Collins

Key Stage 3 Science

Teacher Pack 1

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Contents

Extra resources on CD-ROM

All pages from this print book available as PDF and editable Word files

Student worksheets in 2 formats; reusable and write-on (all available as PDF and Word files)

Practical sheets (as PDF and Word files)

Technician's notes (as PDF and Word files)

Each type of resource sheet collated in chapter batches to enable easy printing

Scheme outline for Teacher Pack 2

Scheme outline for Teacher Pack 3

Introduction

Purpose of the Collins Key Stage 3 Science course

This course has been developed to provide support to teachers in planning and delivering exciting, engaging and effective lessons. The overarching priorities have been to:

- ensure that the requirements of the National Curriculum Programme of Study have been responded to
- support teachers in teaching lessons in which students make good progress and are on track to achieve well at the end of KS4
- offer ways of tracking, reporting on and responding to progress given the move away from levels in the National Curriculum
- enable schools to select the period of time they decide to devote to KS3 before starting on KS4 courses
- address the need to challenge and engage students working at different levels of attainment
- focus on the development of skills and processes as well as content
- provide teachers with clear guidance as to how learning can be managed during the lesson, from initial engagement to consolidation and application.

Overview of changes at Key Stage 3

Some concepts previously associated with GCSE are now in KS3, such as:

- the role played by Watson, Crick, Wilkins and Franklin in the development of the DNA model
- the chemical properties of metal and non-metal oxides with respect to acidity
- the properties of ceramics, polymers and composites
- heating and thermal equilibrium
- the superposition of waves
- resistance as the ratio of potential difference to current
- the concept of electrostatic fields
- the light year as a unit of astronomical distance.

How Science Works has been replaced with Working Scientifically, which covers a similar range of skills and processes but which moves away from the social and economic implications of scientific developments.

There are no levels or any descriptors of progression. Nevertheless, schools are expected to track progress, report accordingly and respond with further challenge or support.

Organisation of the Collins Key Stage 3 Science course

There are two biology, two chemistry and two physics chapters in each year. This means that science can be delivered as one subject or by subject specialists. A scheme of work shows both 3-year and 2-year routes though the course to aid long-term planning, see page 242. Support and strategies for building and assessing progress are embedded throughout. For more details please see *Planning the learning process* on pages 3-7.

How the lesson plans work

Chapter introductions

These:

- give an overview of the of the content and skills covered in the chapter
- help in assessing prior learning and identifying misconceptions
- list the overarching learning objectives to help medium-term planning.

Learning objectives and outcomes

- Learning objectives for each topic are shared with students in the Student Book for short-term planning.
- Learning outcomes at three levels are listed, and it is shown which learning activities contribute to achieving each outcome.

These help in tracking the progress of all students, identifying those making good progress and who are on the right trajectory for sound results at GCSE, those who are making better than expected progress and are headed for the top results at GCSE, and those making less progress and for whom some intervention is needed.

Skills development

Ensuring progression in skills has underpinned the development of the course. There are three skill sets used, developed from a range of sources including PLTS, SEAL and APP in Science:

- **Thinking scientifically** relates to the relationship between evidence, ideas and theories, and has a strong role to play in science generally and in KS4 courses. It includes asking questions, considering the quality of evidence, understanding how theories develop, evaluating risks, using units and nomenclature, using equations and analysing data.
- **Working scientifically** relates to conducting practical investigations and includes making predictions, designing investigations, recording evidence, presenting evidence, interpreting evidence, developing explanations and evaluating data.
- **Developing as learners** is not a science-specific set of skills, though science can play a strong part in developing the skills, and they are recognised by the Ofsted school inspection framework. They include planning progress, acting responsibly, developing resilience, asking questions, communicating effectively, respecting others and collaborating effectively.

Resources needed gives an overview of all the resources needed for a lesson. More detailed guidance for practicals is given in student practical sheets and technician's notes on the accompanying CD-ROM.

Common misconceptions highlight specific misconceptions for the topic.

