Incorrectly reading the thermometer, taking the thermometer out, incorrectly reading the time, not heating the liquid consistently.
3a Increase the temperature of the liquid.
b Students should draw a diagram similar to that of "particles of a substance in the gas state" on page 64.
c The particles would move around at a faster speed, not touching each other and moving apart to fill the container they were in.
4a the same as
b smaller than
c the same as
5

Property	**Explanation**
You cannot compress a solid.	The particles move around, in and out of each other.
If a gas is in a container with no lid, it escapes from the container.	There is no empty space between the particles.
A liquid takes the shape of the bottom of its container.	Its particles are in fixed positions.
A solid cannot be poured.	The particles move around in all directions.

6a The bromine vapour has diffused from one jar to the other.

b **i** At the lower temperature, the orange vapour would not have diffused as well between the two jars.

ii At a lower temperature, the gas particles have less energy and so move around less, slowing down the speed of diffusion.

7a 62 cm^3

b $69 - 62 = 7$ cm^3

c $11.5 \div 7 = 1.64$ g/cm^3

8a **i** substance that diffuses

ii distance from top of agar gel to bottom of colour

iii To ensure that none of the other variables affect the distance from top of agar to bottom of colour.

b Wear goggles, gloves, and ensure that she washes her hands after using potassium dichromate(VI).

c

Substance	**Distance from top of agar to bottom of colour (cm)**
Potassium manganate(VII)	
Copper sulfate	
Potassium dichromate(VI)	
Iodine	

d **i** To ensure that her results were reliable.

ii She may have left the experiment to run for different amounts of time.

She may have used different amounts of solid.

7 Material properties

7.1 Atoms

1 An atom is the smallest part of an element that can exist.

2 An element is a substance that cannot be split into anything simpler.

3 the same

4 different

7.2 Elements and their symbols

1 hydrogen: H, helium: He, lithium: Li, beryllium: Be, boron: B, carbon: C, nitrogen: N, oxygen: O, fluorine: F, neon: Ne.

2 Na: sodium, Mg: magnesium, Al: aluminium, Si: silicon, P: phosphorus, S: sulfur, Cl: chlorine, Ar: argon, K: potassium, Ca: calcium.

3 Platinum is silvery white, it conducts electricity, is shiny, and is not damaged by water or air. It is used for making jewellery, in hard drives, and in catalytic converters.

7.3 Discovering the elements

1 Sulfur, gold, and carbon exist naturally on their own, not joined to other elements

2 platinum (Pt), zinc (Zn), phosphorus (P), arsenic (As), bismuth (Bi)

3 rhenium and technetium

7.4 Organising the elements

1 Mendeleev used creative thinking to suggest an explanation.

2 Name of element, the properties, mass of one atom of the element.

3 Can scientists use patterns in properties to help find new elements?

4 Over time, Mendeleev's predictions were found to be correct.

7.5 Interpreting data from secondary sources

1 Oxygen, silicon, aluminium.

2 Haki is incorrect, the pie chart has "all other elements 1%", tin could be included in this amount.

3 As you go down the Group 1 elements, the melting points decrease. As you go down the Group 7 elements, the melting point increases.

7.6 Explaining differences between metals and non-metals

1 Melting point (high in metals, low in non-metals). Appearance (shiny in metals, dull in non-metals).

Ability to conduct electricity (metals are good conductors, non-metals are poor conductors except graphite).

Conductors of head (metals are good conductors, non-metals are poor conductors ex. diamond).

2 In a thin sheet of metal, the rows of atoms can slide over each other; whilst in non-metals, there are weak forces within the molecules that can be easily broken.

3 Chromium (a metal) has strong forces holding the atoms together which require lots of energy (a high temperature) to break, whilst argon (non-metal) has very weak forces existing between the atoms and requires relatively little energy (low temperature) to break.

7.7 What are compounds?

1 A compound is a substance that is made up of atoms of elements joined to atoms of other elements.

2 An element is made up of one type of atom, compounds are made up of at least two types of atoms (elements) joined together.

3a 1

b 1

c 2

4 At 20 °C carbon is a solid and oxygen is a colourless gas that you can't live without.

At the same temperature, carbon monoxide is a toxic gas.

7.8 Making a compound

1 A hazard is a possible source of danger, a risk is the chance of damage or injury from a hazard.
2 Time, distance, shielding.
3 It is important to use scientific knowledge to explain and justify a conclusion to an investigation.

7.9 Naming compounds and writing formulae

1 copper sulfide: carbon and sulfur
silver bromide: silver and bromine
aluminium iodide: aluminium and iodine
iron sulfate: iron, sulfur, and oxygen
sodium carbonate: sodium, carbon, and oxygen
silicon dioxide: silicon and oxygen.
2 KCl: potassium chloride, ZnO: zinc oxide, SO_2: sulfur dioxide, SO_3: sulfur trioxide, $CuSO_4$: copper sulfate, $Pb(NO_3)_2$: lead nitrate
3 P_2O_5, $CaSO_4$

7.10 Oxides, hydroxides, sulfates, and carbonates

1 Calcium and oxygen, basic
2 Lithium, hydrogen, and oxygen.
3 Sodium, sulfur, and oxygen.
4 CaO: calcium oxide, SiO_2: silicon dioxide, KOH: potassium hydroxide, $Mg(OH)_2$: magnesium hydroxide, $CaCO_3$: calcium carbonate, Na_2SO_4: sodium sulfate
5 Magnesium oxide is used in furnaces as it has a very high melting point.

7.11 Chlorides

1 Potassium chloride
2 Using a table makes it easier to use the data in calculations, and keeps the data organised.
3 An average of the results is more accurate than just one result.
4 It is very difficult to evaporate all the water from the evaporating dish.

7.12 Mixtures

1 A mixture is a group of substances that are mixed up but not joined together.
2 Both compounds and mixtures have more than one type of atom, however, in a compound the atoms are joined together.

Mixtures can be separated into simpler substances easily, compounds cannot.

Compounds have different properties from the elements, whilst mixtures have the same properties as the substances that comprise it.

Amounts of the elements are always in the same ratio in compounds, whilst the amounts of substances can change in a mixture.

3 Mixtures: salt and water, stones and rice, sand and salad, iron nails and copper nails in a jar, air, iron and sulfur mix, orange juice.

Compounds: carbon dioxide, iron sulfide, any of the compounds on the previous pages or any reasonable compound.

4 A mixture of elements and compounds.

7.13 Separating mixtures – filtering and decanting

1 Students should draw something similar to the decanting and filtration diagrams on page 118.
2 Franco could decant the olive oil from the water.
3 Salty water contains salt dissolved in the water as a solution rather than a mixture. The salt particles are too small to be separated using the filter paper.

7.14 Separating mixtures – evaporation and distillation

1 Sodium chloride, lithium compounds
2 Evaporation removes the solvent from the solution (the water from the salt water) leaving the solute (salt) behind. Distillation would collect the water and leave the salt behind.
3 Place the ink solution into rounded-bottomed flask, heat the solution, cool the steam in the condenser, collect it in the beaker.

7.15 Separating mixtures – fractional distillation

1 Mixtures of liquids with different boiling points.
2 As the temperature of the fractioning column increases, the substance with the lower boiling point will evaporate first, leaving the fractioning column first and so condensing first.
3 Hexane
4 Russia, Saudi Arabia, USA

7.16 Separating mixtures – chromatography

1 Coloured compounds in leaves, dyes in ink. These are the only two options that are substances within a mixture of soluble substances.
2 The substance may dissolve better, one substance may stick to the chromatogram better. There are several possible answers.
3 Measure alcohol content in blood, look for explosives on body hair, identify nutrients in food.

7.17 Separating metals from their ores

1 During panning, the more dense substance falls to the bottom of the pan whilst the less dense substance can be mixed with water and removed.
2 Filtration and gravity.
3 It is heated with carbon and then melted.
4 1% of 100 kg = 1 kg of tin produced. 99 kg of waste would be produced.
5 China

7.18 What are you made of?

1 Hydrogen, oxygen, nitrogen, carbon.
2 Minerals are compounds that contain small amounts of other elements, such as iron and calcium.
3 You can suffer from tiredness, lack of energy, and shortness of breath.
4 Calcium deficiency: weak bones and frequent fractures.
Iodine deficiency: swelling of thyroid gland in neck, tiredness, brain damage.
Zinc deficiency: reduced growth in children, problems with senses and memory.

7.19 Review

1

Element	Chemical symbol
boron	B
beryllium	Be
silicon	**Si**
sodium	**Na**
sulfur	**S**
chlorine	**Cl**
fluorine	**F**
potassium	**K**

2 top to bottom: element, compound, element, element, compound, compound
3a 2, 4
b 2, 4
c 2, 4
4 When the metal is bent, the rows of atoms slide past each other, bending without breaking.
5a A, B, D
b A, B, C, E
c A
d C
e B
f D
g E
6 more than one, different from, are always the same, more than one, the same as, can vary.
7 Top to bottom:
calcium and oxygen
sodium and chlorine
potassium, hydrogen, and oxygen
iron, sulfur, and oxygen
magnesium, carbon, and oxygen
8a magnesium sulfate
b sodium chloride
c calcium carbonate
d beryllium oxide
e potassium hydroxide
9a Aluminium (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), magnesium (Mg).
b Aluminium
c Oxygen and silicon
d An element is only comprised of one type of element, a compound is comprised of different elements.
10a The second question is more specific and can be carried out in a school.
b To let air (oxygen) into the crucible to allow the magnesium to continue reacting with the oxygen in the air.
c Top to bottom:
– Wear appropriate clothing, stand back, do not lean over the crucible, have sand/fire extinguishers available.
– Do not look directly at the flame.
d i 32.40 – 32.00 = 0.40 g of MgO
ii 32.40 – 32.00 – 0.24 = 0.16 g of O_2
e During the experiment, 0.16 g of oxygen reacted with 0.24 g of magnesium to form 0.40 g of magnesium oxide. The results show that as the magnesium burns, the mass increases.

8 Material changes

8.1 Chemical reactions

1 Chemical reactions create new substances, and are not reversible.
2 See flames, sparks, bubbles, notice a smell, feel the chemicals changing temperature, hear a noise.
3 Reactants: iron and oxygen.
Product is iron oxide.
4 The product (carbon dioxide) is a gas which escapes.
5 0.08 g of oxygen

8.2 Writing word equations

1 iron + sulfur → iron sulfide
2 calcium + oxygen → calcium oxide
3 reactants: copper oxide, hydrochloric acid
products: copper chloride, water
4 magnesium + hydrochloric acid → magnesium chloride + hydrogen

8.3 Corrosion reactions

1 oxygen and water
2 iron + oxygen + water → hydrated iron oxide
3 Rust crumbles easily, leaving the underlying iron exposed to rust again. The cycle repeats, degrading the iron.
4 Coating iron in paint, another metal, or oil/grease prevents oxygen and water from reacting with the iron.

8.4 Doing an investigation

1 Seb: Variables to control: size and type of nail, volume of water used, temperature of the water.
Variables to change: amount of salt added to the water

Variable to observe: level of rust compared with the other nails.

Seb could prepare 5 test tubes with 5 different solutions of salt water (1 g of salt per 10 ml, 2 g of salt per 10 ml etc). Once prepared, Seb could add a nail to each test tube. After 1 day, Seb could compare the levels of rust on the nails, concluding which solution of salt produced the rustiest nail.

Students could draw something similar to the test tube diagram on page 138.

2 Tahlia: Apparatus list: 4 test tubes, 1 test tube rack, 4 iron nails (one painted, one greased, one coated with zinc, one left as a control), 4 bungs.

Tahlia should place each nail in a test tube and cover with water before sealing with a bung. She should leave the nails for a day (or two) before comparing the amount of rust formed on each nail.

Tahlia should ensure that all the variable should be kept the same (temperature, amount of water, type and size of nail etc).

8.5 Using reactions to identify chemicals

1 Dip the end of a clean nichrome wire into the compound that you are testing. Hold the end of the wire in a hot flame. Observe the flame colour.

2 sodium

3a green

b aluminium hydroxide

4 iron(II) chloride + potassium hydroxide → iron(II) hydroxide + potassium chloride
The iron(II) hydroxide forms a green precipitate.

8.6 Review

1a sodium + chlorine → **sodium chloride**

b zinc + **oxygen** → zinc oxide

c **iron** + sulfur → iron sulfide

d iron + oxygen → **iron oxide**

e carbon + **oxygen** → carbon dioxide

f **sulfur** + oxygen → sulfur dioxide

2 react to make

3a Question ii is too broad as there are lots of possible factors that could speed up rusting. Question iii is more specific and would be easier to test.

b **i** amount of salt
ii how much of the nail has gone rusty
iii size of salt crystals, volume of water
iv To ensure that other factors do not interfere in the results of the experiment.

c The nail is in contact with both air and water to be able to compare the amount of rust formed in the air and in the salty water and because both oxygen and water are needed to make rust.

d Amount of salt added.

4a Reactants: sodium, iodine.
Product: sodium iodide.

b Reactants: carbon, oxygen.
Product: carbon dioxide.

c Reactants: sulfuric acid, copper oxide.
Products: copper sulfate, water.

d Reactants: magnesium, hydrochloric acid.
Products: magnesium chloride, hydrogen.

e Reactant: copper carbonate.
Products: copper oxide, carbon dioxide.

