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SECOND EDITION

# INTERNATIONAL SECONDARY SCIENCE

GRADE

8

## TEACHER HANDBOOK

Pakistan Edition

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Saleem

Biology and Physics SNC unit plans by Saima Haque; SNC Physics answers by
Catherine Jones

Welcome to your **International Secondary Science** Teacher Handbook. This Teacher Handbook has been written to provide classroom support and teaching materials for PNC and Cambridge checkpoints.

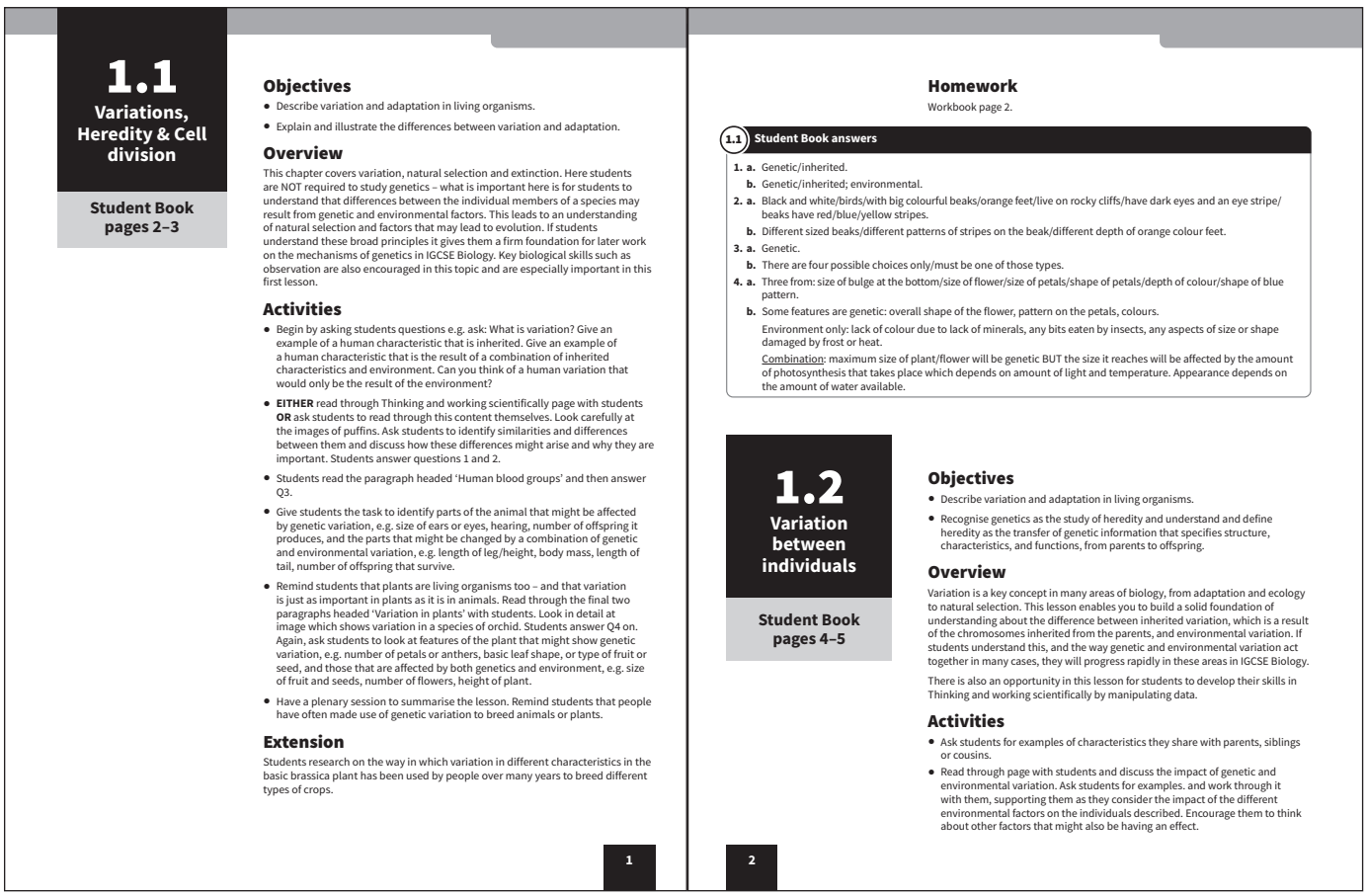
Your Teacher Handbook includes a book of lesson plans as well as answers to all of the Student Book questions for your reference at any time.

The answers to the workbook questions are provided at the end of the handbook for your ease of reference.

## Using your book

This book contains suggested lesson plans and answers to all of the questions in the Student Book. There is also information about students' prior knowledge.

There is one lesson plan for every unit in the Student Book, including Thinking and Working Scientifically, Science in Context, as well as Extension for the topic. Each lesson plan suggests activities for use in the classroom linked to the topics covered on the Student Book spread.



**1.1**
**Variations, Heredity & Cell division**

**Student Book pages 2–3**

### Objectives
- Describe variation and adaptation in living organisms.
- Explain and illustrate the differences between variation and adaptation.

### Overview
This chapter covers variation, natural selection and extinction. Here students are NOT required to study genetics – what is important here is for students to understand that differences between the individual members of a species may result from genetic and environmental factors. This leads to an understanding of natural selection and factors that may lead to evolution. If students understand these broad principles it gives them a firm foundation for later work on the mechanisms of genetics in IGCSE Biology. Key biological skills such as observation are also encouraged in this topic and are especially important in this first lesson.

### Activities
- Begin by asking students questions e.g. ask: What is variation? Give an example of a human characteristic that is inherited. Give an example of a human characteristic that is the result of a combination of inherited characteristics and environment. Can you think of a human variation that would only be the result of the environment?
- **EITHER** read through Thinking and working scientifically page with students **OR** ask students to read through this content themselves. Look carefully at the images of puffins. Ask students to identify similarities and differences between them and discuss how these differences might arise and why they are important. Students answer questions 1 and 2.
- Students read the paragraph headed 'Human blood groups' and then answer Q3.
- Give students the task to identify parts of the animal that might be affected by genetic variation, e.g. size of ears or eyes, hearing, number of offspring it produces, and the parts that might be changed by a combination of genetic and environmental variation, e.g. length of leg/height, body mass, length of tail, number of offspring that survive.
- Remind students that plants are living organisms too – and that variation is just as important in plants as it is in animals. Read through the final two paragraphs headed 'Variation in plants' with students. Look in detail at image which shows variation in a species of orchid. Students answer Q4 on. Again, ask students to look at features of the plant that might show genetic variation, e.g. number of petals or anthers, basic leaf shape, or type of fruit or seed, and those that are affected by both genetics and environment, e.g. size of fruit and seeds, number of flowers, height of plant.
- Have a plenary session to summarise the lesson. Remind students that people have often made use of genetic variation to breed animals or plants.

### Extension
Students research on the way in which variation in different characteristics in the basic brassica plant has been used by people over many years to breed different types of crops.

1

### Homework
Workbook page 2.

**1.1 Student Book answers**

**1. a.** Genetic/inherited.
**b.** Genetic/inherited; environmental.
**2. a.** Black and white/birds/with big colourful beaks/orange feet/live on rocky cliffs/have dark eyes and an eye stripe/beaks have red/blue/yellow stripes.
**b.** Different sized beaks/different patterns of stripes on the beak/different depth of orange colour feet.
**3. a.** Genetic.
**b.** There are four possible choices only/must be one of those types.
**4. a.** Three from: size of bulge at the bottom/size of flower/size of petals/shape of petals/depth of colour/shape of blue pattern.
**b.** Some features are genetic: overall shape of the flower, pattern on the petals, colours.
Environment only: lack of colour due to lack of minerals, any bits eaten by insects, any aspects of size or shape damaged by frost or heat.
Combination: maximum size of plant/flower will be genetic BUT the size it reaches will be affected by the amount of photosynthesis that takes place which depends on amount of light and temperature. Appearance depends on the amount of water available.

**1.2**
**Variation between individuals**

**Student Book pages 4–5**

### Objectives
- Describe variation and adaptation in living organisms.
- Recognise genetics as the study of heredity and understand and define heredity as the transfer of genetic information that specifies structure, characteristics, and functions, from parents to offspring.

### Overview
Variation is a key concept in many areas of biology, from adaptation and ecology to natural selection. This lesson enables you to build a solid foundation of understanding about the difference between inherited variation, which is a result of the chromosomes inherited from the parents, and environmental variation. If students understand this, and the way genetic and environmental variation act together in many cases, they will progress rapidly in these areas in IGCSE Biology.

There is also an opportunity in this lesson for students to develop their skills in Thinking and working scientifically by manipulating data.

### Activities
- Ask students for examples of characteristics they share with parents, siblings or cousins.
- Read through page with students and discuss the impact of genetic and environmental variation. Ask students for examples. and work through it with them, supporting them as they consider the impact of the different environmental factors on the individuals described. Encourage them to think about other factors that might also be having an effect.

2

Each lesson plan begins with a reference to the pages of the Student Book that it covers and a summary of their objectives.

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 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, games, class discussions or Internet research.

*Lesson plans* that are matched to Thinking and Working Scientifically and Science in Context units 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®. Some of these could be carried out in class, whilst others could be set as homework.

Every content unit 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*.

Finishing each unit are the answers for all of the questions in the Student Book for quick reference in the classroom.

# Contents

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# 1.1

## Variations, Heredity & Cell division

**Student Book pages 2–3**

## Objectives

- Describe variation and adaptation in living organisms.
- Explain and illustrate the differences between variation and adaptation.

## Overview

This chapter covers variation, natural selection and extinction. Here students are NOT required to study genetics – what is important here is for students to understand that differences between the individual members of a species may result from genetic and environmental factors. This leads to an understanding of natural selection and factors that may lead to evolution. If students understand these broad principles it gives them a firm foundation for later work on the mechanisms of genetics in IGCSE Biology. Key biological skills such as observation are also encouraged in this topic and are especially important in this first lesson.

## Activities

- Begin by asking students questions e.g. ask: What is variation? Give an example of a human characteristic that is inherited. Give an example of a human characteristic that is the result of a combination of inherited characteristics and environment. Can you think of a human variation that would only be the result of the environment?
- **EITHER** read through Thinking and working scientifically page with students **OR** ask students to read through this content themselves. Look carefully at the images of puffins. Ask students to identify similarities and differences between them and discuss how these differences might arise and why they are important. Students answer questions 1 and 2.
- Students read the paragraph headed ‘Human blood groups’ and then answer Q3.
- Give students the task to identify parts of the animal that might be affected by genetic variation, e.g. size of ears or eyes, hearing, number of offspring it produces, and the parts that might be changed by a combination of genetic and environmental variation, e.g. length of leg/height, body mass, length of tail, number of offspring that survive.
- Remind students that plants are living organisms too – and that variation is just as important in plants as it is in animals. Read through the final two paragraphs headed ‘Variation in plants’ with students. Look in detail at image which shows variation in a species of orchid. Students answer Q4 on. Again, ask students to look at features of the plant that might show genetic variation, e.g. number of petals or anthers, basic leaf shape, or type of fruit or seed, and those that are affected by both genetics and environment, e.g. size of fruit and seeds, number of flowers, height of plant.
- Have a plenary session to summarise the lesson. Remind students that people have often made use of genetic variation to breed animals or plants.

## Extension

Students research on the way in which variation in different characteristics in the basic brassica plant has been used by people over many years to breed different types of crops.

## Homework

Workbook page 2.

### 1.1 Student Book answers

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2. **a.** Black and white/birds/with big colourful beaks/orange feet/live on rocky cliffs/have dark eyes and an eye stripe/beaks have red/blue/yellow stripes.
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3. **a.** Genetic.
   **b.** There are four possible choices only/must be one of those types.
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   Combination: maximum size of plant/flower will be genetic BUT the size it reaches will be affected by the amount of photosynthesis that takes place which depends on amount of light and temperature. Appearance depends on the amount of water available.

# 1.2 Variation between individuals

**Student Book pages 4–5**

## Objectives

- Describe variation and adaptation in living organisms.
- Recognise genetics as the study of heredity and understand and define heredity as the transfer of genetic information that specifies structure, characteristics, and functions, from parents to offspring.

## Overview

Variation is a key concept in many areas of biology, from adaptation and ecology to natural selection. This lesson enables you to build a solid foundation of understanding about the difference between inherited variation, which is a result of the chromosomes inherited from the parents, and environmental variation. If students understand this, and the way genetic and environmental variation act together in many cases, they will progress rapidly in these areas in IGCSE Biology.

There is also an opportunity in this lesson for students to develop their skills in Thinking and working scientifically by manipulating data.

## Activities

- Ask students for examples of characteristics they share with parents, siblings or cousins.
- Read through page with students and discuss the impact of genetic and environmental variation. Ask students for examples. and work through it with them, supporting them as they consider the impact of the different environmental factors on the individuals described. Encourage them to think about other factors that might also be having an effect.


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- Summarise the fact that everyone inherits genetic information from their parents, but the environment each child grows up in is different, even in the same home (having siblings, changing family circumstances, etc).
- Ask students to read the paragraph 'Identical twins' on page 201 and then answer questions 1 and 2. If you have identical twins in your class, you may find that they are happy to discuss their similarities and environmental differences, but this must be handled carefully as some students would not be comfortable with this.
- Introduce students to the interaction of genes and environment in determining height. Read through the Thinking and working scientifically box.

## Key words

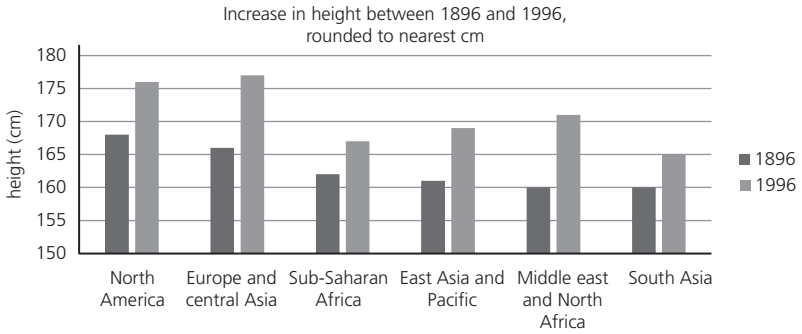
inherited variation, environmental variation, identical twins

## 1.2 Student Book answers

**1.** Each child has a random selection of genes from each parent, so they will have some in common and some that are different.

**2.** They are genetically identical and so all of the features controlled by their genes will be the same. The environment will not have had time to make many changes. The older twins get, the more different environmental factors will have an impact on some of their characteristics, e.g. height and body mass are affected by eating habits and exercise, etc. Features entirely controlled by genes remain the same.

**3.a.**




**b. i.** Percentage increase = (1996 reading −1896 reading)/1896 reading × 100 SA = 3.1%, MENA = 6.9%, EAP = 5.0%, SSA = 3.1%, ECA = 6.6%, NA = 4.8%. Biggest increase is the Middle East and North Africa; smallest is both South Asia and East Asia and Pacific.

**ii.** Possible reasons: The countries with the biggest increases may have seen the biggest improvements in living standards/food availability, countries with small increases relatively little improvement; countries with relatively little improvement may have had a higher standard of living in 1896 and so been nearer to their genetic height potential, so less scope for getting taller; any other sensible suggestions.

**c. i.** 1996 reading − 1896 reading for tallest area: (168 − 160) cm so difference in height = 8 cm
1996 reading − 1896 reading for shortest area: (177 − 165) cm so difference in height = 12 cm

**ii.** In 1896 neither population reached full genetic height potential as both had relatively poor levels of nutrition. NA taller as genetically taller population. By 1996 NA population reaching full genetic height potential as plenty of food available. Bigger difference between tallest and shortest – full genetic height difference showing. It might be that shortest population are genetically much shorter OR, although food levels have improved everywhere, lack of food may still mean full genetic potential not reached in shortest population.

# 1.3 Sources of variation

## Student Book pages 6–7

**Prior learning**

- Sexually reproducing organisms get half of their chromosomes from each parent.
- genetics is the study of heredity and heredity is the transfer of genetic information that specifies structure, characteristics, and functions, from parents to offspring.

## Homework

Workbook page 3 OR questions 1 and 3 from the student book spread.

## Key words

Heredity, genetics, genes, chromosomes, deoxyribonucleic acids, inherited traits, instincts, learned behaviours, variation, adaptation, cell division, mitosis, meiosis.

## Objective

- Identify sources of variation from environmental and genetic factors.

## Overview

Continuing from the previous unit, this lesson will delve further into variation resulting from genetic and environmental sources. An in-depth understanding of this topic will be later useful in developing students' skills to think and work scientifically, and to apply science to real life context of health, disease and lifestyle.

By the end of this lesson, students should be able to explain the link between mutations and variations, and differentiate traits which show continuous variation or discontinuous variation. They should be able to interpret given data, based on application of their knowledge of continuous and discontinuous variation.

## Activities

- Begin the lesson by reviewing variation and its presence in organisms. Ensure the students are clear on the concept that variation can be caused by genes or the environment. Ask the students if they can share traits which are result of genetic or environmental variation. Remind them that genetic variation can lead to evolution or how environmental variation can affect the survival of a species.
- Enquire of the students, if they have ever observed any examples of variation, due to reason other than genetic or environmental.
- Introduce the concept that many times variation is a result of combined effects (interaction) of genetic and environmental factors. Discuss the examples given in the spread (skin colour and weight) but remember to be sensitive as many students at this age may be aware and potentially embarrassed about these factors. You can ask them to consider height, eyesight or even intelligence.
- Introduce the Risk Continuum activity: Explain the risk of hereditary diseases. Ask the students to research minor hereditary diseases such as diabetes, high blood pressure, eye diseases etc. and to observe whether their family history might have a record of such diseases. Review how the risk of such diseases increases with a sedentary, stressful or unhealthy lifestyle. Refer to the twin studies section in the spread.
- Lead the discussion that in humans twins are the best of study of variation, as it is not ethical or moral to conduct deprivation studies in humans. However, for further detailed studies, experimentation using genetically identical plants is a viable option. Read the discuss the section on investigating variation in class, then lead the students to attempt question 2 in class: facilitate a discussion on past c.

### 1.3 Student Book answers

**1.** Genetic variation results from the different inherited information of each individual. Environmental variation is brought about by factors such as food availability, temperature etc

**a.** the effect of light on growth or health of a plant.

**b.** to ensure a fair and accurate test of effect of an environmental factor.

**c.** encourage students to discuss and prepare answers in their own words. The responses should include discussions about the type of plant, its light requirement, weather conditions, soil conditions and growth parameters measured.



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**2. a.** encourage students to draw a simple bar chart. You can also ask them to display values in other chart forms and then ask them which form of a graph proves to be the best at conveying information.

**b.** height.

**c.** mass.

# 1.4 Natural selection in action

**Student Book pages 8–9**

## Objective

- Explain how different adaptations affect the chances of survival of different species of organism.

## Overview

In this lesson, you introduce students to the key biological principle of natural selection and give them examples of natural selection in action. The fundamental idea is that most organisms produce many offspring and relatively few of them survive. Those that do survive will be the organisms with the genes that give them characteristics which are best fitted to their environment. These are the genes that will be passed on from one generation to the next. If you can help your students to develop a clear understanding of this idea now, then it will give them an advantage when they begin their IGCSE Biology studies.

## Activities

- Remind students of the work on variation they carried out in their previous lesson.
- Read through page with your students, explaining the process of natural selection clearly.
- Now read through and discuss the different examples of natural selection given in Table and ask students for any other examples of natural selection they can think of.
- Students work through questions 1–4.
- Summarise the main points of the lesson. Introduce the idea that environment drives natural selection and ask students to think about examples of this and how it links to their work on the carbon cycle and climate change, before the next lesson.

## Extension

Give students and discuss look at the story of natural selection in the oysters of Prince Edward Island in Canada, draw a bar chart and explain the evidence in terms of natural selection.

## Homework

Workbook page 3.

## Key words

natural selection

## 1.4 Student Book answers

1. The parent organisms die, not all of the offspring survive.
2. **a.** A natural process by which the organisms best able to survive are the ones which live and reproduce, passing on advantageous characteristics to their offspring.
   **b.** Each individual inherits genetic variation from their parents and is different from all other members of their species. Individuals with characteristics that give them an advantage are the ones most likely to survive. The successful individuals survive long enough to reproduce and pass on their useful characteristics. This process is repeated many times until these characteristics become more common in the population. Over a long period of time, it may lead to the development of a new species.
3. Look for two local examples with clear understanding of how natural selection has led to particular characteristics, e.g. butterflies with long tongues to access nectar or similar.
4. Look for two local examples with clear understanding of how natural selection has led to particular characteristics, e.g. plants with deep roots to access water/flower at night for bat pollinators.

# 1.5 Environmental change and natural selection

**Student Book pages 10–11**

## Objective

- Explain how different adaptations affect the chances of survival of different species of organism.

## Overview

In the previous lesson, students learned that natural selection results in organisms that are well suited to their environment. In this lesson, you challenge them to think about the situation when that environment changes – this links holistically with the carbon cycle and climate change. Making this sort of link has great value in helping students to see how the biology they learn fits together, and how each area of learning supports the others.

## Activities

- Question students to see how many examples of natural selection in action they remember from the previous lesson. Introduce the term adaptation – natural selection produces populations with adaptations that mean they survive well in their environment.
- Read through page with students. Take time to discuss the ideas, take questions from students and help them to make the connection between environmental change and natural selection. Look carefully at the information given, combining the written information with the data in the diagrams.
- Students answer questions 1 and 2.
- Move on to read ‘Gradual change v. extreme events’ with students, before students answer Q3.
- Summarise the principle that populations change and become better adapted to a change in their environment as a result of natural selection, with students offering examples.

## Homework

Workbook page 4.

## Key words

adaptation



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## 1.5 Student Book answers

**1.** If the environment changes, many organisms are no longer well adapted to their environment. Every population contains genetic variation. Some of the variants will be better adapted to the new conditions. They will breed successfully. As a result of natural selection most of the population will become this new form, adapted to the changed environment.

**2. a.** Best adapted; make the most seeds – 28 per plant.

**b.** Both the 5-flowered plants and the 3-flowered plants cope better with the dry conditions than the 7-flowered plants. The 5-flowered plants make 15 seeds but the 3-flowered plants only make 6 seeds. The 5-flowered plants make more seeds so they reproduce more successfully/and become the most common form by natural selection.

**c.** It would depend how the climate changes but one of the other variants might be better adapted to the new conditions. If it reproduces successfully it will become the main form by natural selection, e.g. if it gets wetter, the 7-flowered plant might become more common again by natural selection/if it gets even drier, the 3-flowered plants may cope better and be selected; even though they don't make many seeds they become the main form.

**3. a.** In normal years, whatever the temperature, kestrels raise an average of almost 3.3 young birds per nesting pair. When there is a drought, fewer young kestrels survive – on average fewer than 2.9 per nest.

**b.** The data shows fractions of birds – but in any one nest it would be whole birds that survived. So must be the average of several or many nests in each case.

**c.** As the temperature of the environment increases, those kestrels which are best adapted to the warmer conditions/ e.g. eat a wider range of prey, regulate internal temperature better/will be more successful at raising chicks. Those less well adapted will raise fewer chicks – the overall effect will be that population numbers remain the same. In a severe drought it will be chance which birds find water or food – so population numbers fall and natural selection has little effect.

# 1.6 Extinction!

**Student Book pages 12–13**

## Objective

- Explain how different adaptations affect the chances of survival of different species of organisms.

## Overview

In this lesson on extinction, students learn that species cannot always respond to changes in their environment and may become extinct. It is a common misconception that extinction is always a bad thing. In fact, 99% of all the species that have ever lived have become extinct – this is why we don't have dinosaurs like *T. rex* any more! Without extinction there is no room for new species. So, in biological terms, extinction is needed and important. The problem at the moment is the rate at which species are becoming extinct – it is too fast to be sustainable. These are the key concepts for this lesson. Students look at how people are having an impact and causing extinction. As an extension, they consider how people are also working to prevent extinctions. It is important that students see people as part of the solution as well as part of the problem.

## Activities

- Begin by asking students about different types of dinosaurs and where the dinosaurs are now. Discover what they know about extinction.
- Read through 'What is extinction?' with your students, emphasising that extinction is a natural part of life when species cannot adapt to changes in conditions. Students read through the rest of pages. Divide your class into

six small groups and give each group one of the endangered animals. Give students a few minutes to prepare, then each group describes their animal to the rest of the class and explains why it is endangered and at risk of becoming extinct. Discuss how these examples illustrate the information.

- Students answer questions 1 and 2.
- Ask students to complete expanded version of Q3.
- Have a plenary session on extinction and the threats to animals and plants caused by human activities and tell students that they will be looking at this further in another lesson.

## Extension

Students write a report with the title: *Extinction: when natural selection fails*. Challenge them to explain extinction in terms of natural selection and to highlight the rapidly increasing rate of extinctions seen in the 20th and 21st centuries.

## Homework

Workbook page 5.

## Key words

extinct

## 1.6 Student Book answers

**1. a.** Extinction is when there are no more individuals of a particular species alive either in an area (local extinction) or anywhere on Earth (global extinction).

**b.** Species become extinct because new species which are better adapted to the changed environmental conditions take their place. Extinction means there are not enough resources to go round.

**2. a.** Any four from: climate change; temperature of an area increasing; temperature decreasing; new disease; new predators; new competitors; changes in land use; catastrophic events; hunting; habitat destruction; pollution; any other sensible point.

**b.** Extinction happens because there are no longer enough organisms left to breed and maintain a population so that when the final organisms die out the species becomes extinct.

**3. a.** 1800

**b.** Amphibians. Global warming/loss of habitat; new fungal disease.

**c.** Data shows that extinction rates have increased rapidly over the last 200 years for all types of vertebrates. This is the period of time when we know the environment has been warming much more quickly. Suggests that the increase in extinctions is linked to the increase in global temperatures. Numbers increased particularly during 20th century when measured global warming also increased. Data show the percentage of all the species of each type of vertebrate that have gone extinct. There are thousands of species, so 2% of that is many species. If vertebrates are going extinct, invertebrates and plants will also be affected. There are many more species of invertebrates and plants than vertebrates so the numbers of extinctions linked to climate change is very large.


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# 1.7

## Investigating the peppered moth: past and present

TWS

**Student Book pages 14–15**

## Objectives

- Explain how different adaptations affect the chances of survival of different species of organism.
- Make conclusions by interpreting results informed by reasoning.
- Describe how people develop and use scientific understanding.

## Overview

This lesson helps students to develop their skills in Thinking and working scientifically.

It presents students with the story of the original work on peppered moths, with some of the evidence to support the theory. It contains plenty of data for students to interpret and analyse. They see how a changing environment leads to changes in the appearance of the moths over a relatively rapid timescale. Explain how scientists constantly question and challenge accepted ideas, to make sure that the evidence is strong. Finally, present modern work on the theory of the peppered moths, giving students the opportunity to analyse the data to see how it supports the original conclusions.

## Activities

- Remind students of what they know about natural selection. Talk about timescales – originally people thought that natural selection always took a very long time.
- Introduce students to the peppered moth – they may be local to you as they are found in many countries around the world.
- Read through 'Kettlewell's theory' with students. They should read on through 'Kettlewell's findings', looking closely at figures and completing Q1 on page.
- Read through the first paragraph on page with students before they answer Q2 then discuss their answers. Students continue to work manipulating the data to show the changes in colour of the peppered moths in a different way and evaluating the different ways of displaying data.
- Talk to students about the doubts raised on Kettlewell's studies. Explain that scientists often challenge each other's work and ideas – this is how the evidence is kept strong. Students read through and answer Q3.
- Summarise the findings of the lesson with students by asking them to identify a model of natural selection, how unexpected results led to an increase in understanding, and how our scientific understanding of the impact of industrial pollution on natural selection in peppered moths has developed and been used.

## Extension

Students calculate the percentages of the different types of moths that were NOT eaten and add these to their bar charts.

## Homework

Workbook page 6.

## 1.7 Student Book answers

**1. a.** If natural selection causes changes in moth populations, clean woodlands will contain mainly pale moths. Pale moths are more likely to survive and reproduce, because they are camouflaged against the tree trunks where they rest. Darker moths produced by natural variation will be seen and eaten by birds. In polluted woodlands, he predicted that dark trees would make it easy for birds to find pale moths, so moths with genes for lighter colours would be eaten. As a result, in polluted woodlands there would be many more dark moths than light ones in the population.

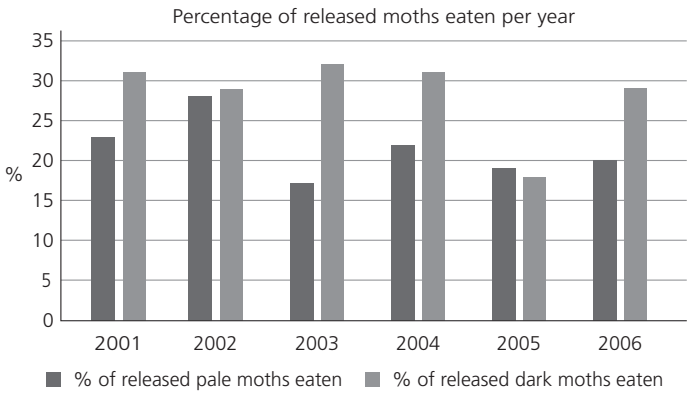
**b.** Looked at colours of old collections/took data from amateur moth collectors all over the country/did field experiments on birds eating different coloured moths.

**c.** Old collections were a way of looking back at moths that had lived before the Industrial revolution. Taking data from moth collectors gave him evidence about colours of peppered moths in many populations and many different environments; field experiments allowed him to see if birds find more of one colour of moth than another on different coloured tree trunks.

**2. a.** Shows that the population of pale moths was very high until 1850. It fell until, by 1900, it was very low. Remained low until around 1970s when it increased again until, by around 2000, most moths are again the pale form. Shows that the population of dark moths was very low until 1850. It rose until, by 1900, it was very high. Remained high until around 1970s when it fell rapidly until, by around 2000, very few moths were the dark form.

**b.** Until 1850, most peppered moths in clean woodlands were pale because dark form shows up clearly and those moths were eaten by birds so remain rare. From 1850s, woodlands became polluted as a result of industry. Became harder to see dark moths but easier to see pale moths so the proportions eaten by birds changed. After 50 years, mainly dark moths with just a few pale by natural selection. Around 1970s, pollution levels fell and woodlands became cleaner. Dark form became easier to see and were eaten; light form harder to see, so by the 2000s most peppered moths were again the light form by natural selection.

**3. a.**




**b.** Majerus carried out an investigation over many years. He observed peppered moths in their natural habitat to see where they rested and what ate them. He released 4864 moths over 6 years and observed where they rested, what ate them and the colours that were eaten. He built up a large data set which showed that, as Kettlewell observed, peppered moths do rest on tree trunks, they are eaten by birds and that, in a clean woodland, birds see the dark form more easily than the light and a greater proportion of the dark moth population is eaten. Thus natural selection will result in a larger number of pale moths as more of them live to reproduce. His findings confirmed the work of Kettlewell 50 years earlier.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# 1.8 Genetics and heredity

**Student Book pages 16–17**

## Objectives

- Recognise genetics as the study of heredity and define heredity as the transfer of genetic information that specifies structure, characteristics and functions from parents to offspring.
- Differentiate between the concept of genes and chromosomes and relate them to how genetic characteristics are inherited.

## Overview

In this lesson, students learn how sex is inherited in humans, which has relevance both in their biology studies and in life. It is valuable to learn that every pregnancy has a similar chance of producing a boy or a girl, and that the inheritance of characteristics is an almost random process.

## Activities

- Ask students how many chromosomes there are in a human body cell, how many pairs of chromosomes there are in a human body cell and how many chromosomes there are in human eggs and sperm (46, 23 and 23).
- Summarise the process of fertilisation and remind students that half of the DNA in an embryo comes from the mother and half from the father.
- Students read and answer questions 1 and 2. Work through the workbook page 7 with students.
- Read through the topic on inheritance of blood groups. Make sure students understand the calculation of possible inheritance of a blood group using the Punnet Square method.
- Students answer questions 3 and 4 to complete the lesson.

## Homework

Workbook page 8.

### 1.8 Student Book answers

**1.** Heredity is the transfer of genetic information that specifies the structure, characteristics and function of an individual from parents to offspring.

**2. a.** DNA

**b.** chromosomes

**3. a.** When cells divide the DNA forms long threads called chromosomes. The chromosomes form Pairs, one inherited from the mother and one from the father. The units of DNA on the Chromosomes which carry the information about structure, characteristics and function are called the genes. The pairs of chromosomes carry paired genes. Each member of a pair of genes codes for the same features.

**b-** 42.

**4.** In the family where all children have same blood group, the parents either have the same blood group (e.g. Either AA, or BB, or OO) or one of the parents carries a dominant allele (e.g. Either A or B). As we do not know which blood group is carried by the children, the answer can be blood group A (AA or AO), B (BB or BO) or even O (OO), as can be demonstrated by the Punnett square below:

| Parent alleles | A | B | O |
|---|---|---|---|
| A | AA | - | AO |
| B | - | BB | BO |
| OO | AO | BO | OO |

In the family where only 2 children have the same blood group, it is probable that one of the parents carries both a dominant and a recessive allele (an AO or a BO). The answer can be demonstrated by the Punnett square below:

| Parent alleles | A | B | O |
|---|---|---|---|
| A | - | AB | AO |
| B | AB | - | BO |
| O | AO | BO | OO |

# 1.9 Modelling DNA

**Student Book pages 18–19**

**Prior learning**

- The structure and function of DNA.

## Objectives

- Describe the composition and structure of DNA.
- Design a model of DNA to demonstrate its structure and function, and various components.

## Overview

This lesson builds on the previous learning about DNA as the molecule that holds the blueprints in all living things. The content is delivered through the modelling activity of two students, which the students can themselves replicate. This is an excellent opportunity for the students to consider the history of science and the impact of technology on our development of our scientific understanding. You can share the roles of James Watson, Francis Crick and Rosalind Franklin in the discovery of the DNA. This is a good opportunity for students to understand that technology and hands-on modelling both have important place in the scientific process.

## Activities

- Begin by introducing the story of how the DNA structure was the last to be discovered, well after the discovery of its ability to transform the properties of cells. Introduce that in 1953, an X-ray of the crystallized form of DNA taken by Rosalind Franklin, formed the basis of the famous double helix structure model of DNA, proposed by Watson and Crick.
- Discuss in class, using the images in the spread or ideally a poster or videos, the structure of DNA. Explain that due to its nature as a long molecule made of many repeating units, DNA is able to store, encode and transfer biological information. Its unique structure is made up of three parts: a sugar molecule, a phosphate group, and a nitrogenous base. The alternate sugar and phosphate sections, make up the backbone of the molecule, whereas the sequence of the four nitrogenous bases (adenine (A), thymine (T), guanine (G), and cytosine (C)) determines the genetic code.
- Ensure that the students are clear on the structure of the DNA molecule before moving on to the working of the DNA molecule. Explain the joining of the DNA molecule using the images in the spread. Alternatively, show the students a video in class, such as this one https://www.pbslearningmedia.org/asset/acbd76bd-f744-4e6d-9b97-b40e61e668a0/
- Facilitate a class discussion based on question 3 of the spread. Divide students into teams and encourage them to attempt question 4 of the spread, using easily available class arts and craft materials.


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## Homework

Questions 1 and 2 from the student book spread. Also workbook page 9.

## Key Words

Heredity, genetics, genes, chromosomes, deoxyribonucleic acids, inherited traits, instincts, learned behaviours, variation, adaptation, cell division, mitosis, meiosis.

### 1.9 Student Book answers

**1.** DNA is a polymer, a long molecule made up of many repeating units known as nucleotides.

The combination of a phosphate group, a sugar and a base is known as a nucleotide.

The base is a made of one of possible nitrogen containing biological compounds which are indicated using the letters A, C, G and T.

A double helix is the twisted, spiral form in which long strands of DNA are form.

**2.** Students can refer to the diagrams in the spread to discuss and describe the various parts of a DNA strand.

**3.** Encourage students to discuss the questions and then share their answers in a group activity.

**4.** Encourage students to use unorthodox materials to demonstrate the DNA structure. They make choose to create a new structure and argue its merits. Encourage them to consider the packing of DNA within nucleus and the coding of genes along the strands.

# 1.10 Mitosis and meiosis

**Student Book pages 20–21**

## Objectives

- Describe cell division and its types – mitosis and meiosis and relate them to the passage of genetic information through reproduction.
- Explain the process of mitosis and meiosis and identify their key phases.

## Overview

This lesson enables students to understand the processes by which body cells and reproductive cells divide into two. They build on the knowledge they have about the sexual and asexual modes of reproduction and learn further detail about the processes of DNA replication and cell division that occur in both.

## Activities

- Begin by asking students to summarize what they remember about the asexual and sexual modes of reproduction. Remind them that asexual reproduction is the process of cell replication, by which a cell makes a copy of its genetic material and then divides into two "daughter" cells, each identical to the parent cell. In single celled organisms, this method allows them to pass their genetic material to the next generation. Multicellular organisms, however, use this process to grow by increasing the number of cells they have and to repair their tissues by replacing damaged cells. Introduce the idea that in multicellular organisms, animals as well as plants, the reproductive cells (gametes) are produced by a different method due to their different functional requirements.
- Read the introductory paragraph with the students. Discuss and explain the process of mitosis in detail, ensuring the students are clear on the name and description of each step. You can also show them a video to clarify their

**Prior learning**

- Cells division is essential for growth.
- Cells -> tissues -> organs -> systems -> organisms

concept, as an example: https://www.pbslearningmedia.org/resource/tdc02.sci.life.stru.dnadivide/mitosis/

- Ask the students to work in pairs to review and then present in a summarised form, the process of sexual reproduction in plants. Remind them that plant gametes are present inside the pollen grain and the ovum and contain only half the number of chromosomes. Explain that gametes work similarly in animals as well, and the process for creation of gametes is known as Meiosis. This process is also known as Reduction Division as it reduces the number of chromosomes in daughter cells by half.
- Review the process of meiosis in detail, ensuring the students are clear on the name and description of each step. Elicit if they find the second half of meiosis similar to mitosis.
- Divide students in pairs and assign them Q3 from the student book spread. Encourage them to create and share the answer in form of an infographic.

## Homework

Questions 1 and 2 from the student book spread. Also workbook page 10.

## Key Words

Heredity, genetics, genes, chromosomes, deoxyribonucleic acids, inherited traits, instincts, learned behaviours, variation, adaptation, cell division, mitosis, meiosis.

### 1.10 Student Book answers

**1. a.** Mitosis is the process by which body cells divide to produce 2 identical daughter cells with the same number of chromosomes as the parent cell.

**b.** Meiosis is the process by which special cells divide to produce 4 daughter cells with half the number of chromosomes as the parent cell, and variation in genetic Information.

**2.** Mitosis is essential for formation of identical body cells with the same number Of chromosomes. Meiosis is essential for formation of gametes, which contain only half the number of chromosomes.

**3.** Encourage students to collate and present the information in the spread in a tabular form.

# 1.11 Review answers

**Student Book pages 22–23**

## Student Book answers

**1. a.** Differences between organisms of the same species. **[1]**

**b.** Bar chart/graph **[1]**

**c.** Inherited/genetic variation; environmental variation, e.g. different amounts of food given or found. **[2]**

**2. a.** O **[1]**

**b.** AB **[1]**

**c.** Body mass is decided by a combination of genetics and your environment. The amount you eat affects it. Blood groups are inherited/genetic variation. Nothing in the environment will change them. **[4]**

**3. a.** Natural selection is the process by which the organisms with the characteristics best adapted to their environment live and reproduce, passing on the useful characteristics to their offspring. **[2]**



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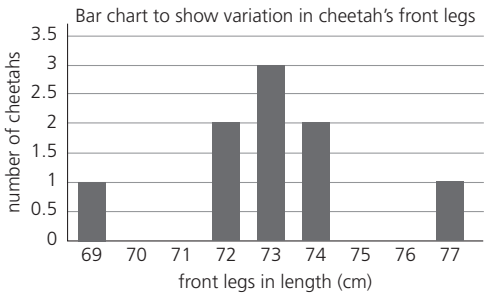
**b.** **[5]**




**c.** A combination of genetic and environmental variation. **[2]**

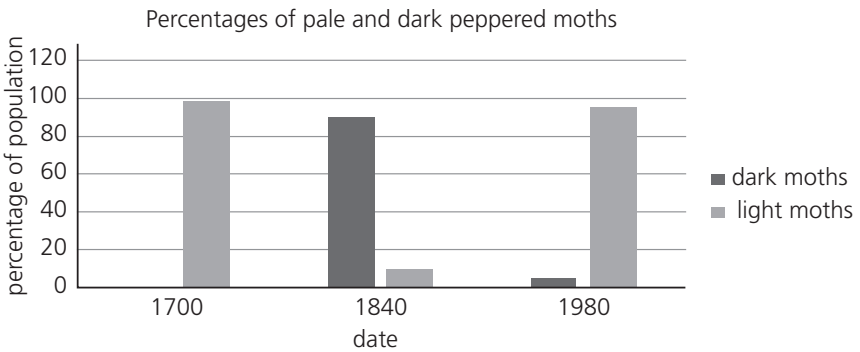
**d.** Cheetahs with the best leg length will be most able to run fast enough to capture prey without breaking their bones. These are the cheetahs that are most likely to survive to reproduce and pass on their genes for long legs. As a result of this natural selection, most female cheetahs have legs that are (72–74) cm long. A few cheetahs have short legs or particularly long legs as a result of natural variation. **[6]**

**e.** Until the environment changed and a new plant-eater arrived, cheetahs with shorter legs were at a disadvantage, even though they used less energy. When a slower moving prey that reproduces quickly appears, shorter legged and slower cheetahs can catch them easily. As they also use less energy, they will be at an advantage, do well and become more likely to survive and pass on their genes. The population will change; most animals will have shorter legs and use less energy, as a result of natural selection. **[6]**

**4. a.** Organisms in a species show genetic variation → The organisms with the characteristics best adapted to the environment survive and reproduce. Less well adapted organisms die. → Genes from the successful organism are passed on to the offspring. They are likely to have the useful characteristics that made their parents successful → The process is repeated until most of the population have the useful characteristics. **[6]**

**b.** A population or species is adapted to its environment. If the environment changes, e.g. warms due to climate change, the organisms will not be as well adapted. Some individuals in the population will be different as a result of natural variation. If some of the population cope better with the changed environment, they will be more likely to breed successfully and pass on their advantageous characteristics until most of the species have these characteristics and are adapted to the changed environment. **[6]**

**5. a.** **[5]**




**b.** The population was almost entirely pale moths in 1700. By 1840, 90% of the population were dark moths. **[2]**

**c.** Pale moths would be more visible. **[1]**

**d.** Light moths became the most common form again, changing from 10% of the population to 95% of the population. The dark moths did the opposite and became rare again. **[3]**

**e.** In 1700, trees and buildings were clean. The pale form of the moth was hard to see. Dark moths were easy for birds to see and eat. Mainly pale moths survived to reproduce and so by natural selection most of the population was pale.