Key vocabulary is highlighted throughout to support literacy.

Teaching sequence

The lesson plans all use the same learning sequence. This is based on the idea that learning develops in stages during a lesson and that different parts of the lesson have different functions.

Engage This section draws students in to thinking about the ideas, and includes possible starter activities. Here students encounter ideas that will make them want to find out more.

Challenge and develop Students meet something that will challenge their existing understanding. It might be questions, ideas, demonstrations or experiments that make them realise the inadequacy of a simpler explanation.

Explain Students are encouraged to develop a good explanation and supported in capturing ideas in words or graphically. Differentiation ideas are given for students making less or more than expected progress.

Consolidate and apply Students realise how the new learning is to be consolidated and applied, including real-world applications. Again, differentiation ideas are given for students making different levels of progress.

Extend Addresses how the ideas of the topic can be extended to stretch students able to progress further.

Plenary suggestions Varied activities help in gauging student progress.

Answers All answers to Student Book questions and worksheet questions are provided.

Extra resources on the accompanying CD-ROM

Every lesson has an associated differentiated worksheet to support written work. These are provided as write-on versions with lines for student responses, and reusable versions without lines that can be used again and again to reduce photocopying costs. Practical sheets are provided to give support for planning, carrying out and analysing practical work. Technician's notes are provided to explain the materials and setup and help with planning.

Collins Connect is a linked publication of digital resources to enhance lessons. The resources are listed by lesson in the scheme of work on page 242.

2.1 Introduction

When and how to use these pages

The Introduction in the Student Book indicates some of the ideas and skills in this topic area that students will already have met from KS2 or from previous KS3 work, and provides an indication of what they will be studying in this chapter. *Ideas you have met before* is not intended to be a comprehensive summary of all the prior ideas, but rather to point out a few of the key ones and to support the view that scientific understanding is progressive. Even though we might be meeting contexts that are new to us, we can often use existing ideas to start to make sense of them.

In this chapter you will find out indicates some of the new ideas that the chapter will introduce. Again, it isn't a detailed summary of content or even an index page. Its purpose is more to act as a 'trailer' and generate some interest.

The outcomes, then, will be recognition of prior learning that can be built on and interest in finding out more.

There are a number of ways this can be used. You might, for example:

- Use *Ideas you have met before* as the basis for a revision lesson as you start the first new topic.
- Use *Ideas you have met before* as the centre of spider diagrams, to which students can add examples, experiments they might have done previously or what they found interesting.
- Make a note of any unfamiliar/difficult terms and return to these in the relevant lessons.
- Use *In this chapter you will find out* to ask students questions such as:
  - Why is this important?
  - How could it be used?
  - What might we be doing in this topic?

Overview of the chapter

In this chapter, students will learn about the human digestive system and breathing system; about the role of each of the organs involved and the way that each organ is adapted to its particular function. They will learn more about a healthy diet and the consequences of not having one, and about the effects of some lifestyle choices and diseases on the breathing system. They will also learn about the links between the digestive system, breathing system and circulatory system and study how the products of digestion and breathing are exchanged in our bodies. They will also start to learn about how we use some of the products of breathing and digestion to generate energy.

This chapter offers the opportunity for students to use and evaluate models of the digestive system and the breathing system. They will also analyse and evaluate primary and secondary data linked to digestion and breathing.

Obstacles to learning

Students may need extra guidance with the following terms and common misconceptions:

- **Diet** A diet is made up of all the food and drink that a person takes in. It does not refer to 'being on a diet' to lose weight, for example.
- **Breathing** Breathing is the process by which air moves in and out of the lungs. It should not be confused with respiration, which is a chemical process that takes place in cells to release energy from glucose. Oxygen from breathing is usually required for respiration.
- **Food groups** A food group is a set of foods that share similar nutritional properties. A common approach is to group foods as carbohydrates, proteins, fats, vitamins, minerals, fibre and water. A healthy diet includes all the food groups. An 'eatwell plate' gives an indication of the relative proportions of each required.
- **Energy requirements** The amount of energy needed from food varies with age, gender and activity. When working out how to meet energy requirements, data about the food groups and the nutrients needs to be looked at to ensure a balanced diet and to avoid deficiency diseases.