5a sodium + bromine → sodium bromide

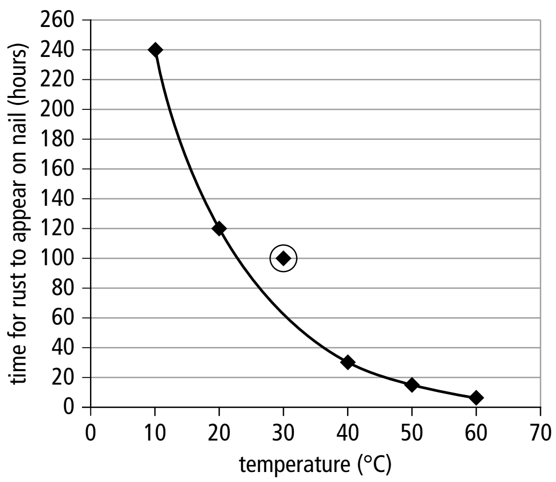
b sulfur + oxygen → sulfur dioxide

c calcium carbonate → calcium oxide + carbon dioxide

d zinc + hydrochloric acid → zinc chloride + hydrogen

e copper oxide + hydrochloric acid → copper chloride + water

6a-d



e The measurements may not have been carried out correctly: the temperature could not have been measured correctly. Or the controlled variables may not have been kept the same.

7

Test tube number	Prediction	Reason for prediction
1	Nail will rust.	The nail is in contact with air and water.
2	Nail will not rust.	Paint prevents air and water being in contact with the nail.
3	Nail will not rust.	Grease prevents air and water being in contact with the nail.
4	Nail will not rust.	Magnesium is higher in the reactivity series than iron, so it reacts instead.
5	Nail will not rust.	The zinc coating prevent air and water being in contact with the iron.

9 Energy changes

9.1 Energy changes in chemical reactions

1 Burning a fuel, neutralisation reactions

2 Melting and evaporating

3 Dissolving

4 When a reaction releases energy, the energy heats up the mixture before being transferred to the surroundings, increasing the temperature.

9.2 Investigating fuels

1 Fatima repeats her investigation to make sure her results are reliable and reduce errors.

2 The average temperature change for ethanol was the lowest value.

3 The question is not specific enough/too open ended.

9.3 Choosing fuels

1 A fuel is a substance that releases useful heat when it burns.

2 hydrogen: water
ethanol: carbon dioxide and water

3

Fuel	Advantage	Disadvantage
Ethanol	Made from a renewable source (sugar cane). Liquid at room temperature. Convenient to transport and store.	Produces carbon dioxide (a greenhouse gas). Sugar cane is grown instead of food reducing food production.
Hydrogen	Only product is water. Made from a renewable source (methane). Releases 3 times more energy per gram than diesel and almost 5 times more than ethanol.	Hydrogen is difficult to store and transport. Hydrogen is highly explosive.
Diesel	From a non-renewable source. Liquid at room temperature. Convenient to transport and store.	Produces carbon dioxide (a greenhouse gas) and small products that can increase the risk of cancer or heart disease.

9.4 Calculating food energy

1 $H = m \times c \times \Delta T$
$H = 1 \times 4.2 \times (80–20)$
$H = 252$ J

2 Some of the heat released from the food would have been transferred to the surroundings rather than the water

3 Temperature is a measure of how hot or cold something is. Heat is a type of energy that can be transferred from one thing to another.

9.5 Investigating endothermic changes

1 Variable to change: volume of solvent

Variable to observe: temperature change (the greater the temperature change, the greater the amount of heat taken in)

Variable to control: substance used, mass of solute

2a Decide on which substances to use, decide on the volume of water to use, choose the equipment they need to use.

b

Substance	Temperature change (°C)

9.6 Review

1 given out, increases, taken in, decreases

2

Type of change	Is the change exothermic?	Is the change endothermic?
combustion (burning)	✓	
neutralisation	✓	
evaporation		✓
melting		✓
freezing	✓	

3a copper sulfate

b potassium nitrate

4a The reaction is endothermic, taking in energy (heat) from the surrounding area, reducing the temperature of the water, causing it to freeze.

b Endothermically, the surrounding area gets cooler (the water freezes) demonstrating that heat has been taken in (an endothermic reaction).

5a $56 - 23 = 33\,°C$

b An increase in temperature shows that heat has been given out. Exothermic reactions give out heat.

6a fuel

b temperature change

c the amount of fuel, the temperature of the water at the start, the distance between the spirit burner and the calorimeter

d The temperature change in large/small volumes would be harder to measure and less accurate.

e **i** propanol/temperature at start: 20 °C
butanol/temperature change: 45 °C

ii ethanol

f To improve the reliability of her results.

g the surroundings

7a To reduce the chance of error and to improve reliability.

b The result is not consistent with the other results.

c The neutralisation reactions are all exothermic. The hydrochloric acid and potassium hydroxide reaction is the most exothermic.

10 Forces

10.1 Tension and upthrust

1a Extension: 4.5 cm – 3 cm = 1.5 cm

b Extension is proportional to the forces. 4 N is twice as much as 2 N, so the extension would be 2 × 1.5 cm = 3 cm

c Length of spring = original length plus extension. 6 N is three times as much as 2 N, so the extension would be 3 × 1.5 cm = 4.5 cm.
4.5 cm + 3 cm = 7.5 cm

2 The upthrust is equal to the weight, so it is 20 000 N.

3 Diagram of a weight underwater with forces of upthrust (4 N) and tension (6 N) pointing up and weight (10 N) down.

4 The elastic limit of a spring is the point where a spring will no longer return to its original length when the weight is removed.

5 The weight of an object affects the amount an elastic material will stretch, its extension. To do a bungee jump people need to be given a bungee rope that will stretch the right amount for their weight.

10.2 Presenting results – tables and graphs

1 A suitable column heading with the units of measurement.

2 A line of best fit shows the pattern or trend in a set of data. Joining all of the points may not show this trend, especially if there are any anomalous points.

3a

Colour of spring	Extension (cm)

b The colour of spring is not a continuous variable, so the data collected cannot be displayed on a line graph.

4 3 N

5 Suma might not have measured the extension of the spring correctly, she might have misread the measurement or written it down incorrectly, she might not have put the right weight onto the spring.

10.3 Round in circles

1 Centripetal force is a force that keeps an object moving in a circle. It acts towards the centre of the circle.

2 Friction between the car tyres and the road provides the centripetal force when a car moves around a corner.

3a gravitational force

b The Moon would carry on moving in a straight line in the direction it was moving when the force stopped acting. It would begin to move away from the Earth.

4 For the satellite to stay in orbit it must be constantly changing direction. An object can only change direction if a force is acting on it, so there must be a force acting on the satellite.

10.4 Review

1a Table D

b An elastic material will stretch when a force is applied to it, and then return to its original length when the force is removed.

c It would not be a good idea to use an elastic band in a forcemeter as the amount the band stretches is not proportional to the weight hung on it, or the force applied.

2a Graph of the points, with a straight line of best fit passing through points 1, 2, 4, and 5

b 4 cm

c 2.25 N

d No, almost all of the results show an extension that is proportional to the force applied to the spring. If the spring was beyond its elastic limit this would not be the case.

e The spring would return to its original length.

3a smaller than

b the same as

c bigger than

4a elastic limit

b proportional

c C/tension

11 Energy

11.1 What is energy?

1 Coal, oil, and wood.

2 200 kJ = 200 000 J

3 Keeping the body warm and breathing.

4 Children also need energy to grow.

5 1500 kJ / 25 kJ per minute = 60 minutes

11.2 Energy from the Sun

1 Missing words in order: Sun, photosynthesis, animals, plants.

2 The energy in chicken comes from the Sun because the chicken gets its energy from eating plants, which have in turn used energy from the Sun to grow.

3 A biofuel is a fuel we get from living things, a fossil fuel is made from plant and animals that died millions of years ago.

4 A solar cell converts energy from the Sun directly into electricity. A solar panel uses energy from the Sun to heat water.
5 Hydroelectricity is generated from the movement of water as it falls downhill through a special dam. This energy is originally from the Sun, because the Sun evaporates water that will fall as rain and be trapped behind a dam.

11.3 Energy types

1 The Sun or a candle.
2 Gravitational potential energy
3 Elastic potential energy
4 It has less kinetic energy.
5 The Sun provides energy for the Earth as light only. This energy is not produced by burning or a fire. The process that takes place in the Sun to produce this energy is nuclear fusion.

11.4 Energy transfer

1 Energy transfer diagrams show how energy has been transferred and transformed by an object or process.
2 chemical energy → EPE → kinetic energy
3a Electrical energy is transferred into thermal energy.
b Chemical energy in the battery is transferred into electrical energy, which is then transferred into light energy and some thermal energy.
c The chemical energy from the child is transferred into kinetic energy as he or she moves the swing. This kinetic energy begins to transfer into GPE as the swing moves, when the swing reaches the point where it changing direction all of the kinetic energy is GPE until it begins to move again and the GPE transfers to kinetic energy.
4 chemical energy → kinetic energy → GPE → kinetic energy
5 nuclear energy → light energy → chemical energy → electrical energy → light, sound, thermal energy

11.5 Conservation of energy

1 The law of conservation of energy is a law that states that energy cannot be created or destroyed, it can only be transferred in a process.
2a A hairdryer. Useful energy = thermal energy. Wasted energy = thermal energy and sound energy.
b A television. Useful energy = light energy and sound energy. Wasted energy = thermal energy.
c A kettle. Useful energy = thermal energy. Wasted energy = thermal energy and sound energy.
3 Missing words in order: useful, wasted, thermal.
4 An energy efficient light bulb produces less wasted thermal energy, so it would be cooler.
5 More efficient electrical devices save you money as they waste less energy. This means you use less electricity, and pay for less electricity, when you are using them.

11.6 Gravitational potential energy and kinetic energy

1 Kinetic energy is the energy that an object has when it is moving. GPE is the energy that an object has because of its position, for example if an object is on a high shelf it will have more GPE than an object on the floor.
2a The man has more kinetic energy because his mass is larger.
b They could have the same amount of kinetic energy if the man was running slower than the boy, as both speed and mass affect the amount of kinetic energy something has.
c The man has more GPE because his mass is larger.
3 GPE → kinetic energy → sound energy
4 Energy is wasted on a rollercoaster ride because they are designed to hold more or heavier people than they normally do, so that the rollercoaster will always work. This means they are often designed to gain more GPE than they might really need to loop the loop or go up the next hill.

11.7 Elastic potential energy

1a As the student stretches the elastic band it gains elastic potential energy as it shape changes. When she lets the band go, the elastic potential energy changes into kinetic energy.
b If the band is pulled back further it will gain more EPE, so the band will move further when it is released as there is more EPE that can be transferred into kinetic energy.
2a GPE → kinetic energy → EPE → kinetic energy → GPE
b Not all of the kinetic energy the bungee jumper had before he or she bounces is transferred into kinetic energy after the bounce, some is transferred to the environment as thermal energy. Eventually all the energy is transferred to the environment and the jumper stops bouncing.
3 A ball will never bounce higher than the height you drop it, as some of the GPE and kinetic energy it has before bouncing is lost to the environment as thermal energy.

11.8 Suggesting ideas

1 No you cannot answer the question ‘Which fuel is cheapest?’ with a practical investigation. A practical investigation involves changing one variable and keeping everything else the same. It may be possible to answer this questions by making observations and collecting data without changing or controlling variables.

2 Lumasi's question is 'Which fuel heats up water the fastest?' Liquid ethanol heats up water the fastest as it takes the shortest amount of time to heat 25 cm^3 of water from 20 °C to 30 °C.

3 Scientists repeat their investigations to improve their reliability. If you repeat your experiment, you can us an average result, and any anomalous results will stand out from the rest.

11.9 Suggesting ideas continued

1a A field study is different from a practical investigation because scientist collect data from observations without affecting what they are studying. A practical investigation involves changing and controlling variables to find out how they affect what the scientist is studying.

b A field study is similar to a practical investigation because both are methods of carrying out investigations to collect data that will answer a scientific question.

2 Two people may not agree on 'Which is the best fuel?' because they may not agree on what makes a fuel good. One person may think the best fuel is the cheapest, another may think the best fuel is the one that produces the least greenhouse gases. This question cannot be answered by collecting data because the answer does not depend on data but on a persons opinion.

3a Yes – data can be collected about the amount of greenhouse gases, particulates or other waste products a fuel releases into the environment.

b No – scientists could make prediction for the future based on data collected on how we use fuel now, and how much fuel is left, but our lifestyles might change in the future.

c No – this question cannot be answered by collecting data, the answer will depend on a person's opinon.

11.10 Energy calculations and Sankey diagrams

1 Energy cannot be lost or created. A machine that is not very efficient transfers more energy into a form that is not useful, for example a light bulb wastes thermal energy.

2 Efficiency = 75 J / 100 J × 100% = 75%

3 A machine cannot be more than 100% efficient because energy cannot be created or destroyed, only transferred, and a machine cannot transfer more energy than it is given.

4a Diagram that shows an arrow of 200 J, with 160 J going forwards and 35 J and 5 J lost as thermal energy and sound energy.

b Efficiency = (useful energy/total energy) × 100%
= 160 J / 200 J × 100% = 80%

11.11 Review

1a People who do different jobs or sports will use different amount of energy to carry out these activities. Therefore they need different diets in order to get the right amount of energy from their food.

b sitting, walking slowly, cycling – sitting requires the least amount of energy because your body is not moving; cycling requires the most amount of energy because you are moving quickly and are providing energy to move the bike as well.