By 1840 the industrial revolution had resulted in a lot of smoke and many trees were blackened. Now the pale moths were easy for the birds to see and eat. Dark moths were camouflaged. They survived to reproduce and pass on the dark colour genes. The population became largely dark in colour by natural selection.

In the 1970s, the air was cleaned up. Trees became pale again. The paler moths had the advantage and survived to breed. Dark moths were seen and eaten. So natural selection drove the population back to being mainly pale moths with a few dark variations.

**6. a.** the plants are genetically adapted to grow better at 24°c.

**b.** Genetic variation results from the different inherited information of each individual. Environmental variation is a result of factors such as food availability, temperature, etc.

**c.** identical twins are very useful in the variation because all of their characteristics are completely determined by their genes, like their blood groups, will be the same. However, some of their characteristics will also affected by factors such as diet, health, and exercise levels. The older they will get, the less identical they will look, as their different environments affect them more and more.

**7. a.** DNA.

**b.** a phosphate group, a pentose sugar and nitrogenous base.

**c. i.** meiosis

**ii.** ask the students to recall and label the different stages of meiosis depicted.

| **Stage name** | **Description** |
|---|---|
| Prophase I | The chromosomes are copied as the DNA replicates. Two chromatids joined together now make up each chromosome. The nuclear membrane is breaking down. |
| Metaphase I | The membrane round the nucleus has gone. A structure called the spindle forms, and the chromatids line up along the middle of it. |
| Anaphase I | The spindle fibres shorten and pull the chromatids towards the ends of the cell. |
| Telophase I | A nuclear membrane forms round each new set of chromosomes at the ends of the cell. The cytoplasm starts to divide. |
| Prophase II | There is NO REPLICATION of the chromosomes in the new daughter cells. The new nuclear membrane breaks down. |
| Metaphase II | The spindle forms and pairs of chromatids line up on the spindle. |
| Anaphase II | The chromatids are pulled to opposite ends of the cell by the spindle. |
| Telophase II | A nuclear membrane forms round each new set of chromosomes at the ends of the cell. The cytoplasm starts to divide. |
| Daughter Cells | In total four new daughter cells (gametes) result, each with half the chromosome number of the original cell. |

**iii-** formation of gametes. **[12]**

# 2.1 Human Nervous System

## Student Book pages 24–25

**Prior learning**

- Know that the human body has a number of systems, each with its own function.
- the brain works as the control station of a human body.

## Objectives

- Identify the organs, functions and processes of the human nervous system.
- Sketch and label a diagram of the human nervous system.

## Overview

This unit introduces students to the fascinating world of sensitivity and sense organs. Sensitivity is one of the main characteristics of life found in all living organisms. Students discover that multi-celled complex organisms such as human beings are able to traverse the world easily due to an extremely complex and coordinated system of neurones, nerve tissues, and sense organs in their bodies.

## Activities

- Begin by reviewing with students the major characteristics of life. Ask the students if they can explain what is meant by sensitivity.
- Explain that that sensitivity is the ability to detect changes in the environment (stimulus) and the nervous system is responsible for sensitivity and coordinating responses to those all changes in the environment.
- Read through the text to understand sense organs, the peripheral nervous system, and the central nervous system: Facilitate a discussion the function of each.
- Divide the students into groups. Encourage each group to create posters or charts detailing function and location of sense organs, the peripheral nervous system, and the central nervous system.
- Have students complete a handout on the human nervous system (optional).
- End the lesson by reviewing the key points and answering any questions students may have.
- In preparation for lessons ahead, you can assign student groups or pairs research the different types of sensory receptors or the functions of the brain.

## Homework

Questions from the student book spread. Also workbook page 11.

## Key Words

Central nervous system, peripheral nervous system, brain, spinal cord, neurons, motor neurons, sensory neurons.

### 2.1 Student Book answers

**1.** The human nervous system (i) detects changes inside and outside the body and (ii) coordinates responses to these changes.

**2. a.** The sense organs detect changes in the environment.

**b.** The peripheral nervous system carries information around the body.

**c.** The central nervous system that coordinates the incoming information and controls responses.

**3.** The nervous system enables coordination between the body systems and behaviour, And reaction to external surroundings.

# 2.2

# The structure and function of neurones

## Student Book pages 26–27

**Prior learning**

- The brain receives different types of information through sense organs.

## Objective

- Describe the role and function of neurones in transmitting messages through the body.

## Overview

In the previous lesson, students gained an overview of the complex nervous system found in human beings. They discovered that other mammals have similar nervous systems. In this unit the students learn the type(s) of neurones and how their structure helps them perform their functions. They also learn the difference between neurones and nerves.

## Activities

- Begin by reviewing the previous lesson. Introduce the students to the definition and description of neurones.
- Read the student book with students and explain that neurones form the basic units of the human nervous system.
- Introduce the different parts of a neurone and its function, such as the cell body, dendrites, axon, and synapses.
- Introduce the concept of different types of neurones and relate to their functions. Ask the students if they can guess the location of each type of neurone based on its function.
- Discuss the difference between a neurone and a nerve (tissue).
- Encourage the students to produce the answers to questions 1 and 2 in infograph formats.
- You may suggest the students do a research project (literature review) on the role of neurones in on the ability to learn.

## Homework

Q3 from the student book spread. Also workbook page 12.

## Key Words

Central nervous system, peripheral nervous system, brain, spinal cord, neurons, motor neurons, sensory neurons, signal, cerebrum, cerebellum, brainstem, sensory organs.

### 2.2 Student Book answers

**1.** Neurons are cells specialised for the passage of electrical impulses.

**a.** Sensory neurons carry impulses from sensory receptors to the CNS.

**b.** Motor neurons carry impulses from the CNS to effectors such as muscles and glands.

**c.** Relay neurons link sensory and motor neurons in the CNS.

**2.** Neurons are the basic units of the human nervous system. They all have a cell body, dendrites, an axon and synapses. Many human neurons also have an insulating Myelin sheath.

**3. a.** students can reproduce the labelled diagrams given in the spread.

**b.** encourage students to compare and contrast the structure and functions of sensory and motor neurons, using a fishbone infographic.



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# 2.3

# The structure and function of the central nervous system

**Student Book pages 28–29**

**Prior learning**

- the brain works as the control station of a human body.

## Key Words

Central nervous system, peripheral nervous system, brain, spinal cord, neurons, motor neurons, sensory neurons, signal, cerebrum, cerebellum, brainstem, sensory organs, neurodiversity, neurological conditions, sympathetic nervous system, parasympathetic nervous system, adrenaline, hypothalamus, fight and flight responses.

## Objectives

- Explain how the brain works as a control station for the body.
- Identify the three main parts of the brain – the fore brain, mid brain and hind brain, and describe their various functions.
- Describe the structure of the cerebrum, its division into two hemispheres (left and right) and the role of each hemisphere in the control of the body.
- Match various body functions with the relevant part of the brain that controls or regulates them.

## Overview

In this unit the students delve further and focus on the human brain itself, which acts as the control station for the whole body. They will learn what allows the brain to work as a control station for the body, i.e. the three main parts of the brain and their functions. They will learn to recognize the major parts of brain, such as the cerebrum, cerebellum and brain stem. Students will learn to recognize the role the brain plays in regulation of many human body systems.

## Activities

- Begin by reviewing the functions of the nervous system, by asking students to summarize and share. Ensure they are clear that the brain is the control center of the body, which makes it responsible for everything from breathing and digestion to movement and thought.
- Use a 3D model or a poster (alternatively use the illustration in the book) to indicate the forebrain, midbrain, and hindbrain.
- Explain the function of each part. Assign each part to a different group of students and encourage them to share in a presentation the location and function of their assigned part.
- Read through the text on cerebrum and introduce the cerebral hemispheres to the students. Review the functions of each hemisphere. Facilitate a discussion on what might happen if there is an injury to cerebrum.

## Homework

Questions from the student book spread. Also workbook page 13.

### 2.3 Student Book answers

**1.** The fore brain, the mid brain and the hind brain.

**2.** The fore brain is made up of the cerebrum and the olfactory lobes. The cerebrum controls consciousness, intelligence, memory and language. The olfactory lobes give us our sense of smell.

**3.** The cerebrum is the part of the fore brain responsible for control of consciousness, intelligence, memory and language. The cerebellum is the part of the hind brain responsible for muscle movements and balance.

**4. a.** The hind brain on the left side of the brain.

**b.** the reason is that the cerebellum located in the hind brain is responsible for muscle movement. Also, since the left side of the brain is responsible for the motor control of the right, we can reasonably conclude that the blood clot is in the left hind brain.

# 2.4

# Nervous control of the body

## Student Book pages 30–31

**Prior learning**

- The brain receives different types of information, processes and responds to the information in different ways.

## Homework

Questions from the student book spread. Also workbook page 14.

## Key Words

Central nervous system, peripheral nervous system, brain, spinal cord, neurons, motor neurons, sensory neurons, signal, cerebrum, cerebellum, brainstem, sensory organs, neurodiversity, neurological conditions, sympathetic nervous system, parasympathetic nervous system, adrenaline, hypothalamus, fight and flight responses.

## Objectives

- Explain and represent how messages flow through the body to and from the brain, and how the brain collaborates with the sensory organs to regulate this process.
- Map the various steps in the transmission of messages through the body and to the brain.
- Predict what would happen if a nerve connection broke.

## Overview

Now that the students have an understanding of the role and function of the brain in the nervous system, they will be introduced to the more complex workings of the nervous control in the body. They will be introduced to the general patterns of consciousness and control, in a systemic manner. They will then learn the more detailed working behined our conscious actions and the role of spinal cord in maintaining the connection between the brain, the sensory receptors and the motor receptors. They will also gain an appreciation of why a spinal cord injury is dangerous.

## Activities

- Before beginning this unit, you can ask the students about the functions of human nervous system; bonus if they remember the difference between CNS and PNS.
- Next ask them if they remember the difference between the sensory and motor neurons. Encourage them to focus their answers on the difference in functions of both.
- Remind them that the sensory neurones are responsible for sending messages from the body to the brain, and the motor neurones are responsible for sending messages from the brain to the body.
- Introduce the terms, with a focus on their functions: sensory receptors, sensory neurons, the CNS, motor neurons, and effectors.
- Next, use these definitions to detail the steps in the transmission of messages through the body and to the brain, and explain the effects of a possible broken nerve connection. Ensure the students understand the difference between a damaged sensory nerve and a damaged motor nerve.
- As a class activity, trace the pathway of a conscious thought to action completion.

### 2.4 Student Book answers

**1.** Sensory neurons -> coordinator (CNS) -> motor neurons -> effector -> the effect

**2.** The collaboration of the brain with sensory organs means that the brain receives information from them and analyses it to coordinate the response of the body. Encourage students to imagine scenarios using input from different sense organs and how the brain might coordinate the most logical response.

**3.** Broken sensory nerves cause loss of sensation, damage to motor nerves causes loss of the use of parts of the body and damage to mixed nerves results in both loss of sensation and movement.

**a.** loss of sensation

**b.** loss of movement

**c.** loss of both sensation and movement



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# 2.5

## Reflex arches

**Student Book pages 32–33**

**Prior learning**

- The nervous system processes and responds to information in different ways.

## Objectives

- Explain and represent how messages flow through the body to and from the brain, and how the brain collaborates with the sensory organs to regulate this process.
- Map the various steps in the transmission of messages through the body and to the brain via a reflex arch.

## Overview

This unit picks up once the students are sufficiently clear on the pathway of a conscious thought to action. Here the students will be introduced to the concept of unconscious thoughts, behaviour and actions. They will learn about the reflex actions and pathways related to it. Ensure the students are sufficiently clear on the difference and similarities between pathways of conscious and unconscious actions.

## Activities

- Begin by introducing the idea that not every action requires conscious thought. Ask the students to share the conscious thought pathway, as you sketch it out on the board. Next ask them if they can think of any action which does not follow this pathway, i.e., does not require conscious thought: elicit actions such as breathing, hiccupping, or even jumping when scared.
- Introduce the concept of a Reflex as an automatic response to stimuli. Explain that reflexes help us avoid danger or manage basic body functions.
- Introduce the reflex arch as the pathway for a reflex. Detail the different parts of it along with their functions. Ensure the students have a clarity on the difference between a conscious thought pathway and a reflex arch.
- Explain that there are spinal reflexes and brain reflexes: one is coordinated in the spinal cord and the other in specific regions of the brain. Ask the students to remember which unconscious or reflexive action (e.g. coordination or breathing) requires a brain reflex and which (such as moving away from a hot object!) would require a spinal reflex. You can ask them to create a Venn or fish and bone diagram to compare and contrast the two types of reflexes.

## Homework

Q1 from the student book spread. Also workbook page 15.

## Key Words

Central nervous system, peripheral nervous system, brain, spinal cord, neurons, motor neurons, sensory neurons, signal, cerebrum, cerebellum, brainstem, sensory organs, neurodiversity, neurological conditions, sympathetic nervous system, parasympathetic nervous system, adrenaline, hypothalamus, fight and flight responses.

### 2.5 Student Book answers

**1.** Students can use the information and adapt the diagram in the spread to create a labelled diagram for the answer.

**2.** The transmission of messages via a reflex arch does not involve conscious thought.

Stimulus receptor -> sensory neurons -> coordinator (CNS) -> motor neurons -> effector

**3.** While messages are transmitted through the body in a reflex arch, other neurones are also stimulated in the spinal cord.

# 2.6
# A healthy brain

**Student Book pages 34–35**

**Prior learning**

- humans receive different types of information through their senses, process the information in our brain and respond to the information in different ways.

## Key Words

peripheral nervous system, brain, spinal cord, neurons, motor neurons, sensory neurons, signal, sensory organs, neurodiversity, neurological conditions, sympathetic nervous system, parasympathetic nervous system.

## Objectives

- Create a plan of activities and exercises to maintain a healthy brain.
- Discuss issues which involve and/or require scientific understanding.
- Describe how people develop and use scientific understanding.

## Overview

It is recommended to treat this unit as wrap up and review of the complete section. Students should be able to explain the role and function of nervous system and associated organs. This unit is designed as science in context unit to provoke an appreciation of the role of lifestyle and choices on maintaining a healthy and active brain and cognitive abilities.

## Activities

- Begin by reviewing the previous units. It is suggested that a class activity is done in which different groups create visual summaries of what they have learned.
- Share the visual summaries on the class board. Then ask the question of how the students were able to create their presentations. Explain that they used their reasoning, learning, memory and creativity, which are all cognitive functions resulting from a healthy brain.
- Read through the unit, the students can be encouraged to role play the different parts. Summarize that that a healthy brain is essential for our overall health and well-being.
- Discuss the roles of exercise, sleep, healthy diet and lifestyle on our brains. You can encourage the students to attempt in pairs the reaction time activity.
- Explain the role of stress and smoking on decreasing our mental acumen.
- As a class project, ask the students to create any of the following as paired work:
- Creating a Healthy Brain Plan: a plan for maintaining a healthy brain, including activities to fulfil goals that they would like to achieve. They can include different brain exercises that are purported to improve cognitive function. They should include a chart or list of the different exercises and their benefits.
- Food for Thought: a research report, poster or presentation on the different foods that are said to be good for the brain (e.g. dark chocolate) and their benefits.

## Homework

Questions from the student book spread. Also workbook page 16.

### 2.6 Student Book answers

1. Eating a healthy diet, taking regular exercise, getting plenty of sleep, avoiding smoking and reducing stress, doing brain exercises and eating dark chocolate.
2. Encourage a class discussion on this topic. Ensure that students include some of the points from the earlier answer as well.



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# 2.7

## Review answers

### Student Book pages 36–37

## Student Book answers

**1. a.** detection of changes inside and outside the body and coordination of responses to these changes.

**b. i.** Detection of changes in the environment.

**ii.** Carrying messages to and from the CNS.

**iii.** Coordination of incoming information and bodily responses.

**iv.** Carry impulses from sensory receptors to the CNS.

**v.** Carry impulses from the CNS to effectors such as muscles and glands

**2. a. i.** Motor neuron

**ii.**

| | |
|---|---|
| A | Nucleus |
| B | Cell body |
| C | Dendrites |
| D | Axon |
| E | Myelin sheath |
| F | Synapse |

**b. i.** Sensory neuron

**ii.**

| | |
|---|---|
| A | Cell body |
| B | Junctions with sensory receptors |
| C | Axon |
| D | Myelin sheath |
| E | Dendron |
| F | Junctions with neurons in CNS |

**3.** A neuron is a basic unit of human nervous system, whereas a nerve is a bundle of up to thousands of neurons.

**4. a.** The fore brain, the mid brain and the hind brain.

**b.** fore brain: cerebrum, the mid brain: optic lobes, the hind brain: brain stem.

**c. i.** the fatality is due to the fact that the brain stem (marked as A) controls all the involuntary but essential functions, such as breathing, heart rate, blood pressure and the movements of digestive system, etc.

**ii.** lack of balance and muscle coordination for movement.

**iii.** this area controls the sense of smell, as well as consciousness, intelligence, memory, and language. Therefore, it is difficult to predict exactly what function will be affected.

**5. a.** the right and left cerebral hemispheres.

**b.** encourage students to recall or use the infograph in spread 2.3 for their answer.

**6. a.** encourage students to add diagrams showing parts of the nervous system to answer this question. The answer can be deduced from spread 2.4

**b.** use the infographic in spread 2.4 and encourage students to draw and insert details as per requirement.

**7. a.** the process occurs this way:

**1.** the hammer taps the knee.

**2.** Sensory receptors in the knee send messages along a sensory neuron to The CNS.

**3.** the message passes into a motor neuron and leaves the spinal cord.

**4.** The message reaches the leg muscles which contract.

**5.** the leg moves away from the hammer.

**b. 1.** the hammer taps the knee.

**2.** Sensory receptors in the knee fire off messages along a sensory neuron to The CNS.

**3.** In the spinal cord the messages move into a relay neuron without involving conscious thought.

**4.** A message passes into a motor neuron and leaves the spinal cord.

**5.** The message reaches the leg muscles which contract to move the leg away from the hammer.

**c.** the spinal cord is injured as neither sensation is detected and nor is movement (indicated by testing knee jerk reflex) possible.

# 3.1 Ecology

## Student Book pages 38–39

**Prior learning**

- habitats provide living things with what they need.

- As a class activity, encourage students to provide their answers with reasons for question 3.

## Homework

Q1, 2 and 4 from the student book spread. Also workbook page 17.

## Key Words

Producers, Consumers, Decomposers, Autotrophs, Herbivores, Carnivores, Omnivores, global warming, climate change, competition.

## Objective

- Describe and illustrate through examples key ecological relationship between organisms, including competition, predation and symbiosis.

## Overview

In this lesson, you introduce your students to the terms ecosystem, environment, ecological relationships, and biodiversity.

This lays the foundations for all the ecology they will study in IGCSE Biology. Whenever you talk about ecosystems or habitats, discuss the adaptations of organisms to live there, even when you are not studying adaptations. This will help students when they consider variation, evolution and biodiversity as well as ecology. Remind them that all of the ecology we learn is based on practical investigations and field observations.

## Activities

- Begin by askign the students what they remember from previous classes, especially the definitions of (and difference between) environment and ecosystem.
- Introduce the concept that an ecosystem is a community of organisms that live in a particular area and interact with each other and the physical environment.
- Read through the unit and engage the students by asking them to identify ecosystems in their local environments.
- If possible, arrange a fieldtrip after studying about the Indus Valley ecosystem, so that students can make firsthand observations.
- Introduce the concept of biodiversity, which is the variety of different organisms that live in an ecosystem. Elaborate its importance and how it can be affected by human behaviour.
- Provide an overview of the different types of ecological relationships, such as predator-prey relationships, competition, and symbiosis. Explain that there exist ecological relationships between abiotic factors as well, which are affected by the biotic factors, such as cycling of oxygen and carbon dioxide in ecosystems.

## 3.1 Student Book answers

**1 a.** the physical surroundings in which a person, other animal or plant lives.

**b.** students can list any from the following: type of soil, the air, the average rainfall, light levels, the temperature, the type of and the altitude.

**2.** An ecosystem is made up of all the organisms that live in an area, and the physical environment they interact with. An environment can contain multiple ecosystems.

**3 a.** encourage students to list and discuss the examples of ecosystem they have observed in their daily life. Ensure all students get a chance to list at least one ecosystem they observed personally.

**b.** students can list any from the following:

**c.** Ways of obtaining food e.g. Photosynthesis, eating plants and eating other animals

**d.** Feeding relations including food chains and food webs

**e.** Ecological relationships such as predation, symbiosis and competition, predation and symbiosis

**f.** The cycling of substances through an ecosystem including carbon dioxide and oxygen, based on interactions between chemical reactions such as photosynthesis, respiration and combustion

**4.** Biodiversity measures how many different types of organisms are present in an ecosystem. It is important because it helps ecosystems survive changes in the environment.

# 3.2

## Food chains, food webs and decomposers

TWS

**Student Book pages 40–41**

**Prior learning**

- Use results to draw conclusions and to make further predictions

## Extension

Write a sentence explaining what you would expect to see:

a. if Shakira kept a piece of potato at 40 °C

b. if Aardan kept a sample of milk at 50 °C.

## Homework

Workbook page 18.

## Objectives

- Draw a food web diagram to illustrate the food relationships between organisms.
- Describe how energy flows from producers to consumers, and how only part of the energy flows from one level of the pyramid to the next.

## Overview

This lesson helps students to develop their skills in Thinking and working scientifically. It takes students through the process of developing a hypothesis, planning an investigation, collecting and analysing results and drawing conclusions. The questions encourage students to evaluate the results and suggest ways in which the investigation could be improved . They are provided with further data to practise their graphing skills.

## Activities

- Look at the images on a big slide so everyone can see them without opening their Student Books. Talk about the information on decomposition rates in the first paragraph, relating it to the images.
- Students close their books – then ask them for ideas on how they might investigate the rate of decomposition. Questions might include:
  - Different factors affect the rate of decomposition. Which would you choose to investigate?
  - If you investigate the effect of temperature on decomposition, what is your hypothesis? Suggest how you might investigate this. What factors would you control? How would you measure decomposition? What do you predict would be the result of your investigation, based on your scientific knowledge?
- Students then work through and answer questions 1, 2 and 3.
- When students have completed their answers, find out what improvements to the investigation they have suggested and use a show of hands to find out how many of the class have thought of the different ideas.

Ask students what happens to milk if it is left in a warm place. Most will have experience of milk going off. Give students the task to list possible factors affecting the rate at which milk goes bad.

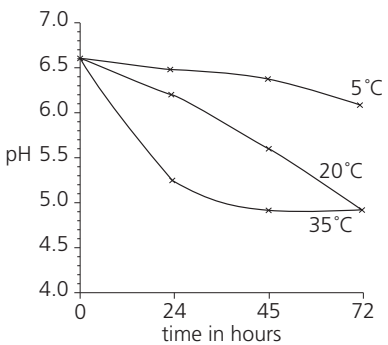
### 3.2 Student Book answers

**1.** They are infected by decomposers and digested away; they dry out.

**2.** She could have three pieces of potato at each temperature and take mean values – or similar.

**3.** She could observe what happens at lower temperatures, e.g. in a fridge/she could observe what happens at higher temperatures. Is there a maximum beyond which the decomposers do not work, for example?

**4. a.**




**b.** Temperature increases the rate of milk decomposition. The rate at 5 °C is significantly slower than at 35 °C.



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# 3.3 Key ecological relationships

## Student Book pages 42–43

**Prior learning**

- Know how food chains can be used to represent feeding relationships in a habitat
- Know that food chains begin with a plant which uses energy from the sun
- Understand the terms producer, consumer, predator and prey

## Objective

- Describe and illustrate through examples key ecological relationships between organisms, including competition, predation and symbiosis.

## Overview

Students build on their knowledge of food chains and food webs to understand how organisms are interdependent and how changes in the population of one species affects the population of other species. This lesson gives students the opportunity to use data handling skills. Students are developing a more complex understanding of the inter-relationships between organisms, which they will carry forward into their IGCSE Biology studies. This level of understanding will help them to achieve well at both CLSS and IGCSE.

## Activities

- Ask students to describe a food chain and a food web. Ask them to write down three food chains and one food web.
- Discuss the interdependence of life and explain that it is more complex than simple food chains and food webs. Introduce the idea of populations – then students read page of the Student Book. Students graph the population changes and suggest reasons for the changes observed.
- Look for explanations such as plenty of food to begin with, no predators so caribou breed fast and population grows; so many caribou that they eat all the plants → starvation, caribou can't breed, die of starvation, overcrowding means diseases spread fast, etc.
- Explain that normally there are predators and prey organisms in any ecosystem, and that in a healthy ecosystem the populations balance each other out.
- Have a plenary discussion on the interdependence of organisms and students answer questions 1 to 3.

## Extension

Students produce a graph showing the changes in the global human population over the last 1000 years. They compare the appearance of the graph with that of the caribou on St Paul Island – it keeps increasing – and discuss factors that affect the growth of the human population, e.g. disease control through vaccination and medicines, growing our own food, importing food, controlling family size.

## Homework

Workbook page 19.

## Key words

interdependence of life, population

## 3.3 Student Book answers

1. **a.** A population of animals might suddenly increase because more food becomes available/a predator competitor dies out/any other sensible point. A plant population might suddenly increase due to a big tree falling over so more light is available, a very wet season so more rain, a poor year for caterpillars – any sensible point.

   **b.** New disease, new predator, new competitor for food.

2. The wolf population is relatively low so the caribou population grows because there are few predators. As the caribou population grows, the wolves have more to eat and so they breed more successfully and the wolf population grows. The wolf population reaches a point when it is reducing the caribou population (there may be a lack of food for the caribou as well). The caribou population falls until there are so few caribou that the wolves die from lack of food so the caribou have few predators again and the population grows again. The two populations are interdependent and the pattern continues.

3. The interdependence of organisms reflects the way in which organisms depend on each other for survival, e.g. plants need animal waste for fertiliser to grow, herbivores need plants to eat, carnivores need prey animals. When there is little biodiversity, each species is dependent on only a small number of other species, so a change in the environment – a new disease, a drought, etc. – can have a big impact. In an ecosystem with a lot of biodiversity, there are many more species in the feeding relationships. It is much easier for organisms to simply change food source in a crisis.

# 3.4 Changing ecosystems

**Student Book pages 44–45**

**Prior learning**

- living things respond to environmental conditions.
- plants and animals are adapted to environments they live in.

## Objectives

- Predict how changes in an ecosystem can affect available resources, and thus the balance among populations.
- Hypothesize what would happen in the ecosystem if the population of one of the participants in different ecological relationships is affected.

## Overview

This lesson helps students to develop their understanding of science in context of greater and smaller decisions made every day. Students are given a brief overview of global changes that are occurring in ecosystems and their impact on the available supply of water.

They will learn much more about how changes in an ecosystem can affect the balance among populations. This is students' first introduction to the interactions between the environment and living organisms. If students develop a sound understanding of the interactions of abiotic and biotic factors in the environment, this will support their success in future at IGCSE.

## Activities

- Begin by reviewing the food web and key ecological relationships. Remind the students to pay special attention to how these relationships also impact the presence of abiotic factors.
- Introduce the concept that any change in the environment, affects the balance of populations within an ecosystem.
- Enlist and explain the different causes of changes in an ecosystem, such as natural disasters, climate change, and human activities. Explain that these result in different effects on populations, such as changes in the availability of resources, changes in the distribution of populations, and changes in the interactions between populations.
- Read through the unit and facilitate a discussion on which factor may potentially be a source of greatest ecological disruption. Ensure the students provide a thought through reasoning for their points of view.



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- Alternatively, divide students into groups and have them hypothesize and prepare presentations on what would happen in an ecosystem if the population of one of the participants in different ecological relationships is affected.

## Homework

Q1 from the student book spread. Also workbook page 20.

## Key Words

Producers, Consumers, Decomposers, Autotrophs, Herbivores, Carnivores, Omnivores, Energy pyramids, Food webs, respiration, photosynthesis, combustion, fossil fuels, global warming, climate change, competition, predation, symbiosis, mutualism, commensalism, parasitism, replantation, waste management, recycling.

### 3.4 Student Book answers

**1.** This information is present in the spread. Encourage students to present this information in form of an infographic.

**2.** The herbivores will begin to die off due to lack of food, as the increased number of rabbits will eat any and all producers. Initially the number of carnivores will increase due to increased number of rabbits, but as the number of producer (grass) decreases, so will the number of rabbits and therefore so will the number of carnivores. However the hypothesis ignores the alternate producers that the herbivores may have in their diet, the available resources for producers, and the change in predation interactions between herbivores and carnivores.

**3. a.** if a herbivore is over-hunted, there will be more grazing for other species. Without grazing, the plant population may increase.

**b.** however, if a herbivore is over-hunted, there may end up being less available food for the natural predators of the herbivore, who will either hunt other species, or begin to die off.

# 3.5 Cycles in nature

**Student Book pages 46–47**

**Prior learning**

- living things respond to environmental conditions.

## Objectives

- Describe the role of living things in cycling oxygen and carbon through an ecosystem, citing the processes of respiration, photosynthesis and combustion.
- Relate how oxygen and carbon cycles are complementary processes that bring balance and symmetry to life on Earth.

## Overview

This chapter looks at the carbon-oxygen cycle(s) and their impact on maintaining a balanced climate. In this lesson, you introduce students to the carbon and oxygen cycles, and the different processes by which carbon (and oxygen) cycles through the living and non-living world. This topic provides opportunities for students to understand the wider impact of everyday biological processes. It also covers content which is important for success in IGCSE, and which will help your students become informed and scientifically aware global citizens.

## Activities

- Begin by reviewing the everyday processes such as respiration, photosynthesis, decomposition and combustion.

## Key Words

Producers, Consumers, Decomposers, Autotrophs, Herbivores, Carnivores, Omnivores, Energy pyramids, Food webs, climate change, competition, replantation.

- Introduce the concept that these processes are result of biotic and abiotic factors interacting in nature. Two such interactions are the carbon and oxygen cycles.
- Begin by reading through the carbon cycle text in the spread. Introduce the idea that water is not the only substance that cycles in nature.
- Explain that the carbon cycle is a series of processes that move carbon between living organisms and the physical environment.
- carbon cycle and why it is so important to living organisms.
- Discuss the carbon cycle illustration in the spread. Encourage students to pay special attention to the interactions between
- different organisms and the atmosphere and ask them examples of the different organisms involved.
- Encourage each student to recreate the carbon cycle in either a poster or diorama form.
- Move on to introducing the oxygen cycle as a series of processes that move oxygen between living organisms and the physical environment.
- Remind the students that processes discussed earlier, i.e. respiration, photosynthesis, decomposition, and combustion, are important in both cycles.
- Reinforce the idea that the carbon and oxygen cycles are complementary processes that bring balance and symmetry to life on Earth. Question 3 will be useful for this step.
- You can ask the students to research the impact of climate change on the carbon cycle or the development of sustainable technologies that reduce the impact of human activities on the oxygen cycle, as a class project.

## Homework

Q3 a from the student book spread. Also workbook page 21.

### 3.5 Student Book answers

1. **a.** The carbon cycle is a series of processes that move carbon between living organisms and the physical environment.
   **b.** It returns carbon dioxide from organisms to the atmosphere, to be taken up and used again in photosynthesis.
2. **a.** any of the following: respiration, photosynthesis, feeding, decomposition, combustion.
   **b.** Respiration takes place in all living organisms, where glucose molecules are Broken down producing carbon dioxide ($CO_2$) and water.
   **c.** Photosynthesis takes place in the green parts of plants and in algae, using energy from light, trapped by chlorophyll. The carbon dioxide from the air is combined with water to produce glucose and oxygen.
   **d.** During Feeding carbon is passed from one organism to another and some is released into the environment through respiration at the same time.
   **e.** Decomposition is the process carried out by the decomposers, which feed on the waste materials produced by animals, the dead leaves produced by plants, and the dead bodies of animals and plants. They break them down, releasing carbon dioxide back into the atmosphere.
   **f.** During Combustion energy is released in the form of light and heat. Many fuels, when they burn produce carbon dioxide and water which are released into the atmosphere.
3. **a.** encourage students to present their information in the form of an infographic, using the information in the spread.
   **b.** if the cycles are not balanced with each other, the mixture of gases in the atmosphere changes, resulting in many problems for life on Earth.


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# 3.6 Disturbing the balance

**Student Book pages 48–49**

**Prior learning**

- Humans have positive and negative effects on the environment

## Objectives

- Describe global warming and explain how threats to the carbon-oxygen balance such as overpopulation, reliance on fossil fuels and deforestation are contributing to global warming and climate change.
- Understand how using science can have a global environmental impact.

## Overview

This lesson continues directly from Unit on the carbon cycle. Your students need to understand how people affect the carbon cycle and how that, in turn, has an impact on the climate of the Earth. They look at how human activities, often based on scientific discoveries, are adding to the greenhouse effect. One common misconception is that the greenhouse effect is a bad thing, when in fact it is the greenhouse effect that maintains a suitable temperature for life on the surface of the Earth. If you can support your students to reach this understanding, they will be well prepared for their further studies in IGCSE Biology. This lesson also contains many opportunities for students to practise their Thinking and working scientifically skills in handling and manipulating data.

## Activities

- Sketch out a carbon cycle on the board by asking students to give you the different stages of the process.
- Read through 'A perfect planet' Explain the greenhouse effect carefully, Emphasise the importance of the greenhouse effect for life on Earth before moving on.
- Read through the final paragraph of this section – students should recognise that increases in carbon dioxide concentration in the atmosphere will lead to a rise in temperature at the surface of the Earth and that this will affect ecosystems.
- Work through the section headed 'People and carbon dioxide' with students. This supplies them with data for producing a pie chart showing some of the major sources of carbon dioxide resulting from human activities.
- Students answer questions 1 and 2.
- Discuss the fact that different parts of the world produce different levels of carbon dioxide with students. Emphasise there are different ways of measuring carbon dioxide production, from total output of a country or region to the mean carbon dioxide produced per person. Students read the section headed 'Who produces most?' before answering Q3.
- Summarise the main points of the lesson and ask students to consider the evidence they would look for ready for the next lesson.

## Extension

Give students the task to complete, an example of a different set of data illustrating global differences in carbon dioxide production.

## Homework

Workbook page 22.

## Key words

greenhouse gases, greenhouse effect, carbon sinks

## 3.6 Student Book answers

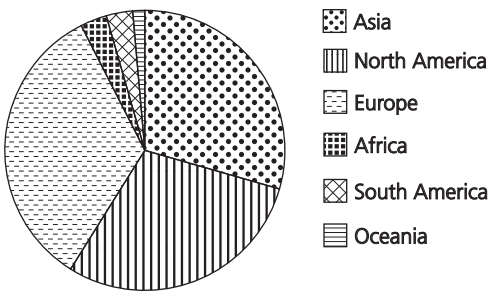
**1. a.** The greenhouse effect: Light from the sun reaches the Earth. Lots is reflected back into space. Greenhouse gases like carbon dioxide trap energy from the sun, keeping the surface of the Earth warm enough for life.

**b.** Increase in carbon dioxide = increase in the energy trapped in the atmosphere = increase in temperature at the surface of the Earth.

**2.** Human transport systems: based on engines which burn fossil fuels like petrol; when fossil fuels burn they produce carbon dioxide which goes into the atmosphere. Humans use a lot of transport so a lot of carbon dioxide produced; fossil fuels like gas, coal and oil burned to generate electricity; carbon dioxide produced when they burn increasing carbon dioxide in the atmosphere.

Deforestation: Removes trees that take carbon dioxide out of the atmosphere. The trees are burnt which adds carbon dioxide to the atmosphere.

**3. a.**




**b.** Europe produces much more of the global carbon dioxide emissions, and Asia a lot less than in modern times; no data for international aviation and shipping.

**c.** During most of the time period 1751–2017 there was no international aviation and shipping used wind power, not combustion of fossil fuels.

**d.** Asia has grown more powerful/carries out many of the industrial processes/people everywhere travel more using vehicles/people everywhere want electricity, refrigeration, etc. so usage and thus generation and carbon dioxide production goes up – any other sensible points.

# 3.7 The impacts of climate change

**Student Book pages 50–51**

## Objective

- Describe global warming and explain how threats to the carbon-oxygen balance are contributing to climate change.

## Overview

It is a common misconception with students that climate change is something new. In this lesson, you show that climate change has happened both across the history of the Earth and in relatively recent history, highlighting the evidence that shows us these changes. This is another lesson that presents opportunities for developing TWS skills, as students are asked to manipulate and draw conclusions from data.

## Activities

- Ask students what they know about climate change – vary your approach to the lesson depending on how well they understand the situation.
- Explain that the climate of the Earth appears to have been changing throughout history. Students read the section headed 'Climate change: ancient history'. Ask them to explain the different theories about cold periods and hot periods. Draw simple diagrams on the board to clarify the different causes. Students answer Q1.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- Introduce the idea that the climate has been changing and getting warmer relatively quickly in recent history and that the changes seem to be linked to increases in greenhouse gases produced by human activities.
- Read through 'Climate change: recent history' with students and discuss the ideas, including whether there has been any evidence of climate change in your own region. Students answer Q2 to summarise this information.
- Give students help to answer Q3.
- Now give students the task to design a poster to warn of the potential problems that may arise as a result of global warming. Bring students together to summarise the learning points of the lesson.

## Extension

Students write a paragraph to explain the impact of climate change on sea levels and why this is likely to have an effect on people around the world.

## Homework

Workbook page 23.

## Key words

glaciers

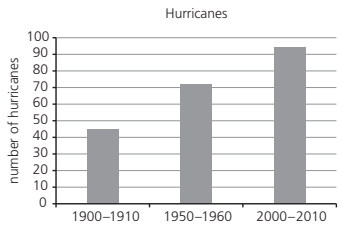
## 3.7 Student Book answers

**1. a.** e.g. glaciation/global warming.
**b.** Ash from volcanoes or dust from meteorite hits blocking the Sun; changes in orbit of Earth or activity of the Sun/increased carbon dioxide levels in the atmosphere.

**2.** Any four from: sea levels rising, flooding, drought, extreme weather events; Earth's surface temperature rising; ice melting.

**3. a.** Trend has been a steady increase in the number of major storms.

**b.**




**c.** The trend is similar – the numbers of major storms and the numbers of hurricanes increase steadily over time.
Percentage increase in storms = 81/89 × 100 = 91%
Percentage increase in hurricanes = 49/45 × 100 = 109%
Rate of increase of hurricanes greater than the increase in tropical storms.
Climate change is causing an increase in extreme weather.

# 3.8

## Predicting the future

**Student Book pages 52–53**

## Objectives

- Describe how people develop and use scientific understanding.
- Apply mathematical concepts to analyze data and present the data collected in the form of graphs, charts and tables.
- Make conclusions by interpreting results informed by reasoning.

## Overview

In this unit, students will learn how we try to predict the impact of future climate change and the difficulties of doing this. This lesson reinforces the potential impacts of global climate change and emphasises that these effects are not certain – they depend on decisions made by people and by the behaviour of each individual. There are opportunities for data handling and manipulation, giving students further valuable opportunities to practise the Thinking and working scientifically skills that are so important for success in IGCSE Biology.

## Activities

- Remind students of the greenhouse effect – ask them to describe it.
- Read through the introduction and 'How hot will it get?' with students and explain the role of the IPCC as an organisation with representatives from many different countries collecting data from scientists all over the world. They use this information to assess what is happening and to predict what impact it may have. Look at an example of the type of data they collect. Read the first short paragraph of 'Future impacts' before students answer Q1.
- Get different students to read aloud the paragraphs on the different predicted future impacts: 'Sea level rises', 'Droughts and heatwaves', 'Increased rainfall and flooding', 'Colder or warmer temperatures' and 'More extreme weather events'. Students answer Q2.
- Read through the final paragraph 'Hope for the future' and discuss the difficulty of predicting the future. Ask students for reasons, e.g. people may change the way they generate electricity/develop new cleaner technologies/drive electric cars instead of burning fossil fuels/find ways to remove carbon dioxide from the atmosphere/plant more trees/stop cutting trees down/tackle the problems of getting all countries to work together/any other factor we haven't foreseen – encourage them to think of lots of ideas. Then give students bigger, clearer versions of the graphs to answer Q3 – a Thinking and working scientifically activity, as they are interpreting and analysing data. It also provides a further activity which considers the difficulties of using evidence such as this to make predictions.
- Draw together the work so far on the difficulties of changing carbon dioxide levels or predicting climate change and global warming.