	Topic title	Overarching objectives
2	Exploring a healthy diet	Content of a healthy human diet: carbohydrates, lipids (fats and oils), proteins, vitamins, minerals, dietary fibre and water, and why each is needed
3	Testing foods	
4	Comparing energy needs	Calculations of energy requirements in a healthy daily diet Comparing energy values of different foods (from labels) (kJ)
5	Exploring obesity and starvation	The consequences of imbalances in the diet including obesity, starvation and deficiency diseases
6	Understanding deficiency diseases	
7	Understanding the human digestive system	The tissues and organs of the digestive system, including adaptations to function
8	Investigating the start of digestion	The tissues and organs of the digestive system, including adaptations to function and how the digestive system digests food (enzymes simply as biological catalysts)
9	Understanding the roles of the digestive organs	The tissues and organs of the digestive system, including adaptations to function
11	Introducing enzymes	How the digestive system digests food (enzymes simply as biological catalysts)
12	Recognising the role of bacteria	The importance of bacteria in the human digestive system
13	Understanding how we breathe	The mechanism of breathing to move air in and out of the lungs, using a pressure model to explain the movement of gases
14	Measuring breathing	The mechanism of breathing to move air in and out of the lungs, including simple measurements of lung volume
15	Evaluating gas exchange in humans	The structure and functions of the gas exchange system in humans, including adaptations to function
16	Investigating diffusion	The structure and functions of the gas exchange system in humans, including adaptations to function Diffusion in liquids and gases driven by differences in concentration Diffusion in terms of the particle model
17	Exploring the effects of disease and lifestyle	The impact of exercise, asthma and smoking on the human gas exchange system

2.2 Exploring a healthy diet

Lesson overview

Learning objectives

- Describe the components of a healthy diet.
- Examine the importance of each component of a healthy diet.
- Evaluate the quality of evidence contained in advertising about a healthy diet.

Learning outcomes

- Identify various components of a healthy diet. [O1]
- Explain the function of each of the components of a healthy diet. [O2]
- Critically evaluate diets with regard to health. [O3]

Skills development

- Thinking scientifically: consider quality of evidence
- Working scientifically: n/a
- Learner development: collaborate effectively

Resources needed an example of a 'healthy eating' advert; examples (or pictures) of foods representing each of the food groups; Worksheet 1.2.2

Common misconceptions Water is not a food or a food group. Diet means ‘on a diet’, rather than what we eat and drink.

Key vocabulary food group, nutrient, balanced diet

Teaching and learning

Engage

- Show the students a 'healthy eating' advert and ask them to focus on the heading. Use this as a starting point to discuss and identify what a healthy eating plan might include. [O1]
- Alternatively ask the students to **consider** and **justify** which foods we need in our diet (showing some examples of the food groups). [O1&2]

Challenge and develop

- Ask small groups to **consider** whether or not the discussion has changed their original views about what may be included in a healthy eating plan, and if so why. [O1&2]
- Present the students with examples of different foods and ask them to **suggest** which of the food groups (listed in Table 1.2.2 in the Student Book) they fit into. You could use food labels to inform discussion. Introduce the word *lipids* for fats and oils. [O1&2]
- Ask the students to **devise** ways of remembering the seven food groups, such as a mnemonic or a story that includes each group. [O1]

Explain

- **‘Jigsaw’ activity** Arrange the students in mixed groups of four to learn about the importance of each food group. Assign each student a number from 1 to 4. Student 1: vitamins and minerals; Student 2: proteins and carbohydrate; Student 3: water and fibre; Student 4: fats and oils. [O1&2]

  You may want to assign lower-attaining students number 3 or 4.