2 20 J, 0.2 kJ, 2000 J, 20 kJ, 2000 kJ

3a Photosynthesis is the process that plants use to transfer light energy from the Sun into chemical energy.

b A fossil fuel stores energy from the Sun as chemical energy.

c Hydroelectricity is electrical energy generated from the GPE of water held behind a dam transferred into kinetic energy by turbines as the water falls. The kinetic energy is transformed into electrical energy by a generator.

d A solar cell transfers light energy from the Sun into electrical energy.

4 1 – C, 2 – A, 3 – D, 4 – B

5 d is incorrect – kinetic energy *does* depend on the mass of the object.

6a chemical

b kinetic

c thermal

d GPE, kinetic energy

e chemical

7a Energy is wasted as: thermal energy and sound energy.

b chemical energy → kinetic, thermal and sound energy (these are drawn as separate transfers)

8 C

9 lamp – light, bell – sound, kettle –thermal, bicycle – kinetic

10 C, A, D, B

11a B

b C

c A

12a

Position	GPE (J)	KE (J)	Total energy (J)
A	6000	**0**	**6000**
B	**4500**	1500	**6000**
C	3000	**3000**	**6000**
D	**1500**	4500	**6000**
E	**0**	6000	**6000**

b The law of conservation of energy.

c I have made the assumption that no energy is transferred to the environment as thermal energy as the diver falls due to air resistance.

d When the diver hits the water most of her kinetic energy is transferred to the environment as thermal and sound energy.

13 A – Yes, a practical investigation can be carried out by stretching the elastics bands with different forces and measuring the point that they break.
B – Yes, a field study could be carried out to collect data to answer this question.
C – No, this is a matter of opinion.

14a The student has not included an explanation of her prediction.
b No they do not. The results are very similar for all of the volumes of fuel used.
c She could measure out a volume of fuel and use this to heat the same volume of water every time.
d Chemical energy in the fuel is transferred into thermal energy in the water and the surrounding air.
e Yes, both the useful and wasted energy is thermal energy as thermal energy is transferred to the environment as well as the water.
f It is difficult to get accurate results because a lot of thermal energy is transferred to the environment.

12 Speed

12.1 Speed

1 150 km / 2 hours = 75 km/h
2 200 m / 40 s = 5 m/s
3 Nikita
4a True – Car 1 = 100 km / 2 hours = 50 km/h. Car 2 = 100 km / 3 hours = 33.3 km/h.
b True – Girl = 10 m / 4 s = 2.5 m/s. Boy = 10 m / 3 s = 3.3 m/s.
c False – Motorbike = 50 km / 0.5 h = 100 km/h. Car = 100 km / 0.45 h = 133.3 km/h.
5 The two speeds are measured in different units so it is not possible to tell which speed is faster by the number. The speeds need to be changed into the same units to know which one is fastest.

11.2 Taking accurate measurements

1 Timing gates are more accurate than using a stopwatch because the measurement is taken exactly when the light beam is broken. Using a stopwatch is less accurate because you reaction times mean that there is a delay in taking the measurement.
2 Automatic timing is more important for timing over a short period of time because a delay from reaction time would have a greater effect on the results. A sprint takes place over a shorter period of time than a marathon, so automatic timing is more important.
3 Kyra's time is more precise because she measured to time to a greater number of significant figures.
4a less than 0.2 seconds
b Typical reaction time is 0.2 seconds. If a sprinter leaves the blocks less than 0.2 seconds after the gun, it is unlikely that they are reacting to the sound and have false started.

12.3 Distance-time graphs

1 Section E – it is the steepest which she has moved a greater distance in a shorter time, and so is moving faster than anywhere else on the graph.
2a Amira
b David – there is a section of his graph where the distance does not change.
c David
d Amira
e Average speed = total distance / total time = 4500 m / 15 minutes = 4500 m / 900 s = 5 m/s
3 C = 1400 m / 13 mins = 1400 m / 780 s = 1.8 m/s
E = 2100 m / 10 mins = 2100 m / 600 s = 3.5 m/s

12.4 Acceleration and speed-time graphs

1 Speed is the distance travelled in a given time. Acceleration and deceleration are how speed is changing over time, acceleration is when the speed is increasing and deceleration is when it is decreasing.
2 Correct words in order: acceleration, horizontal, is not.
3 Acceleration = 25 m/s – 0 m/s / 0.05 s = 25 / 0.05 = 500 m/s^2
4 Acceleration = 0 m/s – 10 m/s / 0.1 s = –10 / 0.1 = –100 m/s^2
Deceleration = 10 m/s 0 m/s / 0.1 s = 10 / 0.1 = 100 m/s^2
5a Car B has the greater acceleration because the graph is steeper meaning the speed is increasing more over the same time.
6b Car B is accelerating at: 45 m/s – 0 m/s / 2.5 s = 45 / 2.5 = 18m/s^2
Car B is accelerating at 18 m/s^2, this is greater than Car A that is accelerating at 12 m/s^2.

12.5 Presenting results in tables and graphs

1 The number of races a driver has won is a discrete variable and must be shown on a bar chart or pie chart, it cannot be displayed on a line graph like speed and time, which are continuous variables.
2a 10 – 14 seconds.
b 14 – 18 seconds.
c 0 – 10 seconds, and 18 – 20 seconds.
3a 400 m
b The car was moving at a steady speed between 10 and 14 seonds, this is not the same as not moving, and so the distance moved continued to increase during this time.
4a The distance time graph would show a horizontal line for the time the car was stopped in the pits because the car is not moving.
b The speed-time graph would show the car decelerating to 0 m/s before a horizontal like

when it was stopped in the pits – this is the same as moving at a steady speed. As the car leaves the pits the graph would show acceleration.

5a Acceleration = 55 m/s – 0 m/s / 4 s = 55 / 4 = 13.75 m/s^2

b Acceleration = 78 m/s – 89 m/s / 4 s = –11 / 4 = –2.75 m/s^2

Deceleration = 89 m/s – 78 m/s / 4 s = 11 / 4 = 2.75 m/s^2

12.6 Asking scientific questions

1 Any suitable answers: it would not be possible to walk, drive, play football, hold objects, etc. It would still be possible to sit or lie down, swim, etc.

2a When a boat is moving on a river it is slowed down by forces of water resistance, air resistance and friction. In order to keep moving at a steady speed these forces must be balanced by an equal force acting in the opposite direction, this is the thrust provided by the engine. Therefore the engine must be kept running for the boat to move at a steady speed.

b If the engine was turned off, the boat would slow down as the forces acting on it would no longer be balanced. The drag forces would be greater than the thrust and the boat would begin to slow, it would eventually stop.

3 No it wouldn't make a difference, as it would not change the forces acting on the ball.

12.7 Review

1 A, C, D

2a m/s, km/s

b km, m

c h, s

3a The line on the graph is straight and is the same gradient for the whole graph, this means the girl was cycling at a steady speed. If she had been moving at different speeds, then the gradient of the graph would change too.

b Speed = 12 km / 120 min = 12 km / 2 h = 6 km/h

4 d

5a Speed = 1440 km / 2 hours = 720 km

b accelerating

c The average speed would be lower when the plane has to fly into the wind because it is experiencing more drag.

6a Speed = 110 m / 10 s = 11 m/s

b Speed = 3 km / 0.5 h = 6 km/h

7 5.14 seconds

8a 10 minutes

b 3000 metres

c 50 minutes

d Aadi travels the fastest between 30 and 40 minutes.

e Speed = 3000 m / 30 minutes = 3 km / 0.5 h = 6 km/h

9a Speed = 1 m / 10 min = 0.1 m/min

b Speed = 2 m / 8 min = 0.25 m/min

c Speed = 3 m / 20 min = 0.15 m/min

10a Tables B and D.

b Tables A and C.

c units

d Categoric variables: colour, manufacturer.

e Top speed, engine size, cost.

11a False

b True

c False

d True

e False

12a

Object	Time (s)
Tennis ball	0.53
Football	0.68
Table tennis ball	0.72

b Timing gates work by shining a beam of light across the path of the object. When the object passes through the top light beam, the beam is broken and the timer starts. When the object passes through the second gate, the beam is broken and the timer stops.

c Tennis ball = 1 m / 0.53 s = 1.89 m/s
Football = 1 m / 0.68 s = 1.47 m/s
Table tennis ball = 1 m / 0.72 s = 1.39 m/s

d Draw a bar chart because the ball types is a discrete variable.

13 Light

13.1 Refraction: air and water

1a Their speed would still slow down.

b Their direction would not change.

2 If they dived at an angle the change in their speed would change the direction of their dive making it more difficult to aim.

3 Below – as light changes direction at the boundary of water and air it makes objects in the water appear closer than they are.

4 Refractive index = 300 million km/s / 230 million km/s = 1.3

13.2 Refraction: air and glass

1 Daren's second prediction is better because it explains his prediction using scientific knowledge.

2 As the ray enters the glass block it slows down and changes direction, when it leaves the glass block it speeds up by the same amount that it slowed down by before. The angle of refraction when it leaves the block is the same as the angle of incidence when it enters the block and the rays are parallel.

3 In his diagram the angles of incidence and reflection where the ray hits the boundary are not equal.

13.3 Dispersion

1 Twice

2 The spectrum is continuous because all of the wavelengths have been refracted by different amounts. The refracted wavelengths can have any value between the longest wavelength, at the start of the red light, to the shortest wavelength at the end of the violet light.

3 Light can be refracted, for example in through a rectangular glass block, without being diffracted. For the spectrum to be visible, diffractions, all of the wavelength must be refracted by different amounts so that the different colours spread out – it will not be visible if this does not happen.

4 Red light travels the fastest in glass. Red light is refracted the least, which means it is slowed down the least.

13.4 Colour

1 A green filter only transmits green light – all other colours of light will be absorbed.

2

Combining …	Makes …
red + blue	magenta
cyan + red	white
blue + yellow	white

3 This is not correct. White light is made up of every colour of light combined, filters absorb some wavelengths of light so that only one colour is visible.

4 No light is transmitted. A blue filter absorbs red and green light transmitting blue light. A yellow filter absorbs blue light. It would transmit red and green light but they have already been absorbed, so no light is transmitted.

13.5 Presenting conclusions: more on colour

1 A yellow flower looks yellow because it absorbs blue light and reflects red and green light, which combine to make yellow light.

2 A combination of red, yellow, and blue paint looks black because red, green, and blue light are all absorbed and none of the light is reflected.

3a Red shirt and red shorts.

b Green shirt and green shorts.

c Black shirt and blue shorts.

4 The red object will also appear red in yellow light, so this evidence does not support Aru's conclusion that a red object will only look red in red or white light.

13.6 Asking scientific questions

1 The idea that light was made of particles was popular because people were able to understand it more easily as they could see other objects that behaved like particles and also like light, such as balls that bounced off walls.

2 Newton was famous because he had published a lot of ideas about gravity and so he was considered a good scientist.

3a If you throw a football at a wall it will bounce back in the same way that Newton explained why light is reflected from a wall. If you throw the ball at a 90 ° angle it is reflected back directly. If you throw it at a different angle, e.g. 30 ° to the normal, it will bounce away at an angle that is 30 ° from the normal in the opposite direction.

b Any suitable answers: you could show refraction by rolling a football along one surface onto a different one, for example a path onto grass, the change in speed would change the direction of the football.

4 Any suitable answers: It explains how we can see a reflection in a window, and that light will also pass through the window. It does not explain why the light changes direction when it is refracted.

13.7 Lasers

1 A laser is different to sunlight because the light is only one colour and the waves are all in step with each other. A laser also produces a narrow beam of light, unlike light from the Sun.

2 Using a laser is a very precise way of cutting material.

3 A high power laser is used to make the pits and a low-power one will read it. The high powered one is need to cut the material, but if it was used to read it as well it would destroy the markings.

4a A laser can be focused precisely on the mirror on the Moon. It is stronger than normal light and sunlight so the reflection would be clearly detectable.

5b They could measure the time it takes for the laser light to reach the Moon and be reflected back to Earth to calculate the distance to and from the Moon. The distance to the Moon would be half of this distance.

13.8 Review

1a refraction

b The light changes direction because its speed changes.

c The fish can see the bottom of the lake as well as the water's surface and the bank above the river because some light from the bottom of the lake is reflected back into the water, whilst light from the surface and bank is refracted when it enters the water.

2a 0°

b The ray at A enters the block and its speed will reduce, but its direction does not change.

c 45°

d The ray is reflected.

e The critical angle must be less than 45°.

f If the critical angle was greater than 45°, then the light would be refracted out of the prism instead being reflected internally.

3a A, C, E, D, F, B, G

b This method ensures the measurements of the angles are as accurate as possible because the dots show exactly where the light enters and leaves the block. When the block is removed a straight line is drawn using a ruler because light travels in a straight line.