## Extension

Students complete another Thinking and working scientifically activity where they sketch graphs showing different scenarios if carbon dioxide levels increase, remain the same or fall and comment on the impact these different situations would have on conditions at the Earth's surface.

## Homework

Workbook page 24.

## Key words

Intergovernmental Panel on Climate Change (IPCC), extinct



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## 3.8 Student Book answers

1. **a.** Intergovernmental Panel on Climate Change.
   **b.** It studies evidence from thousands of scentists all over the world and advises governments globally.
   **c.** 1.3–1.8 °C
2. **a.** Sea levels will continue to rise: (26–82) cm by the end of the century.
   **b.** Low lying countries will disappear, loss of coastal land (breeding grounds etc), etc.
3. **a.** 415 − 370 = 45 (allow ±2 ppm)
   **b.** 0.6 °C
   **c. i.** Carbon dioxide: between 2000 and 2020 (20 years) increase was 415 − 370 = 45 ppm. If rate continues the same for the next 80 years will be 45 × 4 = 180 ppm more than current level. 415 + 180 = 595 ppm in 2100.
   **ii.** Surface temperature: between 2000 and 2020 (20 years) there was a 0.6 °C rise in temperature. If that continues for the next 80 years, the temperature increase will be 0.6 × 4 = 2.4 °C. Allow appropriate calculations based on student's answer in **3a**.

Extension

# 3.9 Evaluating evidence for climate change

**Student Book pages 54–55**

## Objectives

- Apply mathematical concepts to analyze data and present the data collected in the form of graphs, charts and tables.
- Make conclusions by interpreting results informed by reasoning.
- Discuss issues that involve and/or require scientific understanding Describe how people develop and use scientific understanding.

## Overview

This lesson may be used as an extension session but you can also use it for Thinking and working scientifically coverage, with lots of data analysis, and/or Science in context, with students looking at issues that affect everyone but that need scientific understanding to make the right choices. Students share some of the ways in which scientists gather evidence of historical climate changes and their effect on living organisms, and then use this evidence to predict patterns of change in the future. This work includes ideas that students may have met already, such as the analysis of ice cores, along with less well-known techniques such as tree ring analysis, bog cores and pollen species, and plant and animal distributions.

## Activities

- Remind students that people all over the world are looking for ways to tackle rising carbon dioxide levels and climate change. This is all based on scientific evidence both of rising greenhouse gas levels in the atmosphere and changes in the global climate. Ask students how we evaluate scientific evidence and decide if it is reliable.
- Look at the figure in the spread with students. It is widely used as strong evidence for rising carbon dioxide levels in the atmosphere. Read the paragraph on the Mauna Loa data and ask students to list reasons why this data is widely judged to be reliable.
- Ask students to read through the sections headed 'Looking back in Time' on and 'Predicting the future' and ask them to answer Q1. Then go through and discuss their responses to the questions, highlighting strengths and weaknesses of the different types of data.

- Give students help them to answer Q3. Ask them to answer Q3b by adding different coloured dots to the map on the worksheet, with a key to show what the colours represent.
- Look at Q4 and have a class discussion on the importance of strong evidence. Remind students to revise for end of chapter review.

## Extension

Students give a full written answer to Q4.

## Homework

Workbook page 25.

### 3.9 Student Book answers

**1.** Mauna Loa curve: Accurate, reliable, good recording conditions/ only goes back to late 1950s, only taken in one place.

Ice cores: give access to air bubbles thousands of years old, very pure/difficult to collect, accurate dating difficult.

Tree rings: Clear record, can relate weather to evidence from other sources/have to cut the tree down, most trees don't live hundreds or thousands of years.

Bog cores: clear evidence of climate at the time/ difficult to collect, depends on accurate identification of the plants.

Changes in the distribution of plants and animals: modern evidence, collected now, clear changes, local impacts/ depends on accurate observations; difficult to tell if something is extinct.

**2. a.** 32 ± 2

**b.** The weather was warm and wet. The tree grows well when conditions are warm and wet so it makes big rings like those seen here; it grows slowly when conditions are cold and dry so it makes small narrow rings.

**3. a.** 1968–1990 moths all clustered to the south of the country. 1991–2011 global temperatures increasing, moth moves north where it can survive as it is warmer.

**b. i.** The distribution of the moth stays similar. **ii.** The moths will spread even further northwards.

**4.** Climate change driven by global warming is having many impacts, e.g. rising sea levels, increased flooding, droughts and extreme weather events. The evidence shows that the rise in global temperatures is the result of rising carbon dioxide levels in the atmosphere. The evidence is also strong that the rise in carbon dioxide levels is the result of human activities. This is important because people must change their behaviour to slow or stop the rise in carbon dioxide and so slow or stop climate change. It makes it easier to convince people when the evidence is strong.

# 3.10 Humans can help

**Student Book pages 56–57**

## Objective

- Explain ways in which human behaviour (e.g. replanting forests, reducing air and water pollution and protecting endangered species) can have positive effects on the local environment.

## Overview

It is a common misconception with students that climate change is an unsolvable dilemma. In this lesson, you show that climate change has happened both across the history of the Earth and in relatively recent history, highlighting the evidence that shows us these changes. However, the students will understand how people and their everyday choices affect their local environment, which in turn, has an impact on the climate of the Earth. They will look at how human activities, often based on scientific discoveries, are adding to the greenhouse effect. One common misconception is that the greenhouse effect is a bad thing, when in fact

**Prior learning**

- biotic and abiotic factors create a balance to sustain any ecosystem.
- Recognize the value of a balanced ecosystem.

it is the greenhouse effect that maintains a suitable temperature for life on the surface of the Earth. If you can support your students to reach this understanding, they will be well prepared for their further studies in IGCSE Biology. This lesson reinforces the potential impacts of global climate change and emphasizes that these effects are not certain – they depend on decisions made by people and by the behaviour of each individual. There are opportunities for data handling and manipulation, giving students further valuable opportunities to practise the Thinking and working scientifically skills that are so important for success in IGCSE Biology.

## Activities

- Begin by asking the students their thoughts on the key points of human impact on the environment.
- Explain that historically, human behavior has had many negative effects on the environment, such as loss of ice caps and increased pollution. Explain that human behavior is impactful enough to also have positive effects on the environment, such as when forests and mangroves are replanted, thereby reducing air and water pollution, and providing homes for endangered species.
- For this lesson, introduce the 'expert group' activity. Divide the class into groups of three. These are their home groups. In each group they decide who is going to focus on which of the three parts of question 1 in the spread.
- They meet with others who have chosen the same activity and work out how to teach the others. These are the expert groups. They return to their home groups to teach each other and remain there to make a poster about what they have learned.
- Facilitate a class discussion or alternatively, a KWL chart on the topics of pollution and protecting endangered species.
- As an extension, you can assign students either of these activities:
- Poster comparing the Negative vs the Positive Effects of Human Behavior on the Environment: encourage the students to research the negative and the positive effects of human behavior on the environment. They can create a poster or presentation to share their findings with the class.
- Action Plan: Alternatively, the students can work in groups to create an actionable plan for protecting the environment. Their plan should include specific actions that they can take to reduce their impact on the environment.
- Alternatively, have them research the impact of climate change on the environment or the development of sustainable technologies that reduce the impact of human activities on the environment. They should present these findings in a presentation, with their own recommendations for- or against the adoption of said technologies.

## Homework

Questions from the student book spread. Also workbook page 26.

## Key Words

combustion, fossil fuels, global warming, climate change, replantation, waste management, recycling.

## 3.10 Student Book answers

**1. a.** because the trees are able to store lots of carbon, and constantly take carbon dioxide out of the atmosphere in photosynthesis.

**b.** reforestation is the process of replanting large areas with new young trees helps restore forest. The trees photosynthesise, using carbon dioxide from the air to build new tree biomass. They will provide shade and new ecosystems for local wildlife as well as eventually helping to prevent global warming.

**c.** students can come up with own reasons, start them off with "big old trees are existing stores of carbon which are working to take out carbon dioxide from atmosphere" and "trees take a long time to grow and provide shade and function as ecosystems for wildlife".

**2. a.** Burning fossil fuels in vehicles and factories, and burning wood in homes, leads to high levels of air pollution.

**b.** use cleaner versions of fossil fuels; use renewable and sustainable energy sources such as solar, wind and nuclear energy to generate electricity; reduce the use of fossil fuels eg increase public transport.

**3.** When ecosystems change or are destroyed, the populations of animals and plants that they support are put in danger. To protect endangered species, we must protect their environment. We must also ensure that National parks remain well managed, and hunting and poaching are banned.

# 3.11 Review answers

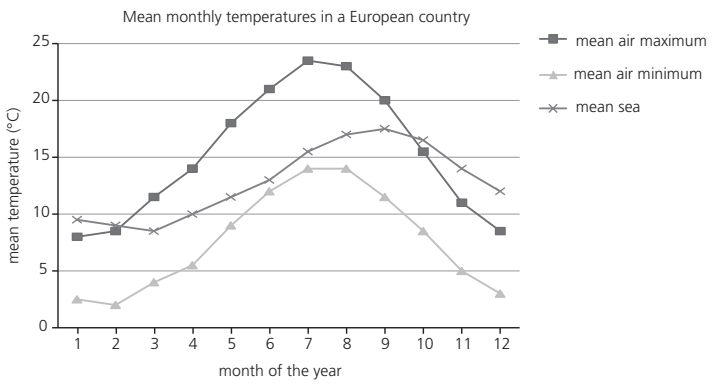
**Student Book pages 58–59**

## Student Book answers

**1. a.** An ecosystem is made up of all the organisms – animals, plants and microorganisms – that live in an area, and the physical environment they interact with. **[1]**

**b.** predation, symbiosis and competition. **[2]**

**2. a.**




**b.** Mean sea temperatures are lower than air temperatures all year.

Range of mean sea temperatures is smaller than range of air temperatures, e.g. min 8.5 °C, max 17.5 °C, whereas minimum air temp is 2.0 °C and maximum air temperature is 23.5 °C. Any other sensible points. **[3]**

**c.** Sea organisms do not have extremes of temperature to deal with – 9 °C difference all year – compared with land organisms, so they have less temperature stress, which makes life easier.

**d.** changes in air temperature, a result of greenhouse gases build up in the atmosphere, result in an increase in the temperature at the surface of the earth. As a result,



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**(i)** glaciers melt, sea levels rise and the climate changes across the world.

**(ii)** Some countries become hotter and drier, others colder.

**(iii)** Everywhere gets more extreme weather events. Storms, hurricanes and major flooding become more common and cause more damage. **[2]**

**3. a.** The carbon cycle is a series of processes that move carbon between living things and the physical environment. **[2]**

**b. i.** B **ii.** C **iii.** D **iv.** E **[1, 1, 1, 1]**

**4. a.** Photosynthesis removes carbon dioxide from the atmosphere when it is absorbed by green plants. Photosynthesis uses energy from light, trapped by chlorophyll in the chloroplasts to combine carbon dioxide with water to produce glucose and oxygen used for respiration and to build the biomass of plants. **[3]**

**b.** During respiration in animal cells, glucose molecules are broken down using oxygen, producing carbon dioxide ($CO_2$) and water. The carbon dioxide passes out of the animal into the atmosphere. **[3]**

**c.** Wood and fossil fuels like coal, oil and gas contain carbon. In combustion, they react with the oxygen in the air to produce carbon dioxide and water. Combustion puts carbon dioxide into the atmosphere. **[3]**

**d.** Decomposition is the process carried out by microorganisms such as bacteria and fungi that feed on the waste materials produced by animals, the dead leaves produced by plants and the dead bodies of animals and plants. They break them down, releasing carbon dioxide back into the atmosphere. **[3]**

**5. a.** Each segment is 18 degrees. Industry has 3 segments so 3 × 18° = 54°; 54°/360° × 100 = 15% **[4]**

**b.** Deforestation **[1]**

**c.** It reduces the numbers of trees and other plants. Plants remove carbon dioxide from the atmosphere in photosynthesis. Removing plants leaves more carbon dioxide in the air. Trees are often burned. Combustion of wood produces carbon dioxide raising the levels in the air. **[4]**

**6. a.** The concentration of carbon dioxide in the atmosphere in ppm (parts per million). **[2]**

**b.** Near the top of Mauna Loa volcano in Hawai'i. **c.** 1958 **[2, 1]**

**d.** The trend increases from 1958 to 2020. The rise in concentration is steady from 1958 to the 1990s. Then the rate at which the carbon dioxide levels go up increases. Any other sensible points, e.g. variations through each year. **[3]**

**7. a.** Cooling; glaciation/warming. **[2]**

**b.** Ash from volcanoes, dust from meteorites, changes in orbit of the Earth or activity of the sun/ increased carbon dioxide concentration in the atmosphere. **[2]**

**8. a.** Diagram similar to drawn in the unit. **[5]**

**b.** Greenhouse gases trap some of the energy from the Sun in the Earth's atmosphere. This keeps the surface of the Earth relatively warm so it is the right temperature for life. **[2]**

**c.** Current level of carbon dioxide in the atmosphere keeps the surface of the Earth at the right temperature for life. Increasing levels of carbon dioxide in the atmosphere will increase the amount of energy trapped and so increase the temperature at the Earth's surface. **[3]**

**d.** 1.3–1.8 °C **[2]**

**e.** Any selection of valid points based on different impacts of a rise in global temperatures on land, animals, plants and people. Look for descriptions, e.g. rising sea level, extreme weather events AND awareness of their impacts, e.g. loss of countries/land/breeding grounds. **[10]**

**9.** Encourage students to summarise and present the information in unit 3.10 in their own words. **[4] each**

# 4.1 Biotechnology

**Student Book pages 60–61**

**Prior learning**

- Recognize the main groups of microorganisms (bacteria, virus and fungi).

## Homework

Questions from the student book spread. Also workbook page 27.

## Key Words

Biotechnology, genetic modification, Nucleic Acid, Deoxyribonucleic acid (DNA), Traits, Characteristics, Genes, Genetic Information.

## Objective

- Define biotechnology as the use of living cells and organisms in products and processes that can improve the quality of life.

## Overview

This chapter provokes an interesting discussion about the impact of technology on our life and health. It begins with familiar materials such as bread, yoghurt and cheese, and allow students to explore the role of microorganisms in their production, before considering less familiar uses of microorganisms such as in industrial processes to make medicines. This unit lays out the introduction of biotechnology and helps students understand that it is composed of tools and techniques in use by humans since ancient times.

## Activities

- Begin by asking the students if they had bread or cheese for breakfast in the morning. Ask them if they enjoy pizza or froyo as snack?
- Introduce the idea that bread, cheese, and yoghurt are all results of use of biotechnology. Explain that biotechnology is the use of living cells and organisms in products and processes that can improve the quality of life.
- Remind the students that the study and application of biotechnology builds on the study of microorganisms and their uses. Ask students to list ways in which people use microorganisms.
- Remind the students that this unit will focus exclusively on use of microorganisms in production of food.
- Ask the students to read through the unit and facilitate a discussion on how the microbes aid in production of bread, yogurt and cheese. Ask the students if they can identify the process involved in production of these foods. Explain that:
- 1. Yeast, sugar and water mixed → yeast feeds on sugar, respires and produces carbon dioxide → mixed with flour and water, the carbon dioxide makes dough rise → bread cooked – gas bubbles expand making bread lighter, yeast killed.
- 2. Yoghurt: bacteria mixed with warm milk; feed on sugar in milk; solidifies milk and produces lactic acid which gives sharp taste.
- 3. Cheese: bacteria mixed with warm milk; feed on sugar in the milk; produce a lot of lactic acid, more than yoghurt bacteria; make milk separate into very solid curds and liquid whey; further bacteria may be added to change flavour over time.
- Divide the class into 2 groups: have one group attempt question 2 and the other attempt question 3. Encourage them to present their answers in class and facilitate a discussion.

### 4.1 Student Book answers

**1.** It is the use of living cells and organisms in products and processes that can improve the quality of life.

**2.** Encourage the students to display the information in an infographic.

**3.** Yeast is composed of living cells, which require sugar, warmth and air. When they receive these conditions, the respire and begin to grow fast, producing carbon dioxide. This carbon dioxide is what cause the bread dough to rise and the texture to become lighter.



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# 4.2

# Biotechnology and medicine

## Student Book pages 62–63

**Prior learning**

- Recognize some common diseases are caused by microorganisms.
- Recognize the advantages of microorganisms in nature.

## Objective

- Illustrate how biotechnology is a discipline/field that has the potential to transform how we live.

## Overview

This unit delves more into the use of biotechnology in production of medicines. As a result, it is more of a recent history review, which helps students develop an appreciation for application of science in real life context. Ensure by the end of lesson that students are cleared of the misconception that antibiotics can be used in viral infections, they must understand that antibiotics do not work against viruses.

## Activities

- Begin by asking students if they have heard of the term antibiotic. Ask them if they can explain what it means.
- Read the paragraphs 1-3 in class and ensure the students understand that antibiotics do not work against viruses. Encourage them to prepare a visual map of what they have learned about antibiotics in their notebooks.
- Read the paragraphs on vaccines and insulin production. Encourage the students to share what they remember from previous grade regarding uses of vaccines.
- Remind students that both, vaccine production and insulin production require huge amounts of modified bacteria to be grown. Ask them if they can suggest any methods which might work well to fulfil this requirement.
- Introduce the student to fermenters, enlisting their useful features. Read through the page 63 in class. As reinforcement ask the students to attempt question 3 in class.

## Homework

Questions 1 and 2 from the student book spread. Also workbook page 28.

## Key Words

Biotechnology, genetic modification, Nucleic Acid, Deoxyribonucleic acid (DNA), Traits, Characteristics, Genes, Genetic Information.

### 4.2 Student Book answers

**1.** Antibiotics are medicines that stop bacteria growing, or kill them, curing the infectious diseases that they cause. Many different antibiotics have been produced using the process of biotechnology, often from other microorganisms.

**2.** Encourage students to research the topic, and ensure that they include how Pakistan is developing biotechnology to create mRNA vaccines against COVID-19 and other major diseases.

**3. a.** image is present in spread 4.2. Encourage students to create a model of the fermenter using everyday objects.

**b.** fermenters are used to grow bacteria for either insulin harvesting or for other medicines or foods.

# 4.3

# Biotechnology and food science

## Student Book pages 64–65

**Prior learning**

- Recognize the main groups of microorganisms (bacteria, virus and fungi).
- Recognize the advantages of microorganisms in nature.

## Objective

- Relate the use of biotechnology in food sciences in producing foods with higher nutritional value and improved taste and quality.

## Overview

This unit is a continuation of the topics in unit 4.1. The students will discover the link between biotechnology and food science. They will be able to identify different applications of biotechnology in food science, such as the production of foods with higher nutritional values, improved taste, and quality. They will also realize the benefits and risks of biotechnology in food science, such as the potential to improve health and nutrition, but also the potential to create new allergens and environmental problems.

## Activities

- Begin by asking the students if they can identify the difference between biotechnology and food science. Remember there is no hard and fast answer, the aim is to guide students towards a connection between these two terms.
- Ask them to summarize what they remember from unit 4.1, i.e., ways in which people use microorganisms.
- Read the topics on Food science and genetic modification (GM) and food science in class. Ask the students if they can think of any scenario where they would not prefer to have increased or better tasting yield. Encourage them to think beyond GM application, in terms of real-world, variation and climate change.
- Read the paragraphs on application of GM on rice and towards surviving climate change.
- Finally review the role GM plays in fermentation.
- Encourage the students to produce a poster on the role of biotechnology and GM in food yield in Pakistan. They can focus on the "Benefits and Risks of Biotechnology in Food Science" or on "Biotechnology in the Future of Food Science".

## Homework

Questions from the student book spread. Also workbook page 29.

## Key Words

Biotechnology, genetic modification, Nucleic Acid, Deoxyribonucleic acid (DNA), Traits, Characteristics, Genes, Genetic Information.

### 4.3 Student Book answers

**1.** The study of food, including how foods are made and processed, how they are stored and how they are used. It involves many different areas of science such as biochemistry, chemistry, nutrition, microbiology, and engineering. Food science is very important in improving the food supply for the growing population around the world and in Pakistan.

**2. a.** Genetic modification is a collection of techniques which allow us to edit the genes of organisms. We can add or change genes in the DNA of an animal or plant.

**b.** GM (genetic modification) helps food scientists to remove, add or change genes in the DNA of an animal or plant. These changes may mean the organism:



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- Gives a bigger yield
- Has a better taste and quality
- Has a higher nutritional value - contains more nutrients
- Survives difficult conditions better
- Contains pesticides to reduce crop loss to pests
- Lasts longer without decaying

**3.** Rice is high in carbohydrates but relatively low in mineral nutrients such as iron, very important for avoiding anaemia.

**i.** Iron deficiency is a major health problem, especially for Pakistani women and children. Applying the biotechnology of genetic modification, scientists have successfully introduced genes from soybeans to increase the iron content of rice. This has the potential to improve the lives of millions of people around the world.

**ii.** Similarly, the deficiency of vitamin A can be overcome by introducing genes to increase the vitamin A content of rice.

**4. a.** helps to preserve foods longer than an unfermented food can be preserved.

**b.** foods fermented using GM organisms are:

**i.** Produced faster

**ii.** Use fewer ingredients

**iii.** Produce better tasting food

**iv.** Made faster and safely on a large scale.

# 4.4

# The impact of biotechnology

**Student Book pages 66–67**

## Objective

- Discuss the applications of biotechnology in a Pakistani context, and their effects on the people and the environment of Pakistan over time.

## Overview

This final unit reviews and consolidates the learning in the previous units. The students will discover how biotechnology has the potential to transform how we live. They will gain an overview of the number of key biotech institutes in Pakistan such as those in Faisalabad, at the University of Karachi and in Lahore, and the work being done there.

## Activities

- Begin by reviewing the key points of the application of biotechnology in food and health industries the students have studied so far.
- Introduce the idea that biotechnology has been practiced since ancient times and even now has the potential to transform our lives.
- Read in class the topic of biotechnology and food in Pakistan. Encourage a class discussion by the students.
- Read the section on impact of biotechnology on Pakistani Agriculture. If possible, take students on a field trip to a local biotech institute. Ask the students to prepare a report on what they observe.
- Finally, read and review the section on biotech and health in Pakistan. Facilitate a discussion on the potential of biotechnology to improve health industry, but also the potential to create newer health problems if unregulated.

**Prior learning**

- Recognize the advantages of microorganisms in nature.

- As a class project, assign students research on either of these topics: the development of new food crops that are resistant to drought OR the use of biotechnology to treat malaria.

## Homework

Questions from the student book spread. Also workbook page 30.

## Key Words

Biotechnology, genetic modification, Nucleic Acid, Deoxyribonucleic acid (DNA), Traits, Genes.

### 4.4 Student Book answers

**1.** Pakistan is known for beautiful, coloured fabrics, exported around the world. The dyes that produce the beautiful colours were originally from natural materials, now synthetic dyes are used. These often end up polluting rivers and soil, as many are toxic and do not break down in the environment. Applications of biotechnology is improving the colouring industries in two ways:

- Genetically modified microorganisms make natural dyes in large quantities relatively cheaply.
- Genetically modified microorganisms and plants break down synthetic dyes in the environment, cleaning our water and soil and making it safe to use for growing crops again.

**2. a.** food, agriculture, health.

**b.** encourage students to prepare an infographic on this topic. They can use the information in the spread or research on any one area in further detail.

**3. a.** expected life expectancy will be closer to 70 years (between 69-70 years).

**b.** life expectancy in 1950 = 34.2 years Life expectancy in 2022 = 67.6 years % increase = ((67.6-34.2)/34.2) * 100 = 97.66%

**c.** students to formulate own answer using any three of the following:

**i.** The production and availability of vaccines to protect against diseases ranging from polio, TB and cholera to COVID-19 and influenza.

**ii.** The production and availability of antibiotics which, used wisely, can cure bacterial infections for years to come.

**iii.** The development of genetically modified organisms for large-scale production of many different medicines, to treat diseases including diabetes, cancers and growth problems

**iv.** The use of gene technology to help diagnose diseases early so they are treated before they cause too much damage.

# 4.5 Review answers

## Student Book pages 68–69

## Student Book answers

**1. a.** biotechnology is the use of living cells and organisms in products and processes that can improve the quality of life.

**b.** production of yoghurt, preserved foods such as achaar, cloth dyes.

**2. a.** Bacteria feed on the sugar in milk and break it down into lactic acid. This slidifies the milk and gives it a sharp taste.

**b.** He should control the quantity of milk/ and bacteria/ and the containers they are in and should only change the temperature. Students can add any other sensible Point.



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**c.** When the pH is 4.5 (pH of yoghurt).

**d.** Encourage students to plot the graph in their graph books.

**e.** 32.5°C

**3. a.** When the dough with yeast and sugar is kept in a warm place, it gets bigger. Dough without yeast does not change size.

**b.** Yeast uses the sugar to respire. It produces carbon dioxide gas as a waste product. The bubbles of gas make the dough rise and expand.

**c.** Because the process is using yeast cells to improve the baking process and the quality of food preparation. This is the definition of biotechnology.

**4. a.** Medicines that stop bacteria growing or kill them; used to cure bacterial diseases.

**b.** i. 1300

**ii.** Accept 850 or 900

**iii.** 600

**iv.** 200

**c.** vaccination: discuss antigens and mRNA vaccines.

**5. a.**

| | |
|---|---|
| A | Motor |
| B | Warm water outlet |
| C | Oxygen inlet |
| D | Outlet for culture harvesting |
| E | Cold water inlet |
| F | Water cooled jacket |
| G | Paddle stirrer |
| H | Probe to measure temperature and pH |

**b.** Fermenters are used to grow bacteria in large quantities, in order to ultimately harvest from them the desired product, such as human insulin. The gene for human insulin (or any desired enzyme) is inserted into the bacteria, which are them grown inside fermenters. As a result, when the bacterial culture is grown and Harvested, the extract is purified to get insulin which is used to save the lives of people with diabetes in Pakistan and around the world.

**6. a.** Genetic modification is a collection of techniques which allow scientists to edit the DNA of an animal or plant, in order to add or change genes.

**b.** encourage students to prepare a poster using the information in the unit.

**7.** Students to provide answer based off of their own understanding of the issues and the current and future impact of biotechnology. Encourage them to focus on the different areas of application such as health, food sciences, industrial applications etc.

# 5.1 The Periodic Table

**Student Book pages 70–71**

## Objectives

- Recognise the Periodic Table as a way of classifying the elements in groups and periods.
- Identify the names and locations of the first 18 elements.

## Overview

Students will recognize the Periodic Table as a systematic way of classifying elements into groups and periods. They will identify the names and locations of the first 18 elements on the Periodic Table, understand the significance of their positions, and explore the patterns in their properties.

## Activities

- Present visual aids or a large version of the Periodic Table to the class.
- Discuss the concept of groups and how elements in the same group have similar chemical properties due to their similar electron configurations.
- Ask the students to locate magnesium in the periodic table.
- Discuss that the Group 2 elements are metals, with similar physical properties. They are good conductors of electricity and heat. They are shiny when freshly cut.
- They are also malleable (easy to hammer into different shapes) and ductile (easy to pull into wires). Overall, melting point decreases from top to bottom of Group 2.
- Explain the concept of periods and how elements are arranged in the horizontal rows of the Periodic Table. Magnesium is in Period 3.
- Identifying the First 18 Elements: Provide each student with a printed copy of the Periodic Table.
- Instruct students to locate and identify the names and symbols of the first 18 elements on their tables.
- Discuss the properties and uses of some of these elements as you go through the list.

## Activity: Group and Period Identification:

- Divide the class into small groups and provide each group with a chart paper and markers.
- Assign each group a specific group or period from the Periodic Table.
- Instruct each group to write down the names and symbols of elements in their assigned group or period on the chart paper.
- Have the groups present their findings to the class.
- Summarize the main points of the lesson, emphasizing the significance of the Periodic Table as a tool for classifying elements.
- Encourage students to explore and learn more about elements and their properties using the Periodic Table.
- Discuss the importance of understanding the arrangement of elements for further studies in chemistry and science.

## Extension

To extend the lesson, students can research and present on specific elements from the first 18 and their applications in various industries, investigate the properties of elements in specific groups, or conduct experiments related to the chemical properties of elements.

## Homework

Workbook page 31.

### 5.1 Student Book answers

1. B = barium Al= aluminium Ga= gallium In= indium Tl= thallium
2. Hyrodgen and helium
3. Group V
4. Period 2
5. Silicon – Si
6. Chlorine - Cl



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# 5.2 Magnificent metals

## Student Book pages 72–73

**Prior larning**

- Physical properties are properties that you can observe or measure without changing the material.
- In the periodic table, metals are on the left of the stepped line.

## Objectives

- Identify properties of metals.
- Relate the properties to the uses of metals.

## Overview

The lesson starts with an opportunity to elicit students' prior knowledge of metals and their properties. There is also a short matching activity to ensure that students understand the meanings of words describing properties. Students then do a practical activity to explore the properties of metals (and non-metals) in more detail. The lesson continues with a card sorting activity to reinforce the properties of metals. It concludes with a brief discussion about how the uses of metals are linked to their properties.

## Activities

- Display samples (as big as possible) of one or two metal elements. Ask student pairs to describe the appearance of the metals and to suggest any other properties they are likely to have. The purpose of this activity is to elicit students' prior knowledge of the physical properties of metals.
- Student pairs match cards prepared earlier to build knowledge of vocabulary that describes properties.
- Students test the following properties for a selection of elements: thermal and electrical conduction; hardness; appearance. They list the physical properties that are typical of metals.
- Students sort cards to reinforce their knowledge of typical metal properties.
- Finish the lesson by describing uses of different metals. Students note down one or two properties that explain why metals are suitable for each of these uses.

## Extension

Students use the Student Book, and the internet, to explain in more detail how the properties of some metal elements are linked to their uses.

## Homework

Workbook page 32.

## Key words

malleable, ductile

### 5.2 Student Book answers

**1.** Six from: high melting points, high boiling points, shiny when first cut, sonorous, good conductors of thermal energy, good conductors of electricity, malleable, ductile, strong

**2.** Aluminium is a good conductor of electricity.

**3.** Shiny, malleable

# 5.3 Non-metal elements

## Student Book pages 74–75

**Prior learning**

- Non-metals are on the right of the stepped line of the periodic table.

## Objectives

- Identify properties of nonmetals.
- Compare the properties of metals and non-metals.
- Deduce whether an element is a metal or a non-metal.

## Overview

The lesson begins with an opportunity to look at some non-metal elements, as well as a short activity to elicit students' prior knowledge about non-metal properties. Then follows a data analysis exercise, in which students draw bar charts to display the melting points of metals and non-metals. Finally, students explore the links between the properties and uses of non-metal elements, presenting their findings in a table or on posters.

## Activities

- Display samples of non-metal elements, for example, sulfur, carbon (as charcoal), and a gas jar with a lid labelled 'nitrogen'. Point out that the term 'non-metals' refers to elements only. For example, wood is not a metal. But, because wood is not an element, in chemistry, it is not called a non-metal.
- To elicit prior knowledge, students note in rough the properties that they think are typical of non-metals. Establish that, in the solid state, non-metals are dull (not shiny), brittle (easy to break with a hammer), not bendy, and electrical and thermal insulators. Point out that these are all physical properties, which are properties that you can observe or measure without changing the material.
- Students do the tasks including drawing a bar chart to display the melting points of some metals and non-metals. Establish that most non-metals have low melting points (and low boiling points), so they are in the gas state at room temperature. Point out some exceptions – the metal mercury has a low melting point (it is liquid at room temperature) and carbon, as diamond and graphite, has high melting and boiling points.
- Students use the Student Book to explore the links between the properties and uses of some non-metal elements.
- Finish the lesson by comparing the properties of metal and non-metal elements – either by repeating the card sort activity or by getting student pairs to ask each other questions based on the table in Student Book.

## Extension

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

## Homework

Workbook page 33.

## Key words

brittle, insulator

**5.3 Student Book answers**

1. Most in the gas state at room temperature; in the solid state, most are dull, brittle, soft, and they do not conduct thermal energy or electricity well.
2. Glass is not an element.
3. Properties of sulfur that are typical of non-metals – dull, brittle, does not conduct thermal energy/electricity well; property of sulfur that is not typical of non-metals – in the solid state at room temperature.
4. Metal
5. Paragraph including the points in the table above the question, which compares one pair of properties at a time. For example, most metals are in the solid state at room temperature, but most non-metals are in the gas state at this temperature.



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# 5.4

# Extension: Explaining metal and non-metal properties

**Student Book pages 76–77**

**Prior learning**

- Physical properties of typical metals and non-metals.

## Objective

- Explain differences in the physical properties of metals and non-metals.

## Overview

This lesson covers an Extension topic that will not be assessed, but it will help students prepare for moving on to the next stage of the curriculum.

Having observed samples of a few metal and non-metal elements, students review key differences in their physical properties. They also look at models showing the atom arrangements in typical metal and non-metal elements. Students then work in groups to learn how the different physical properties of metals and non-metals are explained by considering their particle arrangements, as well as how strongly their particles are held together.

## Activities

- Display samples of a few metal and non-metal elements. Review their physical properties, and refer to the differences shown in Student Book. Tell students that, in this lesson, they will explain the different physical properties of metal and non-metal elements by considering their particle arrangements and how strongly their particles are held together.
- If possible, use models to show how, in a metal in the solid state, the atoms are arranged in layers and how most non-metals exist as single atoms, or as molecules. If models are not available, display the diagrams in Student Book.
- Divide students into groups of four. Within each group, allocate one pair to do each question**.** The pairs are called *sub-groups*. Sub-groups tackle the questions using information from the Student Book, and plan how to teach the rest of the 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 in the spread.

## Homework

Workbook page 34.

### 5.4 Student Book answers

**1.** How the particles are arranged, how strongly the particles are held together.

**2.** Metal atoms are held together in the liquid state more strongly than the molecules or single atoms of non-metals.

**3.** Metal atoms are held together more strongly than the molecules or single atoms of non-metals.

**4. a.** X, because it has a high boiling point and is strong.

**b.** X, because it is a metal.

# 5.5

## Radius and reactivity

**Student Book pages 78–79**

## Homework

Workbook page 35.

## Extension

To extend the lesson, students can research and present on specific elements and their reactivity based on their atomic sizes, investigate the reactivity trends in different groups and periods of the Periodic Table, or explore how changes in atomic size impact chemical bonding and reactions.

## Objectives

- Define atomic radius and reactivity of elements.
- Relate reactivity of elements to their atomic sizes.

## Overview

Students will learn about atomic radius and reactivity of elements, and relate the reactivity of elements to their atomic sizes. They will explore how atomic size influences the chemical behavior of elements and understand the importance of this relationship in understanding chemical properties.

Begin the lesson by ddefining atomic radius as the size of an atom, which is measured as the distance from the nucleus to the outermost electron. Atomic radius is measured in nanometres, nm. One nanometre is 0.000 000 001 metre.

Define reactivity as the tendency of an element to undergo chemical reactions and form compounds with other elements.

## Activities

- Present visual aids or diagrams to show the relationship between atomic radius and reactivity.
- Explain that elements with larger atomic radii have more loosely held electrons in the outermost energy level, making them more reactive.
- Discuss how elements with smaller atomic radii have more tightly held electrons, making them less reactive.
- Sodium reacts vigorously with water, and with oxygen. sodium is highly reactive. The non-metals chlorine and fluorine are also highly reactive.
- The elements in Group 0, such as neon and argon, are unreactive. Unreactive elements do not take part in chemical reactions.
- Provide each student with a printed copy of the Periodic Table.
- Instruct students to identify and compare the atomic sizes of elements in different groups and periods of the table.
- Guide students to observe how elements with larger atomic radii are found in certain groups, while elements with smaller atomic radii are found in others.
- The Group 1 elements are metals. Potassium atoms are bigger than sodium atoms, so potassium is more reactive than sodium.
- The Group 7 elements are non-metals. Fluorine atoms are smaller than chlorine atoms, so fluorine is more reactive than chlorine.
- Divide the class into small groups and provide each group with a chart paper and markers.
- Assign each group a specific group from the Periodic Table (e.g., alkali metals, halogens).
- Instruct each group to discuss and write down the reactivity of elements in their assigned group and relate it to their atomic sizes.
- Have the groups present their findings to the class.
- Summarize the main points of the lesson, emphasizing the relationship between atomic radius and reactivity of elements.
- Encourage students to apply this knowledge to predict the chemical behaviour of elements and their reactivity in different situations.
- Discuss the significance of this relationship in various fields of chemistry and its role in explaining chemical properties.



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## 5.5 Student Book answers

**1.** It is the distance from the nucleus of an atom to the outermost electron.

**2.** The reactivity of a substance is its tendency to take part in chemical reactions.

**3.** Sodium is reactive and neon is unreactive.

**4. a.** 0.126

**b.** Potassium = 0.231 rubidium = 0.244

**c.** Rubidium will be more reactive because of its bigger atomic radius.

# 5.6 Review answers

**Student Book pages 80–81**

## Student Book answers

**1. a.** Periodic table

**b.** Periods

**c.** groups

**d.** non- metals

**e.** sodium

**f.** sulphur

**2. a.** N and P

**b.** H and He

**c.** Be

**d.** Al

**e.** Chlorine

**f.** strontium

**g.** Na

**h.** Ne

**3.** High melting point Shiny Malleable Sonorous Good conductor of electricity

**4. a.** B

**b.** B,C and F

**c.** A, D and E

**5. a.** C

**b.** A and D. Because they have low melting points and dull appearance.

**c.** B and C

**d.** D

**6.** Do not conduct electricity; Poor conductors of heat

**7. a.** Sodium

**b.** Aluminium

**c.** Magnesium and aluminium

**d.** Atomic radius is decreasing across the period from left to right

**e.** Sodium as due to its large atomic radius it loses its outer electrons faster.

# 6.1 Chemical reactions and Bonds

## Student Book pages 82–83

**Prior learning**

- Distinguish between reversible and irreversible changes

## Objective

- Identify chemical reactions and give examples.

## 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 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 that create new substances and are not easily reversed. In a chemical reaction, the atoms are rearranged and join together differently. Energy is transferred to or from the surroundings. Point out that chemical reactions happen everywhere, including in plants and animals, and in cooking and burning. Students read page of the Student Book.
- Students read the information in the Thinking and working scientifically box on Student Book page. Then demonstrate burning magnesium in air, or allow students to carry out the chemical reaction themselves. In either case, students must not look directly at the burning magnesium – they should observe through a narrow gap between their fingers. Introduce the terms *reactant* and *product*.
- Finish the lesson by asking a few quick questions to check that the objectives have been met.

## Extension

Students plan a short talk to tell people at home what they have learnt about chemical reactions. The talk should include a demonstration of a chemical reaction, for example, cooking.

## Homework

Workbook page 36.

## Key words

chemical reaction, reactant, product, flammable, hazard symbol

**6.1 Student Book answers**

1. A change in which the atoms rearrange and join together differently to make new substances.
2. Three from: sparks, flames, smell, temperature change, sound of fizzing.
3. Reactants – magnesium and oxygen; product – magnesium oxide.
4. Hold the magnesium ribbon with tongs; look at the flame through a narrow gap between fingers.
5. Reactants – magnesium and iron oxide; products – magnesium oxide and iron.



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# 6.2

## Mass in chemical reactions

**Student Book pages 84–85**

**Prior learning**

- In a chemical reaction, the atoms are rearranged to make new substances.
- Chemical reactions are not easily reversed, and involve the transfer of energy to or from the surroundings.

## Objectives

- Describe how atoms are rearranged in chemical reactions.
- Explain why total mass does not change in chemical reactions.
- Define the law of conservation of mass and demonstrate the law with an experiment.
- Describe one way that science can have a global environmental impact.

## Overview

In this lesson, students use models to show that – in chemical reactions – atoms are rearranged and join together differently. They then consider the use of hydrogen as a fuel, in vehicles and for cooking and heating. They communicate their findings to others by making a poster or by recording a podcast or video.

## Activities

- If possible, show a short video clip of a hydrogen-filled balloon exploding. Tell students that some rockets burn hydrogen when they take off. In this chemical reaction, the reactants are hydrogen and oxygen from the air. There is one product – water.
- Remind students that, in chemical reactions, atoms are rearranged and join together differently. If possible, student pairs use molecular model kits to model how the atoms are rearranged in the reaction of hydrogen with oxygen to make water.
- Point out that – because the numbers of atoms of each element do not change in a chemical reaction – the total mass of reactants is equal to the total mass of products.
- Tell students that hydrogen is increasingly used as a fuel for vehicles, heating, and cooking. The burning reaction is carefully controlled so that explosions do not occur.
- Ask some student groups to display the posters – or play their podcasts or films – created in response to the task given in extension below.

## Extension

Students design a model, either on paper or using available objects, to show how the atoms are rearranged and join together differently in the reaction of magnesium with oxygen. They will need to refer to the diagram in the Student Book.

## Homework

Workbook page 37.

### 6.2 Student Book answers

**1.** They are rearranged and join together differently.

**2.** The numbers of atoms of each element do not change.

**3.** 32 + 32 = 64 g

**4.** Smaller amounts of harmful substances and greenhouse gases would go into the atmosphere.

# 6.3 Investigating a chemical reaction

TWS

**Student Book pages 86–87**

**Prior learning**

- In a chemical reaction, the total mass of reactants is equal to the total mass of products.

## Homework

Workbook page 38.

## Objectives

- Demonstrate the law of conservation of mass with an experiment.
- Distinguish between different types of reactions - combustion.
- Describe some stages in a scientific enquiry.

## Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

The lesson starts with a demonstration to show that, when iron burns in air, the mass of solid product is greater than the mass of solid reactant. 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 on Student Book (planning, carrying out, and analysing the evidence). You need about 4 g of iron wool and a metre ruler, metal if possible. If the ruler is wooden, cover the end in foil before heating.
- Students investigate the mass change involved in the combustion reaction of magnesium.
- Gather together results from all groups. Most students should have found (correctly) that the mass of product was greater than the mass of magnesium at the start. Some students may have found that the mass of product was less, most likely because some magnesium oxide escaped (as white powder) on opening the lid.