  Each group should then split into ‘expert groups’ made up of students assigned the same number across the class. Provide each group with the information relevant to their food group. Allow groups 5–10 minutes to assimilate the information and write notes using only 10 words, supported by diagrams. The original groups then re-form and each student spends 2 minutes teaching the group what they have learned. The rest of the group should **complete** Worksheet 1.2.2 as a summary of the work. [O1&2]

Consolidate and apply

- Focus on the additional text and pictures from the advert used in the engagement activity and ask the students to **evaluate** the material by asking questions such as: 'Where is the evidence that this is a good plan?'; 'How has the company tried to persuade us that we should buy into this plan?'. [O3]
- Ask the students to **devise further questions** to ask before deciding whether or not to sign up for the plan. [O3]

Extend

- For students able to progress further, introduce the ideas of *objectivity* and *validity*. Explain that we can judge objectivity by considering if the company has reason to give us inaccurate or misleading information. Explain that in order to determine whether or not data are valid, we must consider the methods used to collect the data. Ask the students to **relate these ideas** to the healthy eating plan advert and **respond to questions** to help them to assess whether or not the claims made are objective and valid. [O3]

Plenary suggestions

Role-play The students **role-play** the manager of a healthy eating company and a potential customer. The customer asks questions and the manager defends the company and explains why the customer should sign up. [O2&3]

Plan a diet Alternatively students **plan** a balanced and healthy diet for a day, **assess** each other's work, highlight reasons why the plan is good and **suggest improvements**. [O2&3]

Answers to Student Book questions

1. protein
2. two of: bread, pasta, biscuits, potatoes, fruit juice
3. protein and fats
4. Fat is a source of both energy and an insulating layer. Olive oil, a source of fat in the diet, is sometimes linked to a healthy heart. However, too much fat of some kinds can lead to obesity and heart disease.
5. The Mediterranean diet contains lots of fruit and vegetables. These contain lots of fibre and so help prevent constipation.
6. fruits, vegetables and carbohydrates; protein such as meat / eggs and dairy products; foods high in fats and sugar
7. The advert for a Mediterranean diet including olive oil gives evidence from a study about the reduced risk of heart disease and cancer in 1.5 million adults. The advert for a vegetarian diet states facts but does not cite evidence from a particular scientific study.
8. We might want to be cautious about trusting adverts because the advertiser will make money from selling the product or may want to persuade people in some ways, for example not to eat animals. Questions might include: 'What motives might these organisations have?' and 'What evidence is there for the claims made?'.

Answers to Worksheet 1.2.2

1. Carbohydrates: energy; protein: repair and growth; fats and oils: insulation and energy; vitamins: wide range of roles, e.g. repair of skin (vit. C), taking up calcium (vit. D); minerals: wide range of roles, e.g. calcium for healthy bones and teeth, iron for red blood cells; fibre: move food through the digestive system; water: prevent dehydration.
2. a) carbohydrates b) fibre c) protein
3. Letter including possible points such as: supplements contain specific vitamins or minerals but not such a good balance of food groups as can be obtained from eating a healthy diet; foods such as crisps are high in fat, also crisps are high in salt which can cause health problems.

Worksheet 1.2.2 Exploring a healthy diet

1 The importance of the food groups >

Summarise the importance of each of these food groups to the human body:

- carbohydrate
- protein
- fats and oils
- vitamins
- minerals
- fibre
- water

2 Which food groups? >>

For each of these people, decide which food group(s) would be most important for them:

a) A builder needing lots of energy to work.

b) A person suffering from constipation.

c) A male model wanting to build up his muscles.

3 Diet or supplements? >>>

You have a friend who has a very poor diet – eating lots of crisps and chocolate and hardly any fruit or vegetables. They tell you that they have vitamin supplements and so do not need to worry about what they eat.

Write a letter to your friend explaining why they should also think about eating a healthier diet.

2.10 Applying key ideas

Can you stomach it?

Objectives

- Extract ideas from the text about diet and digestion in other animals.
- Use information about the structure of other digestive systems to explain how they are adapted to their function.
- Apply ideas about digestive systems to the efficiency of digestion in different animals.