4 B, C

5a green

b magenta

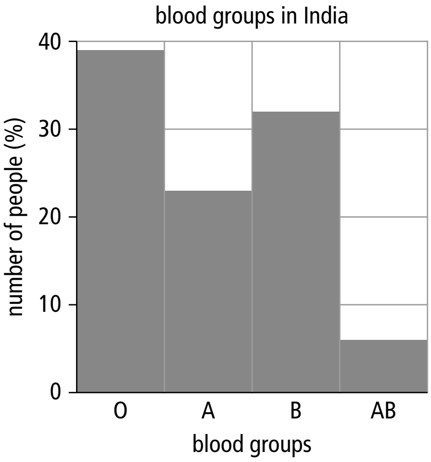
1 Variation and classification

1.1 Variation

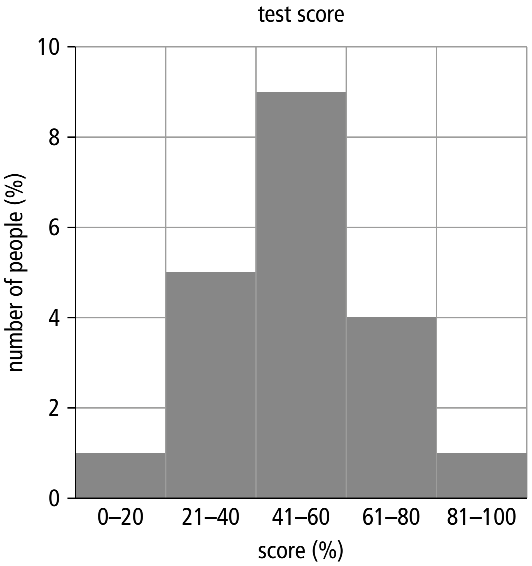
1 The missing words are: unique, identify, range, continuous, discontinuous.

2 **a** D **b** C **c** C **d** D **e** C

3



4

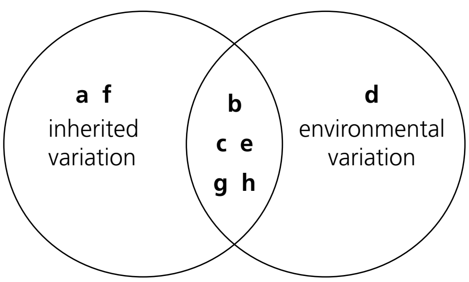


Ea Biometric data prevents the use of stolen passports because no two people have the same data.

b Security systems used at airports need to be fast and reliable so the best biometric data to use could be iris patterns for security or face shapes for speed.

1.2 Causes of variation

1



2 **a** T **b** T **c** F **d** T **e** T **f** T **g** F

c **Identical** twins always have identical genes.

g Cells specialise by switching on **different** genes.

3 The average height of students is increasing in many parts of the world because they eat more nutritious food and a bigger percentage reach the maximum height their genes can produce.

4a Identical twins separated at birth have the same genes so any differences between them must be caused by environmental differences.

b If inherited variation determines behaviour, identical twins separated at birth will be just as alike as identical twins who grew up together.

1.3 Species

1 The missing words are: characteristic, species, Latin, world, infertile, hybrids.

2

Same species	Similar species	Very different species
	Equus ferus	*Tetracerus quadricornis*
	Equus africanus	*Syncerus caffer*

3 **a** T **b** F **c** T **d** F **e** T **f** F

b Similar species share the same first Latin name.

d Members of the same species don't always look similar.

f Members of different species usually have **infertile** offspring if they breed.

Ea Dzos have not bred to form large herds because they are infertile hybrids.

b Yaks and dzos could be distinguished using breeding experiments (only yaks would produce fertile offspring), or by examining their DNA.

1.4 Classification

1 The missing words are: differences, groups, classification, backbones, invertebrates, characteristics, species.

2 Top row: molluscs – soft bodies; cnidarians – tentacles; annelids – segmented bodies; flatworms – flat bodies.
Bottom row: echinoderms – spiny skin; arthropods – jointed legs; nematodes – long thin bodies.

3 Arachnids – 8 legs; insects – 6 legs; crustaceans – 2 pairs of antennae; myriapods – long bodies divided into segments.

E The dung beetle is: an arthropod because it has jointed legs; an insect because it has 6 legs; and a beetle because it has tough covers over its wings.

1.5 Vertebrates

1 Top row: mammals – have fur, give birth or produce milk, warm blooded; reptiles – have hard scales, lay waterproof eggs, cold blooded; fish – lay eggs in water and have soft scales, gills, and fins, cold blooded.
Bottom row: birds – have feathers and wings and lay shelled eggs, warm blooded; amphibians – have smooth skin and lay their eggs in water, cold blooded, and their larvae have gills.

2 **a** T **b** T **c** F **d** T
e F **f** T **g** F
- **c** **Amphibians** can only reproduce where there is water, or reptiles can **reproduce without** water.
- **e** Fish **and larval amphibians** have gills.
- **g** Whales **are mammals and** feed their young on milk.

3a Mammals.
b Mammals have fur or hair and feed their young on milk.
c Echidnas lay eggs instead of giving birth to live young.

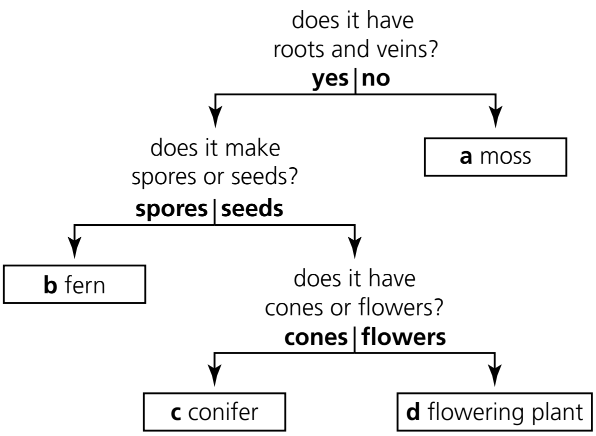
Ea *Archaeopteryx* is difficult to classify because it has features from more than one group.
b It shares features with birds (feathers and a beak) and reptiles (teeth and a tail).

1.6 Classification of plants

1

Type of plant	moss	ferns	conifers	flowering plants
Roots and veins?	no	yes	yes	yes
Spores or seeds?	spores	spores	seeds	seeds
Cones, flowers or neither?	neither	neither	cones	flowers

2



3 **A** Conifer. **C** Fern.
B Flowering plant. **D** Moss.

E Flowering plants are better adapted to life on land because they have roots and veins to carry water through the plant and they produce seeds which can survive dry conditions.

2 Humans

2.1 The human skeleton

1 A – a hinge joint, found in the knee, lets leg bend and straighten.
B – a ball and socket joint, connects leg to hip, lets leg swing freely.

2 Ligament – holds bones together but lets them swing freely.
Cartilage – prevents the end of bones from banging together in a joint.
Bone – provides support and can be pulled around by muscles to move your arms and legs.
Synovial fluid – lubricates joints so bones can slide over each other smoothly.

3 **a** T **b** F **c** F **d** F **e** T
- **b** Your backbone prevents damage to your **spinal cord**.
- **c** Your backbone is a **column of small bones** that runs down your back.
- **d** Your bones are joined together by hinge joints **at your elbow and knee**.

Ea A is cartilage, B is synovial fluid.
b The cartilage in an arthritic joint is worn away.
c The arthritic joint is painful and difficult to move.

2.2 Muscles and movement

1 The correct words are: bones, muscles, tendons, straightens, bends.

2 **a** F **b** T **c** F **d** T
- **a** Tendons hold **muscles and bones** together.
- **c** Muscles **pull** on bones to make you move.

3 **a** Karis, **b** Marie.

4 The muscles added to diagram B should be shorter and fatter at the back of the arm (triceps) and longer and thinnner at the front (biceps) as shown below.

E Carla's muscles are controlled by nerve messages from her brain. If these are not controlled they will receive instructions to contract at random times.

2.3 Organ systems

1 **a** Respiratory system. **b** Digestive system. **c** Nervous system. **d** Circulatory system.

2 Skeletal system – provides support and protection, allows movement.
Muscular system – contracts and pulls on bones to cause movement.
Nervous system – senses your surroundings and controls your actions.
Respiratory system – carries out gas exchange, adds oxygen to your blood, and removes carbon dioxide.
Digestive system – breaks down large particles in food so they can get into your blood.

3 **a** Nervous system. **b** Digestive system. **c** Respiratory system. **d** Skeletal system. **e** Muscular system.

E The correct order is: e, d, a, f, c, b
Emran's nervous system controls his muscles; his muscles pull on bones to make him move; his skeletal system provides support; and his joints to allow him to move.

2.4 The circulatory system

1 From the top: lung, vein, heart, artery.

2 The missing words are: reaction, oxygen, digestive, respiratory, energy.

3 Artery – carries blood away from the heart.
Vein – returns blood to the heart.
Capillary – thin-walled to let gases in and out.

E When the blood supply is cut, heart muscle gets no glucose or oxygen, respiration stops, and it runs out of energy.

2.5 Studying the human body

1 The missing words are: body, healthy, disease, lives, knowledge.

2 Haematologist – examines blood to help doctors diagnose illnesses.
Optometrist – examines your eyes to check for signs of disease and poor vision.
Neuroscientist – studies how the nervous system controls our bodies.
Dietician – recommends how we could improve our health by changing what we eat.
Prosthetic limb developer – makes replacements for missing hands, arms, and legs.

3a Dietician.
b Optometrist.
c Prosthetic limb developer.
d Haematologist.
e Neuroscientist.

Ea Dietician – to study the food patients eat.
b Sports scientist – to measure fitness.
c Haematologist – to check their blood for signs of illness.

2.6 Extending lives

1 The missing words are: transplant, rejection, kidney, two, waste, urine, live.

2 Transplant – move an organ from one person to another.
Kidney – the organ that cleans your blood and makes urine.
Urine – a waste product made by your kidneys and stored in your bladder.
Scaffold – what tissues are grown on to build body parts like ears.
Reject – fail to accept a transplanted organ.

3 **a** T **b** F **c** F **d** T

4a More organ transplants will be needed in future because the population is rising and people are living longer, which means that their organs are more likely to wear out.
b A heart will be harder to grow than a bladder because it has a complex 3D shape and contains several different sorts of tissue.

3 Diet

3.1 Food

1 Carbohydrates – most of our energy intake should come from these.
Fats – used to build cell membranes and a good source of energy.
Proteins – essential for growth and repairing cells.
Vitamins – help chemical reactions take place in your cells.
Minerals – help cells to function properly and strengthen bones and teeth.

2a Carbohydrates.
b Fats.
c Carbohydrates and fats.
d Proteins and fats.
e Proteins and fats.
f Carbohydrates.
g Proteins and fats.
h Carbohydrates.

3 Fats are needed: for insulation, for making cell membranes, and as a source of energy.

4

Nutrient	Small molecules joined to make it
starch	glucose
proteins	amino acids
fats	glycerol and fatty acids

E Their diet lacks protein so their growth may be slowed (stunted).

3.2 Managing variables

1 **a** Changed. **b** Controlled. **c** Controlled. **d** Controlled. **e** Measured. **f** Measured. **g** Calculated.

2

Measuring instrument	Quantity measured	Units used
thermometer	temperature	°C
measuring cylinder	volume	cm^3
electronic balance	mass	g

3 Any two from: a large amount of fuel would make the water boil (so she could not calculate an accurate temperature rise); some of the heat would escape around the sides of the test tube; pieces of burning food could fall off and be a hazard.

E

Temperature rise (°C)	Temperature rise per gram (°C per gram)
30	20
46	46
66	33

Bread produces a lower temperature rise per gram because it contains less fat than chicken or cheese.

3.3 A balanced diet

1 The missing words are: nutrient, proportions, proteins, fatty acids, minerals, rice, energy.

2a The missing values are:

Type of nut	Unsaturated fat (g/100 g)
brazil	47
coconut	7
almond	35

b A patient at risk of heart disease should eat almonds because they have least saturated fat.

3 Chocolate is high in sugar which causes tooth decay, and saturated fat which has a high energy content. Too much saturated fat could cause heart disease or diabetes.

4 Proteins contain many different amino acids. Most plant products do not contain every amino acid we need.

E Energy from fat $= \frac{25}{100} \times$ energy needed

$= \frac{25}{100} \times 8000$ kJ

$= 2000$ kJ

Mass of fat = 2000 kJ ÷ 37 kJ/g = 54 g

3.4 Deficiencies

1 The missing words are: ill, explain, scurvy, deficiency, lack, vitamins, nutrients.

2 Anaemia – iron
Kwashiorkor – protein
Scurvy – vitamin C
Beri-beri – vitamin B1
Rickets – vitamin D
Night blindness – vitamin A

3a Anaemia.
b Night blindness.
c Scurvy.
d Beri-beri.
e Rickets.
f Kwashiorkor.

Ea Hassina may have scurvy and anaemia.
b Scurvy would cause bleeding gums, swollen legs, and a lack of energy. Anaemia would cause tiredness, painful sores in her mouth, and weak nails.

3.5 Choosing foods

1 The missing words are: body, obese, energy, fat, diabetes, blood, heart.

2 Make fatty and sugary foods more expensive to reduce demand for them. Encourage people to exercise more so eating sugars and fats won't make them obese. Add extra nutrients to common foods so people automatically get a balanced diet. Add extra genes to common crop plants so extra nutrients aren't needed.