### 6.3 Student Book answers

**1.** A possible explanation that is based on evidence and that can be tested further.

**2. a.** Iron wool can cut skin; iron wool catches fire easily.

**b.** Wears eye protection, wears gloves to avoid cuts from iron wool, keeps spare iron wool in a jar with a closed lid.

**3.** Make a hypothesis, make a plan, make a prediction, decide what equipment to use and how to work safely, carry out the investigation, write a conclusion, suggest improvements and carry them out.

# 6.4 Types of chemical reactions

**Student Book pages 88–89**

## Objectives

- Distinguish between different types of reaction- displacement.
- Predict whether given pairs of substances take part in displacement reactions.

## Overview

The lesson begins with an exciting demonstration – the thermite reaction. Students then read about displacement reactions. They make predictions about which metal–salt solution pairs react, and do experiments to test their predictions. The lesson ends by returning to the thermite reaction to show how it is useful and explain why it occurs.



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**Prior learning**

- The reactivity series lists metals in order of how vigorously they react with other substances.

## Activities

- Demonstrate the thermite reaction. This is described in detail on the Royal Society of Chemistry website – search for *thermite reaction RSC.* It is vital to follow the safety guidance. Students record the procedure and their observations.
- Tell students that the thermite reaction is an example of a displacement reaction. In a displacement reaction, a more reactive metal displaces a less reactive metal from its compounds. Students read Student Book. They then predict which metal–salt solution pairs react, and do experiments to test their predictions.
- Return to the thermite reaction by showing a video clip in which the thermite reaction is used to weld railway rails together. Search for *thermite welding railway* to find a video clip. Elicit that the more reactive metal (aluminium) has displaced a less reactive metal (iron) from one of its compounds (iron oxide).

## Homework

Workbook page 39.

## Key words

metal displacement reaction

### 6.4 Student Book answers

1. Metal displacement reaction – a reaction in which a more reactive metal displaces – or pushes out – a less reactive metal from its compound.
2. Reactions that occur – **a**, **c**, and **d**
   Equations: magnesium + iron oxide → magnesium oxide + iron
   zinc + copper sulfate → zinc sulfate + copper
   copper + silver nitrate → copper nitrate + silver

# 6.5 Double displacement reactions

**Student Book pages 90–91**

## Objectives

- Distinguish between different types of chemical reaction – double displacement.
- Explain what precipitation reactions are and how they are useful.

## Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

The lesson begins with a demonstration of the formation of a bright yellow precipitate, and defining key terms. Students then carry out precipitation reactions, and consider how they are useful in identifying unknown substances in solution. The lesson ends with a quick quiz to check learning from the lesson.

## Activities

- Demonstrate the formation of a bright yellow precipitate, lead iodide. Wearing eye protection and gloves, start with these solutions: 0.3 g of lead nitrate in 100 $cm^3$ of water with a few drops of 1 $mol/dm^3$ HCl; 0.3 g of potassium iodide

**Prior learning**

- A chemical reaction is a change in which the atoms rearrange and join together differently to make new substances.
- The reactants and products of a chemical reaction have different properties.

in 100 $cm^3$ of water with a few drops of 1 $mol/dm^3$ HCl. Pour one solution into a 250 $cm^3$ conical flask. Add the other solution. Immediately, a bright yellow precipitate forms. Introduce the terms *precipitate* and *precipitation reaction*.

- Elicit that a chemical reaction has happened. The two reactants in solution have reacted together to make an insoluble substance, lead iodide. This forms as a suspension of tiny solid particles, which is the yellow precipitate. Show students the summary of the reaction in Student Book and ask them to use this to name the soluble product of the reaction.
- Point out how you did the demonstration safely by displaying the hazard symbols for lead nitrate (Student Book page 82), and explaining how you took these into account.
- Students do the precipitation reactions. They also answer the questions. As a class, discuss how this method can be used to identify unknown compounds.
- Finish the lesson with a quick quiz, in which students predict the colours of the precipitates formed when different pairs of solutions react together, as well as identify the hazard symbols introduced in the lesson. For example: nickel nitrate and sodium hydroxide solutions make a pale green precipitate; copper nitrate and potassium hydroxide solutions make a blue precipitate.

## Extension

Students compare combustion and precipitation reactions, by describing how they are similar and how they are different.

## Homework

Workbook page 40.

## Key words

precipitation reaction, precipitate, combustion

### 6.5 Student Book answers

1. Precipitation reaction – reaction in which two reactants in solution react to make a precipitate; soluble – a substance that dissolves; insoluble – a substance that does not dissolve.
2. Corrosive, avoid contact with skin. Wash hands immediately if solution gets on skin and/or wear gloves.
3. Iron

# 6.6 Distinguishing chemical reactions

**Student Book pages 92–93**

## Objectives

- Distinguish between different types of reactions (combination, displacement, double displacement, combustion).
- Write word equations to represent chemical reactions.

## Overview

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

**Prior learning**

- A chemical reaction is a change in which the atoms rearrange and join together differently to make new substances.

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 *nitrogen reacts with oxygen to make nitrogen monoxide*. Tell students they can summarise the reaction using just four words by writing a word equation.
- Students follow the guidance to carry out five quick chemical reactions. They record their observations.
- As a class, discuss the observations of the chemical reactions. Give the names of the reactants and products 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. Students then complete word equations for each reaction, as instructed on the worksheet.
- Students complete the questions to practise writing word equations.

## Extension

Write a sentence to give the meaning of each word equation on Student Book. For example, sodium + chlorine → sodium chloride becomes: *Sodium reacts with chlorine to make sodium chloride.*

## Homework

Workbook page 41.

### 6.6 Student Book answers

**1. a.** Magnesium and hydrochloric acid
**b.** Magnesium chloride and hydrogen
**c.** Reacts to make
**2. a.** nitrogen + oxygen → nitrogen monoxide
**b.** nitrogen monoxide + oxygen → nitrogen dioxide
**c.** iron + sulfur → iron sulfide
**3.** zinc + hydrochloric acid → zinc chloride + hydrogen

# 6.7 Energy changes

**Student Book pages 94–95**

## Objectives

- Distinguish between endothermic and exothermic changes.
- Recognise the importance of endo ethermic and exothermic changes in daily life.
- Use temperature change to deduce whether a change is exothermic or endothermic.

## Overview

This lesson introduces exothermic and endothermic changes. It begins with a brief demonstration, to illustrate an exothermic reaction (burning) and an

**Prior learning**

- A chemical reaction is a change in which the atoms rearrange and join together differently to make new substances.

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.

## Activities

- Demonstrate burning a piece of paper or wood. Through discussion, point out that a chemical reaction is taking place. The reaction transfers thermal energy to the surroundings. 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 energy is transferred ***from*** the surroundings (the hand) to the melting ice. Melting is an endothermic change.
- **Practical activity:** Students follow the instructions to perform four chemical reactions. They classify each as exothermic or endothermic. Emphasise that, for changes involving solutions:
  - An exothermic reaction transfers energy ***to*** the surroundings. During the reaction, the energy first heats up the reaction mixture. Then energy is transferred to the surroundings and the mixture returns to room temperature.
  - An endothermic change transfers energy ***from*** the surroundings. During the reaction, the reaction mixture cools as energy is taken from it. Then energy is transferred from the surroundings and the mixture returns to room temperature.
- Finish the lesson by pointing out that every chemical reaction transfers energy to or from the surroundings, so every chemical reaction is either exothermic or endothermic. Tell students that physical changes, such as changes of state and dissolving, also transfer energy. Melting and evaporation are endothermic; condensing and freezing are exothermic. Some substances dissolve exothermically, and other dissolve endothermically. Students answer questions 2 and 3.

## Extension

Explain in detail the reasons to determine if a reaction is exothermic or endothermic.

## Homework

Workbook page 42.

## Key words

exothermic change, endothermic change

### 6.7 Student Book answers

**1.** Exothermic change – a change that transfers energy to the surroundings; endothermic change – a change that transfers energy from the surroundings.

**2. a.** For example, burning, freezing, condensing

**b.** For example – melting, boiling, evaporating

**3.** Endothermic



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# 6.8 Introducing chemical equations

## Student Book pages 96–97

**Prior learning**

- A chemical reaction is a change in which the atoms rearrange and join together differently to make new substances.
- A word equation is a simple way of representing a chemical reaction.
- The chemical formula of a substance gives the relative number of atoms of each element in the substance.

## Objective

- Interpret balanced chemical equations.

## Overview

The lesson begins by considering methane as a fuel, and noting its products of combustion. Next, students use molecular model kits to show that – in this combustion reaction, as in all chemical reactions – the number of atoms, and therefore the total mass, do not change. The lesson continues with an introduction to symbol equations, followed by opportunities to practise interpreting them.

## Activities

- Tell students that some buses burn methane gas in their engines, and point out the picture of the biobus on Student Book. Elicit that the reaction is a combustion reaction, in which methane reacts with oxygen from the air. Tell students that the burning reaction has two products – carbon dioxide and water.
- If possible, student pairs use molecular model kits to show how the atoms are rearranged and join together differently in the reaction of methane with oxygen. Student Book shows molecule diagrams of the reactants and products.
- Elicit that, for all chemical reactions, there are the same number of atoms of each element before and after the reaction. Point out that, since the number of atoms does not change, the mass of reactants is equal to the mass of products. This means that mass is conserved in chemical reactions.
- Students read the paragraphs about conserving energy on Student Book. Check that they understand the meaning of the phrase *energy is conserved.*
- Remind students that word equations are a simple way of representing chemical reactions. Students write word equations for a few reactions.
- Introduce symbol equations as another way of representing chemical reactions. Students read the paragraphs about symbol equations on Student Book page 203. Ask questions to check that they know the positions of reactants and products in symbol equations, and that they know the purpose of balancing numbers.
- Students answer the questions to practise interpreting a symbol equation.
- Students reinforce their learning from the lesson by answering questions 1–3 on Student Book spread.

## Homework

Workbook page 43.

## Key words

mass is conserved, symbol equation, balancing number

**6.8 Student Book answers**

**1.** Mass is conserved – the total mass of products equals the total mass of reactants; energy is conserved – the total amount of energy does not change.

**2.** Reacts to make

**3. a.** Carbon and hydrogen

**b.** Carbon dioxide, $CO_2$ and water, $H_2O$

**c.** Two million

# 6.9 Writing balanced equations

## Student Book pages 98–99

**Prior learning**

- A word equation is a simple way of representing a chemical reaction.
- The chemical formula of a substance gives the relative number of atoms of each element in the substance.
- Symbol equations show chemical reactions with chemical formulae.

## Objective

- Write and balance chemical equations.

## Overview

This lesson covers an Extension topic that will not be assessed, but it will help students to prepare for moving on to the next stage of the curriculum.

This lesson begins with a quick reminder about why word and symbol equations are useful. Students then practise interpreting a symbol equation. Next, students use displayed formulae to help them balance symbol equations for burning and displacement reactions. The lesson concludes with exercises in which students balance unbalanced symbol equations and write balanced symbol equations given word equations and formulae.

## Activities

- Demonstrate the reaction of silver nitrate with potassium iodide solutions. There are two products – silver iodide (a yellow precipitate) and potassium nitrate (formed as a colourless solution). Ask students to write a word equation for the reaction, and elicit that it is useful because it shows the reactants and products.
- Next, write the symbol equation for the reaction on the board. Remind students that symbol equations provide more information – they give formulae of reactants and products, as well as an indication of how the atoms are rearranged. Ask students a few questions about the reaction, for example, *How many silver atoms are shown in each side of the equation? What are the formulae of the products?*
- Students use displayed formula as a first stage in helping them to balance equations.
- Go through the stages given on Student Book pages to show students how to balance equations. Students then work through the questions. They practice balancing unbalanced symbol equations and writing balanced symbol equations given word equations and formulae.

## Homework

Workbook page 44.

### 6.9 Student Book answers

**1.** $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

**2.** $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

**3.** $N_2(g) + O_2(g) \rightarrow 2NO(g)$



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# 6.10 Making ionic bonds

**Student Book pages 100–101**

## Objectives

- Discuss the formation of ionic bonds as a result of electrostatic forces between ions (NaCl).
- Draw dot and cross structures showing the formation of ionic compounds.
- Name certain ionic compounds.

## Overview

Students will understand the formation of ionic bonds between ions through electrostatic forces, specifically focusing on the example of sodium chloride (NaCl). They will learn to draw dot and cross structures to represent the formation of ionic compounds.

## Activities

- Begin the lesson by asking students what they know about ions and how they form.
- ions are charged particles. A negatively charged ion forms when an atom gains one or more electrons. A positively charged ion forms when an atom loses one or more electrons.
- ions form in order to achieve a stable electronic structure.
- Sodium and fluoride ions form in the chemical reaction of sodium with fluorine.
- Introduce the concept of an ionic bond as the electrostatic attraction between oppositely charged ions.
- Explain that ionic bonds form between metals and nonmetals, resulting in the transfer of electrons from one atom to another.
- The Formation of Sodium Chloride (NaCl) :
- Present visual aids or diagrams to illustrate the formation of sodium fluoride (NaF) through ionic bonding.
- Discuss how sodium (Na) donates one electron to chlorine (Cl), resulting in the formation of sodium cations (Na+) and chloride anions (F-).
- The sodium ion has 8 electrons in its outer shell. The outer shell is full. Its structure is stable.
- The fluoride ion has 8 electrons in its outer shell. The outer shell is full. Its structure is stable.
- Ionic bonds act in all directions. They hold the ions in a three-dimensional
- pattern. The pattern makes a giant ionic structure.
- Explain that the positive and negative charges attract each other, forming the ionic bond in NaF.
- Drawing Dot and Cross Structures Provide each student with a blank piece of paper and instruct them to draw dot and cross structures to represent the formation of NaF.
- Guide students step-by-step as they place dots (representing valence electrons) around the sodium and chloride ions and draw arrows to show the transfer of electrons.

### 6.10 Student Book answers

1. Ions are charged particles. The electrostatic forces of attraction that hold the oppositely charged ions together is called ionic bonding. Ionic bond holds the ions in a three-dimensional pattern. The pattern makes a giant ionic structure.
2. See pages 100-101 of textbook
3. Lithium ion= +1 charge
   Chloride ion= -1 charge

## Extension

To extend the lesson, students can research and present on other examples of ionic compounds, investigate the properties and uses of specific ionic compounds in real-world applications, or explore the relationship between ionic bond strength and the properties of ionic compounds.

## Homework:

Questions from the spread and workbook page 45.

- Review the dot and cross structures drawn by the groups and ensure correct naming of the ionic compounds.
- Divide the class into small groups and provide each group with model kits or printed images of different ions.
- Instruct each group to create dot and cross structures for the formation of ionic compounds using the given ions.
- Have the groups exchange their structures and practice naming the ionic compounds based on the elements involved.
- Summarize the main points of the lesson, emphasizing the formation of ionic bonds through electrostatic forces between ions.
- Encourage students to continue practicing drawing dot and cross structures and naming ionic compounds on their own.
- Discuss the significance of ionic bonds in the formation of various ionic compounds and their importance in different fields of chemistry.

# 6.11

# Making covalent bonds

**Student Book pages 102–103**

## Objectives

- Discuss the types and formation of covalent bonds as the result of mutual sharing of electrons between atoms (e.g. $H_2$, $O_2$, $N_2$).
- Draw dot and cross structures showing the formation of covalent compounds.
- Name certain covalent compounds.

## Overview

Students will understand the types and formation of covalent bonds as a result of the mutual sharing of electrons between atoms, using examples of covalent compounds such as $H_2$, $O_2$, and $N_2$. They will learn to draw dot and cross structures to represent the formation of covalent compounds and practice naming certain covalent compounds.

## Activities

- Begin the lesson by asking students what they know about covalent bonds and how they form.
- Introduce the concept of a covalent bond as a result of atoms sharing electrons to achieve a more stable electron configuration.
- Explain that covalent bonds form between nonmetals, resulting in a molecular compound.
- Present visual aids or diagrams to illustrate the formation of covalent compounds such as $H_2S$, $H_2$, $O_2$, and $N_2$.
- Hydrogen sulphide exists as molecules. Each molecule has two hydrogen atoms and one sulphur atom. Covalent bonds hold the atoms together.
- Show the electronic structures of hydrogen and sulphur atoms. The dots (•) and crosses (x) represent electrons. All the electrons are the same, but the dots and crosses show which electron belongs to which atoms.
- In hydrogen sulphide, hydrogen and sulphur atoms achieve full outer shells by sharing electrons. Each shared pair of electrons is one covalent bond.

- Discuss how hydrogen ($H_2$), oxygen ($O_2$), and nitrogen ($N_2$) atoms each share electrons with another atom of the same element to achieve a full valence shell.
- The covalent bonds in a hydrogen sulphide molecule are single bonds.
- The element hydrogen also exists as molecules, $H_2$. There is a single covalent bond between the two hydrogen atoms.
- An oxygen atom has six electrons in its outer shell. It needs two more electrons to achieve a full outer shell. This is why there are two shared pairs of electrons in an oxygen molecule, $O_2$. A covalent bond that has two shared pairs of electrons is a double bond.
- A nitrogen atom has five electrons in its outer shell. It needs three more electrons to achieve a full outer shell. This is why there are three shared pairs of electrons in a nitrogen molecule, $N_2$. A covalent bond that has three shared pairs of electrons is a triple bond.
- Provide each student with a blank piece of paper and instruct them to draw dot and cross structures to represent the formation of covalent compounds.
- Guide students step-by-step as they place dots (representing valence electrons) around the atoms and draw lines to show the sharing of electrons.
- Divide the class into small groups and provide each group with model kits or printed images of different atoms.
- Instruct each group to create dot and cross structures for the formation of covalent compounds using the given atoms.
- Have the groups exchange their structures and practice naming the covalent compounds based on the elements involved.
- Engage students in a discussion about the formation of covalent bonds and the process of naming covalent compounds.
- Review the dot and cross structures drawn by the groups and ensure correct naming of the covalent compounds.
- Summarize the main points of the lesson, emphasizing the types and formation of covalent bonds through the mutual sharing of electrons.
- Encourage students to continue practicing drawing dot and cross structures and naming covalent compounds on their own.
- Discuss the significance of covalent bonds in the formation of various molecular compounds and their importance in various fields of chemistry.

## Extension

To extend the lesson, students can research and present on other examples of covalent compounds, investigate the properties and uses of specific covalent compounds in real-world applications.

## Homework:

Questions from the spread and workbook page 46.

### 6.11 Student Book answers

1. A covalent bond is a shared pair of electrons that holds two atoms together.
2. **a.** 2
   **b.** 4
3. An oxygen atom has six electrons in its outer shell. It needs two more electrons to achieve a full outer shell. This is why there are two shared pairs of electrons in an oxygen molecule, O2.
4. Please see page 102 of textbook

# 6.12 Review answers

**Student Book pages 104–105**

## Student Book answers

**1. a.** Chemical reaction **[1]**

**b.** Reactants **[1]**

**c.** Products **[1]**

**d.** Combustion **[1]**

**2. a.** Hydrogen and chlorine **[1]**

**b.** Hydrogen chloride **[1]**

**c.** Green **[1]**

**d.** 2 **[1]**

**e.** 2 **[1]**

**f.** There are two chlorine atoms and two hydrogen atoms in both the reactants and products. Since the numbers of atoms does not change, the mass also does not change. **[2]**

**3. a.** Precipitation **[1]**

**b.** Corrosion **[1]**

**c.** Combustion **[1]**

**d.** Precipitation **[1]**

**4. a.** 32 + 4 = 36 g **[2]**

**b.** 1.2 + 3.2 = 4.4 g **[2]**

**c.** 88 g – 56 g = 32 g **[2]**

**d.** 64 – 32 = 32 g **[2]**

**5. a.** (ii) (iii) **[2]**

**b.** lead + copper oxide → lead oxide + copper **[2]**
zinc + lead oxide → zinc oxide + lead **[2]**

**6. a.** Copper and zinc sulfate **[1]**

**b.** A more reactive metal (zinc) replaces a less reactive metal (copper) in its compound **[1]**

**c. i.** Zinc, because it replaces nickel in its compound in a displacement reaction **[2]**

**i.** zinc + nickel nitrate → zinc nitrate + nickel **[2]**

**ii.** There would be no reaction because nickel is less reactive than zinc/ nickel is lower in the reactivity series than zinc. **[2]**

**7. a.** For example, she cannot measure the masses of all metals because she does not have access to all metals / does not have time **[1]**

**b.** To allow oxygen/air to enter the apparatus so that it can react with the magnesium **[1]**

**c.** Keep spare magnesium away from flames [1]; do not look directly at the magnesium [1]; do not touch apparatus until it has had time to cool down **[1]**

**d. i.** 32.40 g – 32.00 g = 0.40 g **[2]**

**ii.** 0.40 g – 0.24 g = 0.16 g **[2]**

**e.** Because the magnesium reacted with oxygen from the air [1] and oxygen atoms have mass **[1]**

**8. a.** Oxygen and water **[2]**

**b.** Corrosion **[1]**

**c.** For example, paint the sign **[1]**



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# 7.1

## Acids, Bases and Salts

**Student Book pages 106–107**

**Prior learning**

- The chemical properties of a substance describe its chemical reactions.

## Objectives

- Give examples of acids and alkalis.
- State whether acidity and alkalinity are physical or chemical properties.
- Describe what equipment is required to carry out an investigation. Classify acids, alkalis, and salts and give examples of each.
- Identify the physical properties of acids, alkalis, and salts.

## Overview

The lesson begins with an introduction to acids and their uses. It continues by introducing the idea of alkaline solutions, which at this stage can be regarded simply as the chemical opposite of acids. Having briefly observed using litmus paper as a way of distinguishing acids and alkalis, students make their own natural indicator from hibiscus petals or red cabbage.

## Activities

- Read out the statement *Acids are dangerous*, and ask students to indicate whether or not they agree with the statement. Student pairs then sort cards into three piles – you should create these cards earlier, with examples showing that acids can be useful, examples showing that acids can be harmful, and any ambiguous examples. The purpose of the activity is to generate discussion and to dispel the misconception that all acids are dangerous.
- Introduce the term *alkaline* as the chemical opposite of an acid. Give examples of alkaline substances, and point out that – while some alkaline substances are useful (for example, toothpaste and soap) – there are hazards associated with using others. Students read the first section of Student Book page 88, which reinforces learning so far and introduces the term *neutral*.
- Display a bottle containing a colourless solution. Ask students how they could find out whether the solution is acidic, alkaline, or neutral. Introduce the idea of indicators by dropping, in turn, dilute hydrochloric acid and dilute sodium hydroxide onto red and blue litmus paper.
- Students follow the instructions to make a natural indicator. They calibrate the indictor by observing its colours in known acidic, alkaline, and neutral solutions. They then use their indicator to test an unknown solution.
- To finish the lesson, students answer questions 1 and 2 to consolidate learning so far.

## Homework

Workbook page 47.

## Key words

acidity, alkalinity, indicator neutral

**7.1 Student Book answers**

**1.** Chemical properties

**2.** Indicator - a solution of a dye that turns a different colour in acidic and alkaline solutions; neutral – a neutral substance is neither acidic nor alkaline.

**3.** Red

**4.** Yellow

# 7.2
## The pH scale

**Student Book pages 108–109**

**Prior learning**

- Indicators show whether a solution is acidic or alkaline.

## Objectives

- Define pH and its ranges with reference to indicators.
- Interpret the pH scale and identify acids and alkalis.
- Classify acids and alkalis.
- Describe some applications of science.

## Overview

Having established the need for a scale to compare the acidity and alkalinity of different solutions, students read about the pH scale. They then use universal indicator to find the pH of different solutions. Next, they apply their learning to analyse pH data. The lesson ends with a brief discussion about the discovery and uses of sulfuric acid.

## Activities

- Student pairs discuss whether or not they could use their indicator to find out which of a pair of acidic solutions is more acidic. Elicit that, with the evidence they have so far, they could not do this.
- Tell students that the pH scale measures acidity and alkalinity. Students read about the pH scale and how to measure pH on Student Book.
- Student pairs follow the procedure to use universal indicator to measure the pH of six solutions.
- Reinforce the point that, for acids, the lower the pH, the more acidic the solution. For alkaline solutions, the greater the pH, the more alkaline the solution.
- Finish the lesson by discussing the information about the discovery and uses of sulfuric acid, as describe on Student Book page 91.

## Extension

Use the Internet to find out how sulfuric acid is used to make one of the products listed in Student Book.

## Homework

Workbook page 48.

## Key words

universal indicator

### 7.2 Student Book answers

**1.** 7.0

**2. a.** Acidic solutions – black coffee, lemon juice, milk, orange juice, sulfuric acid, tea, vinegar; alkaline solutions – blood, sodium hydroxide, drain cleaner; neutral solution – pure water

**b.** Sulfuric acid

**3.** Add a few drops of universal indicator solution to each solution. Compare the colours to the colour chart and find the pH of each solution. The solution with the lowest pH is most acidic. The solution with the highest pH is least acidic.



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# 7.3 Neutralisation reactions

## Student Book pages 110–111

**Prior learning**

- The pH scale measures the acidity or alkalinity of a solution.

## Objectives

- Describe neutralisation reactions with real life examples.
- Describe neutralisation reactions with real life examples.
- Describe how to neutralise an acid.
- Describe some applications of science.

## Overview

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

## Activities

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

## Extension

Students consider how to reverse the neutralisation process and test their ideas.

## Homework

Workbook page 49.

## Key words

neutralisation

**7.3 Student Book answers**

1. Neutralisation – type of chemical reaction in which an alkali reacts with an acid and the pH gets closer to 7.
2. Ola's solution is alkaline, so he should add acid to neutralise it.
3. The soil is slightly alkaline. Onions grow best in slightly acidic soil, so he should add acid.

# 7.4 Investigating neutralisation

TWS

**Student Book pages 112–113**

**Prior learning**

- Neutralisation is a type of chemical reaction in which an alkali reacts with an acid and the pH gets closer to 7.

## Objective

- Discuss issues that require scientific understanding.

## Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

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

## Activities

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

## Extension

Students think of another question about indigestion tablets they could investigate, and plan how to answer this question.

## Homework

Workbook page 50.

### 7.4 Student Book answers

1. Independent variable – the variable that the investigator changes; dependent variable – the variable that changes when the independent variable changes/the variable that the investigator observes or measures.
2. So that the investigation is fair.
3. The measuring cylinder shows smaller differences in volume than the beaker, therefore the volume can be measured more precisely.



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# 7.5
## Acid rain

SIG

**Student Book pages 114–115**

**Prior learning**
- Some substances are acidic.

## Objective
- Discuss issues that require scientific understanding.

## Overview
This lesson helps students develop their understanding of Science in context.

The lesson begins with an introduction to acid rain, in the context of how it has damaged the Taj Mahal. Student groups then carry out an activity to answer key questions about acid rain. They plan talks and present these to each other to communicate what they have learnt. The lesson ends with an opportunity to discuss what individuals can do to reduce acid rain – either by their own actions, or through campaigns.

## Activities
- Display a picture of the Taj Mahal, and tell students that it is being damaged by acid rain. Point out that rain is naturally slightly acidic, but that some human activities make rain more acidic. Point out that governments, organisations, and individuals can take action to make rain less acidic, so preventing further damage.
- Divide students into groups of three. These are *home groups*. Within home groups, each student is allocated one question from the student book spread.
- 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 Student Book each group needs information from at least two non-consecutive sections of these pages. Expert groups also 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 plan talks to tell another group what they have learnt about acid rain.
- Home groups gives their talks to one other group. The other group peer assesses**.**
- To finish, student pairs discuss what they personally can do to reduce acid rain. Can they make better travel choices? Can they organise a campaign to persuade an organisation to reduce the amounts of acidic gases it produces?

## Extension
Students carry out their personal actions or campaigns to reduce acid rain. They might also present their talks to external audiences.

## Homework
Workbook page 51.

### 7.5 Student Book answers
**1.** Damage to buildings, damage to trees, lakes become acidic so some plants and animals cannot live in them.

**2.** Any well-reasoned answer.

# 7.6 Gas products of acid reactions

**Student Book pages 116–117**

**Prior learning**

- Chemical reactions make new substances, called products. Some products may be in the gas state.

**7.6 Student Book answers**

1. **a.** Hydrogen
   **b.** Carbon dioxide
2. Bubble the gas through limewater solution. If the limewater turns cloudy, carbon dioxide is present.
3. Collect the gas in a test tube. Place a glowing splint in the gas. If the splint relights, oxygen is present.
4. Hydrogen

## Objectives

- Identify the chemical properties of acids.
- Name the gas products of the reactions of acids with metals and with carbonates.
- Describe how to test for hydrogen, carbon dioxide, and oxygen gases.

## Overview

Students carry out tests to show the presence of carbon dioxide, hydrogen, and oxygen gases. They then name the reactants and products in two of the reactions they observed. Finally, there is a quick quiz to check learning from the lesson.

## Activities

- Demonstrate the reaction of calcium carbonate (as marble chips) with 1 mol/dm$^3$ hydrochloric acid in a big beaker. Tell students that the bubbles show that one of the products of the reaction is in the gas state. In this lesson, they will learn how to test for three gases – carbon dioxide, hydrogen, and oxygen.
- Student pairs then learn how to test for carbon dioxide, hydrogen, and oxygen. The carbon dioxide and hydrogen are made in reactions involving acids. The oxygen is made by the decomposition of potassium manganate(VII).
- Students use Student Book to name all the reactants and products in the first two chemical reactions they carried out.
- Finish the lesson with a quick quiz to check learning from the lesson. Alternatively, students answer questions 1 to 4 in Student Book.

## Homework

Workbook page 52.

# 7.7 Moving a model car

**Student Book pages 118–119**

## Objective

- Design a car that is powered solely by a chemical reaction and can travel.

## Overview

This lesson provides a fun way for students to utilise the exothermic reactions. Ensure they make safe and reasonable choices about the apparatus they use. Next, help them carry out a risk assessment for the experiment they will do to power their creation.

## Activities

- Begin by reviewing the types of reactions with the students.
- Help them follow the procedure as laid out in the book.
- Ensure Safety and Risk Assessment is carried out prior to start of experiment.
- Once the experiment is complete, ask the students for their feedback re how the experiment can be improved.


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**7.7 Student Book answers**

**1.** ethanoic acid and sodium hydrogen carbonate

**2. a.** sodium ethanoate, carbon dioxide and water

**b.** carbon dioxide

**3. a.** Any from the list given in TWS box.

**b.** the distance travelled due to force of reaction and production of gas.

# 7.8 Making salts from acids and metals

**Student Book pages 120–121**

**Prior learning**

- Acidic solutions have a pH less than 1.

- Repeat the experiment incorporating reasonable suggestions.

## Homework

Questions from the students book.

## Objectives

- Define the term salt and give examples of salts.
- Describe how to make a salt from a metal and acid.
- Interpret the pH scale and identify salts.
- Choose suitable equipment.
- Do a risk assessment.

## Overview

The lesson starts with a look at salts, and defining the term in chemistry. Students then make choices about the apparatus to use in making a salt in the laboratory. Next, they carry out a risk assessment for the experiment they will do next lesson – making magnesium chloride from magnesium and hydrochloric acid. Finally, students answer questions about the planned practical.

## Activities

- Display crystals of different salts. Include coloured salts, for example, copper sulfate and salts of iron. Tell students that a salt is a compound made when a metal ion replaces a hydrogen ion in an acid.
- Tell students that, next lesson, they will make their own salt, magnesium chloride. Display apparatus pairs, as below, and ask student pairs to choose the more suitable piece of apparatus from each pair. In each pair, the first mentioned apparatus listed is more suitable:
    - Measuring cylinder or beaker to measure acid volume.
    - Beaker or conical flask as the reaction vessel, in which the reacting mixture is stirred.
    - Filter paper and funnel or sieve to separate solid magnesium from magnesium chloride solution.
    - Beaker or conical flask to collect the filtrate in filtration.
    - Evaporating dish/basin or beaker to evaporate water from the magnesium chloride solution that is made in the reaction.

### 7.8 Student Book answers

1. A salt is a compound made when a metal ion replaces the hydrogen ion in an acid.
2. Filtration
3. zinc + hydrochloric acid → zinc chloride + hydrogen
   salt made – zinc chloride
4. Iron and sulfuric acid

- Students make magnesium chloride crystals from magnesium and dilute hydrochloric acid. They then complete a risk assessment for the activity.
- To finish the lesson, students answer the questions in the student book spread.

## Extension

Students answer question 4.

## Homework

Workbook page 53.

## Key words

salt

# 7.9 More about salts

**Student Book pages 122–123**

**Prior learning**

- Acidic solutions have a pH less than 1.

## Objective

- Choose reactants to make different salts

## Overview

In this lesson, students carry out the practical activity they prepared for in the last lesson, to make magnesium chloride crystals from a reaction between a metal and an acid.

## Activities

- Show students the picture of the salt lake and elicit the definition of the term *salt* in chemistry.
- Students make magnesium chloride crystals, following the method and using the risk assessment they did in the previous lesson.
- Finish the lesson by asking student pairs to order these steps for making salt crystals from a metal and acid: evaporation, filtration, chemical reaction, crystallization.

## Extension

Students write a plan to describe how to make zinc chloride crystals.

## Homework

Workbook page 54.

## Key words

salt

### 7.9 Student Book answers

1. **a.** Hydrochloric acid
   **b.** Sulfuric acid
   **c.** Nitric acid
2. Sulfuric acid and either copper oxide or copper carbonate
3. nickel carbonate + hydrochloric acid → nickel chloride + carbon dioxide + water



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# 7.10

## Making salts from acids and carbonates

TWS

**Student Book pages 124–125**

**Prior learning**

- A salt is a compound made when a metal ion replaces the hydrogen ion in an acid.

## Objectives

- Describe how to make a salt from a metal and an insoluble carbonate
- Evaluate a method and suggest improvements
- Observe and write the uses of salts in daily life.

## Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

The lesson starts with a look at copper sulfate. How is it useful? Having assessed hazards, students make copper sulfate from copper carbonate and sulfuric acid. They consider how to maximise the yield of the product, and write word equations to summarise the reactions of other carbonates with acids.

## Activities

- Display crystals of copper sulfate. Ask how the salt is useful. One use is as a fungicide – farmers use it to control fungi on grape plants.
- Tell students they will make their own copper sulfate crystals. Ask students to identify hazards and risks, and to suggest how to reduce the chance of injury or damage.
- **Practical activity:** Students follow instructions to complete a risk assessment and make copper sulfate crystals from copper carbonate and dilute sulfuric acid.
- Students answer questions about the procedure they have followed, including how to maximise the yield of the product.
- Finish the lesson by asking student pairs to remind each other of the definition of the word *salt* in science.

## Extension

Students name the products of – and write word equations for – other reactions of acids with carbonates.

## Homework

Workbook page 55.

### 7.10 Student Book answers

**1.** copper carbonate + sulfuric acid → copper sulfate + carbon dioxide + water

**2.** Chemical reaction, filtration, evaporation, crystallisation

**3.** The water bath heats the mixture more evenly, so spitting is avoided.

**4.** zinc carbonate + hydrochloric acid → zinc chloride + carbon dioxide + water
salt made – zinc chloride

**5.** Magnesium carbonate and nitric acid

# 7.11 Review answers

**Student Book pages 126–127**

## Student Book answers

**1.** Less than, more than, equal to **[3]**

**2. a.** Orange juice – acidic; milk – neutral; cola drink – acidic; sweat – acidic; indigestion medicine – alkaline **[5]**

**b.** Indigestion medicine **[1]**

**c.** One from – orange juice, cola drink **[1]**

**3. a.** Magnesium sulfate **[1]**

**b.** Zinc chloride **[1]**

**c.** Magnesium nitrate **[1]**

**d.** Copper chloride **[1]**

**e.** Zinc sulfate **[1]**

**4. a.** Acidic – red; alkaline – blue **[2]**

**b.** From red [1] to blue **[1]**

**5. a.** Hydrogen **[1]**

**b.** Oxygen **[1]**

**c.** Carbon dioxide **[1]**

**6. a.** Because extra acid comes out in the urine **[1]**

**b.** Its pH increases because the extra alkali comes out in the urine **[1]**

**c.** pH of urine will increase / urine will become more alkaline **[1]**

**7. a.** Cassava **[1]**

**b.** Pineapple and cassava **[2]**

**c.** One from: pineapple, banana, sugar cane, maize, cassava **[1]**

**d. i.** Maize and cassava **[2]**

**ii.** Acid **[1]**

**8. a.** Beaker **[1]**

**b.** Funnel [1] and beaker or conical flask **[1]**

**c.** Test tube **[1]**

**9. a. i.** 7 **[1]**

**ii.** 4.5 **[1]**

**iii.** 22 minutes **[1]**

**b.** More **[1]**

**c.** 13 minutes [1] (from 1 minute to 14 minutes after she ate the sweet)

**d.** Alkaline **[1]**



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# 8.1

## Force and Pressure

**Student Book pages 128–129**

**Prior learning**

- Recognise that when things speed up, slow down, or change direction there is a cause
- Explore how forces can make objects start or stop moving
- Explore how forces, including friction, can make objects move faster or slower or change direction

## Objectives

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

## Overview

This lesson introduces balanced and unbalanced forces using the idea of a car moving and a tug of war. Most students will understand that forces can cancel out, and that if they do not cancel then the motion of objects will change.

Students learn that an object moving with a steady speed can have balanced forces acting on it. A common misconception is that something needs a force acting on it to be moving at all. Students explore the idea of a friction-compensated slope, showing that objects can move with a steady speed when a force of gravity and a force of friction cancel each other out.

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

## Activities

- Ask students to list some situations where objects are speeding up, slowing down, or moving with a steady speed. Ask them to add arrows to a picture of a car that is not moving, accelerating, decelerating, or moving with a steady speed. Introduce the idea of forces being 'balanced' or 'unbalanced'.
- Students follow instructions in pairs to use two forcemeters to look at the effect of different size forces on the motion of an object. **(Safety: Students should not over-extend the spring balances.)**
- Demonstrate the idea of balanced forces on a moving object with a trolley or toy car on a ramp. With the ramp flat, push the car. Ask the students about the forces acting at each stage (when your finger is in contact with the car, when it is no longer in contact, when it has stopped). Discuss the effect of friction on the motion.
- Next, raise the ramp until friction is just compensated for. This time if you push the car it should move with a steady speed. There is just enough of the gravitational force to compensate for friction so it moves with a steady speed.
- Students draw diagrams showing the forces on the car when the ramp is steep, when it just compensates for friction, and when it is horizontal.
- Students consolidate what they have done by making a cartoon strip of a skydiver jumping out of a plane.
- Show a picture of a rocket taking off. Ask students if there are any forces acting on it. How can they tell that there are forces acting on it when they cannot see them?.

## Homework

Workbook page 56.

## Key words

balanced, unbalanced, accelerate, decelerate, resultant, terminal velocity

**8.1 Student Book answers**

1. balanced, unbalanced, balanced, unbalanced
2. The ball will speed up/ accelerate downwards.
3. Alom is correct: objects can move at a steady speed with no resultant force on them.

# 8.2

## Using forces: Friction

**Student Book pages 130–131**

**Prior learning**

- Explore how forces can change the shape of objects

## Objectives

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

## Overview

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

## Activities

- Ask students to rub their hands together. Establish that there is friction between them and ask them what causes that friction. By looking carefully at the surface of their skin they can see the ridges, grooves, and mounds that get caught when they rub them together. This produces the resistance to motion of their hands so that they 'grip'.
- Ask students to make a table headed 'Useful and unwanted friction'. Use the example of a bicycle: the brakes work because of friction, but air resistance slows them down. They identify places where friction is useful and where it is a nuisance. Elicit the fact that we lubricate surfaces to reduce friction.
- Students investigate how different lubricants reduce friction. They pull a block along a surface with and without lubricants and measure the effect. **(Safety: Ensure students report any spillages.)**
- Possible independent variables include:
  - the effect of the surface on the ramp/floor
  - the effect of mass of the trolley
  - the effect of speed (by changing the angle of the ramp).
- Ask students to link what they have learned about friction to how they are able to walk! It is a very simple question, but they may not have thought about the role of friction in walking. When is it easy to walk and when is it not easy? Use ideas about the microscopic reasons (shown in the Student Book) for friction to explain the observations.
- Students can make a model of a hovercraft and describe how this reduces friction. **(Safety: Take care when making the hole.)**

## Extension

Repeat the activity but vary the height of the ramp.

## Homework

Workbook page 57.

## Key words

friction, lubrication, lubricant



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## 8.2 Student Book answers

1. Useful: correct example such as walking, driving a car, riding a bicycle. Not useful: correct example such as: skiing, chain on a bicycle, skateboard wheels.
2. **a.** All surfaces are uneven. When an object slides over another object, the bumps in the uneven surfaces collide with each other, producing the force of friction.
   **b.** The layer of oil means that the bumps do not collide with each other so much. The surfaces slide over each other more easily.
3. **a.** The friction will be less because the surfaces can slide over each other. This means that the skater can go faster.
   **b.** The skater can push the jagged edge into the ice to produce enough friction to stop.
4. The water would act as lubrication between the tyre and the road, causing the car to slide (skid).

# 8.3 Using forces: Tension and upthrust

**Student Book pages 132–133**

**Prior learning**

- Explore how forces, including friction, can make objects move faster or slower or change direction
- Recognise friction (including air resistance) as a force that can affect the speed at which objects move and that sometimes stops things moving

## Objectives

- Describe what happens when you stretch a spring Describe what is meant by elastic limit Explain how upthrust is produced.
- Explain why things float or sink.