Outcome

- Clear and effective responses to questions, indicating understanding and the next steps in learning.

The purpose of this activity is to provide an opportunity to see how successfully students are grasping the key ideas so far. It isn't designed to be used as a formal test; it might be that students work on the questions collectively. It does provide an opportunity for you to look at written work, engage students in discussions and form ideas about progress being made.

The tasks are progressive. Lower-attaining students should be able to tackle the first two or three, and higher-attaining students will find the later ones more challenging.

Resources needed Pictures of different animals; grass; bowl; large sheets of paper; pens; highlighters; Worksheet 1.2.10

Teaching and learning

Engage

- Challenge the students to think back over the previous few lessons and identify some of the key ideas they've met. Draw out some responses about these ideas and say that it's important as learners that they develop a sense of their own progress.
- Show pictures of different animals such as birds, big cats, bears. Ask the students to discuss what they know about the diets of these animals and the ways that they digest foods.

Challenge and develop

- Show a bowl of grass and tell the students that you are going to have a diet of just grass from now on. Take some immediate responses but do not validate answers at this point.
- Ask the students to think about any benefits or drawbacks of eating such a diet. They should work in groups to record their thoughts on a large sheet of paper in any way they choose.

Explain

As a class, read the passage 'Can you stomach it?'. Clarify the meanings of any new or unfamiliar words. It may help to show an image of the stomach of a cow.

Students work in pairs to read the text again. You can hand out Worksheet 1.2.10, which has a copy of the text, and ask the students to highlight:

- examples of different digestive systems (in one colour)
- explanations of how parts of the digestive system are adapted to their function (in a different colour).

Consolidate and apply

- Now ask the students to attempt the tasks – they can do this individually or collaboratively.
- Ask the students to present their responses to various tasks – either orally or by displaying their work.

Extend

- For some students the later tasks are an opportunity for extension work.

Plenary

How did you do? Ask the students for responses to questions such as:

- How well were you able to approach those tasks?
- Did you manage to present some high-quality responses?

Ask the students to note down any ideas that need strengthening in the later part of the topic. Provide the class with some overall feedback and share the ideas that may need developing further.

Likely responses and next steps in learning

1. This gives the students an opportunity to assimilate information from the text and to display it in another format. This also encourages them to reflect on the role and process of digestion.
2. This involves recalling that some foods are more difficult to digest than others. The students also have the opportunity to demonstrate what they understand of a balanced diet and why it is important. A better response would relate a balanced and healthy diet to a greater yield of milk and beef.
3. This recalls, from a knowledge of body systems, that organs are adapted to their function. This allows the students to apply their understanding of adaptations to an unfamiliar context. The students also demonstrate their ability to display data in a logical form.
4. This recalls information from the text and also encourages the students to work independently to find information. This allows them to demonstrate the ability to relate structure to function in an unfamiliar situation.
5. This requires the students to consider ideas used throughout the topic so far. Their understanding is checked as they devise questions to ask others. A better response would include questions directed at a whole range of ideas and would also include questions with unambiguous answers.
6. The animal with the longest digestive system would generally have the most efficient digestion. This allows the students to consider why there is sometimes a compromise in body design. The students discuss the advantage of a shorter digestive system having smaller mass and allowing for more rapid acceleration. A better response would identify that the increase in speed is a bigger advantage than the disadvantage from a loss of efficiency .

Worksheet 1.2.10 Applying key ideas

Can you stomach it?

Cows are sometimes said to have four stomachs. In fact, they have one stomach with four compartments. Each of the compartments has a different role and a different structure to support that role. Cows feed mainly on grass, which is actually quite difficult to digest because the fibre is not easily broken down. Grass does not provide much energy and so the digestive system of a cow must be as efficient as possible. Dairy farmers usually supplement the diet of their cattle with dried cereal, protein, vitamins and minerals.