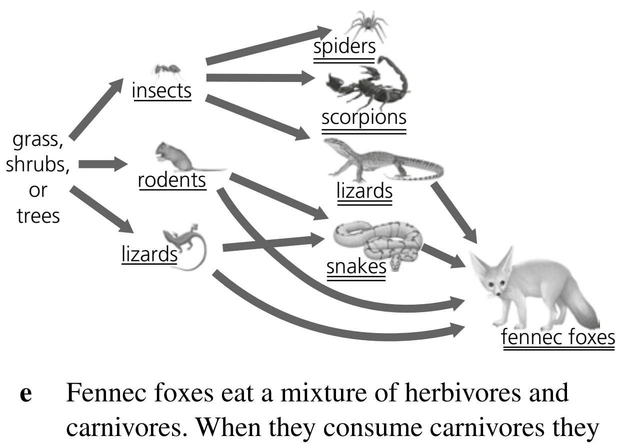
3a Chocolate biscuits cost less than fresh berries; chocolate biscuits are on special offer more often.
b Chocolate biscuits are high in sugar which causes tooth decay, and saturated fat which has a high energy content; eating a lot of biscuits could lead to heart disease or diabetes.

4 Extra nutrients could be added to common foods or extra genes could be added to common crop plants so people get them automatically.

4. Energy flow

4.1 Food webs

1a–d Diagram as shown below.



e Fennec foxes eat a mixture of herbivores and carnivores. When they consume carnivores they are tertiary consumers but when they consume herbivores they are secondary consumers.

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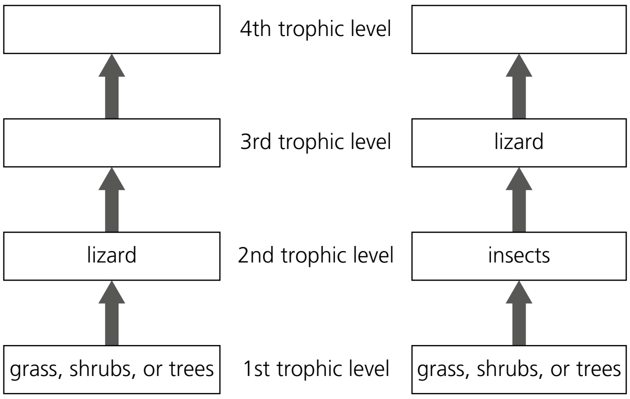
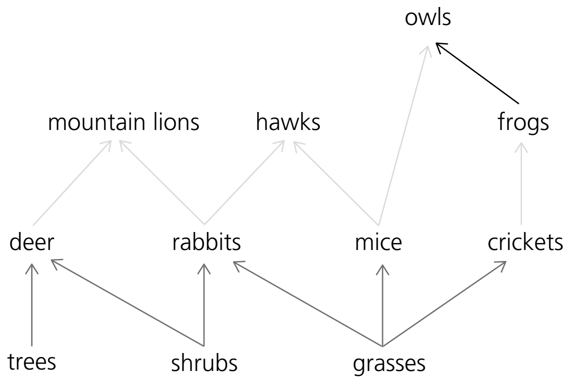
f For lizards that are herbivores:
grass, shrubs, or trees → lizard.
For lizards that are carnivores:
grass, shrubs, or trees → insects → lizard.

g



Ea



b Deer, rabbits, mice, and crickets feed at the second trophic level because they are all primary consumers (herbivores).

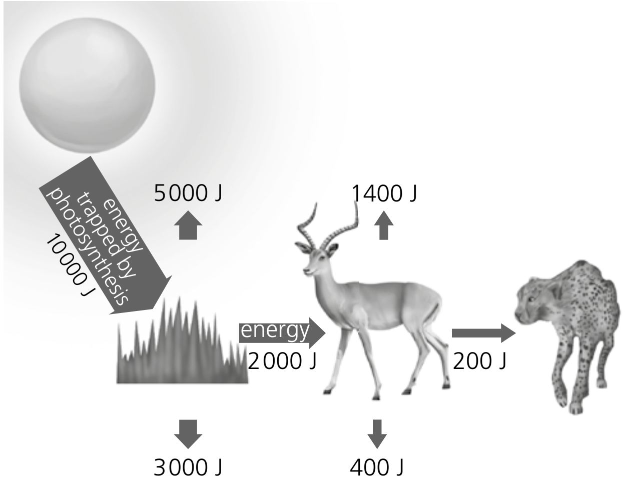
c It is difficult to assign a trophic level to owls because they feed at two different levels. They feed at the third trophic level when they eat mice, but they feed at the fourth trophic level when they eat frogs. So their trophic level is somewhere between 3 and 4.

4.2 Energy flow

1 Food chain – shows where each organism gets its energy from.
Pyramid of numbers – shows the number of organisms in each trophic level.
Pyramid of biomass – shows the mass of living things in each trophic level.
Energy losses – the energy organisms release during respiration or lose in the waste products they excrete.
Energy flow – the transfer of energy from one organism to another.

2 The missing words are: organisms, trophic, biomass, energy, respiration, products, tissues.

E Diagram as shown below.



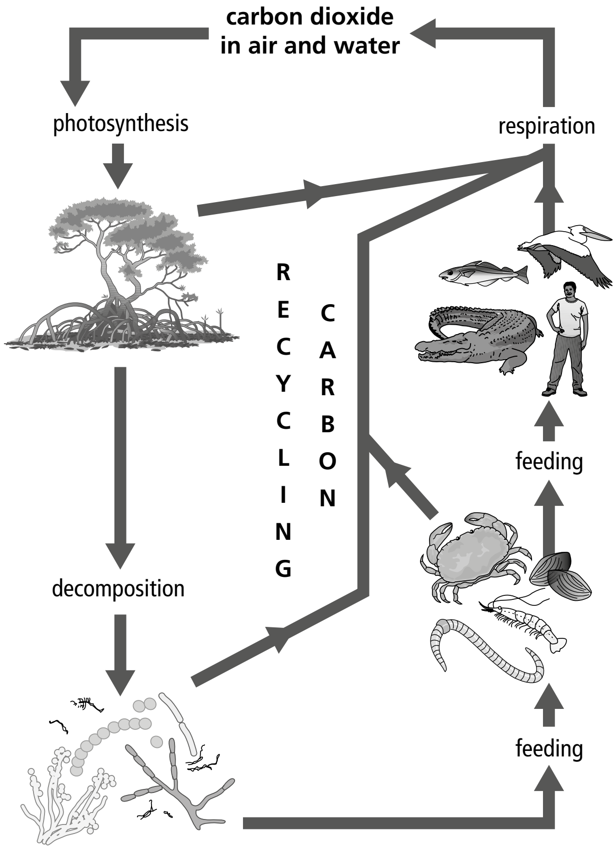
4.3 Decomposers

1 The missing words are: herbivores, energy, living, animals, faeces, minerals, bacteria.

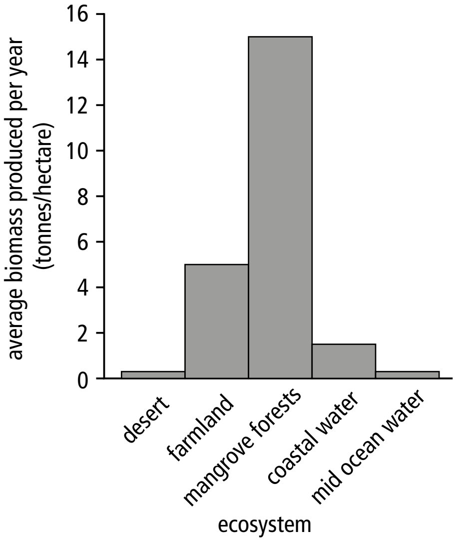
2 Diagram as shown below.

organic matter → fungus → shrimp → fish

3 Diagram as shown below.

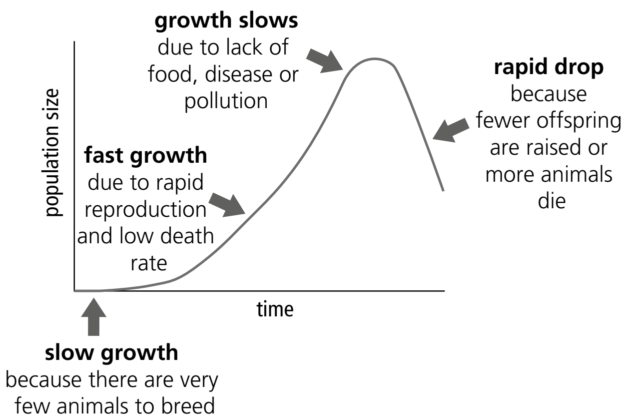


E Graph as shown below.



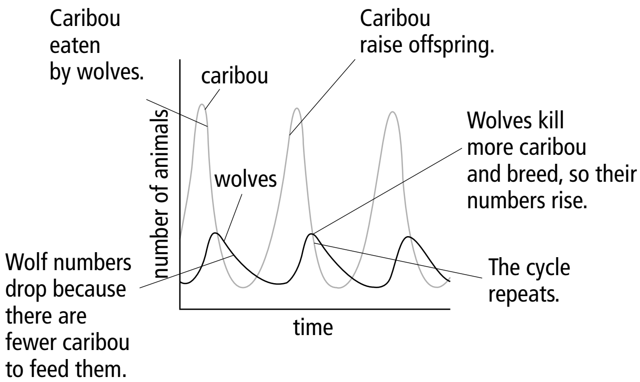
4.4 Changing populations

1 The labels shown below should be added to the diagram.

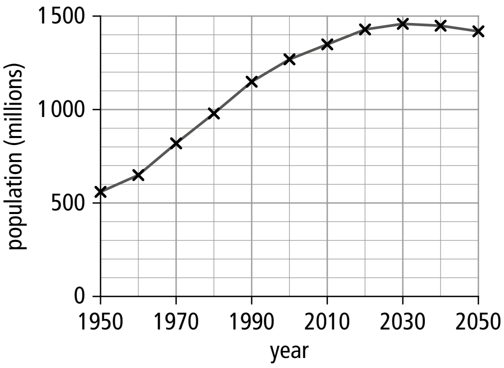


2 Population – the number of individuals present.
Interdependent – species that affect each other's numbers.
Sustainable – able to continue forever.
Biodiversity – a measure of the number of species present.

3 The labels shown below should be added to the diagram.



E Graph as shown below.

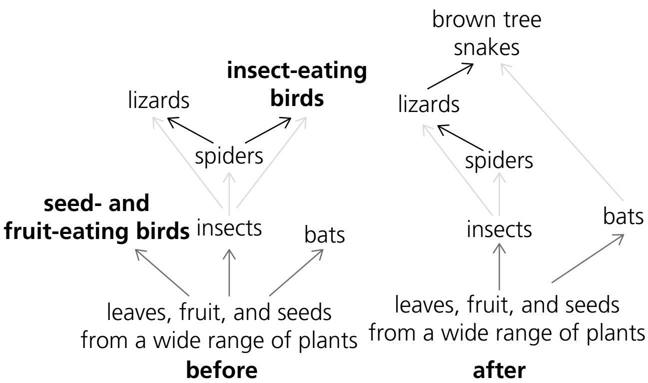


Between 1950 and 1990, the population increased by nearly 15 million per year. Between 1990 and 2030, population growth is expected to slow. After 2030, the population is expected to begin to fall.

4.5 Facing extinction

1 The missing words are: food, disease, predators, extinct, invasive, quickly.

2a The arrows shown below should be added to the diagram.



b Insect-eating birds – DOWN.
Lizards – DOWN.
Spiders – UP.
Bats – DOWN.
Seed and fruit–eating birds – DOWN.
Plants – UP.

c If the insect population increases they could destroy the forest by eating all the leaves on the trees.

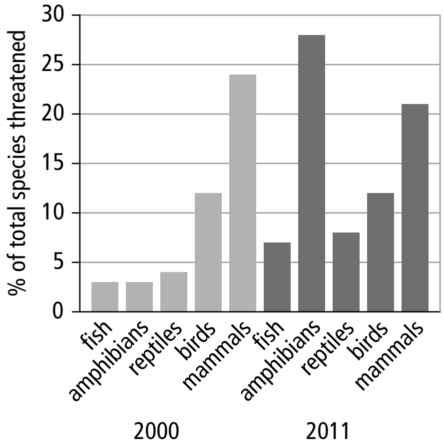
E Credit any logical prediction about the future of the forests on Guam, e.g. the loss of insect-eating birds will have the biggest effect in the short term because it will increase the amount of damage insects do to trees; in the long term the loss of seed- and fruit-eating birds will cause most damage because the existing trees will not be able to reproduce successfully.

4.6 Maintaining biodiversity

1 The missing words are: plant, biomass, habitats, biodiversity, destroyed, extinct.

2 Most biodiversity is found in warm, wet ecosystems.
Farms usually have a low biodiversity.
Infectious diseases have destroyed food crops in the past.
We store seeds to prevent useful plant species from becoming extinct.
To prevent inbreeding in small populations scientists have produced offspring using sperm from a different part of the world.

3a Bar chart as shown below.



b Credit any three differences shown in the bar chart, e.g. a bigger percentage of bird and mammal species were threatened in 2000; the percentage of bird and mammal species threatened did not change between 2000 and 2011; the percentage of fish and reptile species threatened doubled between 2000 and 2011; the percentage of amphibian species threatened increased a lot between 2000 and 2011; in 2011, amphibians had a bigger percentage of threatened species than any other vertebrate group.

5 Digestion

5.1 The digestive system

1 Clockwise from the top right the labels are: gullet, stomach, pancreas, small intestine, rectum, large intestine, gall bladder, liver.

2 The missing words are: molecules, blood, alimentary canal, pieces, enzymes, break, pancreas, small, absorbs, intestine, water.

3a Both.

b Mechanical digestion.

c Mechanical digestion.