## Overview

This is a two-part lesson. In the first part students stretch a spring to find the elastic limit. This links to what they learned about forcemeters in Stage 7 Forces, and links to an experiment collecting data about elastic bands in the 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. This lesson links to the lesson on density. They will need the results of their spring investigation for the 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. 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. **(Safety: Ensure students wear eye protection at all time. Ensure that the stand cannot topple over – clamp the stand or weigh it down.)**
- Ask students to deduce the elastic limit from their results. Elicit the fact that springs stretched beyond their elastic limit do not return to their original length.
- Discuss the use of springs in forcemeters and scales. Elicit the idea 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. **(Safety: Ensure students report spillages or breakages.)**

## 8.3 Student Book answers

1. **a.** 1.5 cm
   **b.** 3.0 cm
   **c.** 7.5 cm
2. 20 000 N, upwards
3. The extension of the bungee cord depends on the weight of the person. If their weight is large then the extension of the bungee cord will be large. If the cord became too long, the person might hit their head on the surface below.

- Discuss the link between the upthrust and the weight in terms of floating and sinking. Students should have deduced that objects float when the upthrust equals the weight.
- 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.

## Homework

Workbook page 58.

## Key words

tension, elastic, plastic, proportional, elastic limit, permanent extension, upthrust, Archimedes' principle.

# 8.4 Presenting data from springs

TWS

**Student Book pages 134–135**

## Objectives

- Describe how to present results in tables.
- Describe how to draw lines of best fit and identify anomalous results.
- Explain which data points are reliable.

## Overview

This lesson helps students develop their skills in Thinking and Working Scientifically.

Students consider how to present the data that they collected in an experiment about stretching an elastic band. They 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 that they collected in the last lesson for the extension of a spring when weights were added to it.
- Discuss the types of graph that you can plot and why. Students can look at the different graphs and charts in the Student Book.
- 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.


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- Students compare the graphs that they have drawn and discuss what to do about any anomalous points.
- Students use the data to plot an appropriate graph or chart. They consider other variables and explain which graphs could be plotted.

## Homework

Workbook page 59.

## Key words

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

### 8.4 Student Book answers

**1.** The name of the variable and the unit.

**2.** Draw a smooth line (straight or curved) that goes through as many points as possible, with as many points above as below the line.

**3.** 3N

**4. a.**

| Colour | Extension (cm) | | | Mean extension (cm) |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| | | | | |

**b.** Colour is a categoric variable. Variables need to be continuous to be plotted as a line graph.

# 8.5 Floating and sinking

**Student Book pages 136–137**

## Objective

- Explain why some things float and some things sink in water

## Overview

Students practice calculating the densities of everyday materials. They learn how density is related to floating and sinking, and consolidate what they have learned by predicting whether objects will float or sink.

## Activities

- Introduce or review the idea of density by showing blocks that are the same size (volume) but have different masses (e.g. metal, wood, glass).
- Recap the units of mass and volume. Introduce density as the ratio of mass to volume. Do a simple calculation for one of the blocks. Demonstrate how to measure the volume and use a balance to measure the mass. Discuss all the possible units for density given the possible units for mass and volume.
- Give students measuring cylinders with coloured liquid and ask them to measure the volume by looking upwards, downwards, and straight at the scale. Discuss the effect of the meniscus and how you should measure volume. This can be extended to making accurate measurements with a ruler.

- Give students a fruit or a vegetable and ask them to suggest how they would measure its volume. Elicit the idea that you can measure the volume of an irregular solid using a measuring cylinder or beaker of water.
- Students find the densities of a range of objects. Students put the fruit and vegetables in order of most dense to least dense before they start, and do the same with the liquids. Present the liquids in containers of different volumes. Some objects will float, such as apples; encourage students to find a solution with the equipment they have (they can use tongs or tweezers to hold the fruit submerged without displacing a lot of extra liquid). **(Safety: Ensure that students report spillages, and that they look up hazards associated with the liquids they use.)**
- Discuss why things float or sink. Take a fruit with a skin that is not very dense (mandarin oranges work well). Show that it floats in water. Peel it and show that it sinks in water. The peel should float. Ask the students to explain this. Recap upthrust and weight. They should now link weight and mass to density.
- Students investigate floating and sinking, and look for a pattern. Discuss the results, and what would happen if you put two liquids of different densities in the same beaker. **(Safety: As above. Ensure students work carefully with scalpels.)**
- Demonstrate that things 'float' at the boundary where they are denser than the top layer. Put liquids of different densities in a large measuring cylinder and add different objects. Descriptions of similar demonstrations can be found online (e.g. https://science-u.org/experiments/density-tower.html, http://www.stevespanglerscience.com/experiment/seven-layer-density-column).

## Homework

Workbook page 60.

## Key words

density, upthrust

### 8.5 Student Book answers

**1.** The water is denser than the person (so the upthrust balances their weight).

**2. a.** density $= \frac{100\,\text{g}}{90\,\text{cm}^3}$

$= 1.1\,\text{g/cm}^3$

**b.** It will sink, because its density is greater than that of water.

**3. a.** The submarine dives when the upthrust is less than its weight/when the density of the submarine is greater than that of water. It increases its density by allowing water to enter compartments so the mass increases, but the volume stays the same.

**b.** When the submarine must rise to the surface, the water is pumped out, so the mass is less but the volume is the same, so the density becomes less than water and it rises.



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# 8.6

## Using ideas about density

SIC

**Student Book pages 138–139**

**Science in context**

- Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.
- Describe how people develop and use scientific understanding, as individuals and through collaboration, for example through peer review.

## Objectives

- Describe how ideas about density have been used.
- Describe how scientists worked in the past and how they work now.

## Overview

This lesson helps students develop their understanding of science in context.

Students learn about Al-Biruni and how he worked as a scientist hundreds of years ago. They examine his method for working out the density of a solid and compare its precision with methods used today. They consider the range of activities in which scientists engage now and how that differs from how they worked in the past. Finally, they consider the role of technology in making precise and accurate measurements.

## Activities

- Students start by reading about Al-Biruni and the experiments that he did with gemstones. Discuss the issues with making very precise measurements of density. Elicit the difference between precision and accuracy by asking students to recall different measurement methods that they have used in science.
- If available, show some minerals and pictures of jewellery with various gemstones in them.
- Students complete an activity to compare the methods of measuring the density of a regularly shaped piece of glass and an irregularly shaped crystal. In this activity they make a model of Al-Biruni's apparatus for measuring volume and compare its use with other methods. **(Safety: Ensure students report spillages, and do not drop rocks or crystals.)**
- Discuss the results that they have obtained, particularly in terms of precision. Groups could present their results and the results could be collated to show the variation between the results. Discuss how scientists obtain very precise values of things like density. If available, show a variety of different weighing scales and balances that measure mass to different degrees of precision. Find the mass of some objects on each balance and discuss the differences.
- Students consolidate their knowledge by looking at data for various gemstones.
- Students research how scientists work today, and how that compares to Al-Biruni. Find and check in advance useful sites to suggest, such as https://www.careerexplorer.com/careers/scientist/. Students make a poster that describes the similarities and differences between the work of early and modern scientists. Alternatively, ask students to research a scientist from the past and a scientist who works today and prepare a poster that contrasts how they work. Students could do this in preparation for this lesson and present their findings at the end.

## Homework

Workbook page 61.

## Key words

gemstone, mineral, accuracy, precision

**8.6 Student Book answers**

**1.** To check whether gemstones were real or fake.

**2. a.** He built on the work of other scientists.

**b.** He worked alone; today most scientists work in teams.

**3.** It took a long time to develop new types of measuring instruments that could produce more precise values of mass and volume.

# 8.7

## Pressure

**Student Book pages 140–141**

## Objectives

- Explain what causes pressure.
- Calculate pressure.

## Overview

In this lesson students learn about pressure and how to calculate it. They look at situations where it is advantageous to spread a force out over a large area. This links to the next lesson where they will look in more detail at different situations in which you need either a small or a large pressure.

In the first two experiments in this lesson students calculate the pressure that they exert and that a block of wood exerts. Finally they complete another experiment making indentations in soft materials to work out forces and areas using the pressure equation. Students may need support with conversions between units of mass and working out weight.

## Activities

- Show pictures of wading birds' feet, camels' feet, and an earth mover, and ask students for the connection between them. Elicit the idea that the area in contact with the ground is large so that they do not sink.
- Introduce the concept of a force being spread out over a particular area and that we call that pressure. Discuss what units you might use to measure pressure, and show students how to calculate it using the pressure equation. Discuss the fact that the units of pressure will depend on the units of area. Students practice using the equation.
- Students explore the idea of pressure in two experiments. **(Safety: Ensure students do not drop the brick or block of wood on fingers or feet.)** In the first experiment they calculate the pressure that they exert on the ground when they are standing on one foot and then two. In the second experiment they calculate the pressure when a brick is placed on a desk on sides of different areas. Discuss the results, and their suggestions for demonstrating the difference in pressure. Elicit/suggest putting the brick on a surface that is easily deformed, like mud.
- Students complete a further experiment into pressure using modelling clay or a similar material. They estimate the pressure needed to make an indentation in the modelling clay and use that number to estimate the weight or area of other objects that would be needed to produce a similar indentation.

## Homework

Workbook page 62.

## Key words

pressure, force, area, newton per metre squared, newton per centimetre squared

### 8.7 Student Book answers

**1.**

| Force | Area | Pressure |
|---|---|---|
| 150 N | 25 $cm^2$ | 6 $N/cm^2$ |
| 60 N | 15 $m^2$ | 4 $N/m^2$ (4 Pa) |
| 5 N | 0.1 $cm^2$ | 50 $N/cm^2$ |

**2.** force = pressure × area
= 0.01 $N/cm^2$ × 300 $cm^2$
= 3 N

**3.** area = force/pressure
= 15 N/0.5 $N/cm^2$
= 30 $cm^2$

**4.** area = force/pressure
= 40 000 Pa/250 000 N
= 0.16 $m^2$
This is the area of 4 feet, so the area of one foot is 0.16 $m^2$/4 = 0.04 $m^2$



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# 8.8
## Using pressure

**Student Book pages 142–143**

## Objectives

- Describe how large pressure can be useful.
- Describe how small pressure can be useful.

## Overview

In this lesson students apply what they have learned about pressure in the previous lesson to a variety of situations. They complete an investigation to show how a bed of nails spreads a force over a large area. They use what they have learned to think about the design of footwear for soft surfaces (such as using studs) and spreading force over a big area in terms of animals' feet and quicksand.

## Activities

- Show pictures of people lying or sitting on a bed of nails. Tell students that it doesn't hurt and ask why. Elicit that the force (weight) is being spread over a large area.
- Students design an experiment to find the effect of using lots of nails, and present their results in a graph. They use their results to predict the effect of using very large numbers of nails, such as in a bed of nails. You may need to steer students towards producing a cylinder about the same size as an inflated balloon. They put the boards with nails pointing up at the bottom, then the balloon, then the piece of card/thin wood with the masses on top. **(Safety: Ensure students check the design of their experiment with you before beginning.)**
- Alternatively students could design an experiment to show the link between force, area, and pressure. This could involve measuring the depth that blocks of different area and weight make in a soft material, like dough.
- There are situations in which we want a large pressure, and others in which we want a small pressure. Students think of a variety of examples and give reasons for their answers.
- They investigate the design of boots with studs, and animal foot size and walking on quicksand.

## Extension

Students work out the pressure required to burst the balloon in each of their experiments.

## Homework

Workbook page 63.

## Key words

pressure, force, area

### 8.8 Student Book answers

1. Blunt knife blades have a large area, so the pressure is reduced, so they may not cut.
2. The area of their feet is bigger than that of most animals of the same weight. This produces a smaller pressure so they do not sink into mud or sand so easily.
3. The pressure produced by the bird with bigger feet will be half the pressure produced by the bird with small feet. Pressure is inversely proportional to area/depends on 1/area.
4. You would sink in to the soft surface because the pressure would be bigger.

# 8.9 Pressure in liquids

**Student Book pages 144–145**

## Objectives

- Explain liquid pressure in terms of particles.
- Explain why liquid pressure increases with depth.

## Overview

In this lesson students investigate the pressure in liquids and how it varies with depth. They learn about the force of a liquid acting in all directions and link the pressure in liquids to the incompressibility of liquids. They learn how to measure pressure with a pressure gauge.

## Activities

- Hold a plastic bag full of water over a big bowl. Ask students to draw what they think will happen if you make a hole in the bag. Demonstrate that the water leaves the bag in a direction that is at right angles to the side of the bag. Make holes all over the bag to show that this is always the case. Make sure that you have a big enough bowl or tray to catch the water.
- Discuss how pressure might vary with depth. Ask students what impact that might have on the design of a dam, or on submarines and other vessels that go deep in the ocean. Show pictures of a cross-section of a dam and a submarine or similar vessel.
- Students investigate how pressure varies with depth using a large plastic bottle with a hole at the bottom. They learn that it is important to repeat experiments where it is difficult to take reliable readings, as in this case. Ask students to present their finding to the class, and explain the measures they took to get accurate results, and their choice of graph. Elicit the link between liquid pressure produced by the weight of water above the hole, and depth as demonstrated in the experiment. **(Safety: Ensure students report spillages.)**
- Demonstrate how you can use a pressure gauge to measure the pressure of a gas. They will be using such a gauge next lesson. Challenge groups to work out what is inside it.
- Demonstrate the 'Cartesian diver' (details at e.g. http://www.exploratorium.edu/snacks/condiment_diver/). Show how an increase in pressure in the liquid compresses the gas inside the diver so that it sinks.

## Extension

Students could find out how submarines are constructed to withstand large water pressures.

## Homework

Workbook page 64.

## Key words

compress, incompressible, upthrust, liquid pressure, pressure gauge

### 8.9 Student Book answers

**1.** The pressure in a liquid is a result of the forces between particles and a surface acting over a particular area.

**2.** The pressure is bigger at the bottom of the ocean than at the surface due to the larger weight of water above pressing down.

**3. a.** The water will come out faster from hole **B**. This is because **the weight of water above produces more pressure in the liquid at the bottom than part-way up**.

**b.** The water comes out at right angles because liquid pressure acts in all directions, so is pushing the water out of the holes.

**c.** The speed will decrease as the water drains out because the pressure decreases as the weight of water above decreases.

**3.** The pressure is shown by the amount of the tube that unwinds. When the tube has unwound, that is the limit of the pressure that can be measured.



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# 8.10

## Pressure in gases

**Student Book pages 146–147**

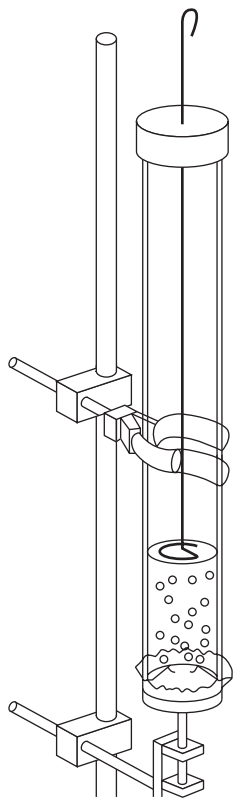

**Figure:** Ball bearings in a clear plastic tube with a plastic piston

## Homework

Workbook page 65.

## Key words

gas pressure, compress, proportional, directly proportional, inversely proportional, atmospheric pressure

## Objectives

- Explain gas pressure in terms of particles.
- Explain the factors that affect gas pressure.

## Overview

In this lesson students learn that a gas exerts a pressure on the walls of a container because the gas particles collide with the walls. They learn about how the pressure changes with volume and link that with the behaviour of gas particles. They learn about atmospheric pressure and explain some effects of atmospheric pressure. In the extension lesson that follows they will consider the macroscopic properties of pressure, volume, and temperature and how these link to the microscopic behaviour of gas particles.

## Activities

- Heat approximately 2 cm of water in a conical flask until it boils. Turn off the Bunsen burner and then place a hard-boiled egg (shell removed) into the neck of the flask.
- As the water vapour cools back to liquid, the air pressure on the egg from outside will be greater than from inside and the egg will appear to be sucked in whole. Use this to stimulate discussions of pressure. Explain what is happening in terms of particles using a suitable animation. Discuss how gases produce pressure because of collisions with the container.
- Students complete an experiment to collapse a can using air pressure. **(Safety: Ensure students wear goggles for this experiment. Steam can scald; so can hot water. They should stand with the can at arm's length when turning it upside down into the washing-up bowl. Ensure the bowl is filled almost to the top with cold water.)**
- Students explain what happened in the collapsing can experiment by drawing a storyboard of each stage of the experiment. Alternatively, they explain what happened.
- Use a demonstration with ball bearings in a clear plastic tube with a plastic piston to show the change in the number of collisions, as shown in the diagram on the left. Make the diaphragm at the bottom vibrate the tube contents with the piston at a certain height. Move the piston down and make the diaphragm at the bottom vibrate again.
- Ask students to describe what happens to the collisions between the particles and the walls of the container as the volume is decreased. They use words such as more/less/bigger/smaller.
- Ask students to describe what happens to the collisions between the particles and the walls of the container as the diaphragm moves up and down more quickly. They use words such as more/less/bigger/smaller.
- Students make a list of ways in which this is a good model of pressure in a gas, and also the limitations of the model.

## Extension

In the final activity get students to think about the quantitative effect of halving the volume.

# 8.11

## STEAM

**Student Book pages 148–149**

**Science in context**

- Pressure
- Uses of pressure

## Objectives

- Build and operate a hydraulic elevator.
- Build and demonstrate a two stage rocket.

## Overview

This lesson helps students develop the skill of Thinking and Working Scientifically. They build models to experience first-hand the practical applications of pressure. They will review the steps involved in model building, namely, designing, modeling, testing, documenting, evaluating, and re-designing. Construction of simple models are a good step towards application of engineering principles and testing the relationships between pressure, area, and force, in real world.

## Activities

- Begin by reviewing the key points with the students. Elicit why the use of models is important to learning about real world applications.
- For the hydraulic elevator, ask them if they have ever witnessed a car being lifted using a jack. You may take them on small field trip to the mechanics to show how a lift uses transfer of pressure to life heavy objects.
- Follow the steps given in students' book to make a hydraulic lift using syringes. Remember to ensure that the syringes **DO NOT HAVE ATTACHED NEEDLES**. Test the weight limits and applications of your model using objects of different sizes and weights to be lifted or moved to different heights.
- For the two stage rocket, ask them if they have ever watched a video showing launch of a rocket. Ask them to share any observations they may have. Follow the steps given in students' book to make the two-step rocket. Test the limits of your model using balloons of different sizes and filling them with different pressure of air. Ask the students to record their observations in a table and compare whether these factors make a difference to the speed of the rocket. Ask what other factors could be tested? Could the rockets be used to transport small objects from one place to another?

## Homework

Questions from the student book spread.

## Key words

pressure, density, pressure, balanced, unbalanced, weight, Newton, pascals, mass, weight.

### 8.11 Student Book answers

**1.** Liquids cannot be compressed so they transmit the pressure/ Gas can be compressed so cannot transmit the pressure

**2.** The balloon pushes the air out backwards and the air pushes the balloon forwards with an equal force.



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# 8.12
## Review answers

**Student Book pages 150–151**

## Student Book answers

<table>
<tr><td>1</td><td>a</td><td>volume =<br>= 20 cm × 10 cm × 6 cm<br>= 1200 cm$^3$</td><td><br>[1]<br>[1]</td></tr>
<tr><td></td><td>b</td><td>density = mass/volume<br>= 2400 g/1200 cm$^3$<br>= 2 g/cm$^3$</td><td><br>[1]<br>[1]</td></tr>
<tr><td></td><td>c</td><td>The density is higher than that of water.</td><td>[1]</td></tr>
<tr><td>2</td><td>a i</td><td>false</td><td>[1]</td></tr>
<tr><td></td><td>a ii</td><td>true</td><td>[1]</td></tr>
<tr><td></td><td>a iii</td><td>true</td><td>[1]</td></tr>
<tr><td></td><td>a iv</td><td>true</td><td>[1]</td></tr>
<tr><td></td><td>b i</td><td>ice, wood<br>Their densities are lower than that of water.</td><td>[1]<br>[1]</td></tr>
<tr><td></td><td>b ii</td><td>all of them (even iron!)<br>Their densities are lower than that of mercury.</td><td>[1]<br>[1]</td></tr>
<tr><td>3</td><td></td><td>When the sac fills with oxygen, the overall density of the fish is reduced.<br>If the density is lower than that of the water around it, it will move up.</td><td>[1]<br>[1]</td></tr>
<tr><td>4</td><td></td><td>C</td><td>[1]</td></tr>
<tr><td>5</td><td>a</td><td>Sink in mercury, sink in water.</td><td>[1]</td></tr>
<tr><td></td><td>b</td><td>Float in mercury, sink in water.</td><td>[1]</td></tr>
<tr><td></td><td>c</td><td>Float in both.</td><td>[1]</td></tr>
<tr><td>6</td><td></td><td>
<table>
<tr><th></th><th>Forces are balanced</th><th>Forces are unbalanced</th></tr>
<tr><td>The object is not moving</td><td>✓</td><td></td></tr>
<tr><td>There is only one force acting on the object</td><td></td><td>✓</td></tr>
<tr><td>The object is accelerating</td><td></td><td>✓</td></tr>
<tr><td>The two forces are the same size but in opposite directions</td><td>✓</td><td></td></tr>
<tr><td>The object is slowing down</td><td></td><td>✓</td></tr>
<tr><td>The two forces are different sizes and in opposite directions</td><td></td><td>✓</td></tr>
<tr><td>The object is moving with a steady speed</td><td>✓</td><td></td></tr>
</table>
</td><td>[1] each</td></tr>
</table>

| | | | |
|---|---|---|---|
| **7** | **a** | **D** | **[1]** |
| | **b** | Returns to its original shape when the force is removed. | **[1]** |
| | **c** | No.<br>The elastic behaviour is not linear/the extension is not proportional to the force. | **[1]**<br>**[1]** |
| **8** | | **C**, **B**, **A** | **[1]** |
| **9** | **a** | pressure = force/area<br>= 5000 N/0.25 $m^2$<br>= 20 000 N/$m^2$ | <br>**[1]**<br>**[1]** |
| | **b** | force = pressure × area<br>= 20 000 N/$m^2$ × 0.01 $m^2$<br>= 200 N | **[1]**<br><br>**[1]** |
| | **c** | The gas would be compressed/the car would not move. | **[1]** |



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# 9.1 Reflection and Refraction of Light

## Student Book pages 152–153

**Prior learning**

- Know that light intensity can be measured
- Explore how opaque materials do not let light through and transparent materials let a lot of light through
- Know that we see because light from a source enters our eyes

## Objectives

- Describe how light travels.
- Explain how we see things.
- Describe how light interacts with objects.

## Overview

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

## Activities

- Introduce the idea of a light journey and what can happen to light after it has been emitted by a source. Include the many words that describe the properties of materials and what happens to light on its journey. Students complete a matching exercise to test their understanding of these words.
- Show a light meter and introduce the quantity of light intensity, with some examples.
- Students investigate the absorption of light by different materials, including water **(Safety: Ensure students know that the ray-box lamps get very hot, and take care when using mains electricity.)**
- How do we see things? Discuss the difference between seeing luminous and non-luminous objects. Ask students to describe the light journey for luminous and non-luminous objects and to consolidate their knowledge.

## Extension

Find out about Vantablack®, a pigment that absorbs nearly all the light that hits it.

## Homework

Workbook page 66.

## Key words

source, detector, transmit, reflect, absorb, transparent, translucent, opaque, luminous, non-luminous

### 9.1 Student Book answers

**1.** non-luminous, reflects from it, absorbed, can

**2.** 'Emit' means to give out. 'Transmit' means to allow travel through.

**3.** In both cases light is emitted from a luminous source but in one case it is the Sun, and in the other it may be a lightbulb.

In one case the light is reflected from the surface of the Moon, in the other it is reflected from the surface of the mirror.

In both cases you see things because light enters your eyes.

# 9.2

## The law of reflection

**Student Book pages 154–155**

## Objectives

- State the law of reflection.
- Use the law of reflection to describe how light is reflected.

## Overview

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

## Activities

- Students set up equipment to measure the angles of incidence and reflection. They record their results and consider how their results would be affected by small changes to the method or equipment. Discuss the results that different groups have achieved and highlight particularly effective methods for getting accurate and precise results. This is an excellent opportunity to talk about precision and accuracy and the difference between them. (**Safety: Ensure students know that the ray-box lamps get very hot, and take care when using mains electricity.)**
- Students extend their investigation into mirrors by finding the number of images that they can see when there are two mirrors together at an angle.
- Students are often puzzled as to why we do not just measure the angles from the mirror to the incident and reflected rays. By trying to construct ray diagrams for rough and curved surfaces, they learn the reason why we use the normal in ray diagrams.
- Give students two plane mirrors, cardboard, scissors, and glue, and challenge them to make a periscope to look over a wall using the law of reflection.

## Homework

Workbook page 67.

## Key words

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

## 9.2 Student Book answers

**1. a.** The angle of incidence is the angle between the normal and the incident ray. The angle of reflection is the angle between the normal and the reflected ray.

**b.** The angle of incidence is equal to the angle of reflection.

**2. a.** They drew the normal and the mirror on a piece of paper so they were in the same place each time.

They marked dots in the rays to record exactly where the rays were.

**b.** Use a narrower beam of light.

**3.** 45°

**4. a.** 60°

**b.** 60°



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# 9.3 Reflection and images

**Student Book pages 156–157**

**Prior learning**

- Know that beams/rays of light can be reflected by surfaces including mirrors, and when reflected light enters our eyes we see the object
- Explore why a beam of light changes direction when it is reflected from a surface

## Objectives

- Use the law of reflection to explain how images are formed.
- Describe the different types of image.

## Overview

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

## Activities

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

## Homework

Workbook page 68.

## Key words

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

### 9.3 Student Book answers

**1. a.** An inverted image is upside down, an upright image is the right way up.

**b.** You have to look in a mirror to see a virtual image, but a real image can be put on a screen.

**2.** Letters: AHIMOTUVWXY

**3. a.** A shiny metal surface reflects light in a regular way to produce an image. There is diffuse reflection from a painted wall so an image does not form.

**b.** The surface of a shiny plate can reflect enough light in a regular way to produce a faint image.

**4.** The rays do not go directly from the image to the eye.

# 9.4 Spherical mirrors

## Student Book pages 158–159

**Prior learning**

- Light rays
- Behaviour and properties of light rays

## Objectives

- Identify concave and convex mirrors.
- Describe the images formed by concave and convex mirrors.
- Describe how mirrors are used in different optical instruments.

## Overview

In this lesson, students will discover the different types of spherical mirrors and the types of images they produce. Introduce the terms and structure of concave and convex mirrors and their properties. Ensure they understand that con-Cave mirrors curve inwards, while con-Vex mirrors curve outwards.

Help the students reconcile what they have already learned about image formation with the image formed by spherical mirrors. Students will also learn about the practical applications of these two types of mirrors.

## Activities

- Recap what the students have previously learned about image formation. Explain that there are more than simple plane mirror surfaces. Show them the reflective surfaces of spoon. Ask them if they can recall other examples of spherical reflective surfaces from daily life.
- Demonstrate how concave mirrors produce magnified, virtual images when the object is between the focal point and the mirror, and smaller, real images when the object is greater than the point of curvature. On the other hand, convex mirrors always produce small, upright virtual images. Ensure the concept is clearly understood by reinforcing through ray diagrams.
- Discuss the practical applications of these two types of mirrors. explain that the concave mirrors are mostly used to magnify, such as in cosmetic mirrors. On the other hand, convex mirrors are used for security and in rearview mirrors.

## Homework

Questions from the student book spread. Also workbook page 69.

## Key words

refraction, reflection, transparent, medium, upright, laterally inverted, mirror image, rare-view mirror, optical instruments, diminished, magnified, object, image, dispersion.

### 9.4 Student Book answers

**1.** Inwards, outwards, virtual, object

**2.** Satellite dishes are concave.

**3. A.** Concave

**B.** Convex.

**C.** Concave

**D.** Concave.

**4.** Convex produce small upright images for a wide field of view. Concave mirror image would be upside down/ formed in front of the mirror.



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# 9.5 Refraction

**Student Book pages 160–161**

## Objectives

- Describe how light is refracted at a boundary between air and water.
- Explain why light is refracted.

## Overview

In this lesson students investigate what happens at the boundary between air and water. They investigate two situations in which 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. This will be developed further in the next lesson when they investigate light travelling through glass blocks.

## Activities

- Students investigate a pencil in a beaker of water and a coin trick. 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 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 a ripple tank is available, use it to show waves being refracted. 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 in the Student Book to show that light is refracted because it slows down. Students can act out the model with marching rows of people. Draw a boundary line on the ground, clap at equal intervals, and get them to march at an angle 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.
- Lower a small beaker of cooking oil into in a larger beaker of cooking oil as a demonstration. An even more impressive version of this demonstration is to lower an empty beaker into the oil, and then fill the beaker slowly; the beaker appears to disappear. Ask the students to explain the observation that it seems to disappear. This demonstration can also be done with a Pyrex test tube full of glycerol in a beaker of glycerol.

## Extension

Students explain the cooking oil demonstration in terms of refractive index.

## Homework

Workbook page 70.

## Key words

refraction, angle of incidence, angle of refraction, real depth, apparent depth, density

### 9.5 Student Book answers

**1. a.** They would slow down.

**b.** Their direction would not change.

**2.** He should aim below. The fish appears to be above where it really is.

**3.** $n = \frac{\text{speed of light in a vacuum}}{\text{speed of light in the medium}}$

$= \frac{300 \text{ million km/s}}{230 \text{ million km/s}}$

$= 1.3$

Assuming that the speed of light in a vacuum is the same as the speed of light in air.

# 9.6

# Refraction and total internal reflection

**Student Book pages 162–163**

## Objectives

- Describe what happens when light goes through a glass block.
- Explain why light is refracted by different amounts in different materials.

## 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 learned last lesson, possibly by repeating the demonstration of the disappearing beaker or test tube.
- 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. 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. **(Safety: Ensure students know that the ray box lamps get very hot, and take care when using mains electricity. Glass blocks will splinter if dropped.)**
- Students look at how light behaves when it meets the glass/air boundary from inside, and measure the critical angle. They can 'see' total internal reflection by looking into a glass block through the thin edge; the upper and lower internal faces behave like mirrors.
- 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 for keyhole surgery.

## Extension

Students research Snell's Law (in fact already described in 984 by ibn Sahl in Baghdad) and use it to work out the refractive index $n$ of the block. They can then work out the speed of light in the block using the equation:

$$\frac{v_{air}}{v_{glass}} = \frac{n_{glass}}{n_{air}}$$

$n_{air} = 1.0$; $v_{air} \approx c = 300\,000\,000$ m/s

## Homework

Workbook page 71.

## Key words

refraction, critical angle, total internal reflection, optical fibre, endoscope

### 9.6 Student Book answers

1. He explained why he thought that the light would be refracted more by a glass block instead of making a prediction without a full explanation.
2. However much the ray slows down when it goes into the glass block is the same amount that it speeds up when it comes out. The ray changes direction by the same amount in opposite directions each time so it ends up parallel.
3. The rays are not reflecting at equal angles each time.

   The angles are too small for the light to be totally internally reflected.



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# 9.7

## The speed of light

**Student Book pages 164–165**

## Objectives

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

## Overview

In this extension lesson students get a feel for the speed of light and how it can be used to measure distance.

Distances in space are so large that it is much more convenient to use light time to measure them. This lesson will give them a sense of the scale of the Solar System, the Milky Way galaxy, and the distance between galaxies. There is significant mathematical content to this lesson and some students may need extra support.

## Activities

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

## Homework

Workbook page 72.

## Key words

speed of light, light year

### 9.7 Student Book answers

**1.** It is like looking back in time because the light takes time to reach us. We are seeing the stars as they were when the light left them.

**2. a.** distance to Saturn = 9.3 × distance to Sun
= 9.3 × 8 minutes
= 74.4 minutes

**b.** time = 9.3 × 19 years
= 177 years

**3.** The shorter time is when Mars and the Earth are on the same side as the Sun. The longer time is when they are on opposite sides.

**4.** The bar may wear away, react with air, or expand or contract with temperature.

# 9.8 Dispersion

**Student Book pages 166–167**

## 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 use what they have learned to work out how rainbows are produced.

## Activities

- Show a picture of a rainbow 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. In the discussion, elicit that the light is refracted at two boundaries by the prism. Later students will learn how the different amount of refraction of different colours can account for the production of a spectrum. 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 should be seven colours. **(Safety: Ensure students know that the ray-box lamps get very hot, and take care when using mains electricity. Prisms will splinter if dropped.)**
- Ask students how they know that the prism split the white light into colours, rather than adding the colours to the light. 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.
- Students use the information in the Student Book to make a poster showing how the prism experiment is linked to the way rainbows are formed.
- Elicit the fact that the explanation for refraction includes the idea that different colours are refracted by different amounts.
- Students to explain the formation of the spectrum using the ideas from previous lessons.

## Extension

Students research why it is not possible to see a rainbow when the Sun is in front of you.

## Homework

Workbook page 73.

## Key words

refraction, prism, spectrum, dispersion, rainbow

### 9.8 Student Book answers

**1. a.** Light is refracted twice as it goes through a triangular prism.

**b.** Violet, indigo, blue, green, yellow, orange, red.

**2. a.** There are no gaps between the colours.

**b.** There is a range of frequencies that we perceive as one colour.

**3.** Red. Red is refracted the least so must slow down the least. It travels the fastest.

**4.** A ray of white light that goes through a glass block is not dispersed when it emerges, but it is refracted. Dispersion happens when different frequencies of light are refracted by different amounts, which happens when the sides of a glass block are not parallel. (Alternatively: a beam of light of one single colour will be refracted but cannot be dispersed.)



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# 9.9 Colour

**Student Book pages 168–169**

## 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 how a colour filter affects light, and that it does not 'add' colour but actually subtracts all colours except its own. This concept 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. By looking through combinations of filters they work out that filters *subtract* light by absorbing some colours and transmitting others. **(Safety: Ensure students know that the ray-box lamps get very hot, and take care when using mains electricity.)**
- Student use filters to produce three beams of coloured light and investigate what happens when they overlap. 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.

## Homework

Workbook page 74.

## Key words

red, green, blue, cyan, magenta, yellow, primary colour, secondary colour, filter, transmit, absorb

### 9.9 Student Book answers

**1.** red + blue = magenta
cyan + red = white
blue + yellow = white

**2. a.** A green filter transmits green light and absorbs all the other colours.

**b.** If you use a green then a blue filter you see no light, not blue/green/turquoise light.

**3.** Filters subtract colours from white light. Only blue light gets through a blue filter, which is absorbed by a yellow filter (which only transmits red and green light).

**4.** Your retina contains light-sensitive cells that detect red, green, and blue light, and a television screen emits red, green, and blue light.

# 9.10

## Looking at coloured objects

**Student Book pages 170–171**

### 9.10 Student Book answers

1. **a.** all colours
   **b.** no colours
2. The flower absorbs all the other colours except yellow. The yellow light is reflected into your eyes.
3. Paint absorbs all the colours except the colour that it appears (that it reflects). A combination of red, yellow, and blue will absorb all the colours and look black.
4. **a.** Red light: red shirt, red shorts.
   **b.** Green light: green shirt, green shorts.
   **c.** Blue light: black shirt, blue shorts.

## Objectives

- Explain why coloured objects look coloured in white light.
- Explain why coloured objects look different colours in different colours of light.

## Overview

Students experiment with looking at different coloured materials under different coloured lights. They learn that coloured objects behave like coloured filters, and why mixing coloured paint is different from mixing coloured light.

## Activities

- Recap what students learned about how we see things. Elicit the concept that light from an object has to enter our eyes for us to see it.
- 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 about how to present the results. Discuss the results and elicit the comparison that coloured materials behave like filters. **(Safety: Ensure students know that the ray box lamps get very hot, and take care when using mains electricity.)**
- 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.
- Ask students to make a poster in colour that will look different when viewed through red, green, or blue filters. This could be a competition, with a prize for the poster judged to be the best by the class.

## Homework

Workbook page 75.

## Key words

reflect, absorb, light, conclusion

# 9.11

## Changing ideas: Light

SIC

**Student Book pages 172–173**

## Objectives

- Recall that there can be different explanations for the same observations.
- Explain why some explanations are accepted and others are not.

## Overview

This lesson helps students to develop their understanding of Science in Context.

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



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## 9.11 Student Book answers

1. People could understand how balls bounced off surfaces, and Newton was a successful scientist who people trusted. His explanation matched many observations.
2. He had published his ideas about gravity, which successfully explained how the stars and planets moved.
3. **a.** Draw a path on the floor at a certain angle to the wall. Roll the ball along the floor so that it bounces off the wall. Draw where it comes off and measure the angle again. Show that they are the same.

   **b.** The ball will change direction if it is allowed to run diagonally down a slope that changes angle and thus makes the ball change speed. However, the model is not a good one: if the slope becomes steeper, the ball moves faster and its path bends towards the normal, whereas light bends towards the normal when it is slowed down. In addition, the weight of the ball makes it speed up.
4. No. There is no reason why some particles would behave differently from others if they are all the same.

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 observations bring new evidence and data 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 pages of the Student Book and prepare for the debate. **(Safety: Ensure students know that the ray-box lamps get very hot, and take care when using mains electricity.)** 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 in which 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 with a simplified description of the discharge of an electroscope and explain it in terms of particles with enough energy (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 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 76.

## Key words

observation, explanation, particle, wave

# 9.12

## The eye and the camera

**Student Book pages 174–175**

## Objectives

- Describe how your eye works.
- Describe how a camera works.
- Compare the camera and the eye.

## Overview

In this extension lesson students learn about how the human eye works, and how an image is formed on the retina of the eye. They investigate images in a pinhole camera (though technically these are shadows). They see how a lens brings light to a focused image on a screen. They consolidate their learning by finding analogies between the eye and a lens camera.

## Activities

- Elicit what students already know about the human eye. Show a diagram of the various parts, and describe how they work. Students demonstrate understanding of the eye and how it works.
- Review how light travels by asking students to explain how we see objects. Elicit that light travels in straight lines. Demonstrate how a shadow changes as you move the object closer to and further from a light source. Explain the changes using the ideas that light travels in straight lines.
- Students use the idea of light travelling in straight lines by using a pinhole camera to form an image of the filament of a lamp. Instructions for making a simple pinhole camera from a box, some greaseproof paper, and some aluminium foil can be found online (e.g. https://spark.iop.org/pinhole-camera-and-lens-camera).
- Alternatively, or as well as the practical, students construct a model of the rays of light forming an image in a camera using string. Students draw a picture of a lamp on a piece of paper. They draw a picture of a pinhole camera on another piece of paper. If they use string from the top and bottom of the filament they can use the model to predict what will happen if they move the camera closer to the lamp, or further from it.
- Students compare and contrast the eye and the camera.

## Extension

Students research the difference between the simple lens camera and cameras in mobile phones.

## Homework

Workbook page 77.

## Key words

source, detector, transmit, reflect, absorb, transparent, translucent, opaque, lux, luminous, non-luminous, eye, lens, cornea, retina, cones, rods, optic nerve

### 9.12 Student Book answers

**1. a.** the iris

**b.** the optic nerve

**2.**

| | Eye | Camera |
|---|---|---|
| Hole to let the light in | pupil | aperture |
| Where the image is formed | retina | sensor/ film |

**3.** Any sensible suggestions, e.g. it is made of soft tissue/contains rods and cones.



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# 9.13
## Review answers

**Student Book pages 176–177**

## Student Book answers

| | | | |
|---|---|---|---|
| **1** | **a** | luminous | **[1]** |
| | **b** | opaque | **[1]** |
| | **c** | inverted | **[1]** |
| | **d** | transparent | **[1]** |
| | **e** | non-luminous | **[1]** |
| **2** | **a** | reflected | **[1]** |
| | **b** | absorbed | **[1]** |
| | **c** | translucent, transparent | **[2]** |
| | **d** | reflected | **[1]** |
| | **e** | opaque | **[1]** |
| | **f** | transparent | **[1]** |
| **3** | | **B** | **[1]** |
| **4** | | **A**, **C**, **F** | **[1]** |
| **5** | **a** | refraction | **[1]** |
| | **b** | The light slows down as it goes from air (less dense medium) to water. If it crosses the boundary between the two at an angle, the change in speed makes it change direction. (Or: light speeds up as it goes from a dense medium to a less dense medium.) | **[1]** **[1]** |
| | **c** | Light is refracted from above the water so the fish can see the bank in the air. Light is totally internally reflected from below the water so the fish can see the bottom reflected on the surface. | **[1]** **[1]** |
| **6** | **a** | **C** | **[1]** |
| | **b** | **A** | **[1]** |
| | **c** | **B** | **[1]** |
| | **d** | The two angles are equal. | **[1]** |
| **7** | **a** | zero (0° to the normal) | **[1]** |
| | **b** | It is not refracted; it goes straight through. | **[1]** |
| | **c** | 45° | **[1]** |
| | **d** | It is totally internally reflected | **[1]** |
| | **e** | The critical angle is less than 45°. | **[1]** |
| | **f** | If the critical angle were more than 45° then the light would be refracted. | **[1]** |
| **8** | **i** | **A**, **C**, **E**, **D**, **F**, **B**, **G** | **[1]** |

| | | | |
|---|---|---|---|
| | **ii** | Any sensible suggestion, e.g. you can see precisely where the rays go. | **[1]** |
| **9** | **a** | His trousers are green. | **[1]** |
| | **b** | His shirt is magenta. | **[1]** |

# 10.1 Electricity and Magnetism

**Student Book pages 178–179**

## Objectives

- Describe what is meant by voltage
- Describe how to measure voltage in series and parallel circuits
- Describe the effect on the voltage of adding cells and lamps in series and parallel circuits

## Overview

Students may already have come to realise intuitively that the voltage is linked to the energy stored in the battery, and in this lesson they learn about the link between energy, voltage, and charge. They learn how to measure voltage with a voltmeter. They measure the voltage across components in series and parallel circuits, and explain their readings using one of the models that they have considered in previous lessons. Finally, they consolidate what they have learned about current and voltage in parallel circuits by making a game of snap involving circuits.