The first stomach compartment contains bacteria that start to digest the fibre. The wall of the second compartment has a honeycomb structure. This compartment traps large food particles. These large particles are regurgitated, re-chewed and re-swallowed to digest them some more. The third compartment contains highly folded muscle to squeeze the water out of the food so that the water stays in the stomach. The fourth compartment is similar to the stomach of humans. It is acidic to allow enzymes to digest proteins.

Snakes eat all parts of their prey. The function of their teeth is to capture the prey, rather than to grind food. They have powerful digestive enzymes to break down hair, feathers and bones.

Birds do not have teeth but use their beaks to tear food. Birds use a lot of energy to keep their bodies warm. So they must digest food as efficiently as possible. To help them to do this, they can hold food in their digestive system for a long time.

Some digestive systems are more efficient than others. The general relationship between the efficiency of digestion and the length of the digestive tract is the longer the tract, the more efficient digestion is.

2.11 Introducing enzymes

Lesson overview

Learning objectives

- Describe the role of different enzymes in digestion.
- Analyse a model of the digestive system.
- Explain observations of a practical activity to explore the role of enzymes.

Learning outcomes

- Describe the roles of some of the digestive enzymes. [O1]
- Explain the results of an enzyme investigation. [O2]
- Analyse a model of the digestive system used in an enzyme investigation. [O3]

Skills development

- Thinking scientifically: analyse data
- Working scientifically: develop explanations
- Learner development: communicate effectively

Resources equipment as listed in the Technician's notes; Worksheet 1.2.11; Practical sheet 1.2.11; Technician's notes 1.2.11

Common misconceptions Enzymes are alive and therefore killed by high temperatures. Enzymes are harmful because they break things down.

Key vocabulary amylase, starch, sugar, catalyst

Teaching and learning

Engage

- Ask the students to **build a molecule** of starch by joining together several small building bricks (or beads that click together) of the same colour. Then ask them to **model** starch being broken down into glucose by amylase enzyme. Ask them to **compare the sizes** of starch and glucose molecules. [O1]
- Repeat the activity for proteins (made from several different-coloured bricks) broken down into amino acids by peptidase enzyme and for fats (made from two different-coloured bricks per molecule) broken down into fatty acids and glycerol by lipase enzyme. [O1]

Challenge and develop

- Give out Practical sheet 1.2.11. **Discuss** the model of digestion included in the investigation. Students work in pairs to set up the experiment up and leave it to incubate for 20 minutes. [O3]
- Demonstrate that the starch solution added to the visking tubing does contain starch (using iodine) and does not contain glucose (using Benedict's solution). [O3]

Explain

- **Pair talk** Ask the students to **predict** what will happen in the investigation. They must predict whether or not starch and/or sugar will be found in the tubing and around the tubing after incubation. [O1&2]
- Ask the students to read 'Enzymes in digestion' and 'More about enzymes' in the Student Book and answer questions 1–6. [O1]

Consolidate and apply

- The students test the liquids for starch and glucose and **record** the results on Practical sheet 1.2.11. They **explain** the results using prompts on the worksheet and say whether their prediction was correct or incorrect. [O2&3]
- The students **complete** the questions about enzymes on Worksheet 1.2.11. [O1]

Extend

- Ask students who are able to progress further to **compare** the model to the digestive system. They should list things that the model and the digestive system have in common and things that are different. Ask the students to **consider** whether they can suggest any improvements to the model. [O3]

Plenary suggestions

Enzyme loop cards Arrange the students in groups of five. Ask each student to write a question about enzymes on a piece of card and the answer to their question on a different colour of card. The cards are collected and redistributed so that each student has one question and one answer. They then play a loop card game – one student reads out a question, the student with the correct card answers, then asks their question, and so on. [O1, 2&3]

Answers to Student Book questions

1. starch to glucose; protein to amino acids
2. starch: mouth and small intestine; protein: stomach and small intestine; fats: small intestine
3. A diagram illustrating: large fat molecules (triangles); an arrow showing digestion by lipase cutting up of bonds in the small intestine; fatty acids and glycerol (smaller triangles).
4. Nothing would happen – enzymes are specific and amylase only breaks down starch.
5. Molecules must be broken down into smaller molecules so that they can be absorbed into the blood through the walls of the small intestine.
6. Not much digestion takes place in the small intestine. Digestion can still take place in the mouth (starch) and stomach (protein).
7. Starch is broken down to glucose by amylase.
8. a) small intestine b) undigested food c) blood
9. Glucose molecules are smaller than starch molecules. The visking tubing has holes that glucose can pass through but starch molecules are too big.