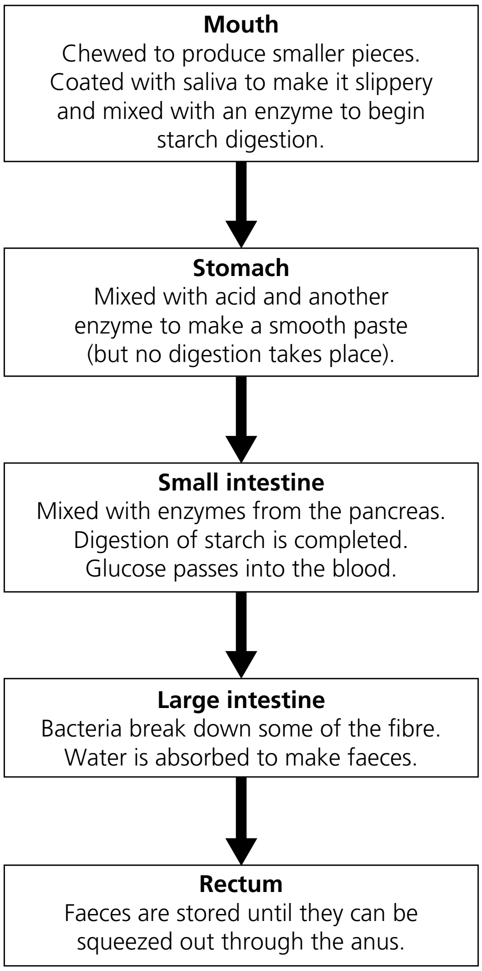
d Chemical digestion.

e Chemical digestion.

f Chemical digestion.

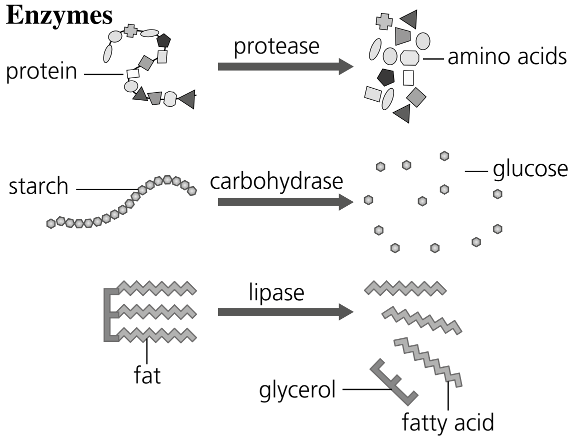
4 Bacteria that live on the fibre in our intestines make important vitamins that we can absorb *or* fibre prevents constipation.

E



5.2 Enzymes

1



2 Enzyme – biological catalyst used to speed up reactions.
Carbohydrase – enzyme such as amylase which breaks down carbohydrates.
Emulsify – break fats into smaller droplets which can mix with water.
Bile – substance that emulsifies fats to increase their surface area.

3 When food is broken into smaller pieces, its surface area increases. That makes it easier for enzymes because they can only work on molecules on the surface.

E Take a number of test tubes; put equal volumes of starch in each one; warm each tube to a different temperature; add an equal volume of amylase to each tube and start a stopclock; remove samples from each tube at regular intervals and test them for starch; they will turn blue-black when starch is present; record the time when all the starch is gone; the evidence supports his idea if starch takes longer to break down at higher temperatures; he should repeat his measurements to check that they are reliable.

5.3 Using enzymes

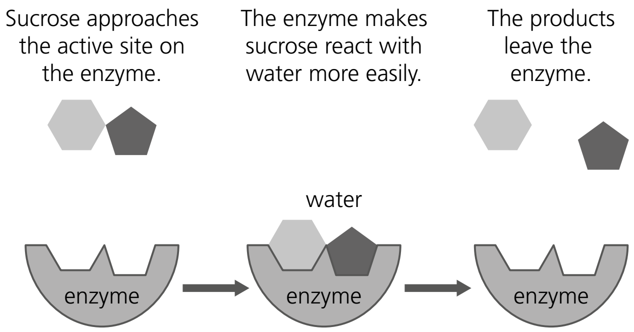
1 Lipase – removes fats from meat or fish and improves the flavour and texture of fatty foods.
Carbohydrase – breaks down corn starch to make it sweeter.
Protease – turns milk into a solid curd during cheese-making.

2 **a** T **b** F **c** F

b The active site of an enzyme is **a different** shape in **different** enzymes.

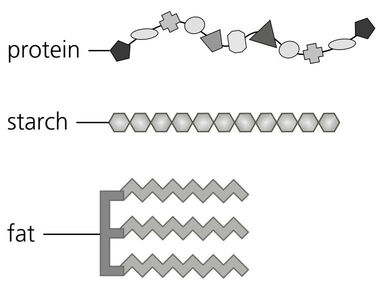
c Enzymes **do not** need to be replaced when they finish catalysing a reaction **because they are left unchanged at the end of the reaction**.

3a Labels similar to those shown below should be added to the diagram.



b Enzymes are only needed in small amounts because they are left unchanged at the end of the reaction. This means that one enzyme can speed up many reactions.

4 More than one enzyme is needed in your digestive system because starch, fats, and proteins are made from different molecules with different shapes.



The active site of each enzyme needs to have the right shape to fit the molecule it breaks down. (Credit any attempt to draw an enzyme with an active site that would fit two glucose molecules from starch, two amino acids from a protein, and glycerol and a fatty acid from fat.)

6 States of matter

6.1 The states of matter revisited

1 Leena and Fiona

2 water, flour, close together, air, far apart

3a freezing

b See image of a gas on p64 of the Student book.

c The particles gain energy and move around more.

d The nitrogen melts and changes to the liquid state – it would be able to flow and would take the shape of its container.

6.2 Explaining diffusion

1 A, C, B

2 move away from, randomly, mix with, evenly, continue to move

E

a Ammonia particles will diffuse more quickly than hydrogen chloride particles because ammonia particles have a smaller mass.

b **i** Yes

ii More confident, since the evidence supports the explanation.

6.3 Explaining density

1a platinum

b mass = density × volume
mass = 7.86 × 4 = 31.44 g

2 C – the particles are less closely packed in liquid mercury than in solid mercury.

3 Balsa wood: 16/8 = 2 g/cm^3
Oak wood: 42/6 = 7 g/cm^3
Copper: 17.8/2 = 8.9 g/cm^3
Aluminium: 2.7/1 = 2.7 g/cm^3
Natural rubber: 1.5/5 = 0.3 g/cm^3

4a 3 cm × 1 cm × 2 cm = 6 cm^3

b 1 cm × 1 cm × 5 cm = 5 cm^3

E

The water particles are less closely packed in ice than in liquid water thus ice is less dense and can float on liquid water.

6.4 Explaining gas pressure

1a F – In a football, air particles are moving in all directions.

b T

c F – Air particles inside the football collide with the plastic and also with each other.

d F – At higher temperatures air particles move more quickly.

e F – The force exerted by air particles colliding with plastic pushes the plastic outwards.

f T

g T

2 In order: D, B, A, C, E

E

Air pressure at the top of a mountain is lower than at sea level because there are fewer particles in the air at the top of a mountain. This means there are fewer collisions between air particles and a surface.

6.5 Ideas and evidence

1a S
b
c S
d S
e S
f
g S
h
2a top to bottom: iii, iv, i, ii
b iii and iv
c i
d i
e i and ii
f iv and i
3 Anything that could be investigated scientifically.

6.6 Doing an investigation

1a

Variable	**change, measure or control?**
temperature of liquid	change
diameter of tube	
height of liquid in tube	measure
mass of liquid	control

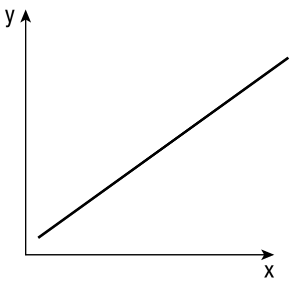
i Esa
ii Esa and Helen

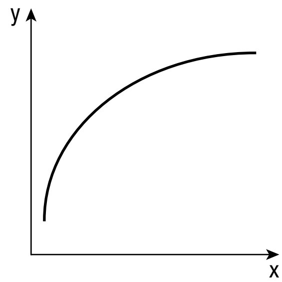
b

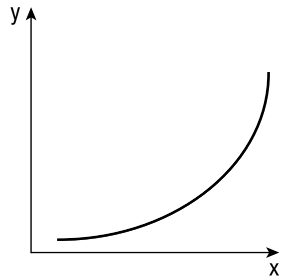
Temperature of liquid (°C)	Height of liquid in tube (cm)

c X axis (horizontal): Temperature of liquid (°C)
Y axis (vertical): Height of liquid in tube (cm)

E







7 Material properties

7.1 Atoms

1a T
b F – An element cannot be broken into anything simpler.
c F – Some things are made of one type of element.
d T
e T
f F – There are 92 atoms that occur naturally on Earth.
g F – Scientists have made at least 25 elements.
h F – Atoms of platinum and silver are different.
2a B, C, D, F
b A and B, A and F, C and D
c B and F
d A and E
e C and D, A and B, A and F.
3 10,000,000,000,000

7.2 Elements and their symbols

1

Name of element	**Symbol**
hydrogen	H
helium	He
lithium	Li
beryllium	Be
boron	B
carbon	C
nitrogen	N
oxygen	O
fluorine	F
neon	Ne

2

Symbol	Name of element
Na	sodium
Mg	magnesium
Al	aluminium
Si	silicon
P	phosphorus
S	sulfur
Cl	chlorine
Ar	argon
K	potassium
Ca	calcium

3 sodium, strontium, scandium, silicon, selenium, sulfur, scandium, seaborgium, samarium, silver
4 calcium, carbon, chlorine, caesium, cobalt, chromium, copper, cadmium, cerium, californium
5 Revision is necessary

E

a P
b Cl
c Be

7.3 Discovering the elements

1a **i** copper, silver, gold, iron, tin, lead
ii These elements naturally exist on their own.
b **i** hydrogen, nitrogen, oxygen, chlorine
ii These elements are found in the air.
2a No other element had the same properties as the new element.
b Information was not easily communicated internationally in the 1800s.
c The strength of the cast iron samples were inconsistent.

7.4 Organising the elements

1a empirical
b experiments
c predictions
d Mendeleev
e mistakes
f confident
g Dalton
h thinking
i different
j observations
k evidence

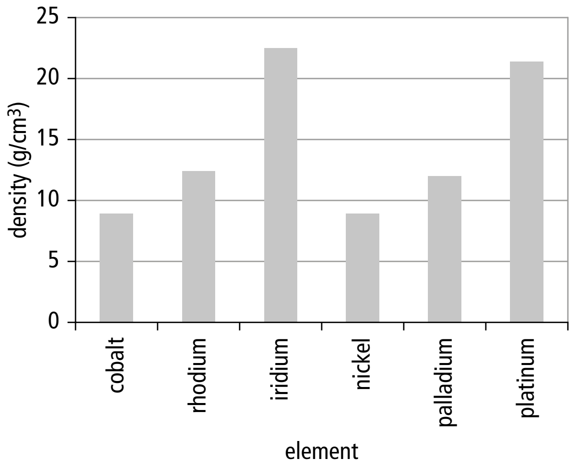
E

a to determine whether or not he was correct
b other scientists may have become more confident in Mendeleev's predictions are more accepting of them.

7.5 Interpreting data from secondary sources

1a It is easier to make a general comparison using a bar chart.
b It is difficult to read the exact values from a bar chart.
c The data is discrete.
d As you move down group 2, the radius of the atom increases.
2a As you move down the group, the density increases.
b In both tables, as you move down the group the density increases. The density increases in table A faster than in table B (8.9 to 22.5 for table A, 8.9 to 21.4 in table B).

3



7.6 Explaining differences between metals and non-metals

1 Area right of the stepped line (B, Si etc). See the periodic table on p104 of the Student book.

2

Property	Typical metal	Typical non-metal
Conduction of heat	Good	Poor
Conduction of electricity	Good	Poor
Appearance	Shiny	Dull
Melting point and boiling point	High	Low

3a The atoms are close together so there are strong forces holding the atoms together. The metal has a high boiling point because much energy is required to overcome the forces holding the atoms together.
b The metal is bendy because the layers can slide over each other.
4a There are weak forces holding the iodine molecules together. Iodine has a low melting point because less energy is required to overcome the forces holding the iodine molecules together.
b There are weak forces holding the iodine molecules together, making them easy to break.

E

A, C, D. Metals are good conductors of heat so have high thermal conductivity values.

7.7 What are compounds?

1 two, elements, are not, new

2

Substance	Element or compound?	State at 20 °C	One property or use of the substance
sodium	element	**solid**	**Shiny metal**
chlorine	**element**	gas	**Green, smelly gas**
sodium chloride	**compound**	**solid**	Used as food flavouring and preservative

3a carbon, oxygen
b carbon, oxygen
c sodium, iodine
d iron, sulfur
e hydrogen, oxygen
E A, C, F
b **i** B or D
ii G
iii A
iv F
v C
vi B or D
vii E or G

7.8 Making a compound

1a If the mass increases.
b **i** 30.74 – 30.50 = 0.24 g
ii 30.90 – 30.50 = 0.40 g
iii Yes, there is an increase in mass.
iv When I heated the magnesium, oxygen atoms from the air joined the magnesium atoms forming magnesium oxide. The mass of the product was greater (0.40 g) than the mass of the magnesium at the start (0.24 g) demonstrating that oxygen must have joined the magnesium.
E Anton may have made a mistake when measuring the mass the crucible and its contents.