## Activities

- Show a variety of batteries (cells) of different sizes and shapes and voltages. Establish that the physical size of a battery or cell is not a measure of the energy stored by connecting up two circuits with batteries of different sizes but the same voltage in order to light identical bulbs.
- Demonstrate how to connect up a voltmeter and use it to measure the voltage across a cell. Explain that voltage is measured with volts and is a measure of the energy transferred by the charges and the push of the cell or battery.
- Students investigate the voltage across components in series and parallel circuits. **(Safety: Ensure students take care when working with electricity.)** In discussion, draw out the idea that the energy stored in the battery is effectively shared between the two bulbs in series, and that this is linked to the decrease in the brightness of the bulbs as more are added in series. Ask students to decide which of the models that they have learned about best helps to explain these observations. Establish that in a parallel circuit the voltage across each of the branches is the same, because each loop is effectively independent of the others. Again, discuss which of the models best helps to explain this.
- Students consolidate what they have learned by making a game in which they have to match circuits where the meter readings are the same. This is quite a substantial activity so could be shortened or used for revision later.

## Extension

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

## Homework

Workbook page 78.

## Key words

voltage, volts, voltmeter

### 10.1 Student Book answers

**1. a.** Current is the charge flowing per second, and voltage is the energy per charge or the push from the battery.

**b.** Voltmeters are connected in parallel, but ammeters are connected in series.

**2.** 6

**3.** Because the energy that is transferred to each component adds up to the energy available from the battery.

**4. a.** 6 V – 2 V = 4 V

**b.** The same size. The current is the same everywhere in a series circuit.

**c.** The voltage across each one is the same as the voltage across the battery, 6 V.

**5.** No, the charges aren't used up. The current transfers the energy from the chemical store in the battery to the components.

# 10.2 Resistance

**Student Book pages 180–181**

## Objectives

- Describe how resistance affects current
- Calculate resistance
- Know the circuit symbols for fixed and variable resistors

## Overview

In this lesson students explicitly learn about the concept of resistance as the property of a component, a property that determines the current in a circuit containing the component and a cell. They learn the circuit symbols for resistors and variable resistors.

Students will have developed a sense of what resistance is from the experiments with lamps in series circuits; the current is smaller because the resistance is bigger. They now learn about a simple model of resistance that can be applied to metal wires, and how to calculate resistance. It is important for them to realise that current is the dependent variable. You choose the resistance and the p.d. and get the current as a result.

Students learn how variable resistors can be used in a wide range of situations.

## Activities

- Show a circuit with one cell and one lamp, and another with one cell and two lamps. Ask students to explain the observations using the models that they have learned.
- Introduce the idea of resistance. Explain that it is the push of the battery and the resistance of the component that determines the current. The rope model explains that particularly well. You can demonstrate this with a piece of rope, or the students can work in groups with a piece of rope. How much you grip the rope is like the resistance, and the speed of the rope is the current. If you grip harder the rope is slower. Remind students to be careful about the tendency to pull the rope harder (increase the voltage); this is the 'constant current' misconception.
- Introduce the equation to calculate current from voltage and resistance first, then change the subject of the equation to give $R = V/I$. This is because current depends on voltage and resistance. Discuss the unit of resistance and its symbol. Students practice using the equation. They should practice converting between mA and A, and kΩ and Ω.
- Show some resistors and the circuit symbol for resistors. Remind students how to measure the current and voltage in a circuit. Students measure the resistance of unknown resistors or other circuit components. Provide two lamps of different resistances. **(Safety: Ensure students take care when working with electricity.)**
- Set up a circuit with a variable resistor and show how it can be used to vary the brightness of a lamp. Ask students to suggest situations where it might be useful to have a variable resistor. Collect responses, then show a range of pictures of dimmer switches, sliders on mixing desks, volume dials on radios, etc.

## Homework

Workbook page 79.

## Key words

resistance, ohm

### 10.2 Student Book answers

**1.** Decrease the resistance.

**2.** $\text{resistance} = \frac{\text{voltage (V)}}{\text{current (A)}}$

$= \frac{12\,\text{V}}{0.25\,\text{A}}$

$= 48\,\Omega$

**3. a.** 1.5 A – 0.4 A = 1.1 A

**b.** The buzzer: the voltage is the same, but the current is smaller.

**c.** resistance of motor = 6 V/1.1 A = 5.5 Ω

resistance of buzzer = 6 V/0.4 A = 15 Ω

**4.** Adding a branch for a lamp increases the total current for the same voltage/ provides an additional path for the charge to flow round, so the total resistance is smaller.



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# 10.3

## Planning investigations: Resistance of a wire

TWS

**Student Book pages 182–183**

## Objectives

- Make decisions about when to use primary data.
- Describe how to plan an investigation.

## Overview

This lesson helps students develop their skills in Thinking and Working Scientifically.

In this lesson students consider the different kinds of questions that you can ask and ideas that can be tested with practical work. They select an idea to test in relation to fruit batteries and complete an investigation. They write up their investigation to show what they have done and found out. They are then paired with someone who has done a different investigation and they each critique the report that the other has written. Finally, students consider how scientists ensure that their conclusions are accurate and consider the importance of results being reproduced by other scientists.

Students could use the information in the Student Book to start their planning, or alternatively draft a plan and check it against the plan in the Student Book. Alternatively, students can complete the investigation shown in the Student Book.

## Activities

- Elicit the difference between a question that science can answer and a question that science cannot answer. Ask students to recall the different parts of an investigation that involves a fair test. Elicit the difference between primary and secondary data.
- Remind students of what they learned about voltage. Demonstrate how to make a fruit battery. Take a piece of acidic fruit, put two different pieces of metal in it, and show that a voltage is produced.
- Ask students to think of three ideas that they could test about the fruit battery. Show them the range of apparatus that they could use. Elicit the idea that there are lots of different types of question, and that students would need to do an experiment or investigation to answer them. Highlight the difference between answering a question such as 'Do all fruits produce a voltage?' and testing a hypothesis such as 'Does the voltage depend on the acidity of the fruit?'. Discuss primary and secondary data collection in this context.
- Students plan and carry out an investigation into fruit batteries. **(Safety: Ensure students take care, as metal pieces may have sharp edges.)** They should conduct the necessary preliminary work to ensure that their investigation will work and write up their investigation as a formal report.
- Pair students who have done different investigations. Explain that scientists review each other's work and feed back on it. Students read each other's reports to give feedback. Students then read each other's feedback and discuss it.
- Alternatively, students can undertake the investigation about the resistance of a piece of wire discussed in the Student Book. **(Safety: Ensure students take care when working with electricity. The wire will get hot, so remind students to connect it only for short periods of time.)** They think of ideas that they can test in relation to the resistance of a wire. You will need to provide different types of resistance wire. Check any wire that you provide and ensure students are aware that the wire could become hot, so they should only connect it for short periods of time.

- Discuss how scientists ensure that what they have found out is accurate. Distinguish between repeatability (the scientist repeating the experiment to check the results) and reproducibility (other scientists conducting the same experiment to check that the results are accurate).
- Match groups who have conducted the *same* experiment together and ask them to discuss how they went about their experiment and what they found out. Each group reports their conclusions to the class.

## Homework

Workbook page 80.

## Key words

resistance, questions, preliminary work, plan

### 10.3 Student Book answers

**1.** ammeter, ruler

**2. a.** change: thickness/diameter; measure: current; control: type of wire, length

**b.** It is difficult to measure the thickness of the wire accurately; it might be difficult to change it (you would need to find another wire that is identical except for thickness).

**3.** The wire could get very hot/risk of burning.

**4. a.** Lakshima would draw a bar chart as her data is categoric, Chetana would draw a line graph as her data is continuous.

**b.**

| Material | Current (A) | Current (A) | Current (A) | Mean current (A) | Resistance (Ω) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

# 10.4 Energy and power

**Student Book pages 184–185**

## Objectives

- Describe the difference between energy and power.
- Calculate power.

## Overview

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

They learn about the link between the power of an appliance, the length of time for which you use it, and the cost on an electricity bill. Finally, they compare LEDs and CFLs and make a leaflet for the general public that describes the differences and compares the costs. They make connections with electricity generation, fossil fuels, and climate change.



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## 10.4 Student Book answers

**1.** 2000 W

**2.** power = energy/time
= 1200 J/60 s
= 20 W

**3. a.** power of CFL needed = 15 W
energy transferred in 10 h = 0.015 kW × 10 h
= 0.15 kWh

**b.** LED: 1 rupee; filament light bulb: 6 rupees; CFL: 1.5 rupees

**c.** 5 rupees

## Activities

- Show students lamps that have different powers, e.g. a 60 W and a 100 W lamp. It would be helpful to have available a range of different types of lamp (incandescent, CFL, and LED). Elicit that some bulbs look brighter than others, and get students to think about the light energy being produced. Explain that it is not about the total amount of energy, but the energy *per second* that means that the light appears brighter.
- If available, use a mains joulemeter to show more energy per second is transferred by the higher power lamp. Explain the difference between energy and power, that power is the rate at which energy is transferred. Introduce the units of power, the watt and the kilowatt.
- Show students the panel plate on an electrical appliance that shows the power of the appliance. Show students a range of appliances (or pictures of them) and ask them to rank them in order – highest to lowest power. Students look at each appliance (or picture) to work out the power and put them in order. supports this activity. **(Safety: all appliances should be switched off.)**
- Students practice using the equation for power.
- Discuss what students understand by 'efficient'. In groups students prepare an explanation about why less efficient appliances cost more to run. Make sure that they use the terms 'power' and 'energy' correctly.
- Discuss the link between efficiency and climate change. More efficient devices require less coal to be burned in a power station to produce the same desired energy transfer. This mean less $CO_2$ is transferred to the atmosphere, which is a very good thing.
- Students to compare the cost of LEDs and energysaving light bulbs and then make a leaflet that informs the general public about the differences, pros and cons, and costs.

## Homework

Workbook page 81.

## Key words

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

# 10.5 Electrical safety in the home

**Student Book pages 186–187**

## Objectives

- List safety measures when using electricity.
- Know how fuses, earth wires and circuit breakers keep you safe.

## Overview

In this lesson, students consolidate what they have learned about safety and the risks of the build-up of electrical charge. They review that charges moving through a material produce a current, which can cause a heating effect or produce visible sparks. Students learn further about how electrical devices and circuits incorporate safety measures using devices known as fuses, earth wires and circuit breakers. Encourage them to incorporate safety measures listed in the book in their daily life.

**Prior learning**

- Energy is the ability to do work.
- Electrical circuits.

## 10.5 Student Book answers

**1.** Earth wire C, fuse A, circuit breaker B

**2. a.** Too many plugs in one socket.

**b.** The cable insulation is damaged.

**c.** Metal knife inside a toaster – may cause electrocution.

**3.** A. 13 A, b. 3A

**4.** Fuses and circuit breakers switch off an appliance if the current is too big. The circuit breaker can be reset / is more reliable/RCCB more sensitive and can prevent electrocution.

## Activities

- Begin the lesson by reminding the students that as a charge is moving through the air, it is heating up the air, just as it heats up the filament of a lamp. Next, you can show a suitable video clip from the Internet.
- Discuss the importance of electrical safety in everyday life. If possible, show the internal circuitry of an electric device such as an electric kettle. Point out the safety measures in the circuit. Alternately you could show a video of the same. Emphasize the importance of not overloading electrical sockets. Discuss the dangers of using damaged wires or using appliances near water.
- Discuss in class the role of fuses and circuit breakers. If possible, show the students how the circuit breaker works in the school building. Explain that fuses and circuit breakers are placed in the live wire and switch off circuits when the current is too high.
- Show the internal wiring of a three-pin plug and discuss the earth wire function in class. Explain that this is a safety wire that is connected to appliances with metal casings.

## Homework

Questions from the student book spread. Also workbook page 82.

## Key words

earth wire, fuse, circuit breaker, switch, wire, ampere, electric power, positive electric charge, negative electric charge, neutral, conductors, insulators, closed and open circuit, electric current, volts.

# 10.6 Electromagnets

**Student Book pages 188–189**

**Prior learning**

- electric current has a magnetic field around it.

## Objectives

- Describe the properties of an electromagnet.
- Describe how devices that use electromagnets work.

## Overview

This lesson is designed to teach students about electromagnets and their properties. They will discover how electromagnets work by reviewing their uses in various devices, such as a loudspeaker and an electric bell.

Students will learn the properties of an electromagnet, especially the production of a magnetic field as electric current flows through its core. The aim is develop a solid understanding of electromagnets and their applications, in students.

## Activities

- Announce to the class that the lesson is to help them understand the properties of electromagnets and how they are used in devices. Ask them where they have heard of uses of electromagnets in everyday life.
- Reviewing the properties of an electromagnet; you may use diagrams or videos to explain the concepts. You can handout circuit diagrams of a loudspeaker or a doorbell and ask the students to identify where the electromagnet is located in each.

## 10.6 Student Book answers

1. Iron, increase, increase.
2. Magnetism can be switched on and off; strength can be varied; poles can be reversed.
3. D B E A C F

- Have the students discuss how the use of an electromagnet can contribute to the function of a device.
- You can lead the class to experiment with an electromagnet to see which factors can affect its strength, magnetism, and pole direction.

## Homework

Questions from the student book spread. Also workbook page 83.

## Key words

static electricity, attraction, repulsion, electric charge, electric current, positive, negative terminals.

# 10.7

# Risk, variables, and tables: Investigating electromagnets

TWS

**Student Book pages 190–191**

## Objectives

- Describe the difference between dependent and independent variables.
- Describe how to show that you have controlled variables in an investigation.
- Write an appropriate risk assessment for an investigation.

## Overview

This lesson helps students develop their skills in Thinking and Working Scientifically.

Students explore ideas about risk, and about identifying and controlling variables. In the context of work on an electromagnet, they learn about dependent and independent variables. They decide which variables to investigate and how to control the other variables.

Wires get hot, which provides a real example of a situation where a risk assessment is essential.

## Activities

- Students, in pairs, complete a card sort to remind them how to plan an investigation. They compare their order with other groups. The class then discusses whether there is a 'definitive' order.
- Discuss previous experiments where students have made electromagnets and elicit the idea that connecting a wire directly across a battery will cause it to get hot. Students practice writing risk assessments. **(Safety: Ensure students take care when using electricity, and only connect the battery for short periods of time as the wire will get hot.)**
- Students plan an investigation into the strength of electromagnets. They should write a risk assessment. The key idea is to present their results in a way that shows very clearly:
  - which is the independent variable
  - which is the dependent variable
  - how the other variables are controlled.
- Students complete their investigations and prepare a presentation for the rest of the class.
- Students evaluate each other's methods and presentations and produce a checklist to help them when they do an investigation in the future.

## Extension

Students to plan and carry out a second experiment to investigate another of the independent variables.

## Homework

Workbook page 84.

## Key words

dependent variable, independent variable, control variable, risk assessment

### 10.7 Student Book answers

**1.** A list of what might cause injury or damage, and the things you will do to reduce the chance of it happening.

**2.** Suggestion/measure, e.g. the elastic band could fly into someone's eye; wear safety goggles.

**3. a.** surface

**b.** height of bounce

**c.** They could list all the control variables, and say what value they have.

**d.**

| Surface | Height of bounce (cm) |
|---|---|
| | |

# 10.8 Review answers

## Student Book pages 192–193

## Student Book answers

| | | | |
|---|---|---|---|
| **1** | | **A**, **B**, **C**, **F** | **[1]** |
| **2** | **a** | **A** – right, **B** – down, **C** – down, **D** – left | **[1] each** |
| | **b** | Any two magnets correctly placed to make the blue magnet move up, e.g. diagram **B** but with S at the top of the green magnet, or diagram **C** but with N at the bottom of the green magnet. | **[1]** |
| **3** | **a** | magnetic field, magnetic field | **[1] each** |
| | **b** | magnetic field, strong, poles | **[1] each** |
| | **c** | pole | **[1]** |
| **4** | **a** | using iron filings<br>using (plotting) compasses | **[1]**<br>**[1]** |
| | **b** | A point where the magnetic fields cancel out. | **[1]** |



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| | | | |
|---|---|---|---|
| | **c** | magnet 1<br>The neutral point, where the field from magnet 1 is cancelled by the field from magnet 2/ where the fields are the same strength, is further away from magnet 1 than magnet 2. | **[1]**<br>**[1]** |
| | **d** | Put a steel ball at different positions. When it is at the neutral point it will not move. | **[1]** |
| **5** | | In the first picture the compass needle is lining up with the magnetic field of the Earth. (The magnetic North pole of the Earth is the pole to which north poles of magnets are attracted.)<br>In the second picture the compass needle is lined up with the magnetic field of the magnet. | **[1]**<br>**[1]** |
| **6** | **a** | A magnet that you cannot turn off. | **[1]** |
| | **b** | A material that is attracted to a magnet/that can be magnetised. | **[1]** |
| | **c** | A region where a magnet/magnetic material experiences a force. | **[1]** |
| | **d** | Lines that show the direction and strength of a magnetic field. | **[1]** |
| | **e** | A coil of wire carrying a current and wrapped around a core. | **[1]** |
| **7** | **a** | The coil becomes an electromagnet. | **[1]** |
| | **b** | The coil is no longer an electromagnet. | **[1]**<br>**[1]** |
| | **c** | The hammer would be brought into contact with the bell and would not move away, because the steel would become magnetised and stay magnetised. | **[1]** |
| **8** | **a** | Wind the wire around the nail.<br>Connect the wire to the battery and switch, and then turn it on. | **[1]**<br>**[1]** |
| | **b** | Wind more turns of wire on the nail.<br>Use a bigger battery (higher voltage). | **[1]**<br>**[1]** |
| | **c** | **A**, **C**, **D**, **B** | **[1]** |
| **9** | **a** | type of core | **[1]** |
| | **b** | strength of the electromagnet | **[1]** |
| | **c** | the number of turns, the current (or voltage) | **[1]** |
| | **d** | Small paper clips, because they can easily be counted and give a more accurate answer than large paper clips, while iron filings would stick to the magnet.<br>Or<br>Iron filings because the mass of filings is a continuous variable. | **[1]** |
| | **e** | **Type of core** \| **Number of small paper clips [or] Mass of iron filings (g)** | **[1]** |

# 11.1

## Technology in Everyday life

**Student Book pages 194–202**

**Prior learning**

- Role and application of biotechnology in every day life.
- How to build an electric circuit.
- Acid-base reactions.
- Saponification.

## Objectives

- Make bioplastic from milk and vinegar as an application of biotechnology.
- Build a concave mirror type solar system.
- Build a working wind turbine.
- Demonstrate an uninterruptible power system operating a low power appliance.
- Make toothpaste as an application of a base in daily life.
- Find out how to make soap as an application of acids and bases in daily life.
- Find out how to make detergent as an application of acids and bases in daily life.

## Overview

The Technology in Everyday Life chapters are designed to enhance the research and technology application skills of the students.

The aim is to have the students recognise importance of science and technology to solve everyday problems and integrate scientific concepts/ STEAM in daily life to improve the quality of their own life and lives of others. And finally, to understand how scientific concepts/ STEAM affect their life and society.

## Activites

The activities added are as per the National Curriculum of Pakistan and detailed in the student book. The hands-on activities must ensure that the following scientific skills are practiced and encouraged during the class:

- use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions to challenges/ inquiry questions
- use secondary sources of information to study the process of making the given products
- apply the process people follow to design new things (make a plan, make drawings of the design, choose the best available material, construct working models and test your design)
- describe the strengths and limitations of your model
- follow safety measures while carrying out practicals
- design the model of a wind turbine using reusable material
- describe how science is applied across societies and industries

Further assurance must be made that the solar oven activity is not performed by students but is demonstrated by the teacher/STEM instructor, as cautioned in the national curriculum.

## Key words

Bioplastic, biotechnology, acid, base, safety measures

## Homework:

For 11.1, Workbook page 85.

For 11.2, Workbook page 86.

For 11.3, Workbook page 87.



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# Student Book answers

<table>
<tr><th>Spread</th><th>Question</th><th>Answer</th></tr>
<tr><td>11.1</td><td>1</td><td>Large molecules made up of long, repeating chains of smaller molecules</td></tr>
<tr><td></td><td>2</td><td>a. Most modern plastics are made of compounds that come from crude oil.<br>b. Bioplastics made from biological materials from living organisms, such as cellulose from plant cell walls and milk from mammals.<br>c.
<table>
<tr><th>Plastic type</th><th>Advantage</th><th>Disadvantage</th></tr>
<tr><td>Synthetic plastic</td><td>Cheaper</td><td>Uses fossil fuel by-products</td></tr>
<tr><td>Bioplastic</td><td>More labor intensive</td><td>Has fewer uses</td></tr>
</table>
</td></tr>
<tr><td></td><td>3</td><td>Students to convert the steps provided in the textbook as basis for flowchart.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>11.2</td><td>1</td><td>turn; reverse; generator.</td></tr>
<tr><td></td><td>2</td><td>It is a device placed between the usual power supply and a sensitive electrical equipment. The system provides a power source which is constant and protected from any spikes or dips in the power supply, available in the event of a power cut for a short time, enough for backup generators to start working or to safely shut down equipment.</td></tr>
<tr><td></td><td>3</td><td>An increased number of parallel rays of light will be brought to the focal point, generating increased heat.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>11.3</td><td>1</td><td>A mixture designed for a particular purpose.</td></tr>
<tr><td></td><td>2</td><td>1. Sodium hydrogen carbonate (also called bicarbonate of soda, or baking soda) – which neutralizes acids in the mouth and polishes the teeth.<br>2. Sodium chloride (salt) – which acts as an abrasive, which helps to remove plaque.<br>3. Peppermint oil – makes the toothpaste taste good.</td></tr>
<tr><td></td><td>3</td><td>To prevent microbial infection or diseases.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>11.4</td><td>1</td><td>Oil and sodium hydroxide</td></tr>
<tr><td></td><td>2</td><td>i. You must wear goggles (not safety glasses) when making soap.<br>ii. If you get sodium hydroxide on your skin, wash it off immediately under running water.</td></tr>
<tr><td></td><td>3</td><td>There might be unreacted sodium hydroxide in it, which is corrosive to skin.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>11.5</td><td>1</td><td>Oil and sulfuric acid.</td></tr>
<tr><td></td><td>2</td><td>Exothermic reaction.</td></tr>
<tr><td></td><td>3</td><td>For safety purposes, small amounts of reactants can be used in a controlled environment.</td></tr>
</table>

# 12.1

## Our Universe

**Student Book pages 204–205**

Objectives

Describe what a nebula is.

Describe how stars form and die.

Overview

In the previous lessons, students have considered the timescale of the formation of the objects in the Solar System. In this lesson students consider stars. They learn how stars form from gas and dust, and how they come to shine. They see how stars have a life cycle, and learn that they themselves are made of the dust of dead stars; they are stardust.

Activities

Use Stellarium software (free to download) to demonstrate the stars in the sky. Pick out some stars that appear to be different colours – for example, Betelgeuse looks orange/red, Rigel looks blue. Both are in the constellation Orion.

Students read about the lifecycle of stars, then put the stages of the lifecycle of a large and small star in order. Students use the information to make a 'flick book' to demonstrate the lifecycle of a large or a small star.

Demonstrate that you see different stars at different times of the year using the software described above or using pictures. Introduce the idea of constellations and discuss why we have the constellations that we do. Emphasise that the patterns themselves have no scientific meaning but are a useful way of working out where you are. Demonstrate how you can find north or south using Ursa Major or the Southern Cross. Demonstrate you see different stars if you live in the Southern Hemisphere than if you live in the Northern Hemisphere.

Demonstrate that it is impossible to judge how bright a star is from looking at it. Use a bright light source, such as a bulb, and a less bright source, such as a candle. If the bright source is further away, it can look of a similar brightness to the weaker light source.

Students summarise what they have learned about stars by writing a leaflet 'A guide to the stars' for grade 7 students.

Student could plan how to find out the answers to those questions that have not been answered given what they know about primary and secondary data.

Homework

Workbook page 88.

Key words

star, stellar nursery, nuclear fusion, nebula, main sequence, red giant, white dwarf, black dwarf, red supergiant, supernova, neutron star, black hole, planetary nebula, massive star

### 12.1 Student Book answers

1. **A** – **2**, **B** – **3**, **C** – **1**, **D** – **4**
2. Appropriate answer, e.g. similarity: both start as nebulae; difference: a low-mass star ends up as a white/black dwarf whereas a massive star ends up as a black hole/neutron star.
3. Gold is made in supernovae, but diamonds can be made by compressing carbon on Earth.



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# 12.2

## Galaxies

**Student Book pages 206–207**

## Key words

Milky Way, Kuiper belt, Oort cloud, exoplanet, galaxy, black hole, Universe

## Objectives

- Describe what is in a galaxy.
- Describe what is in the Universe.
- Describe the 3 different types of galaxy.

## Overview

In this lesson students learn about our place in the Universe. They develop an understanding of the Solar System as part of a galaxy, the Milky Way, that is one of millions of galaxies in the Universe. This is an example of how scientists produce explanations based on observational evidence alone: no-one can or ever will leave the Solar System to travel through interstellar space. Emphasise that the models and images are constructed and that living humans will not be able to look back and take a photograph of the Solar System from beyond it.

In the final activity, some students could use light years in their leaflets to give an idea of scale.

## Activities

- Revise what students know about the Solar System. Give out ten shuffled cards with the names of the planets, the asteroid belt, and Pluto. Get the students to line up in the correct order or give groups a set of cards to put in order, starting with the Sun. Ask students what is outside the orbit of Pluto. Remind students that there are planets around other stars called exoplanets, so those stars must be a great distance from our star.
- Introduce the order: Solar System, other stars and solar systems, galaxy, Universe. Students read the Student Book to learn about the Kuiper belt, Oort cloud, and our nearest star. Show a suitable animation to give an idea of scale, such as *Powers of Ten*, which can be found online, or this one: http://apod.nasa.gov/apod/ap100120.html.
- Students to work out the order of objects in the Solar System.
- They to work out the order of objects in the Universe. They should consider how to incorporate stellar dust and gas, and planetary systems around other stars.
- Students estimate the number of stars in the night sky using another image of the night sky. Discuss the fact that most of the stars that they see are in the Milky Way, and some of the fuzzy objects are galaxies. Compare the number of stars they can see with the billions of stars in the Universe.
- Students write a 'Guide to the Universe' leaflet for the general public that explains what would happen if they travelled in a spacecraft away from the Earth. This could draw on what they have learned throughout this topic on space.

## Homework

Workbook page 89.

## Extension

Students research the Drake equation, and find out how scientists make estimates of the probability of alien life in the Universe.

### 12.2 Student Book answers

1. Kuiper belt, Oort cloud, galaxy
2. A solar system is a collection of planets and moons in orbit around a star. A galaxy is thousands of millions of stars, together with their planetary systems.
3. There are too many to count and we may not have powerful enough telescopes to see them/they are too faint/too far away.

# 12.3

## The origin of the Universe

**Student Book pages 208–209**

## Objectives

- Give the approximate age of the Universe.
- Describe the Big Bang theory of the Universe, and evidence for it.
- Compare the time that humans have lived on Earth with the age of the Earth.

## Overview

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

Students will use this information in the rest of the lessons in the topic on asteroid impacts and the life cycle of stars.

## Activities

- Students can write questions about the Universe to which they would like to know the answer. You can make a display and revisit the questions later. This discussion could be used to consolidate ideas about the sorts of questions that science can and cannot answer.
- Show a photo of the most distant galaxies that have been observed, such as the famous mage from the Hubble Space telescope, http://apod.nasa.gov/apod/ap121014.html. Explain that the galaxies shown in the picture are 13.7 billion light years away. Elicit that we are seeing the galaxies not as they are now, but how they looked over 13 billion years ago.
- Introduce the idea that the galaxies that we observe are all moving away from us, and that we can model this with a balloon. Students use the balloon activity to work out that more distant galaxies are moving away faster. They will need to do the activity in pairs. Demonstrate how to use the string to measure the distances on the curved surface of the balloon.
- Students use the cards to sort out the order of events since the Big Bang. Then they make a timeline.
- Students consolidate their knowledge by putting the events in order with the appropriate timescale. These cards could be used to make a display or be stuck in their books.

## Homework

Workbook page 90.

## Key words

Big Bang, atom, expansion, Universe

### 12.3 Student Book answers

**1. a.** 13 700 million years old

**a.** 5000 million years old

**2.** It is not possible until we know how much mass there is in the Universe.

**3.** No. The dinosaurs died out 66 million years ago and humans have only been around for 500 thousand years.



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# 12.4

## Changing ideas 1: Ancient ideas about the Universe

**Student Book pages 210–211**

## Objectives

- Describe some ideas in ancient astronomy that have changed over time.
- Describe how scientists develop explanations.

## Overview

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

## Activities

- Ask students where astronomers lived in ancient times. Establish that there were people making measurements of the sky and developing explanations all over the world.
- Students imagine what it would have been like for people looking up into the night sky thousands of years ago. Ask them for some of the natural conclusions that people might have made based on what they could see.
- Introduce the difference between a story, or a myth, and a scientific explanation. Collections of myths about the Sun, Moon, and Solar System are available online (e.g. http://www.windows2universe.org/mythology/mythology.html). Discuss the idea that scientific explanations explain and predict, and are based on evidence from observation or experiments.
- Divide the class into groups of three. These are their *home groups*. In each group they decide who is going to answer questions about each of the regions of science. They meet with others who have been given the same questions and work out how to teach the others. These are the *expert groups*. They return to their home groups to teach each other and remain there to make a poster about what they have learned.
- Students should lay their posters out on the desk. Groups should circulate around the posters with stickers and write one positive thing about the poster and one thing about it that that could be improved on their stickers then stick them on a piece of paper next to the poster.
- Each group should think of three reasons why the same ideas appeared in different places at different times. They feed those ideas back to the class and they can be collated. Elicit that communication is the issue and that problems with language or geography could be significant problems. Discuss whether the same problems exist today and whether someone with a very new idea would have that idea accepted.

## Homework

Workbook page 91.

## Key words

communication, question, model, explanation, evidence

### 12.4 Student Book answers

1. You need to be able to write down your observations so that you can see patterns over time.
2. Scientists observed day and night, made a model of the Earth spinning, and used the model to explain the observations.
3. **a.** Any story, such as the Sun being eaten.
   **b.** Eclipses happen when light from the Sun is blocked by the Moon or Earth.
   **c.** The story does not predict eclipses.

# 12.5 Changing ideas 2: The geocentric model

**Student Book pages 212–213**

## Objectives

- Describe some ideas in ancient astronomy that have changed over time.
- Describe how scientists develop explanations.

## Overview

This is the second of three lessons about the model of the Earth's place in the Universe (there was no clear distinction between the Solar System and the Universe for a long time). The emphasis is on the way scientific explanations are developed, examined in the context of the development of the model of the Solar System.

In this lesson students learn about the early model of the Universe and reasons why it was so widely accepted. They consider the nature of evidence and how it can be used to support or refute an existing theory.

They learn what retrograde motion is and how it arises. Point out that this key observation did not overturn the existing model; the model was adapted, which illustrates a tendency for people to hold on to ideas with which they are familiar, and the difficulty in changing ideas.

## Activities

- Review what students learned in the previous lesson. They could try to recall some of the information from their posters and then look back at the posters to see what they missed.
- Ask students to consider the evidence from their experience that the Earth is stationary or that the Earth is moving. Gather ideas together and elicit the statement that our senses do not indicate that the Earth is moving through space.
- Introduce Stellarium software (the software can be downloaded free from www.stellarium.org). Briefly show how the controls can be used to investigate the motion of Mars as viewed from Earth.
- Introduce the idea that technology can have a major impact on scientific explanations. The telescope has had a huge impact, not only in Galileo's time but also in the uncovering of the structure of the Universe since Galileo's time. Students make a simple telescope using a thin convex lenses with a focal length of 50–100 cm and a thin lens with a focal length of 5–10 cm (100 cm and 5 cm work best). **(Safety: Ensure students do not look directly at the lamp, and take care – the lamp will get hot.)**
- If available, use a commercial telescope or binoculars to project sunspots on a piece of card. **(Safety: Under no circumstances use a telescope to look at the Sun, or allow students to do so.)** A risk assessment must be completed. Read instructions for showing sunspots online (e.g. http://solar-center.stanford.edu/observe/).

## Homework

Workbook page 92.

## Key words

geocentric model, retrograde motion

**12.5 Student Book answers**

1. Earth, (crystal) spheres, move
2. It made sense because you cannot feel the Earth moving underneath you.
3. Ptolemy added little circles to the orbits of the planets.



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# 12.6

## Changing ideas: Modern ideas about the Universe

**Student Book pages 214–215**

## Homework

Workbook page 93.

## Key words

telescope, heliocentric model, Universe

## Objectives

- Describe the heliocentric model of the Universe.
- Describe the evidence for the heliocentric model.
- Explain how scientific explanations develop.

## Overview

This is the final of the lessons about how ideas about the Solar System have changed. The emphasis has been on the way scientific explanations are developed. Students consider the impact of technology (the telescope) on the development of the model of the Solar System.

Students produce a television programme to demonstrate how and why the explanation of the observation of the motion of the Sun and planets changed.

Depending on resources, they could use a video camera to record their programme and swap videos for another group to review, or present to the whole class. The group or the class should complete a peer-review sheet. In the discussion, bring out the importance of evidence in changing ideas, but add that it still took time for a new idea to be accepted.

## Activities

- Recap the idea that technology can have a major impact on scientific explanations. Use ideas from other areas of science, such as microscopes and cells. Describe the impact of Galileo's observations on the model of the Solar System.
- Students prepare a television programme that charts the change from the geocentric to the heliocentric model. This guides them through the structure of their programme and what should be included. They can to prepare their storyboard.
- Provide materials for them to make geocentric/heliocentric models (e.g. poster paper, balls, string, card).
- Group members each prepare the script for their section of the programme. The narrator works out how to link the scripts together (if they are using one). Each group rehearses what they are going to present.
- If resources allow, students could tape their programme to share. They assess each other's work.
- Discuss the role of evidence in the development of the model, and draw out how the ancient Greeks preferred to adapt their model to fit the evidence, using epicycles, rather than say that it was wrong.
- To consolidate their knowledge, each group produces a flow chart about how models develop, using the words 'question', 'evidence', 'explanation'. Alternatively, they can play a matching game for the geocentric and heliocentric models. They write researched information on blank cards, and place them face down. Each student takes it in turns to pick two cards. If they match (are about the same model) the student keeps them. The winning student has the most cards.

## Extension

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

### 12.6 Student Book answers

1. In a geocentric model the Earth is at the centre of the Universe. In a heliocentric model the Sun is at the centre of the Universe.
2. The observation of the moons of Jupiter in orbit around Jupiter, not around the Earth.
3. The retrograde motion of the planets.

# 12.7 Exploring space

**Student Book pages 216–217**

**Prior learning**

- the roles of NASA (National Aeronautics and Space Administration) and SUPARCO in space exploration.

## Objectives

- Describe how we collect information on space.
- Describe advancements in space technology.
- Understand the benefits of space technology.

## Overview

This lesson provides a science in context overview of space exploration and its benefits for humankind. Specifically, the students consider the impact of space technology on the quality of life on Earth. This will include the benefits of space technology, such as improved communication, navigation, and weather forecasting.

Students will discover the benefits of space technology and how it has helped us to better understand the universe. They will learn about the various methods used to collect information from space, such as telescopes, satellites, and space probes. They will also learn about the advancements in space technology that have allowed us to explore further and gather more detailed information.

## Activities

- Begin by reviewing the importance of space technology and how it has helped us to better understand the universe. Ask students which instruments come to their mind when we talk about space exploration. Remind them that most exploration is done from the surface of the Earth, using space telescopes and probes.
- Explain the difference between a space telescope, a satellite, and a space probe. If possible, arrange for a telescope and let students take turns looking at the sky through the telescope and note down their observations. If possible, repeat the exercise at evening again and note down observations. Compare the observations in class.
- Initiate a class discussion on the questions in the spread. Encourage students to conduct their own research using online resources and new articles and books.

## Homework

Questions from the student book spread. Also workbook page 94.

## Key words

Star, Galaxy, Milky way, Black hole, Neutron star, Pulsar white dwarf, red giant, Telescope, Hubble Space Telescope, Space Probes, Galileo.



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# 12.8 Review answers

## Student Book pages 218–219

## Student Book answers

| | | | |
|---|---|---|---|
| **1** | **a** | gas<br>planetary | **[1]**<br>**[1]** |
| | **b** | billions | **[1]** |
| | **c** | billions | **[1]** |
| **2** | | **A**<br>**D** | **[1]** |
| **3** | | **C A E B D** | **[5]** |
| **4** | | Spiral B, Elliptical C, Irregular A | **[3]** |
| **5** | | The nuclear fusion reactions have stopped so the star cools down | **[2]** |
| **6** | | Use telescopes both on earth and in space and send probes to other planets in the solar system | **[2]** |
| **7** | **a** | **i, iii, iv, v** | **All correct [2], 1 or 2 correct [1]** |
| | **b** | **i, iii, iv, v** | **All correct [2], 1 or 2 correct [1]** |
| | **c** | **iv** | **[1]** |
| **8** | | Heavier elements have to be formed in a supernova so there must have been a much bigger star here before to make all the elements found on earth | **[2]** |
| **9** | | Light takes a long time to travel to use from great distances. The greater the distance the longer it takes so we see galaxies as they looked millions of years ago. | **[3]** |
| **10** | **a** | In order: Milky Way formed, Earth formed, dinosaurs became extinct. | **[1] Milky Way before Earth**<br>**[1] Earth before dinosaurs** |
| | **b** | It decreased/the Universe cooled down. | **[1]** |
| | **c** | 14 billion light years<br>because light from any further away has not had time to reach the Earth yet. | **[1]**<br>**[1]** |

## 1.1 Variation in animals and plants

1. The missing words are: inherited; genes; offspring; environmental; environment; characteristics; combination; genetic/environmental; environmental/genetic.

2. **a.** They have many different characteristics because there is a lot of genetic difference between them.
   **b.** Organisms of the same species have lots of shared genetic characteristics which is why they look similar and can breed together successfully.
   **c.** Organisms of the same species are not genetically identical so they have some different characteristics. They also grow up in different environments in different conditions which means they have differences resulting from their environments.

3. Reasons for the variation: both leg length and body mass are affected by genes so these families of lion cubs will be different as a result of their different genes. However, body mass in particular is also affected by environment. Perhaps one mother lion brings back more food for her cubs than the other. The best fed cubs will be able to fulfil their genetic potential and gain body mass and their legs will grow as much as possible. Cubs with less food will not be able to grow as well or gain as much body mass.

## 1.2 Natural selection in action

1. From top of the table downwards: 3, 5, 4, 1, 2.

2. **a.** They all have a similar number of bones arranged in the same order but their sizes and shapes are different in each species.
   **b.** The bat finger bones are extended so they hold out its wings to give a large surface area to help it fly. All the bones are very thin to reduce their mass, which also makes flight easier.
   **c.** The arm bones are very short and wide for strength to push against the water and the central finger bones are extended to give the fin a streamlined shape.

### Extension

**a.** Some bacteria in a population may have some resistance to an antibiotic. These are the bacteria that will survive and pass on those successful genes to their offspring. The most resistant offspring will survive and reproduce – so gradually, through natural selection, the whole population becomes resistant to the antibiotic.

**b.** If a population of bacteria become resistant to an antibiotic through natural selection, it makes it difficult to cure the disease. If bacteria become resistant to several different antibiotics through natural selection, a disease may become untreatable and people may die.

## 1.3 Environmental change and natural selection

1. The missing words are: species; characteristics; survive; offspring; characteristics; generation; common; population; natural selection.

2. **a.** White fur provides better camouflage against ice and snow which makes it easier for white bears to catch their prey. It also means they are less likely to be seen and killed by other brown bears when they are young.
   **b.** Bears with white fur living in cold, icy places are more successful hunters than brown bears so they are more likely to survive and reproduce.

   The genes that made them successful are passed to the next generation. Over many generations, these genes become more common and the whole population eventually has white hair.
   **c.** If all the environments where bears live had become and remain icy and snowy, probably only polar bears would exist. Brown bears would struggle to hunt successfully in a white environment because they show up. However, only the Arctic has a white, icy environment. In other areas, white bears would show up much more than brown bears so they would not hunt


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successfully. The different species of bears are adapted to different environments, and as long as those environments are there, the different bear species will survive.

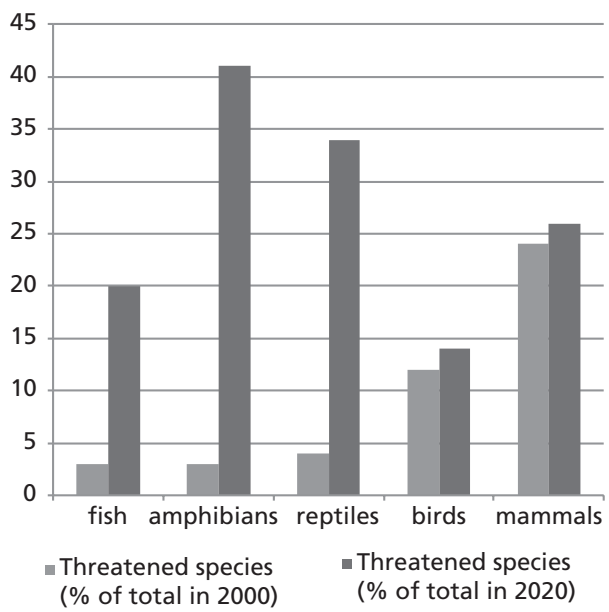
**d.** **Why:** global warming and climate change means the world is warming up and the ice/snow in the Arctic may disappear. **How:** if there is no ice and snow, white polar bears would show up in their environment and be unable to hunt effectively. They would be outcompeted by brown bears and die out /darker cubs would be more likely to survive and white coats would die out by natural selection.

## 1.4 Extinction!

**1.** The missing words are: plant; tropical; biomass; habitats; biodiversity; habitats; destroyed; extinct.

**2. a.**

| Vertebrate group | Threatened species (% of total in 2000) | Threatened species (% of total in 2020) |
|---|---|---|
| fish | 3 | 20 |
| amphibians | 3 | 41 |
| reptiles | 4 | 34 |
| birds | 12 | 14 |
| mammals | 24 | 26 |




**b.** Amphibians and reptiles have seen the greatest increase in threatened extinctions, while birds and mammals have seen the lowest percentage increase – although they have maintained high levels of threat throughout the 20 year period.

**c.** Human impacts are the main causes – look for three clear reasons; e.g. increased habitat destruction; increased pollution; increased hunting/fishing; changes in land use; draining of wetlands, etc.

### Extension

Plant seeds can be collected and stored for many years until habitats are restored. Animals cannot be put in cold storage in this way so conservation has to be much more immediate. They have to be conserved and so do the places where they live, otherwise they are lost forever.

## 1.5 Investigating the peppered moth: past and present

**1.** A5; B4; C2; D3; E1

**2. a.** The data describe the changes in the percentage of different coloured Biston betularia moths captured between 1800 and the early 2000s in the UK.

They show that, from the mid-1800s, the numbers of light-coloured moths caught dropped dramatically from over 95% to less than 5% of those caught, and the percentage of dark moths caught increased over the same timescale from less than 2% to 95% or more.

In the 1970s, this trend was reversed and, by the early 2000s, the numbers of pale moths caught climbed back up to almost 100% and the numbers of dark moths caught fell to almost 0%.

**b.** Initial 1800s natural populations were largely pale moths camouflaged on light tree trunks; occasional dark forms could be easily seen and eaten. After the Industrial Revolution, many trees and buildings were blackened by soot and smoke. Pale moths could now be easily seen.

Darker moths were less visible so they survived to reproduce. Over about 50 years, the colour proportions swapped over so dark became the majority and there were fewer pale moths through natural selection. In the 1970s, laws were made to make the air cleaner. Without the pollution the trees became their natural pale colour again. Now dark moths were easy for birds to see and eat. Pale moths were more likely to survive and reproduce and, by natural selection, the balance of colour in the population returned to mainly pale.

## 1.6 Genetics and Heredity

**1.** A3; B4; C1; D2

**2.** The missing words are: two; asexual; offspring; sexual; two; offspring; DNA; similar; different.

### Extension

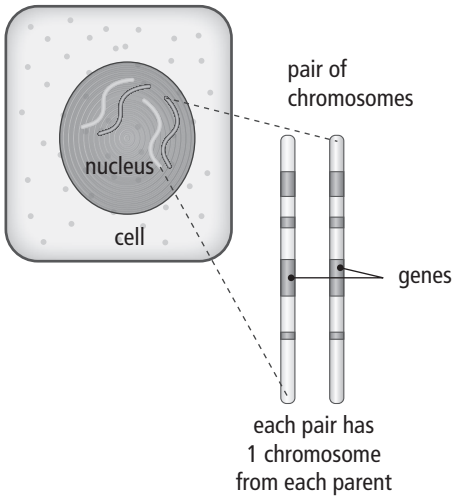
**a.** The plants produced asexually will have exactly the same DNA/genetic material as the parent plant. The plants produced sexually will have different combinations of DNA/genetic material to the parent plant.

**b.** The asexual offspring are produced by the parent plant cells dividing in two and so they are identical. In sexual reproduction the parent plant forms gametes which have half the number of chromosomes of the parent plant. Gametes from different plants join to form the seed that grows into the new plant, so it is similar to but different from its parent.

## 1.7 How does heredity work?

**1.** **1. a.** Both. **b.** Both. **c.** Chromosomes **d.** Chromosomes. **e.** Genes. **f.** Genes. **g.** Chromosomes.

**2. a.**




**b.** The nucleus in the diagram has two pairs of chromosomes, but real human cells have 23 pairs.

The chromosomes in the diagram each contain four different genes, but real human chromosomes can have thousands on genes.

**c.** In humans, 22 out of the 23 pairs of chromosomes are always identical to each other. The sex chromosomes may be the same or different The sex of the individual is determined by the sex chromosomes they inherit. Females have two X chromosomes but males have an X chromosome and a Y chromosome.

**3.**

| Species | Number of chromosomes in body cells | Number of chromosomes in gametes |
|---|---|---|
| human | 46 | **23** |
| elephant | **56** | 28 |
| coconut palm | 32 | **16** |
| boa constrictor | **36** | 18 |
| torch ginger | 48 | **24** |
| tortoise | **52** | 26 |

## 1.8 Modelling DNA

1. The missing words are: molecule; units; polymer; twist; double helix; models; DNA.

2. **a.** **A:** phosphate group; **B:** pentose sugar; **C:** nitrogenous base.

   **b.** The nitrogenous bases line up and join C to G, and T to A. The backbone of the DNA is formed by sugar and phosphate group joined to each other alternately.

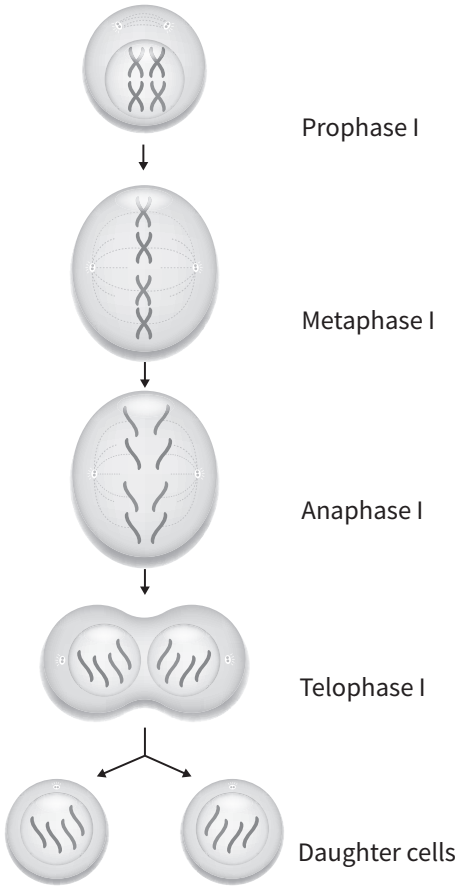
3. Physical models help us understand things which are too small for us to see. Models of the DNA molecule make its structure clear and help us understand its function. The popular double helix DNA model has the advantage of allowing storage of immense amounts of genetic information in an efficient manner. However, the disadvantage can be the possibility of errors during DNA replication, resulting in mutations and health issues.

### Extension

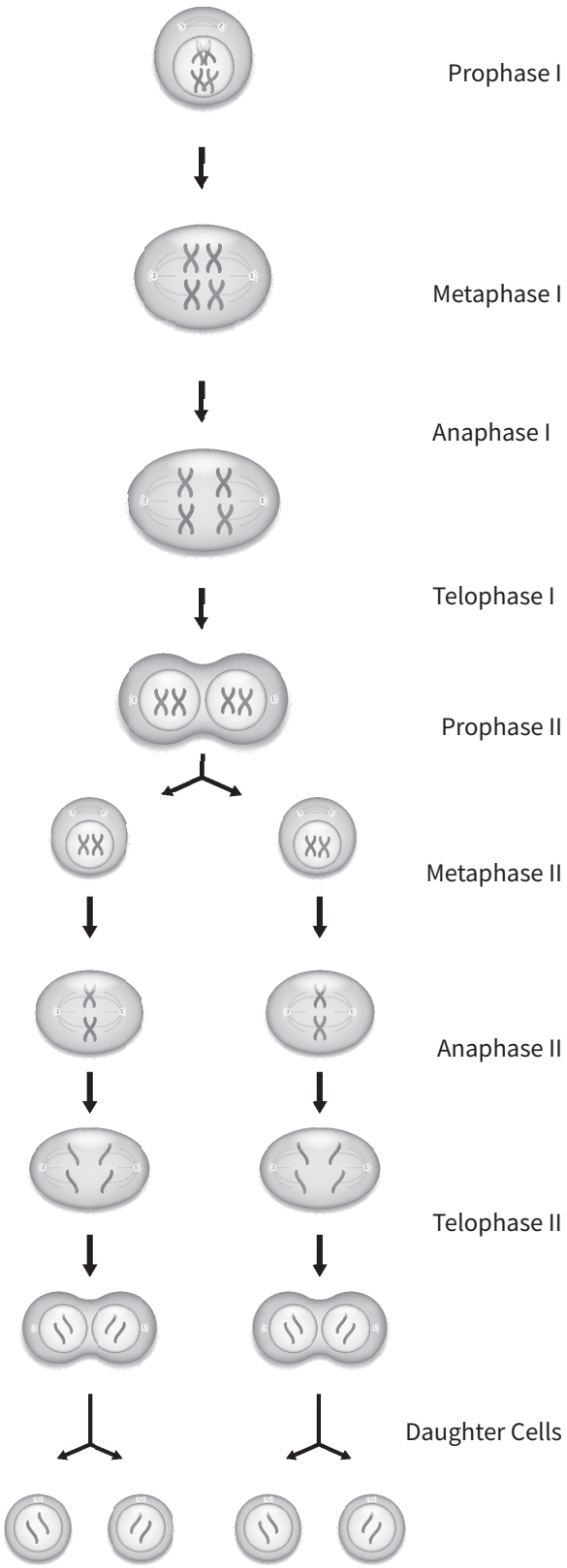
Each gene in a chromosome is made up of hundreds or thousands of bases. These genes control the structure and characteristics of a body by controlling protein synthesis in every cell. Protein synthesis describes the production of proteins in the cell. The order of the bases in the DNA controls the order of the amino acids in a protein. By controlling the proteins, DNA controls the structure, characteristics, and functions of the cell. In this way it controls the whole organism.

## 1.9 Mitosis and meiosis

1. The missing words are: mitosis; meiosis; mitosis; identical; chromosomes; parent; gametes; meiosis; halves; chromosomes; identical; half.

2. 

**3.**




## Extension

| Mitosis | Meiosis |
|---|---|
| Cell divides once | Cell divides twice |
| Parent cell produces two daughter cells | Parent cell produce four daughter cell |
| Daughter cell have the same number of chromosomes as the parent cell | Daughter cells have half the number of chromosomes as the paret cell |
| Control growth in living things | Control genetic factor from parents to offspring |
| Daughter cells have same genetic makeup | Daughter cells have different genetic makeup |

## 2.1 The organs, functions and processes of the human nervous system

**1.** The missing words are: animals; humans; coordinate; respond; nervous system; stimuli; sensitivity; environment.

**2.** **i.** Sensory receptors: ….detect changes in the environment both inside and outside our bodies.

**ii.** The peripheral nervous system: …. carries information around the body.

**iii.** The central nervous system: …coordinates incoming information and controls ourresponses.

**3.** **a.** Eyes : sensitive to light

**b.** Nose : sensitive to chemicals (smell)

**c.** Ears : sensitive to sound and position

**d.** Mouth : sensitive to chemicals (taste)

**e.** Skin : sensitive to touch, pressure, pain and temperature



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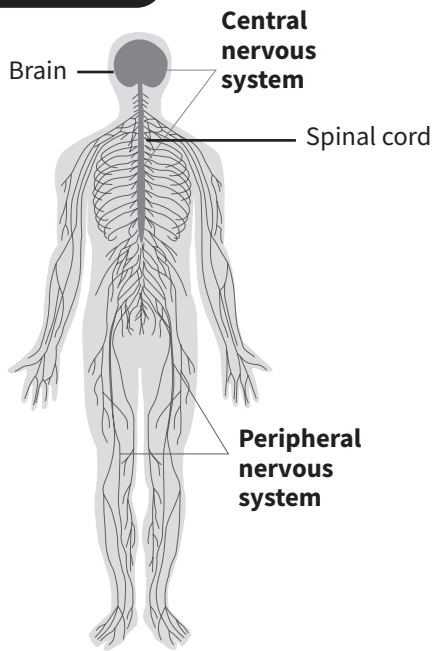
## Extension

**a.**




**b.** The peripheral nervous system is made up of neurones that carry messages to and from the central nervous system.

The central nervous system is made up of the brain and the spinal cord. It coordinates incoming information from the sensory receptors and controls our responses.

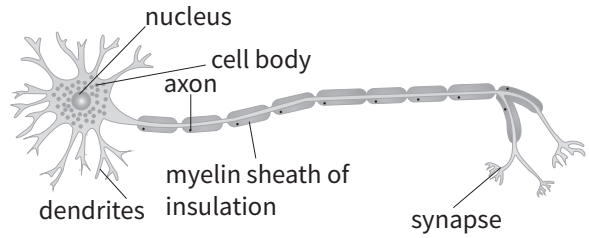
## 2.2 The structure and function of neurons

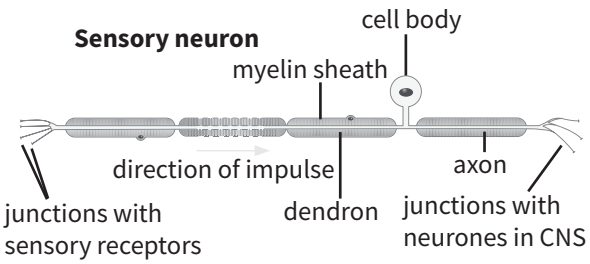
**1. a.** Neurones are basic units of the nervous system. They are cells which are specialised for the passage of electrical impulses.

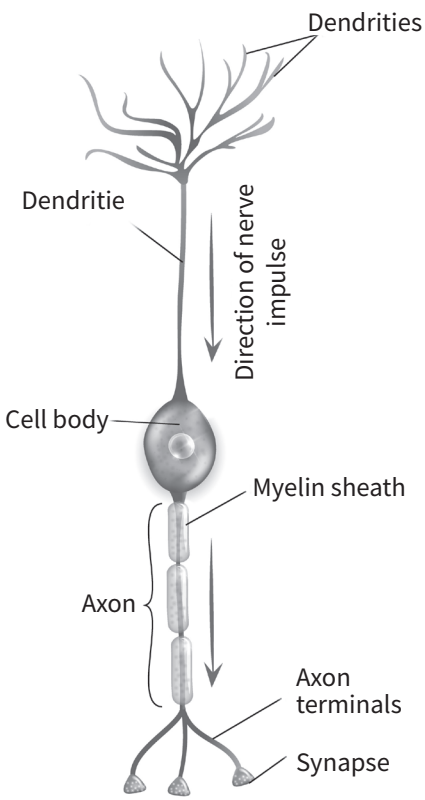
**b.** b. Hundreds or even thousands of neurones bundled together form a nerve.

**c.** Nerves which contain only motor neurones, are called motor nerves. Some nerves only contain sensory neurones – these are the sensory nerves. Some nerves contain both sensory and motor neurones. These are called mixed nerves.

**2.**



## 2.3 The structure and function of the central nervous system

**1.** The cerebrum : controls consciousness, intelligence, memory and language.

The olfactory lobes : give our sense of smell.

The forebrain : consists of the cerebrum and olfactory lobes.

The midbrain : contains the optic lobes which give a sense of sight.

The hindbrain : contains the cerebellum and brain stem.

The cerebellum : controls muscle movements and helps maintain balance.

The brain stem : controls unconscious actions such as breathing and heart rate.

**2. a.** the cerebrum.

**b.**

| LEFT BRAIN | RIGHT BRAIN |
|---|---|
| information from sense organs on the right side of the body | information from sense organs on the left side of the body |
| Recognizing words, letters and numbers | Recognizing faces, places and things |
| Understanding time and sequences | Perception and understanding context |

### Extension

Each gene in a chromosome is made up of hundreds or thousands of bases. These genes control the structure and characteristics of a body by controlling protein synthesis in every cell. Protein synthesis describes the production of proteins in the cell. The order of the bases in the DNA controls the order of the amino acids in a protein. By controlling the proteins, DNA controls the structure, characteristics, and functions of the cell. In this way it controls the whole organism.

## 2.4 Nervous control of the body

**1.** 👁👁 imran sees  the book ⟶ receptors respond to the stimulus of the book ⟶ sensory neurones carry messages to spinal cord ⟶ sensory neurones carry messages up the spinal cord to the brain ⟶ coordination: the brain analyses information from the eye and other areas of the brain ⟶ motor neurones carry messages from brain down to the spinal cord neurones carry messages from spinal cord ⟶ to body muscles (the ⟶ effectors) hand picks up the book. 

**2. a.** Since Naaz has a tumor on her optic nerve, her receptors are not able to respond to the light stimulus properly and thus the information to the optic lobes is not sent, resulting in blindness. Javeria who has tumor in her mid-brain is not able to recognize the information sent by the optic nerve and cannot coordinate the appropriate response.

**b.** Since the damage was to the spinal cord, it indicates that the damage occurred at or just above the pathway of the nerves from legs and feet to the brain.

### Extension

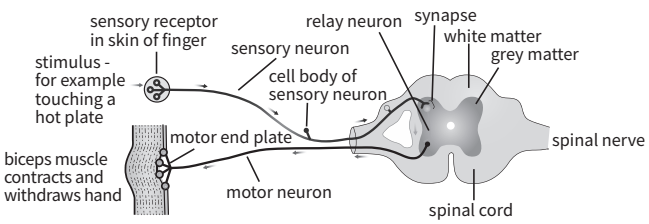
The reason for variable results of an injury is dependant on the type of nerve damaged. If a sensory nerve, containing only sensory neurones, is broken, then only sensation will be lost. If a motor nerve is damaged, then the ability to control parts of the body is lost. However, if a mixed nerve is broken, affecting both sensory and motor neurones, then both sensation and movement are lost.

## 2.5 Reflex arches

**1.**

| Action | Reflex or conscious? |
|---|---|
| Pulling your hand away from a hot pan | **Reflex** |
| Picking up your baby cousin | **Conscious** |
| Blinking | **Reflex** |
| Responding when you step on something sharp | **Conscious** |
| Reaching out for a date | **Conscious** |
| Writing your homework | **Conscious** |

**2.**




### Extension

| REFLEX ACTIONS | DELIBERATE ACTIONS |
|---|---|
| Are automatic and rapid responses to specific stimuli. | Are deliberate and intentional, complex actions. |
| They follow the reflex arch, bypassing the conscious processing by the brain. | The brain consciously controls the outcome by coordinating a combination of conscious and unconscious actions. |

## 2.6 A healthy brain

**1. i.** Eat a healthy, balanced diet which helps to keep the brain healthy.

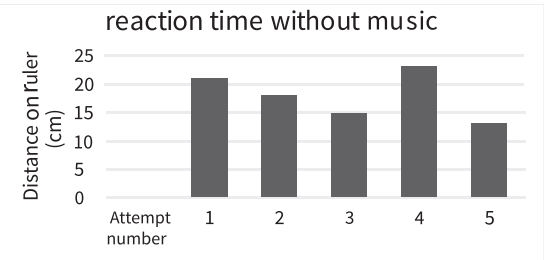
**ii.** Don't smoke! People who don't smoke have healthier brains (as well as healthier lungs and hearts) partly because they have a better blood supply to their brain.

**iii.** Do exercise or use meditation to reduce stress.

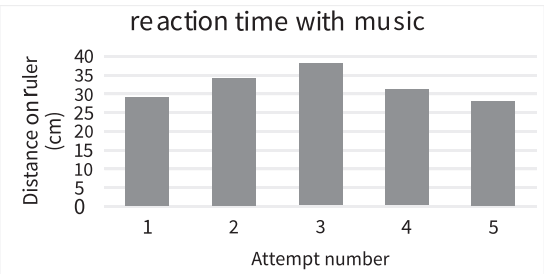
**2.**

| Attempt number | Distance on ruler (cm) without music | Distance on ruler (cm) with music |
|---|---|---|
| 1 | 21 | 29 |
| 2 | 18 | 34 |
| 3 | 15 | 38 |
| 4 | 23 | 31 |
| 5 | 13 | 28 |
| **Average distance (cm)** | | |

**a.** 18 cm without music and 32 cm with music.




**b.**




**c.** The results indicate that listening to music while attempting the test reduces the focus. As a result, the average distance travelled is larger when the participants are listening tomusic, as compared to when they are not listening. This proves that listening to music does Not increase focus, rather it reduces it.

**d.** Encourage the students to follow the experiment design suggestions given in their student books. Follow the experiments designed and note down the observations.

## 3.1 Ecology

**1.** The missing words are: ecosystem; environment; ecosystem; biosphere; ecosystem; abiotic; biotic; soil/temperature; temperature/soil; light.

**2.** The food supply; the numbers of predators and prey; diseases and parasites.

**3.** A3; B5; C4; D1; E2

### Extension

**a.** Biodiversity is a measure of the biological variety of an area.

**b.** Desert – low biodiversity; coral reef – high biodiversity; ocean – moderate biodiversity; temperate woodland – moderate biodiversity; tropical rain
forest – high biodiversity.



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## 3.2 Food chains, food webs and decomposers

**1.** A2; B3; C1; D5; E4; F7; G6

**2.** **a.** maize

**b.** mice

**c.** snakes

**d.** This is the direction in which biomass is transferred through the food chain. The plant has the most biomass because it makes food by photosynthesis. Biomass is lost at each stage of the chain.

**e.** Decomposers arrow goes from mongooses back to maize with label/explanation that decomposers break down biomass and return mineral salts to the soil to be taken up and used by the plants.

**3.** **a.** A food web is a model of the feeding relationships between organisms in an ecosystem. It links a number of food chains together.

**b.** Most animals eat more than one kind of organism so a food web is a more realistic representation of the feeding relationships.

**c.** **Herbivores**: two from ant, mouse, lizard; **carnivores**: two from spider, scorpion, large lizard, snake, fennec fox/fox.

**d.** Producers/plants are missing – they make biomass by photosynthesis so they are the starting point for the whole food web; decomposers – they break down and digest the droppings and dead remains of animals and plants in the food web, returning mineral salts to the soil to be used and recycled by plants.

## 3.3 Key ecological relationships

**1.** A7; B6; C1; D5; E3; F2; G4

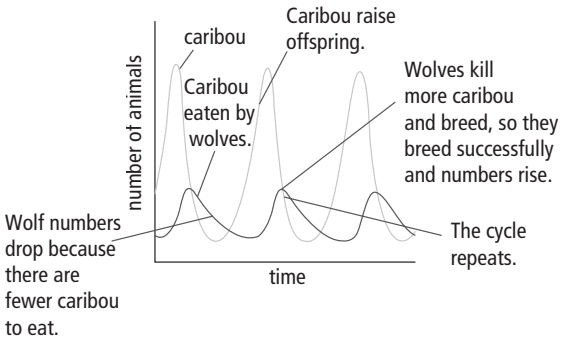
**2.** Population: the number of organisms of a particular type living in an area. Interdependent: species which affect each other within an area.

**3.** **a.** Any good example, e.g. grass ➔ caribou ➔ wolves

**b.** Herbivore numbers increase as there are fewer carnivores to kill and eat them – producer numbers will fall as there are more herbivores eating them.

**c.** Herbivore population might fall because the producer numbers fall because so many herbivores are eating them so there is not enough food to go around. OR Herbivore numbers might fall as carnivore numbers increase again and they start eating more herbivores.

### Extension




## 3.4 Changing ecosystems

**1.** The missing words are: food, disease, predators, extinct, invasive, quickly.

**2.** **a.** Insect-eating birds – Down. Eaten by the brown tree snakes. Lizards – Down. Eaten by the brown tree snakes (but if you said 'up' or stays the same it is OK if you recognise that the lizards have less competition for their insect food once birds are gone so they may do better, at least for a time). Spiders – Up. Fewer insect-eating birds around to eat them. Bats – Down. Eaten by the brown tree snakes. Seed and fruit–eating birds – Down. Eaten by the brown tree snakes.

**b.** If the insect population increases, they could destroy the forest by eating all the leaves on the trees.

**Extension**

Students should be encouraged to share logical predictions about the future of the forests in Guam. These can include the loss of insect-eating birds, which as process will have the biggest effect in the short term because there will be more insects increasing the amount of damage caused by insects 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.

## 3.5 Cycles in nature

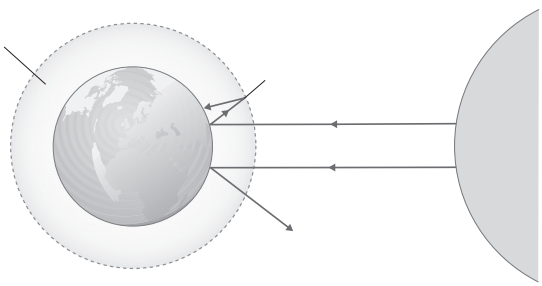
1. **Photosynthesis**: takes place in the green parts of plants and in algae. It uses energy from light, trapped by chlorophyll in the chloroplasts. Carbon dioxide is taken in from the air and combined with water to produce glucose and oxygen. This in turn is used to build the biomass of plants. Photosynthesis is the first stage of most food chains. **Feeding**: animals feed. They eat plants or other animals. They take in the biomass of plants, break it down, and build it back up into animal biomass. Carbon is passed from one organism to another in this way. Some is released into the environment through respiration at the same time. **Respiration**: takes place in all living organisms. Glucose molecules are broken down using oxygen, producing carbon dioxide ($CO_2$) and water. This releases energy to be used by cells. **Decomposition:** the process carried out by the decomposers. Microorganisms such as bacteria and fungi feed on the waste materials produced by animals, the dead leaves produced by plants, and the dead bodies of animals and plants. They break them down, releasing carbon dioxide back into the atmosphere. **Combustion:** the scientific word for burning. When a substance burns, it reacts with oxygen in the air and the energy transferred heats the surroundings and produces light. Many fuels, from wood to fossil fuels like coal, oil, and gas, are carbon compounds. When these fuels burn, they produce carbon dioxide and water which are released into the atmosphere.

**Extension**

The balance of the carbon cycle is being disturbed by human activities such as burning fossil fuels and cutting down trees. The effect is global warming and climate change. Unless people understand the science and how the carbon cycle works, it is hard to show them how we can help to restore the balance in the carbon cycle.

## 3.6 Disturbing the balance

1. The missing words are: Earth; water/carbon/oxygen; carbon/oxygen/water; oxygen/water/carbon; temperature; organisms; live; greenhouse gases; carbon dioxide; energy; Sun; warm.

2. 

3. **a.** The reason for rise in carbon dioxide concentration in the atmosphere can be contributed to either addition of carbon dioxide to the atmosphere or reduce the capability of carbon sinks. Examples include burning of fossil fuels to generate energy for vehicles, electricity, etc. and of deforestation which reduces the planet's capacity to convert carbon dioxide to biomass.

   **b.** Encourage the students to summarize the three points discussed in the unit in their own words.

## Extension

Students should be encouraged to share logical reasons as answer. They should be able to demonstrate an understanding that $CO_2$ levels of an area depend on a combination of natural processes, human activities, and environmental conditions. Some of these factors are:

1. Human activities, such as industrial processes, transportation, and energy consumption.
2. The amount of plant cover and the rate at which plants convert sunlight into energy through photosynthesis.
3. Wind speed and direction: areas with low wind speeds may have high $CO_2$ concentrations. Also, $CO_2$ emissions from neighbouring areas may influence the concentration readings of an area.
4. Variations: these can include seasonal variations in industrial, economic, travel activities and in domestic energy requirements (for example, more energy is required in cold weather than during warmer weather).
5. Changes to usage: these may include policy changes such as timings for high energy usage, adoption of renewable energy sources, deforestation or in some cases either afforestation or reforestation, changes to land management and urban expansion, etc.

## 3.7 The impacts of climate change

1. A4, B1, C5, D2, E3
2. **A** Huge volcanoes erupting, filling the atmosphere with ash and blocking the sunlight. **B** Giant meteorites striking Earth, causing dust that blocked out the Sun. **C** Changes in the orbit of the Earth so it was further from the Sun. **D** Changes in the activity of the Sun.
3.

| Observed change | Explanation |
|---|---|
| sea levels rising | Global warming melts land ice, and mean sea level rises. Rises in sea level increase coastal erosion and changes in ocean currents. This impacts the movements of the tiny organisms supporting all the ocean food chains. |
| flooding | Global warming and climate change are linked to increases in very heavy rainfall which lasts a long time and causes this problem. |
| drought | Climate change can lead to extreme heat and a lack of rain with crops failing and lakes drying. Many people can no longer grow enough to eat. The whole ecosystem is affected. Droughts increase the risk of wild fires which destroy whole ecosystems. |
| extreme weather events | Global warming changing the airflows in the atmosphere, affecting the climate everywhere and causing more extreme weather events such as hurricanes, tornados, blizzards, heavy rain, and very high temperatures. |

## 3.8 Predicting the future

1. **a.** Doubling the amount of carbon dioxide in the atmosphere would make it 5 °C warmer at the surface of the Earth.
   **b.** They show atmospheric carbon dioxide levels increasing and the surface temperature increasing in the same pattern. They are not quite increasing at the rate Arrhenius predicted but they are close.

**2.** Any 3 from:

- As oceans get warmer, and glaciers and land ice melts, some scientists predict a rise in sea levels of 26–82 cm by the end of the 21st century. Low lying countries like Tuvalu, and areas of many other countries, will disappear beneath the sea.
- As temperatures rise and rainfall patterns change, huge areas will become infertile. Plants and animal species will die out if there is no water to support life. People will starve.
- Many parts of the world will get more rainfall and snowfall than ever before, often as extreme storms or blizzards (snow storms). This will lead to floods, washing away fertile soil and causing the loss of homes and lives.
- Some countries will get hotter, so new pests such as mosquitoes, ticks, and crop pests will survive, impacting health and agriculture. Some will get colder. Ecosystems are often very temperature dependent, so plant life, migration patterns of animals, and the species you see around every day will change in future. Many species will become extinct.
- If climate change continues, extreme weather events such as hurricanes and storms will happen more often and affect more of our lives. A single storm can cause huge damage to infrastructure such as power supplies, buildings, roads, and railways.

### Extension

Range of temperatures because of the unpredictability of: people's behaviour, events such as volcanoes, legislation to control carbon emissions, etc.

Any sensible points including human behaviour – changing how we generate electricity, burning less fossil fuel, whether we continue rate of deforestation of slow it down, etc.

## 3.9 Evaluating the evidence for climate change

**1. a.**

| Measurements taken | What the evidence shows |
|---|---|
| past temperature readings from weather stations all over the world | Earth's average temperature is rising. |
| the thickness of tree rings | Because the rings are thicker when the weather is warm and smaller when it is cold, this shows the Earth's temperature has risen and fallen in the past. |
| the amount of carbon dioxide trapped in layers of ice | This shows how much carbon dioxide was in the atmosphere so the amount of carbon dioxide in the atmosphere has risen and fallen in the past. |

**b.** It reveals patterns in the climate of the Earth over time. It shows links between the rise and fall of carbon dioxide in the atmosphere and the temperature at the surface of the Earth. Any other sensible point.

**2. a.** The levels of carbon dioxide in the air from thousands of years ago trapped in bubbles in the ice.

**b.** Scientists record the changes in carbon dioxide levels in the atmosphere over thousands of years and compare it to levels of carbon dioxide recorded in the atmosphere now.

**c.** Over the last two centuries the level of carbon dioxide in the atmosphere has been rising steadily. Many scientists worry because the evidence tells them that when carbon dioxide levels rise the temperature at the surface of the Earth increases, and carbon dioxide levels are rising faster and have reached a higher level than they have ever been in the last 100 000 years.



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## 3.10 Humans can help

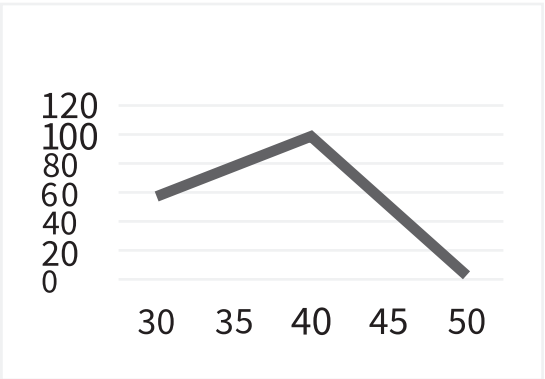
1. **a.** Encourage students to plot the graph using the techniques discussed in the beginning of the students' book.
   **b.** Increasing the production of hydroelectric power reduces the burning of fossil fuels to generate electricity. This reduces the amount of carbon dioxide released into the atmosphere, which in turn reduces the greenhouse effect and reduces global warming and climate change.
2. **a.** Reforestation.
   **b.** Reforestation using local trees results in providing shade and new ecosystems for local wildlife.
   **c.** On a global level reforestation helps to reduce the levels of CO 2 and eventually reduce global warming.
3. Encourage students to research and discuss atleast 3 logical coherent points in their article(s).

## 4.1 Biotechnology and you

1. The missing words are: dough; flour; yeast; respiration; carbon dioxide; soft; rises.
2. **a.** The use of living cells and organisms in products and processes that can improve the quality of life.
   **b.** Cheese and yoghurt.
3. **a.** The extra bacteria increased the pH of the milk.
   **b.** The bacteria feeds on the sugar in the milk, producing lactic acid. This lactic acid thickens the milk and gives yoghurt its sharp, tangy taste.

### Extension

**a.**




**b.** The results may indicate that lesser sugar is available for yeast to use. It may also indicate that after a certain temperature (threshold), the yeast is either inactive or begins to die off. Either of these reasons may result in lesser number of bubbles produced per minute.

## 4.2 Biotechnology and medicine

1. The correct words are: Biotechnology; cells; organisms; improve; bread; yoghurt; antibiotics; vaccines.
2. **a.** Antibiotics are medicines produced by biotechnology which attack the bacteria that cause infectious diseases. They save millions of lives every year.
   **b.** Penicillin.
   **c.** Mould (fungus)
   **d.** **i.** only use antibiotics for bacterial diseases.
   **ii.** always finish the prescribed course of antibiotics, even if feeling better halfway through the course.
3. **i.** A good oxygen supply so the bacteria respire aerobically.
   **ii.** A good food supply for the bacteria.
   **iii.** A stirrer to mix the microorganisms and their food.
   **iv.** A water-cooled jacket to absorb excess heat.
   **v.** Measuring instruments to check pH and temperature so the mixture can be adjusted if necessary.

## Extension

**i.** Production of antibiotics.

**ii.** Production of insulin.

**iii.** Production of vaccines.

## 4.3 Biotechnology and food science

**1.** The missing words are: food; processed; stored; biochemistry; nutrition; microbiology; improving; population.

**2.** For centuries people have used: selective breeding to improve their crops and livestock.

A new tool to improve our food is: genetic modification, which allows us to edit the genes of organisms.

Genetic modification is used to give: better yields, better taste, quality and nutritional value, the ability to survive difficult conditions and food that lasts longer.

An example of genetic modification of crops is to: increase the iron content of rice.

Yeast and bacteria are genetically modified: to improve the fermentation processes important for making and preserving many foods we enjoy.

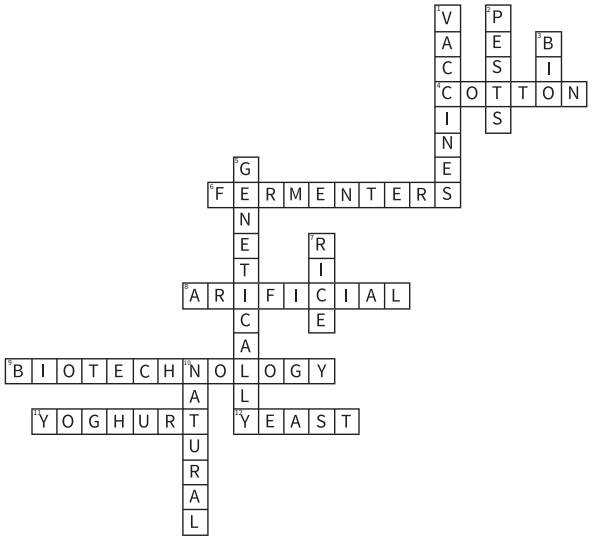
## Extension

**a.** The process of genetic modification allows us to edit the genes of organisms. We can add or change genes in the DNA of an animal or plant.

**b.** Biotechnology is being applied to try and make our food supply both secure and sustainable. This includes genetically engineering rice plants to cope with both periods of drought and long periods completely under water without losing too much of their yield. it also includes traditional selective breeding processes.

## 4.4 The impact of biotechnology

**1.**




## Extension

Encourage students to review the information in the unit and form a short report using the information provided. They may also do further research using online resources.

## 5.1 The Periodic Table

**1.** true statements: b, d, f.

The corrected false statements are:

**a.** The vertical columns in the Periodic Table are groups.

**c.** The horizontal rows in the Periodic Table are periods.

**e.** Magnesium is in group 2 (and period 3).

**2.**

| Element name | Chemical symbol of element | Group in Periodic Table | Period in Periodic Table |
|---|---|---|---|
| Boron | B | 3 | 2 |
| Chloride | Cl | 7 | 3 |
| Flourine | F | 8 | 2 |
| Germanium | Ge | 4 | 4 |
| Helium | He | 0 | 1 |
| Lithium | Li | 1 | 2 |
| Rubidium | Rb | 1 | 5 |

**Extension**

**a.** Encourage students to plot a line graph carefully.

**b.** The density increases from top to bottom of group 5 elements.

## 5.2 Magnificent metals

**1.** Sonorous, shiny when freshly cut, high melting point, good conductor of thermal energy, strong, ductile, good conductor of electricity, hard, malleable.

**2.** Heat sink – good conductor of thermal energy; bells – sonorous; bicycle frames – strong and malleable; electric cables – good conductor or electricity; cooking pans – good conductor of thermal energy; coins – shiny; printed circuit boards – good conductor of electricity.

**Extension**

**a.** Lithium, sodium, and potassium have lower melting points than other metals, for example, copper, gold, and silver.

**b.** Similar – shiny when you first cut them, good conductors of electricity; different – soft, low melting point.

## 5.3 Non-metal elements

**1.** Brittle, poor conductor of thermal energy, low melting point, poor conductor of electricity, dull.

**2.** C, E

**3.** **a.** I, L, K, J, G, H

**b.** G, H, J

**Extension**

**a.** Shiny, conducts electricity.

**b.** Brittle.

**c.** Yes, because two of the properties given are typical of metals and one is typical of non-metals.

## 5.4 Explaining properties of metals and non-metals

**1.** Elements on right of stepped line coloured in.

**2.** **a.** Their atoms are held together strongly.

**b.** Their atoms are held together strongly.

**3.** **a.** It exists as molecules, which are attracted to each other only weakly.

**b.** If a crystal drops, it breaks between rows of molecules.

**Extension**

Metals – J, L, M because their thermal conductivity values are much higher than those of the other elements in the table.

## 5.5 Radius and reactivity

**1.** true statements are: a, c, d, e. the corrected statements are:

**b.** Atomic radius is measured in nanometres (nm).

**f.** In general, for non-metal elements – the smaller the atomic radius, the more reactive the element.

**2.** **a.** Encourage students to plot graph appropriately. They may use a separate graph paper to draw the graph clearly and with ease.

**b.** upwards trend from top to bottom.

**c.** between magnesium and strontium, i.e. a value that is greater than 0.160 nm but smaller than 0.215 nm.

**d.** reactivity increases.

**Extension**

Encourage students to plot a line graph and draw conclusions carefully.



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## 6.1 Chemical reactions and Bonds

**1.** Substances, rearrange, differently, reverse, energy, reactants, products.

**2.**

| Description of reaction | Reactant name(s) | Product name(s) |
|---|---|---|
| Magnesium reacts with oxygen to make magnesium oxide. | magnesium<br>oxygen | magnesium oxide |
| Iron reacts with sulfur to make iron sulfide. | iron<br>sulfur | iron sulfide |
| Magnesium reacts with hydrochloric acid to make magnesium chloride and hydrogen. | magnesium<br>hydrochloric acid | magnesium chloride<br>hydrogen |
| Sodium hydroxide reacts with copper sulfate to make copper hydroxide and sodium sulfate. | sodium hydroxide<br>copper sulfate | copper hydroxide<br>sodium sulfate |
| On heating, copper carbonate makes copper oxide and carbon dioxide. | copper carbonate | copper oxide<br>carbon dioxide |

**3. a.** Flammable.

**b.** Keep it away from flames.

**Extension**

Magnesium has magnesium atoms only; magnesium oxide has both magnesium atoms and oxygen atoms (from the air).

## 6.2 Mass in chemical reactions

**1.** True– **a**, **c**, **d**.
False– **b**, **e**.
Corrected versions of false statements:

**b.** In a chemical reaction, the total mass of products is equal to the total mass of reactants

**e.** A water molecule has two hydrogen atoms joined to one oxygen atom.

**2. a.** 2

**b.** 2

**c.** 2

**d.** 2

**e.** The number of atoms of each element is the same in the reactants and products.

**Extension**

Reactants – 1 methane molecule (1 carbon atom joined to 4 hydrogen atoms) and 2 oxygen molecules (2 oxygen atoms in each); products – 1 carbon dioxide molecule (1 carbon atom joined to 2 oxygen atoms) and 2 water molecules (each with 1 oxygen atom joined to 2 hydrogen atoms).

## 6.3 Investigating a combustion reaction

**1.** From top – hypothesis, prediction, conclusion.

**2. a.** 27 g – 25 g = 2 g

**b.** Colour change from green solid to black solid.

**c.** One of the products, carbon dioxide, leaves the test tube as a gas as it is made.

**d.** 26 g – 25 g = 1 g

**e.** 2 g – 1 g = 1 g

**f.** The mass of solid product is less than the mass of solid reactant because one of the products (carbon dioxide) forms as a gas that leaves the test tube.