7.9 Naming compounds and writing formulae

1a magnesium oxide
b iron sulfide
c aluminium chloride
d iron bromide
2a calcium, carbon, oxygen
b iron, sulfur, oxygen
c sodium, nitrogen, oxygen
3 top to bottom: carbon dioxide, 1 atom of carbon and 1 atom of oxygen, nitrogen dioxide, 1 atom of sulfur and 3 atoms of oxygen
4 iodine – I_2
dinitrogen tetroxide – N_2O_4
carbon monoxide – CO
carbon dioxide – CO_2
sulfur trioxide – SO_3
E top to bottom:
KI
Li_2O
$NaNO_3$
$CaSO_4$
$MgCO_3$

7.10 Oxides, hydroxides, sulfates, and carbonates

1 compounds, oxygen, calcium, oxygen, acidic, carbon dioxide, less than, acids, bases, alkaline
2a sodium, hydrogen, oxygen
b potassium, hydrogen, oxygen
c zinc, sulfur, oxygen
d lithium, carbon, oxygen
3a magnesium oxide
b sodium hydroxide
c calcium carbonate
d copper sulfate
e nitrogen dioxide
f copper carbonate
E top to bottom: K_2O, RbOH, $NiSO_4$, K_2CO_3

7.11 Chlorides

1 BA chloride is a compound of chlorine and one other element.
2a 125.8 g – 120.0 g = 5.8 g
b A, E, C, B, D, F
E Mapiro may have started off with less salt. Moyo may have ground the rock salt better. Moyo may have used more water, allowing more salt to dissolve. Any reasonable answer is acceptable.

7.12 Mixtures

1

	Mixtures of elements	Compounds
Can it easily be separated into its elements?	Yes	No
How do its properties compare to those of its elements?	Same	Different
Are its elements joined together?	No	Yes
Can you change the amounts of each elements in 100 g of the mixture or element?	Yes	No

2a M
b C
c M
d C
e M
f C
g M
3a B
b C

c A
d D
e E
4 A mixture of elements and compounds.

7.13 Separating mixtures – filtering and decanting

1a D
b N
c F
d N
e F
f D
2a salt water
b impurities
c i C
ii D
iii 80 g

7.14 Separating mixtures – evaporation and distillation

1 evaporation, salt, copper sulfate, solvent, solute, distillation, solute, pure water
2 Clockwise from top left: G, I, C, H & J, D, E, A, K & B, F
E Anything plausible. Ideas need to include distillation of some fashion.

7.15 Separating mixtures – fractional distillation

1a Clockwise from top right: E, F, B, A, C, D
b i ethanol
ii 78 °C
2 The place where a mixture of vapours enters the column – C
The hottest part of the column – B
The coolest part of the column – A
E C, F, E, D, B, A

7.16 Separating mixtures – chromatography

1 B, D, F, A, C, E
2 Pen B
3 to determine the nutrients in a food
test alcohol content in blood
test for explosives.
E Chromatogram, three, blue, most, least

7.17 Separating metals from their ores

1 Gold is more dense than sand. If carefully washed with water, the sand will wash away, leaving the gold behind.
2a From top to bottom:
froth flotation
copper iron sulfide floats
waste materials
heat with oxygen
b copper sulfide + oxygen → copper + sulfur dioxide
E 1000 × (0.6/100) = 6 g

7.18 What are you made of?

1 oxygen, hydrogen, nitrogen, carbon
2a water
b hydrogen and oxygen
3a keratin
b carbon, hydrogen, oxygen, nitrogen
4a 2.3 g
b meat, beans, lentils, and dark green vegetables
c Iron is a main component of haemoglobin which is used to transport oxygen round the body.
d Tiredness, dizziness, weakness.
E Minerals to include:
Iron: tiredness, lack of energy, weakness.
Calcium: weak bones and frequent fractures.
Zinc: reduced growth in children, problems with senses and memory.
Iodine: swelling of thyroid gland, tiredness, brain damage.

8 Material changes

8.1 Chemical reactions

1A	C	**C**	C	**E**	C	**G**	R	**I**	C
B	C	**D**	B	**F**	R	**H**	R	**J**	C

2

Change	Tick if change is a chemical reaction	Tick if change is reversible	Evidence
Boiling water		✔	The steam can be condensed into water.
Cooking potatoes	✔		The heat causes irreversible chemical changes within the potato – the potato can never be raw again.
Dissolving sugar in tea		✔	The sugar can separated from the tea using evaporation

A mango ripening	✔		There are irreversible chemical reactions within the mango which make it taste sweet. It is impossible to reverse these changes to make the mango unripe again.
Lighting a match	✔		Once struck, the match catches fire, produces heat, light and different products which are characteristics of chemical reactions.

3a reactants: magnesium and oxygen, products: magnesium oxide

b reactants: carbon and oxygen, products: carbon dioxide

E The product of magnesium and oxygen is solid magnesium oxide which remains. The product of carbon and oxygen is the gas carbon dioxide which escape the container into the surrounding air.

8.2 Writing word equations

1

word or symbol	meaning
reactant	Reacts to make.
product	The chemicals you make in a chemical reaction.
→	The chemical you start with in a chemical reaction.

2a reactants: magnesium and oxygen, products: magnesium oxide

b reactants: iron and oxygen, products: iron oxide

c reactants: carbon and oxygen, products: carbon dioxide

d reactants: sodium hydroxide and hydrochloric acid, products: sodium chloride and water

e reactants: hydrochloric acid and copper oxide, products: copper chloride and water

3a zinc oxide

b oxygen

c oxygen

d sulfur

4a lithium + oxygen → lithium oxide

b calcium + oxygen → calcium oxide

c zinc + oxygen → zinc oxide

5a water

b copper sulfide

6a calcium carbonate + calcium oxide → carbon dioxide

b aluminium + iodine → aluminium iodide

c magnesium + sulfuric acid → magnesium sulfate + hydrogen

d copper oxide + magnesium → magnesium oxide + copper

8.3 Corrosion reactions

1 on the surface, destroy, slowly, oxygen, rust, exposes, can

2 iron + oxygen + water → hydrated iron oxide

3a copper carbonate

b silver sulfide

4

Method of preventing corrosion	Stops air and water being in contact with the iron	Reacts with oxygen and / or water instead of the iron
Covering with grease	✔	
Attaching a piece of zinc to the iron		✔
Painting	✔	
Covering the iron in a thin layer of tin	✔	

E a The iron reacted with water and oxygen in the water, forming hydrated iron oxide (rust).

b In theory, by removing water from the air the iron cannot react with water and oxygen to form rust.

8.4 Doing an investigation

1a

Variable	change	measure or observe	control
Volume of solution			✔
Mass of salt dissolved in water	✔		
Temperature of solution			✔
The metal the nail is made out of			✔
Amount of rust made after 1 week		✔	
Size of nail			✔

b mass of salt dissolved in water (g)

c The variable he changes is continuous and the variable he observes is continuous.

E The ‘amount of rust made after 1 week’ is an inacurate measurement dependent on the observer.

8.5 Using reactions to identify chemicals

1a lithium: crimson
sodium: yellow
potassium: lilac
calcium: red
barium: green

2 iron(II) chloride: green
iron(III) chloride: brown
copper sulfate: blue

3a copper hydroxide

b iron(II) hydroxide

c iron(III) hydroxide

4 (precipitate is underlined)

a copper sulfate + sodium hydroxide → <u>copper hydroxide</u> + sodium sulfate

b iron(II) chloride + sodium hydroxide → <u>iron(II) hydroxide</u> + sodium chloride

c copper chloride + sodium hydroxide → <u>copper hydroxide</u> + sodium chloride

d iron(III) nitrate + potassium hydroxide → <u>iron(III) hydroxide</u> + potassium nitrate

5 lithium

6 copper

9 Energy changes

9.1 Energy changes in chemical reactions

1 Exothermic changes release heat to the surroundings.
Exothermic changes include combustion reactions.
Endothermic changes include evaporation.
Endothermic reactions take in heat from the surroundings.
Endothermic changes include melting.

2 melt, cold, takes in, start, endothermic

3a B: +48
D: −13
E: +61

b A, B, E

c E

d C, D

e C, D

f A, B, E

E Energy is taken in from the surroundings, giving the particles enough energy to overcome the forces holding the particles together as a liquid.

9.2 Investigating fuels

1a top to bottom: control, change, control, measure

b To find out if his experiment will work.

c **i** to reduce error, to make the results more reliable

ii butanol (81)

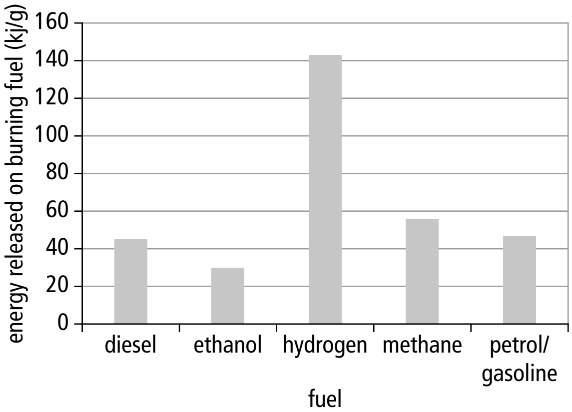
iii 40

iv Butanol releases the most energy when it burns, methanol releases the least.

E Some of the heat released would have heated up the surrounding area.

9.3 Choosing fuels

1a



b ethanol, diesel, petrol/gasoline, methane, hydrogen

c Diesel, ethanol and petrol are liquids at room temperature.

d hydrogen

e **i** Ethanol: made from crops (which are grown).

ii Hydrogen: made from methane (which can be produced easily from natural resources).

iii Methane: made from animal waste and rubbish (which is renewable).

E Sensible comparisons using facts from the table.

9.4 Calculating food energy

1a Top to bottom: wear gloves and be careful when moving around.
Ensure that anyone with allergies is not in the room.

b 100 cm^3, this volume provides a reasonable temperature change without boiling the water.

c **i** To reduce errors and make the results more reliable.

ii

Nut	Temperature change 1 (°C)	Temperature change 2 (°C)	Temperature change 3 (°C)	Average temperature change (°C)
1				
2				
3				

d **i** cashew nut, peanut, walnut

E There is a difference of 6 °C between the highest and lowest values. There could have been some anomalies. Cerena didn’t state the mass of the nuts she would use.

9.5 Investigating endothermic changes

1 takes in, from, freezes, cools down

2a i top to bottom: control, change, control, measure, control

ii Keeping these variables the same makes the results comparable/fair test.

b top to bottom: −13, −6, +23, +7

c Habibah is correct. Solutes A and B are the two endothermic reactions and solute A is the most endothermic.

10 Forces

10.1 Tension and upthrust

1a T

b F – An object floats when the upthrust is equal to the weight.

c F – The force holding a climber on a climbing rope is tension.

d T

2a B

b A – 14 m

c B

d A

e B

E The second boy is correct, as they go into deeper water the water level will stay the same as the forces acting on the boat will not change.

10.2 Presenting results – tables and graphs

1

Area (cm^2)	Time (s)
20	1.5
40	2.2
60	4.2
80	3.6
100	4.1

2a Students should plot the points from their table and draw a line of best fit through points 1, 2, 4 and 5. Point 3 is anomalous.

b Both variables are continuous so it is appropriate to draw a line graph.

c Axis labels are missing from the graph.

d Yes, it is point for 60 cm.

e The student should repeat his experiment to get another result.

E a No

b Even with no air resistance acting on the mass, it will take time to fall.

c Bar chart as the variable is categoric not continuous.

10.3 Round in circles

1 Missing words in order: direction, centre, centripetal, tension, gravity, Earth, centripetal.

2 Q

3a gravitational force

b The cannonball will go into orbit if it is fired with enough force that the force of gravity causes it to fall at the same rate as the Earth curves.

c If the force was too big the satellite would not go into orbit, but would accelerate into space.

4 The chains are designed to hold many times the weight of the person, because this is not the only force acting on them. There is also a centripetal force acting on the chains.

11 Energy

11.1 What is energy?

1 Missing words in order: energy, food, energy, fuel, food, joules, 1000, joules.

2a oil

b wood

c 20 000

d 3 g

e gas

3a Your body needs energy to keep process like breathing or digestion going, even when you are not moving.

b 4 minutes

c Children need energy to grow as well as the energy the use for the activities they do each day.

E a Variables to control: amount of food, amount of water.

b I predict that food with more energy will cause a greater increase in the temperature of the water.

c Some of the energy is lost as heat to the surroundings.

d His value will be smaller than the actual value of the energy stored, because his experiment is not perfect and some energy will not be transferred to the water, but lost to the surroundings.

11.2 Energy from the Sun

1

The process that converts light energy from the Sun into chemical energy is …	… to heat water.
Wind turbines turn …	… photosynthesis in plants.
Energy in our food …	… because biofuels and fossil fuels come from plants and animals.
When it rains, water in rivers flows into artificial lakes that …	… comes from energy stored in plants.

Energy in fuels comes from the Sun …	… can be used to generate electricity called hydroelectricity.
Solar panels use energy directly from the Sun …	… because energy from the Sun makes air move.

2 Flow chart 1: plants use the light energy to make chemical energy, dead plants are buried and turn into coal.
Flow chart 2: plants use the light energy to make chemical energy, animals eat the plants and the energy is transferred.

3a solar cells
b biofuels, gas
c solar panels, petrol
d petrol
E From the sun: solar panels, food.
From the sun and used to generate electricity: solar cells, fossil fuels, wind power, biofuels.
Used to generate electricity: geothermal, hydroelectricity.

11.3 Energy types

1a Correct word in order from top to bottom: lifted up, moving, vibrating, light, thermal, springs, chemical, electrical.
b gravitational potential energy, elastic potential energy, chemical potential energy
c kinetic energy, sound energy, light energy, thermal energy, electrical energy
2a kinetic energy
b kinetic energy, gravitational potential energy
c sound energy
d light energy
e kinetic energy
f chemical energy
E a **1** The reaction that produces energy in the Sun is a nuclear reaction.
2 Nuclear fusion happens when hydrogen atoms combine to form helium.
3 Nuclear fission happens when elements, like uranium, break down.
4 The fuel in a nuclear power station is usually uranium.
b The Sun cannot be a huge ball of fire as fire needs oxygen to burn and there is no oxygen in space.

11.4 Energy transfer

1a T
b F
c F
d T
2 Correct answers in order: light energy, chemical and kinetic energy, kinetic energy.
3 Correct answers in order: plant, radio (battery powered) , kettle
E a Eating breakfast and walking to school: chemical energy (food) → chemical energy (in the body) → kinetic energy and thermal energy
Walking up and down a hill: chemical energy → kinetic energy and thermal energy → GPE → kinetic energy and thermal energy
A candle burning: chemical energy → thermal and light energy
A loudspeaker in a television: electrical energy → kinetic energy → sound and thermal energy
b Eating breakfast, loudspeaker in a television
c Walking, candle burning.
d Photosynthesis – when a plant changed light to chemical energy.

11.5 Conservation of energy

1 Correct words in order: created, destroyed, transferred, conservation, money, the same, types.
2 Correct answers in order: useful, wasted, wasted, useful.
3a Correct answers in order: 20%, 50%.
b The kettle wastes energy heating the air. The radio wastes thermal energy.
c kettle
E a Correct answers in order: 30, 500, 1000, 10
b The law of conservation of energy states that energy can never be lost or gained, so the total energy is always equal to the useful energy and the wasted energy.
c A – less energy is wasted.
d B – less energy is wasted.

11.6 Gravitational potential energy and kinetic energy

1

	GPE	Kinetic energy
Energy that something has because of its position.	✔	
Energy that something has because of its movement.		✔
This gets bigger if an object is higher off the ground.	✔	
Is measured in joules.	✔	✔
A fast-moving elephant has lots of this.		✔
A walking mouse has less of this than the elephant.	✔	✔

2a A
b F
c B
d No – the marble would need more energy to reach a higher point than it has at the start. Energy cannot be created, so it would not reach a higher point.
e Energy has been lost as sound and thermal energy.

3a Gravitational potential energy is transferred into kinetic energy as the ball falls and speeds up. When the ball lands the kinetic energy is transferred back to GPE and some is also lost as sound and thermal energy.
b A
c C
d D

11.7 Elastic potential energy

1a F – When material deform they store **elastic potential energy**.
b T
c F – The springs in a mattress will store **more** potential energy if someone heavier sits on it.
d F – If something **does** return to its original shape when we remove the force, we say it is elastic.
e T
f T
2a As the student stretches the elastic band it gains elastic potential energy as it shape changes. When she lets the band go, the elastic potential energy changes into kinetic energy.
b D, C, A, B
c If the band is pulled back further it will gain more EPE, so the band will move further when it is released as there is more EPE that can be transferred into kinetic energy.
E a A ball will never bounce higher than the height you drop it from as it cannot gain energy.
b The student expected the result as the height of the drop was being doubled, and so he expected the height of the bounce to also double. When you double the height of the drop, the height of the bounce is less than double.

11.8 Suggesting ideas

1 C, D, A, E, B
2a The volume of biofuel and water used in all the tests is the same.
b methanol, ethanol, dry wood, green wood
3a How does the material that a ball is made from affect the height it will bounce?
b Different materials deform by different amounts and will store different amounts of EPE.
c Any suitable answer, but must include: material of the ball, height of bounce.
E a How does the volume of liquid used affect the temperature change in water? How does the type of surface a ball is dropped onto affect the height of the bounce?
b Investigation A: type of liquid fuel, volume of water, time heated.
Investigation B: the ball, height the ball is dropped from.

11.9 Suggesting ideas continued

1

Methods	Definitions
Field study	Make observations over a period of time, or in lots of places at the same time.
Regular observations	Make observations of organisms in their natural habitat.
Make a model	Collect data or make observations in a laboratory.
Practical investigation	Use a computer model or physical model.

2a regular observations
b field study
c make a model
3a regular observations
b make a model
c The data shows that the level of carbon dioxide in the atmosphere is increasing.
d The data does not suggest a link between burning fossil fuels and carbon dioxide levels, so we cannot draw this conclusion from this data alone.
E a They have used several types.
b Carbon dioxide levels have increased in the last 60 000 years, but in the 40 000 years before that they were decreasing.
c How has the carbon dioxide level changed over the last 100 000 years?
d Should we stop using fossil fuels?

11.10 Energy calculations and Sankey diagrams

1 Correct answers in order: %, useful, J, total, J, %.
2 Correct answers in order: 25, 16.7%, 1500, 75%, 5000, 50%, 300, 25%.
3a Efficiency can only ever have a value between 0 and 100.
b He has not given efficiency units, and has divided the total energy by the useful energy.
c Efficiency = 2 J/10 J × 100% = 20%
4a 13 J
b 3.5 J
c 3.5 J/13 J × 100% = 27%
d 73%

12 Speed

12.1 Speed

1a F – to calculate speed you need to know distance and time
b T
c F – speed is not measured in newtons per second.
d F – a steady speed is a speed that is constant.

2a average speed

b The average speed is the total distance travelled divided by the total time, the speed may have varied during this time.

3a 101 seconds

b average speed = 800 m/101 s = 7.92 m/s

c average speed = 400 m/44 s = 9.09 m/s

d 88 seconds

E a 88.89 seconds

b 17.20 seconds

c 1965 – the average speed more than doubles between 1964 and 1965.

12.2 Taking accurate measurements

1a Student 1 – his results are measure to a greater number of decimal places.

b Student 1 – using timing gates will increase the accuracy of his results, as student 2's reaction times will affect his results.

c 1.452, 1.45, 1.4, 1

2a It will be difficult for her to get an accurate reading of the winners time as her reaction times, and the time it takes to hear the gun will affect the results.

b It will be difficult to get a precise reading due to her reaction times.

3a The time interval between the two photos.

b You could be using the wrong time interval to make the calculation, or the second photo might not capture an image of the car.

c The one where the speed limit is 50 km/h will need a smaller time interval in order to take two images of a car in the same distance as the cars will be moving faster.

12.3 Distance-time graphs

1a 20 m/4 s = 5 m/s, 18 m/6 s = 3 m/s, 16 m/8 s = 2 m/s

b graph A shows the fastest speed – the line is steepest meaning the same distance is travelled in less time.

2a 600 m

b 180 s

c average speed = 600 m/180 s = 3.33 m/s

E a 20 m

b The graph gets steeper indicating that the speed is increasing.

c The line should be below the other one, increasing more gradually.

d The larger stone would fall at the same speed but it experiences more air resistance and so speeds up less quickly.

12.4 Acceleration and speed-time graphs

1a F

b F

c F

d T

2a C

b A and D

c B

3a O and A – accelerating; A and B – moving at a steady speed; B and C – decelerating; C and D – stationary.

b acceleration = change in speed/time = 5/5 = 1 m/s^2

c acceleration = –10/3 = –3.33 m/s^2
deceleration = 10/3 = 3.33 m/s^2

d The graph is unrealistic because acceleration is rarely steady, also a vehicle would not normally accelerate to a speed and then travel at a constant speed. There would be variation in speed all of the time.

12.5 Presenting results in tables in graphs

1a

Student	Time (s)
Anyam	16
Ejiro	20
Mimi	17
Ikenna	17
Bayode	14
Iyo	22

b Students should draw a bar chart from their table.

c One of the variables, student, is discrete, so the data must be displayed as a bar chart.

2a

Height (m)	Time (s)
1.35	7.2
1.23	8.4
1.10	9.1
1.00	9.5
1.40	8.1
1.45	7.1

b Students should draw a line graph from their table.

c Both of the variables are continuous so a line graph can be drawn.

3a Line graph, both volume and time are continuous variables.

b Line graph, both extension and weight are continuous variables.

12.6 Asking scientific questions

1a Any suitable answers, see below:

Why this doesn't happen in real life
Friction will slow the ball down on a horizontal slope.
The ball loses energy as it travels, meaning that it won't travel so far.
Friction will slow the ball down over time and it will stop when all of its energy has been lost.

2a thought experiment

b The heavy ball will fall faster than the light ball and hit the ground first.

c The heavy ball will fall faster until the string is taut. It has a greater force than the light ball so the light ball will speed up when the string is taut.

d The two balls cannot fall at different speeds if they are stuck together.

e This thought experiment shows that heavier objects don't fall faster because

f It is more convincing to see the experiment being done with equipment, as this shows what is possible and what will happen. It is possible to imagine things that are impossible.

E a A massive object needs a large force to stop as it has more momentum, also more force is needed to start it moving, so a larger force is acting on the object.

b From smallest to largest force: C, A, B, D.

c Many people think you need a force to keep something moving.

13 Light

13.1 Refraction: air and water

1a Light travels in straight lines. She is standing where light travelling from the coin cannot reach her eye, so she cannot see it.

b Light is refracted, changes speed and direction, when it moves between mediums of different density. Light from the coin is bent as it leaves the water and enters the air. It can now reach her eye and she can see the coin.

c Students show draw a ray that is diffracted toward the eye at the surface of the water.

2a Students should draw a straight line from the eye to the road.

b less dense

c The ray bends away from the normal as it speeds up in the less dense air.

E a Correct answers in order: 300 000, 1.5, 220588.2, 1.58

b Refractive index has no units as it is ratio of how different the speeds are.

c To have a refractive index the speed of light in the material would have to be faster than the speed of light in a vacuum, and nothing is faster than this.

13.2 Refraction: air and glass

1 Missing words in order: refracted, incidence, incident, refraction, refracted, denser, slowly, quickly, parallel.

2a 0°

b Result for the angel of incidence 30°.

c A block with a lower refractive index will slow the light down less, so it will be refracted less.

E a You can see round corners if the light is refracted or reflected and changes direction to reach you.

b Diamond, plastic, glass, water, air.

13.3 Dispersion

1a F – the spectrum is made up of seven colours.

b T

c T

d F – light is refracted as it goes through a prism.

2a R at the top, V at the bottom of the spectrum.

b The points where the light enters and leaves the prism.

c An inverted triangle (the prism) should be added between the prism and the surface.

3 C, B, A, F, D, E

E White light is made up of different colours of light, these have different wavelengths and frequencies. When light is refracted the light with shorter wavelengths changes speed more than light with longer wavelengths and is refracted the most. This produces dispersion.

13.4 Colour

1 Missing words in order: primary, blue, green, secondary, magenta, cyan, yellow, primary, blue, green, red, filter, transmits, absorbs, transparent.

2a In order: blue, cyan, no, no, red.

b it will be less bright as some of the light has been absorbed.

E a Only green light would be transmitted through the filter, so he will only see green light.

b Only red light would be transmitted by the filter, so he will only see red light, but it will be in a different place to the green light.

c He would see no light as only blue light would be transmitted through the blue filter and the red light will absorb this light.

13.5 Presenting conclusions: more on colour

1 Correct words in order: reflect, absorb, reflect, absorb, absorb, reflect.

2 Answers in order: green, blue, red, blue, no light/ appear black, blue.

3 Correct answers in order: black, blue, green or blue, green

E a A and B are the rod and cone cells.

b rod cells

c cone cells

d rod cells

e cone cells

f The cone cells are found only in the centre which is why you cannot see in colour out of the edge of the eye, as there are only rod cells around the edges.

13.6 Asking scientific questions

1a The intromission theory states that light enters the eye after being reflected from other objects, whilst the emission theory states that our eyes produce light to see things.

b **i** Supports the emission theory as light appears to be coming from their eyes.

ii Supports the intromission theory as the eyes are poor or good at detecting light regardless of whether someone with better eyesight looks at it.

iii Supports both, for the emission theory you can only see what your eyes project light onto, and for the intromission theory you can only see objects that reflect light into your eyes.

2 Newton thought that light was made of particles, but Huygens thought it was made of waves and so would have some different properties

E a Any suitable answers: for example taking photographs in a dark room of objects a person is looking at. If the emission theory is correct the objects will be visible under the light emitted from the person eyes, if it is not they objects will not be.

b Any suitable answers: for example, you can see some things in the dark, so some people think light must be projected from our eyes onto them.

13.7 Lasers

1a Lasers are used to make a pattern of pits that record data, like music, onto a CD.

b Lasers read the pattern of pits and change this to digital signal that is transmitted to speakers.

c In order: 0, 1, 3, 6, 7, 6, 4, 2, 1, 2.

d It would reduce the number of tracks as you would need more room for each one.

e **i** blue laser

ii Blue light has a shorter wavelength than red light so it would be able to read pits that were closer together. This means more pits, and therefore tracks, would fit on a CD.

Notes