## 6.4 Types of chemical reactions

**1.** Copper, iron sulfate, displacement, more, copper, displaces, more, less.

**2.**

| Compound / Metal | magnesium chloride solution | iron chloride solution | lead nitrate solution | copper oxide |
|---|---|---|---|---|
| magnesium | | ✓ | ✓ | ✓ |
| zinc | | ✓ | ✓ | ✓ |
| iron | | | ✓ | ✓ |
| lead | | | | ✓ |
| copper | | | | |

**3.** **a.** iron + copper sulfate → iron sulfate + copper

**b.** magnesium + lead nitrate → magnesium nitrate + lead

**c.** iron + copper oxide → iron oxide + copper

**d.** zinc + iron nitrate → zinc nitrate + iron

**e.** zinc + lead oxide → zinc oxide + lead

**f.** magnesium + copper chloride → magnesium chloride + copper

### Extension

**a.** Iron oxide and aluminium.

**b.** Bright sparks/flames.

**c.** aluminium + iron oxide →
aluminium oxide + iron

## 6.5 Double displacement reactions

**1.** the words/phrases in order from top to bottom are: combustion; insoluble; precipitate; displacement; chemical reaction; double displacement.

**2.** D: a, e; DD: b, d; C: c, f.

**3.** **a.** potassium chloride; blue. b. nickel hydroxide; green. c. potassium nitrate; yellow.



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## 6.6 Distinguishing chemical reactions

**1.**

| Word, Phrase or symbol | Defination |
|---|---|
| reactant | Reacts to make |
| product | The starting substances in a chemical reaction |
| → | A chemical reaction in which two elements join together to make a compound |
| combination reaction | A chemical of two ionic compounds - the positive and negative ions of the compounds swap places to make two new ionic compounds |
| double displacement reaction | The substances that are made in a chemical reaction |
| dispalcement reaction | A chemical reaction in which a more reactive element 'pushes out' a less reactive element from its compound |

**2.** In word equation 1: reactants, product, reacts to make, displacement.

Word equation 2: combustion, combination.

Word equation 3: copper hydroxide and sodium chloride; double displacement, blue.

**3.** **a.** $2Fe + 3I_2 \rightarrow 2FeI_3$

**b.** $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

**c.** $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

**d.** $Mg + ZnCl_2 \rightarrow MgCl_2 + Zn$

## 6.7 Energy changes

**1.** Exothermic changes include freezing;
exothermic changes transfer energy to the surroundings;
exothermic changes include combustion reactions;
endothermic changes include evaporating;
endothermic changes transfer energy from the surroundings.

**2.** Melt, cold, from, start, endothermic.

**3.** **a.** B (72 – 24) = 48
D (10 – 23) = –13
E (86 – 25) = 61

**b.** A, B, E

**c.** E

**d.** C, D

**e.** A, B, E

**Extension**

The water takes energy from the surroundings in order to evaporate.

## 6.8 Introducing chemical equations

**1.** True – **b**, **c**, **f**, **g**.
False – **a**, **d**, **e**.
Corrected versions of false statements:
**a.** In a chemical reaction, there are the same number of atoms in the products and reactants;
**d.** In some chemical reactions, energy is transferred to the surroundings;
**e.** In a chemical reaction, the starting substances are called reactants.

**2. a.** 2
**b.** 2
**c.** 4
**d.** 4
**e.** There are the same number of atoms of each element in the reactants and in the products.

### Extension

**a.** Sulfur dioxide, oxygen.
**b.** Sulfur trioxide.
**c.** Reacts to make.
**d.** $SO_2$
**e.** $O_2$
**f.** $SO_3$
**g.** 2
**h.** 100

## 6.9 Writing balanced equations

**1. a.** $O_2$
**b.** $N_2O$
**c.** 2
**d.** 2
**e.** 2

**2. a.** $S + O_2 \rightarrow SO_2$
**b.** $2Zn + O_2 \rightarrow 2ZnO$
**c.** $Mg + 2HCl \rightarrow MgCl_2 + H_2$
**d.** $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
**e.** $2Na + 2H_2O \rightarrow 2NaOH + H_2$
**f.** $2K + 2H_2O \rightarrow 2KOH + H_2$
**g.** $Mg + CuO \rightarrow MgO + Cu$
**h.** $CuSO_4 + Fe \rightarrow Cu + FeSO_4$

**3. a.** $C + O_2 \rightarrow CO_2$
**b.** $2Mg + O_2 \rightarrow 2MgO$
**c.** $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
**d.** $2Li + 2H_2O \rightarrow 2LiOH + H_2$
**e.** $TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$

## 6.10 Making ionic bonds

**1.** 1. **a.** O 2 ; b. N 2 O; c. 2; d. 2; e. 2.

**2.** balanced equations are: a, d, g, h.
**b.** $2Zn + O_2 \rightarrow 2ZnO$
**c.** $Mg + 2HCl \rightarrow MgCl_2 + H_2$
**d.** $2Na + 2H_2O \rightarrow 2NaOH + H_2$
**e.** $2K + 2H_2O \rightarrow 2KOH + H_2$

**3.** a. $C + O_2 \rightarrow CO_2$
**b.** b. $2Mg + O_2 \rightarrow 2MgO$
**c.** c. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
**d.** d. $2Li + 2H_2O \rightarrow 2LiOH + H_2$
**e.** e. $TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$

## 6.11 Making covalent bonds

**1.** the words/phrases in order from top to bottom are: stable electronic structure; ionic bonding; giant ionic structure; covalent bond; molecule; double bond.

**2.** **a.** 1; **b.** 3; **c.** 4; **d. i.** 2; **ii.** 1; **iii.** 8.


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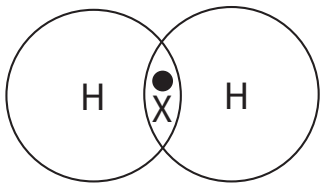
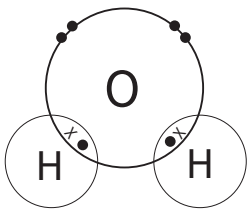
## Extension

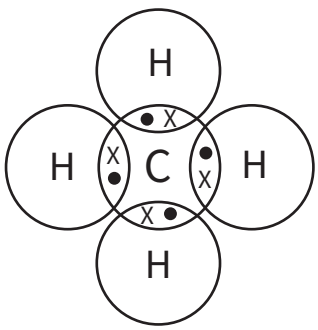
**a.** hydrogen, $H_2$



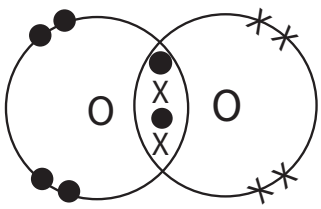

**b.** water, $H_2O$



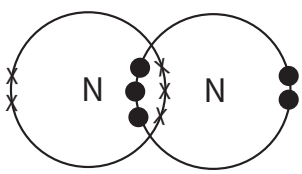

**c.** methane, $CH_4$




**d.** oxygen, $O_2$




**e.** nitrogen, $N_2$




## 7.1 Acids Bases and Salts

**1.** Acidic substances, for example – lemons, limes, vomit; alkaline substances, for example – toothpaste, soap.

**2.** **a.** Corrosive – hazard symbol showing drips onto hand and flat surface.

**b.** Reduce risks by wearing eye protection and gloves.

**3.** Acidic; reason – indicator becomes the same colour as its colour in hydrochloric acid.

## Extension

Add the flowers to warm water, filter, collect the solution.
To test – add the solution to both acidic and alkaline solutions. If the solution becomes different colours in the two solutions, it is suitable.

## 7.2 The pH scale

**1.** True– **a**, **d**, **f**.
False– **b**, **c**, **e**.
Corrected versions of false statements:
**b.** An alkaline solution has a pH greater than 7.0.
**c.** The more acidic a solution, the lower its pH.
**e.** You can use litmus paper to find out whether a solution is acidic or alkaline/you can use universal indicator to find out the pH of a solution.

**2.** **a.** Making fertilisers.

**b.** 2%

## Extension

A, because there is a greater mass of sodium hydroxide in the same volume of water.

## 7.3 Neutralisation reactions

**1.** True– **a**, **e**, **f**.
False– **b**, **c**, **d**.
Corrected versions of false statements:
**b.** If you add water to an acid, its concentration decreases;
**c.** Alex has an alkali of pH 12. He adds acid. The pH decreases;
**d.** If your soil is too acidic for a certain crop, add alkali to the soil to increase its pH

**2.** Purple, alkaline, decreases, 7, neutralised, decreases, red.

## Extension

**C**

## 7.4 Investigating neutralisation

**1. a.** It is possible to answer this question by finding the mass of limestone needed to increase the pH of a sample of water to pH 7.0, and then to scale up to find the mass needed for all the water in the pond.

**b. i.** Mass of limestone
**ii.** pH after adding limestone
**iii.** So that the test is fair

**c. i.** 20 g, this is the minimum amount of limestone required to achieve a neutral pH.

**ii.** The volume/amount of water in the pond.

## 7.5 Acid rain

**1. a.** Cause.

**b.** Effect.

**c.** Cause.

**d.** Effect.

**e.** Effect.

**f.** Cause.

**g.** Cause.

**2. a.** Nitric acid, calcium carbonate.

**b.** Calcium nitrate, water, carbon dioxide.

**Extension**

Any sensible suggestions.

## 7.6 Gas products of acid reactions

**1. a.** Carbon dioxide: $CO_2$, limewater, goes milky.

**b.** Oxygen: $O_2$, glowing splint, splint relights.

**c.** Hydrogen: $H_2$, lighted splint, flame goes out with a squeaky pop.

**2.**

| Reaction | Names of reactants | Names of products |
|---|---|---|
| A | hydrochloric acid<br>calcium carbonate | calcium chloride<br>water<br>carbon dioxide |
| B | zinc hydrochloric acid | zinc chloride<br>hydrogen |

**Extension**

Any correct properties and uses.

## 7.7 Making salts from acids and metals

**1.** Zamman.

**2.** Dilute hydrochloric acid, corrosive – wear eye protection and do not touch;
hydrogen gas, forms explosive mixture with air – keep away from flames;
hot equipment and solutions, burns – wait for apparatus to cool before touching;
sharp edges of broken apparatus, cuts and damage to eyes – wear eye protection and inform teacher of breakages.

**3. A**, **D**, **F**, **B**, **E**, **C**

**Extension**

Calcium and sulfuric acid.

## 7.8 More about salts

**1.** True – **b**, **e**, **f**.
False – **a**, **c**, **d**.
Corrected versions of false statements:

**a.** A salt is a compound made when a metal ion replaces a hydrogen ion in an acid;

**c.** Hydrochloric acid makes chloride salts;

**d.** Sulfuric acid makes sulfate salts

**2. a.** Zinc chloride.

**b.** Magnesium sulfate.

**c.** Magnesium chloride.

**d.** Iron sulfate.

**e.** Magnesium nitrate.

**f.** Zinc nitrate.

**3.** Collect some gas, light a splint, place the lighted splint in the gas, if the splint goes out with a squeaky pop the gas is hydrogen.



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4. **a.** magnesium + hydrochloric acid → magnesium chloride + hydrogen
   **b.** zinc oxide + hydrochloric acid → zinc chloride + water
   **c.** copper carbonate + nitric acid → copper nitrate + carbon dioxide + water
   **d.** nickel oxide + sulfuric acid → nickel sulfate + water
   **e.** magnesium + sulfuric acid → magnesium sulfate + hydrogen

## 7.9 Making salts from acids and carbonates

1.

| | **copper carbonate** | **magnesium carbonate** | **zinc carbonate** |
|---|---|---|---|
| **hydrochloric acid** | copper chloride | magnesium chloride | zinc chloride |
| **nitric acid** | copper nitrate | magnesium nitrate | zinc nitrate |
| **sulfuric acid** | copper sulfate | magnesium sulfate | zinc sulfate |

2. **a.** Copper chloride.
   **b.** Carbon dioxide.
3. **a.** copper carbonate + hydrochloric acid → copper chloride + carbon dioxide + water
   **b.** zinc carbonate + sulfuric acid → zinc sulfate + carbon dioxide + water
   **c.** magnesium carbonate + nitric acid → magnesium nitrate + carbon dioxide + water
   **d.** copper carbonate + sulfuric acid → copper sulfate + carbon dioxide + water
4. **a.** Stops bubbling.
   **b.** **B**, **E**, **F**
   **c.** **E**, **F**

**Extension**

Solution heats more evenly.

## 8.1 Force and Pressure

1. **a.** Incorrect word: balanced. When a cyclist is decelerating uphill the forces on him are **unbalanced**.
   **b.** Incorrect word: cannot. A cyclist **can** reach terminal velocity going downhill.
   **c.** Incorrect word: upthrust. When friction and **air resistance** are equal to thrust, the cyclist is moving at terminal velocity.
2. **a.** The box will **move/accelerate to the left**. The box will **not move**. The box will **move/accelerate to the left, more slowly than in the first case**.
   **b.** To measure the forces on the block you would use a forcemeter/newtonmeter/spring balance.
3. **a.** T **b.** F **c.** T **d.** F
   **b.** F – The forces on a rocket taking off are unbalanced.
   **d.** F – All objects that accelerate have balanced forces acting on them.

**Extension**

**a.** A resultant force is the single force that is equivalent to two or more forces acting on an object.
**b.** From top to bottom: 0 N, 2400 N, −100 N, 1200 N.
**c.** A – continue moving at a steady speed; B – accelerate; C – decelerate; D – accelerate.

## 8.2 Using forces: Friction

1. Correct answers in order: newtons, in contact, lubrication, opposite to.
2. From top to bottom: large, large, small, large.

**3.**

| | |
|---|---|
| Friction … | … of friction. |
| It is difficult to walk on an icy pavement because … | … rely on friction to work. |
| Matches light because … | … there is not much friction. |
| Car brakes … | … always slows things down. |

**Extension**

**a.** Wood, paper, sandpaper, carpet.

**b.** The mass of the block has increased which increases the frictional force, but it also increases the force down the slope so they cancel out.

## 8.3 Using forces: Tension and upthrust

**1. a.** T **b.** F **c.** F **d.** 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.

**2. a. i.** B **ii.** 1400 N

**b. i.** A **ii.** 14 m

**c. i.** B **ii.** A **iii.** B

**Extension**

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.

## 8.4 Presenting data

**1.**

| Area ($cm^2$) | Time (s) |
|---|---|
| 20 | 1.5 |
| 40 | 2.2 |
| 60 | 4.2 |
| 80 | 3.6 |
| 100 | 4.1 |

**2. a.** Students should plot the points from their table and draw a line of best fit (straight, or slight curve) through points 1, 2, 4, and 5.

**b.** Both variables are continuous so it is appropriate to draw a line graph.

**c.** Axis labels/title are missing from the graph.

**d.** Point for 60 cm.

**e.** The student should repeat his experiment to get another result.

**Extension**

**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.

## 8.5 Floating and sinking

**1. a.** Missing words in order: smaller, less.

**b.** The same size as.

**2. a.** When a submarine's tanks are filled with water they increase the mass of the submarine and therefore its density. If the density of the submarine is greater than that of water it will submerge.

**b.** Air is pumped into the tanks and water out to surface. Air is less dense than water and so the submarine's mass and density decreases until it is less than that of the water.

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

**Extension**

The density of the submarine when its tanks are filled with air is $\frac{8\,000\,000\text{ kg}}{10\,000\text{ m}^3} = 800\text{ kg/m}^3$.

This is less than the density of water, so it will float. However, when the outer tanks are full the density of the submarine changes to $\frac{(8\,000\,000 + 6\,500\,000)}{10\,000\text{ m}^3} = 1450\text{ kg/m}^3$. This is greater than the density of water, so it will sink.

## 8.6 Using ideas about density

**1. a.** Any suitable answer: e.g. Henry Cavendish is like Al-Biruni because he spent a lot of time doing experiments and was interested in calculating density.

**b.** Any suitable answer: e.g. Al-Biruni was able to do experiments on the density of gemstone to test his predictions, Cavendish used data to make predictions about the density of the Earth that he was unable to test.

**c.** Scientists today have more observations and better technology and can make more accurate measurements.

**d.** More precise.

**e.** More accurate – scientists have more information available to make a more accurate calculation than Cavendish.

**f.** Any suitable answer: e.g. Scientists used telescopes to make observations about the Sun to work out its density. Lots of scientists worked together to do this. Cavendish worked alone.

### Extension

**a.** Any suitable answer: e.g. Yes, the instruments we have today compared to those in the past enable scientists to make more accurate and more precise measurements. We also know more about the Earth and the Sun and density than they did.

**b.** Any suitable answer: e.g. Yes, scientists publish their results and other scientists verify the measurements so they are more likely to be accurate.

## 8.7 Pressure

**1.** Missing words in order: force, area, bigger, smaller, force divided by area, pascals.

**2. a.** $\frac{50\text{ N}}{5\text{ m}^2} = 10\text{ N/m}^2$

**b.** $\frac{100\text{ N}}{5\text{ m}^2} = 20\text{ N/m}^2$

**c.** $\frac{300\text{ N}}{0.5\text{ m}^2} = 600\text{ N/m}^2$

**3. a.** $10\text{ N/cm}^2$ – when it is standing on the end with the smallest area 5 cm × 2 cm.

**b.** $0.4\text{ N/cm}^2$ – when it is standing on the end with the largest area 10 cm × 5 cm.

### Extension

| Force (N) | Area | Pressure |
|---|---|---|
| 20 | $4\text{ cm}^2$ | **5 N/cm$^2$** |
| 60 | **40 m$^2$** | $1.5\text{ N/m}^2$ |
| **0.6** | $12\text{ m}^2$ | $0.05\text{ N/m}^2$ |
| 75 | $5\text{ cm}^2$ | $15\text{ N/m}^2$ |

## 8.8 Using pressure

| | | |
|---|---|---|
| A large force can be easily applied to the flat head of a pin, this applies a large pressure at the point so that it is easy to push the pin in. | Round stones have a larger surface area in contact with your foot than sharp stones, so the pressure is less and it is less painful to walk on them. | Mud is softer than dry ground and it can hold less pressure before you begin to sink into it. |
| The sharp point of the pole means that the force applied by the hammer creates a larger pressure on the ground. | A plank of wood spreads the force over a greater surface area, lessening the pressure on the quicksand so you won't fall in. | A narrow handle spreads the weight of the bag over a very small area exerting a greater pressure, which can be painful. |
| Swampy ground is soft and can support less pressure. The force (house weight) needs to be spread over a greater area to avoid sinking. | Studs have a smaller area than the surface of the boot, this means they exert greater pressure and will sink into the ground. | Animals that live in a muddy area have big feet to spread their weight over a greater area and therefore exert less pressure on the mud to avoid sinking. |

### Extension

**a.** $15\,cm \times 0.05\,cm = 0.75\,cm^2$

**b.** Pressure $= \frac{15\,N}{0.75\,cm^2} = 20\,N/cm^2$

**c.** $15\,cm \times 0.15\,cm = 2.25\,cm^2$

**d.** Pressure $= \frac{15\,N}{2.25\,cm^2} = 6.667\,N/cm^2$

**e.** The cook must use more force to cut with the blunt knife now.

## 8.9 Pressure in liquids

**1. a.** T **b.** F **c.** F **d.** T

**b.** F – The upthrust is the same.

**c.** F – the bottom of a dam is wider than the top of a dam.

**2. a.** Water cannot be compressed, so under pressure it is forced out of the holes.

**b.** She will not be able to push down because water cannot be compressed and there are no holes for it to escape from.

**3.** Missing words in order: input, pressure, incompressible, output, air, bigger.

### Extension

**a.** $12\,000\,N/m^2$

**b.** There is a curled up tube in a pressure gauge that straightens out as pressure increases, moving the needle.

**c.** B = 18 kPa C = 24 kPa

## 8.10 Pressure in gases

**1.**

| | |
|---|---|
| The particles in a gas are … | … close together. |
| If you compress a gas … | … spread out. |
| Gas pressure is produced … | … you cannot compress it. |
| The particles in a liquid are … | … when molecules collide with a container's walls. |
| If you try to compress a liquid … | … the particles are closer together. |



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**2. a.** B

**b.** Atmospheric pressure is greatest at B because it is the lowest point and there is more gas exerting pressure above it than any other point.

**3. a.** Decreases.

**b.** There are fewer particles in the can because they escaped as steam when the water boiled, so when the gas cools there are fewer collisions with the walls of the can and the can collapses inwards.

**c.** The can collapses because there are fewer collisions between the gas inside the can and the walls of the can. The walls collapse because the pressure outside the can has not changed and is now greater than inside.

**Extension**

**a.** When you suck the straw you reduce the number of air particles, and so the air pressure in the straw, the liquid moves into the region of lower pressure and moves up the straw.

**b.** The pressure at water level will be equal to atmospheric pressure.

## 9.1 Reflection and Refraction of Light

**1.** Completed sentences: You cannot see through opaque materials like concrete. You can see through transparent materials like glass. Light can get through translucent materials but you cannot see through them.

**2. a.** A–C, A–E, B–C, C–E, D–E

**b.** Light cannot travel in a straight line between them as there are buildings in the way.

**c.** The light emitted by the Sun is reflected from the road surface into the person's eye where it is absorbed.

**3. a.** The reading is a measure of how much light is transmitted by the material.

**b.** The reading is a measure of how much light is reflected by the material.

**Extension**

**a.** Yes, even transparent materials absorb a small amount of light.

**b.** The meter reading goes down.

## 9.2 The law of reflection

**1. a.** Line drawn through points for 0°, 20°, 60°, and 80°.

**b.** 40°

**c.** Yes, because it is not in line with the other results.

**d.** They show that the angle of incidence is always the same as the angle of reflection.

**e.** A white screen absorbs more light than a mirror, which means less is reflected.

**2. a.** F **b.** T **c.** F **d.** F **e.** T

**3.** B

**Extension**

**a.** Normal is at right angles to the surface.

**b.** Reflected ray is same angle from the normal as the incidence ray.

**c.** Draw another ray at any other point on the wall.

**d.** Draw an appropriate normal and reflected ray.

**e.** The reflection from a stone wall is not regular because the wall is uneven so you do not see a reflection.

## 9.3 Reflection and images

**1. a.** F – The image you see in a mirror is a virtual image.

**b.** F – if you look in a mirror your image looks as if left and right are swapped over.

**c.** F – The reflection of light from a mirror is regular reflection.

**d.** T

**e.** F – your mirror image appears the same distance from the mirror as you.

**2. a.**

| Things that are the same about you and your mirror image. | Things that are different about you and your mirror image. |
|---|---|
| Size, colours, up and down, distance from the mirror. | Left and right are reversed. |

**b.** 100 cm

**Extension**

**a.** The glass transmits and reflects light. Light from the beaker is transmitted and light from the candle is reflected to the same place making is appear as if the candle is burning underwater.

**b.** Diagram with light transmitted through the glass in straight lines from a beaker.

**c.** Replace the beaker with a lit candle.

## 9.4 Spherical mirrors

**1.** the missing words are: concave, convex, Concave, upright, virtual, shaving mirrors,Convex, smaller, upright, virtual, security.

**2.** Mirror (a) lines drawn showing light reflected to a focal point in front of the mirror as for a concave mirror Mirror (b) showing light reflected as if it came from a focal point in front of the mirror as for a convex mirror.

**3.** The mirror on the left is concave. This is because the image is magnified. Plane mirrors can only produce an image that is the same size and convex mirrors produce smaller images.

The mirror on the right is convex. This is because the image is smaller and appears to be behind the mirror. Concave mirrors can produce smaller images but they appear to be in front of the mirror and the crayons would be need to be further from the mirror. Again it cannot be a plane mirror because the image is not the same size as the object.

## 9.5 Refraction

**1. a.** 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.** Draw a ray that is refracted toward the eye at the surface of the water.

**2. a.** 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.

**Extension**

**a.** Correct answers in order: 300 000, 1.5, 220 588.2, 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.

## 9.6 Refraction and total internal reflection

**1.** Missing words in order: refracted, incidence, incident, refraction, refracted, denser, slowly, quickly, parallel.

**2. a.** 0°

**b.** Result for the angle of incidence 30°.

**c.** A block with a lower refractive index will slow the light down less, so it will be refracted less.



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**Extension**

**a.** You can see round corners if the light is totally internally reflected from the inside surfaces of the optical fibre. Diagram as shown in Unit 7.5 of the Student Book (light reflected in an optical fibre).

**b.** Diamond, plastic, glass, water, air.

## 9.7 The speed of light

**1. a.** $\frac{1}{100\,000\text{th}}$ of a second

**b.** No, this is a too short amount of time to detect and respond to with the human eye.

**c.** 300 000 km – the problem with doing this experiment is that they would not be able to see each other due to the distance and the curvature of the Earth and the light would be too faint to see.

**2. a.** It takes time for light to travel through space to Earth.

**b.** $\text{time} = \frac{\text{speed}}{\text{distance}} = \frac{3.0 \times 10^8}{62\,000\,000\,000}$

$= 20.7$ light seconds

$\text{time} = \frac{\text{speed}}{\text{distance}} = \frac{3.0 \times 10^8}{94\,000\,000\,000}$

$= 31.4$ light seconds

**c.** When Io is furthest from the Earth, the Earth is on the far side of the Sun from Jupiter and Io is on the far side of Jupiter from the Sun and Earth.

**3.** There is a range of values for the distance between Mars and Earth because they orbit the Sun at different speeds so they are at different points of their orbits and the distance between them changes.

## 9.8 Dispersion

**1. a.** F – the spectrum is made up of seven colours.

**b.** T **c.** T

**d.** F – light is refracted as it goes through a prism.

**2. a.** Diagram completed as shown in Student Book, page 142.

**b.** Two circles where the ray enters and leaves the prism.

**c.** Place a second prism upside down to the right of the prism shown in the diagram.

**3.** C, B, A, E, D

**Extension**

To form a rainbow light is refracted, but also totally internally reflected from the inside of the water droplet.

## 9.9 Colour

**1.** Missing words in order: primary, blue/green, green/blue, secondary, in any order magenta, cyan, and yellow, primary, in any order blue, green, and red, filter, transmits, absorbs, transparent.

**2. a.** In order: blue, cyan, no, no, red.

**b.** It will be less bright as some of the light has been absorbed.

**Extension**

**a.** Only green light would be transmitted through the filter, so she will only see green light.

**b.** Only red light would be transmitted by the filter, so she will only see red light, but it will be in a different place to the green light.

**c.** She would see no light as only blue light would be transmitted through the blue filter and the red light will absorb this light.

## 9.10 Looking at coloured objects

**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/cyan, green/yellow/cyan/white.

### Extension

The atmosphere is only allowing the red light to reach our eyes. It must be scattering/reflecting the other colours of light.

## 9.11 Changing ideas: Light

**1. a.** 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

### Extension

**a.** Any suitable answers: e.g. 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, the objects will not be.

**b.** Any suitable answer: e.g. you see things using a torch which emits light.



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## 9.12 The eye and the camera

**1.**

| Part of the eye | Function | Mainly transmitted | Mainly absorbed | Part of the camera |
|---|---|---|---|---|
| pupil | hole to allow light in | √ | | aperture |
| cornea | refracts/focusses light | √ | | none |
| lens | refracts/focusses light | √ | | lens |
| eyelid | protects front of the eye | | √ | lens cap |

**2. a. i.** rod **ii.** cone

**b. i.** rod **ii.** cone

**c.** It is similar to film because there is a chemical reaction.

**3. a.** The light travels in straight lines. The rays cross when they go through the hole.

**b.** The student's friend is correct. Turning the camera upside down would not affect the place that the light is coming from.

## 10.1 Voltage

**1.** Missing words in order: voltage, electrons, energy, charge, volts, voltmeter, adds up to, the same as.

**2. a.** 6 V **b.** 6 V **c.** 3 V

**3. a.** A voltmeter is always connected in parallel with a component.

**b.** You measure the voltage across a component and the current through a component.

**c.** If the voltage across two parallel branches is 3 V the battery voltage is also 3 V.

### Extension

**a.** Lamp A would switch on, the brightness of lamps B and C will not change.

**b.** It will go from 0 V to 12 V.

**c.** It will stay at 6 V.

**d.** It will stay at 6 V

**e.** It will increase.

## 10.2 Resistance

**1.** Words in this order: bigger, smaller, adds up, ohms, voltage by current, more.

**2. a.**

| | In B compared with A | In C compared with A |
|---|---|---|
| the brightness of the bulb or bulbs | brighter | the same |
| the reading on the voltmeter | larger | the same |
| the reading on the ammeter | larger | the same |

**b.** $\text{Resistance} = \frac{\text{voltage}}{\text{current}}$

$= \frac{6\,\text{V}}{0.2\,\text{A}}$

$= 30$ ohms

**c.** It is smaller. The p.d./voltage is the same but the current is bigger, so the resistance is smaller.

**d.** To vary the brightness of the lamp.

### Extension

**a.** $\text{current} = \frac{\text{voltage}}{\text{resistance}} = \frac{12\,\text{V}}{3\,\text{W}} = 4\,\text{A}$

**b.** $\text{current} = \frac{12\,\text{V}}{6\,\text{W}} = 2\,\text{A}$

**c.** current = 4 A + 2 A = 6 A

## 10.3 Planning investigations: Resistance of a wire

1. **a.** A and C
   **b.** If you collected the data yourself it would be primary, but if you used someone else's data it would be secondary.
2. Independent variable: current. Dependent variable: temperature rise of the water. Variables to control: wire, voltage, room temperature time in the water. Students' own answers.

**Extension**

**a.** C is the odd one out because you would do a fair test/vary the type of wire and measure the current, the rest you are finding one value.

**b.** Any suitable answer.

## 10.4 Energy and power

1. **a. F** **b. F** **c. T** **d. F**
   **a.** F – Lamp A is less powerful than lamp B.
   **b.** F – The first motor is more powerful.
   **d.** F – There are 1000 watts in a kilowatt, there is only 1 watt in a watt.
2. Correct answers in order: 1000 W/1 kW, 500 W, 10 W, 800 W.
3. **a.** 10 kJ
   **b.** 6000 kJ
   **c.** 2 seconds
4. **a.** 0.8 kW
   **b.** 0.5 hours, 0.4 kWh
   **c.** 4 rupees

## 10.5 Electrical safety in the home

1. true: b, d; false: a, c.
   The corrected versions of the statements are:
   Fuses are placed in the live wire only.
   If you had too many plugs the current is too large and may cause a fire (overload thesocket).
2. C, A, D, B, E.
3. **a.** The circuit breaker switches off the circuit when there is a fault. You don't want every circuit switched off because there is a fault in one circuit. It allows the circuit breakers to be set differently for each circuit.
   **b.** Lighting circuits carry small currents. If there is a fault they need to switch off when the current exceeds 5 A. Otherwise the wires would melt and start a fire. Other circuits need higher currents to operate.

## 10.6 Electromagnets

1. Any two from can vary the strength of an electromagnet, can reverse poles, can switch it off.
2. **a.** Arrows correctly showing the magnetic field pattern of an electromagnet.
   **b.** The arrows will all point in the opposite direction.
   **c.** arrows will all point in the same direction because the magnetic field has disappeared.
   They are now lined up with the earth's magnetic field.
3. **a.** When the button is pushed the circuit is completed and the electromagnet switches on. This attracts the iron bolt and unlocks the door.
   **b.** The spring pushes the lock back into place when the button is released.

## 10.7 Investigating electromagnets

1. **a.** Correct answers in order: 6, 8, 12, 18, 23.
   **b.** Variables to control: type of wire and core, type and size of paper clips, current and voltage of the circuit.
   **c.** The wire will get hot, so only turn the circuit on for short periods of time.
2. **a.** A, F, E
   **b.** B, F
   **c.** A, D
   **d.** C, E

3. **a.** The strength of the electromagnet will not be affected by the size of the paper clip, but it may be able to pick up fewer of the heavier paperclips.
   **b.** Any suitable answer: e.g. an electromagnet can pick up more small paper clips, so it will be easier to observe any smaller differences in strength.

## 11.1 Making toothpaste

1. True: b, c; false: a, d.

   The corrected statements are:

   Every sample of an homogenous mixture contains the same substances, but in same proportions.

   The chemical formula of titanium oxide is TiO 2 .

2.

| Name | Chemical formula |
|---|---|
| sodium fluoride | NaF |
| sodium lauryl sulfate | NaC12H25SO4 |
| titanium dioxide | TiO2 |
| sodium chloride | NaCl |

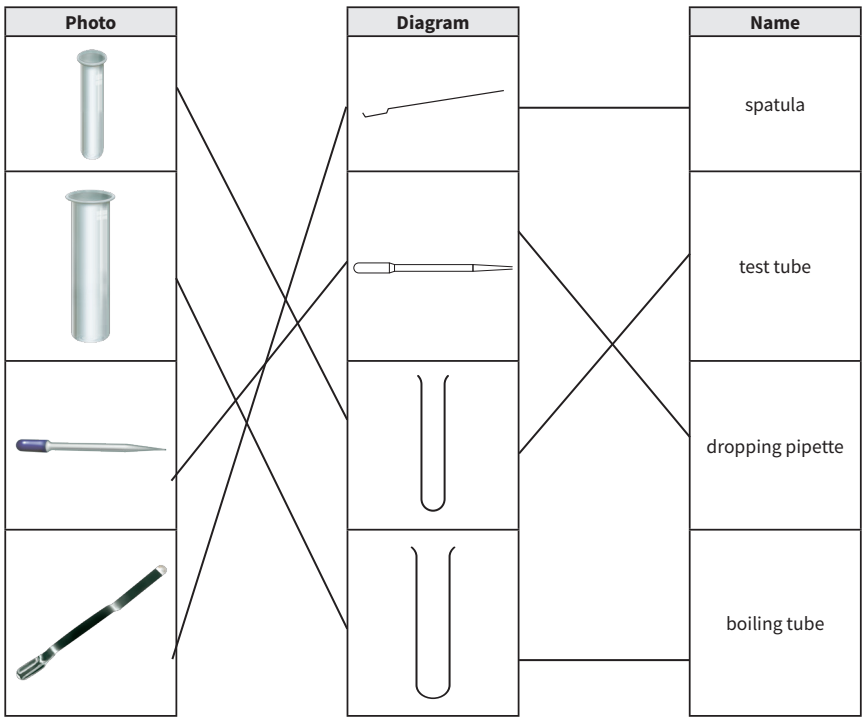
3. **a.** sodium chloride.
   **b.** sodium lauryl sulfate.
   **c.** titanium dioxide.
   **d.** carrageenan.
   **e.** peppermint oil.
   **f.** sodium hydrogen carbonate.

### Extension

Encourage students to formulate their own answers. Correct answers can include any to all of the following points: Safety, Identification and Tracking, Compliance with quality regulations and preventing contamination.

## 11.2 Making detergent

**1.**



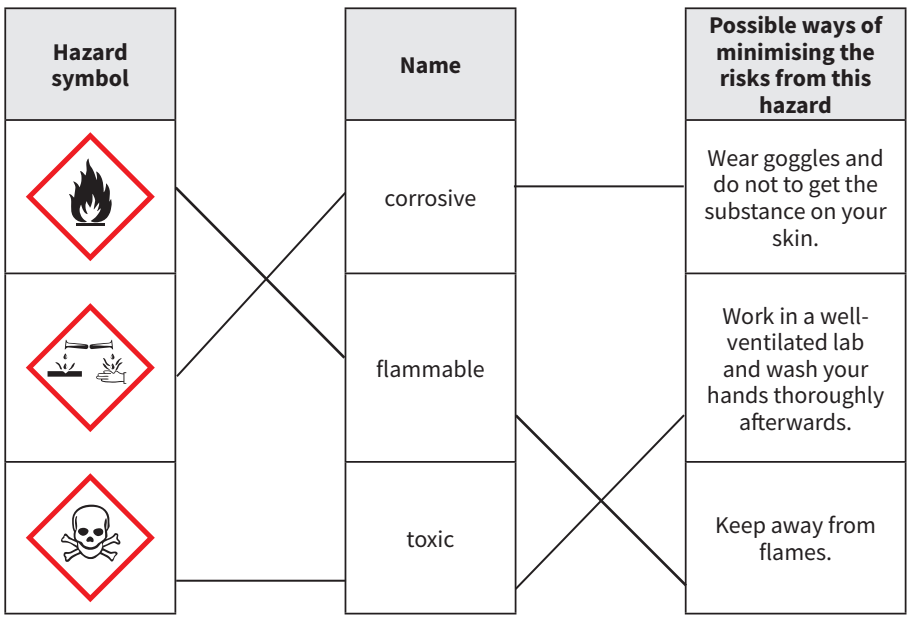

**2. a.** This symbol indicates the substance is corrosive.

**b. i.** Wear goggles the whole time. Safety glasses are not enough. ii. If this gets on your skin, wash off immediately with running water.

**3. a.** Oil and sulfuric acid. **b.** detergent and water.

## 11.3 Making soap

**1.**



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**2.** true: a, d; false: b, c.

The corrected statements are:

If you add sodium chloride to water until no more dissolves, you make a saturated solution.

You must wear goggles throughout the entire soap-making process; you cannot take them off even if they are uncomfortable.

**3.** **a.** soap and glycerol.

**b.** oil and sodium hydroxide.

**c.** it indicates the direction of the reaction.

## 12.1 Our Universe

**1.** **a.** F **b.** T **c.** F **d.** F **e.** T

**2.** **a.**

| Small stars (like our Sun) | Larger stars |
|---|---|
| E, A, B, G, F | E, A, B, H, C, D |

**b.** Planetary nebula.

### Extension

**a.** The M42 Orion Nebula.

**b.** Betelgeuse. It is red so is a red giant or super red giant, which means it is closer to the end of its life cycle.

## 12.2 Galaxies

**1.** true: a, d; false: b, c.

The corrected statements are:

Stars form in the arms of spiral galaxies.

Elliptical galaxies are circular or squashed circles.

**2.** **a.** **E, A, D, C, G, F, B**

**b.** E

**c.** You cannot travel beyond the edge of the Universe in a spaceship because theUniverse is everything that there is.

**3.** **a.** The different separations are within each other.

**b.** Inside the solar system: A, G; Inside the Milky Way, but outside the solar system: C, D, E, F, H; Inside the Universe but outside the Milky way: B, F.

**c.** Planet could be added to all three circles.

### Extension

**a.** Count the number of people in a known small area of the crowd and multiply by the numberof those areas in the photograph.

**b.** Use a telescope to look at one area of the sky, count the galaxies, multiply by the number of those areas in the whole sky.

**c.** Reasonable suggestion, such as: it is difficult to distinguish galaxies from stars, the light from some galaxies my not have reached us.

## 12.3: The origin of the Universe

**1.** It will be easier as each centimetre will represent 70 million years, but it will still be difficult to show when humans began to exist.

**2.** **a.** The student can draw galaxies on the elastic band and stretch it to show they are moving apart.

**b.** If he holds one end and stretches the other, the galaxies at this end will move further away than those closer to the end he is holding.

**c.** All of the galaxies astronomers observe display red shift, this means they are moving away from us.

## 12.4 Changing ideas 1: Ancient ideas about the Universe

**1.** Missing words in order: questions, stories, measurements, measurements, explanations, explanations, model.

**2.** **a.** Movement of the Sun and stars, and solar and lunar eclipses.

**b.** Motion of the planets.

**c.** It was not easy to communicate when Aryabhata was alive, his ideas may not have been written down, or the writings were not taken to other countries or written down in other languages.

## Extension

**a.** The Pole Star does not appear to move as the Earth spins.

**b.** They would make observations of the seasons and the positions of the stars in the sky that change over the course of one year.

## 12.5 Changing ideas 2: The geocentric model

**1. a.**

| Word | Definition |
|---|---|
| geography | graphing/drawing the Earth |
| geothermal | energy/heat from the Earth |
| geology | study of the structure of the Earth |

**b.** Earth-centred, with the Earth at the centre.

**2. a.** Draw the Earth at the centre, planets and sun in orbit around the Earth.

**b.** Beyond the furthest orbit.

**c.** Everything in the night sky appeared to orbit around Earth/the Earth does not seem to move.

**3. a.** Models are based on observations and measurements.

**b.** The planets appeared to wander; their motion did not fit the model.

**c.** Ptolemy added smaller epicycles to the orbits of the planets.

**d.** Ptolemy's explanation was useful because it explained the movement of everything in the sky and could be used to make predictions.

## Extension

**a.** Greek astronomers did not have good enough equipment, such as telescopes.

**b.** Now astronomers have much better equipment, like telescopes and computers to record data.

## 12.6 Changing ideas 3: Modern ideas about the Universe

**1. a.** The size also changes.

**b.** B

**c.** A – This model has a simpler explanation of the changing size of Venus over time.

**2.**

| | True for Copernicus | True for Galileo |
|---|---|---|
| wanted to talk about his ideas | | ✓ |
| thought that the Sun was at the centre of the Solar System | ✓ | ✓ |
| used a telescope to make observations | | ✓ |

## Extension

Geocentric model: b; heliocentric model: a, c, d.

## 12.7 Exploring space

**1.** Freeze dried foods: need for incredibly light food source which keeps its nutritional value.

Shock absorbers for buildings in earthquake zones: to protect sensitive equipment during launch.

Cordless drills and vacuum cleaners: Collecting rock samples in space.

Insulin pumps: to monitor astronauts health in space.

**2. a.** the advantage statements are: ii, iii; the disadvantage statements are: i, iv.

**b.** technology invented for space exploration used on earth, possibility of other planets to colonize, finding additional resource.

**c.** very expensive/does not always add to knowledge/can cause competition between countries.

**3. a.** A year is the time it takes a planet to orbit the Sun. Mars is on a different orbit further from the sun and so it takes longer.

**b.** As far as we know, Water is essential for life.

**c.** Oxygen is vital for humans and plant life. If we were to visit mars would need access to oxygen.



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