Answers to Worksheet 1.2.11

1. chemical; larger; smaller; specific; saliva, starch
2. amylase – starch – mouth; protease – proteins – stomach; lipase – fats – small intestine
3. Drawings or models to represent starch broken down into sugar, proteins broken down into amino acids, fats broken down into fatty acids and glycerol.

Answers to Practical sheet 1.2.11

Explanation: Amylase enzyme breaks down starch so, after incubation, the liquid inside the visking tubing should contain glucose but no starch (or very little). This models the situation with food in the intestine. Starch cannot pass through the visking tubing membrane but glucose can so, after incubation, the liquid around the visking tubing should contain glucose but no starch. This is because the large starch molecules are unable to pass through the wall of the intestine, but when broken down to small glucose molecules, these can pass through and be absorbed into the blood.

Worksheet 1.2.11 Introducing enzymes

1 The role of enzymes >

Complete the paragraph using the following words:

starch	**smaller**	**chemical**
larger	**specific**	**saliva**

Enzymes are involved in the …… digestion of food. They break down …… molecules in food into …… molecules. Enzymes are …… – this means that they only break down one type of food molecule. In the mouth, …… contains an enzyme that breaks down …… .

2 Different types of enzymes >>

Match each enzyme with the food that it breaks down and the place where it acts.

Enzyme
amylase
protease
lipase

What it breaks down
fats
starch
protein

Where it acts
mouth
stomach
small intestine

3 Modelling enzymes >>>

We can use models to picture what is happening inside our bodies. We can model the work of enzymes using building bricks or pictures.

a) Carry out some research to find out what starch, proteins and fats are broken down into.

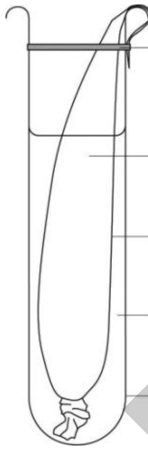
b) Make a model to demonstrate what you have found, using either drawings or building bricks or modelling clay.

Practical 1.2.11 Investigating enzymes

In this practical you will investigate the role of an enzyme in the digestion of starch.

Apparatus

Set up the apparatus as shown in this diagram.



Predictions

Predict whether starch and/or glucose will be found in the visking tubing or around the tubing after incubation.

Method

First, put on eye protection. At the beginning of your investigation, test both the liquid in the visking tubing and the water in the boiling tube for starch and for glucose. Then leave the tube in a water bath at 37 °C for about 20 minutes.

Starch test: Iodine solution is an orangey–yellow colour and is used to test for the presence of starch. When you add it to a liquid or food, it will turn blue–black if starch is present.

Glucose test: Benedict's solution is blue. If it is added to a liquid or food that contains glucose and heated (using a water bath), it will change to a brick-red colour.

After 20 minutes, carry out the starch and the glucose tests again on the liquid in the visking tubing and on the water in the boiling tube.

Results

Record your results.

	Before		**After**	
Visking tubing	glucose starch	yes/no yes/no	glucose starch	yes/no yes/no
Water	glucose starch	yes/no yes/no	glucose starch	yes/no yes/no

Explanation

Explain, in as much detail as you can, how this investigation represents what happens in your digestive system.

Use these words to help you: enzyme; starch; glucose; absorbed; blood; intestine; food; large molecules; small molecules.

Technician's notes 1.2.11 Introducing enzymes

Be sure to check the latest CLEAPSS safety notes before proceeding.

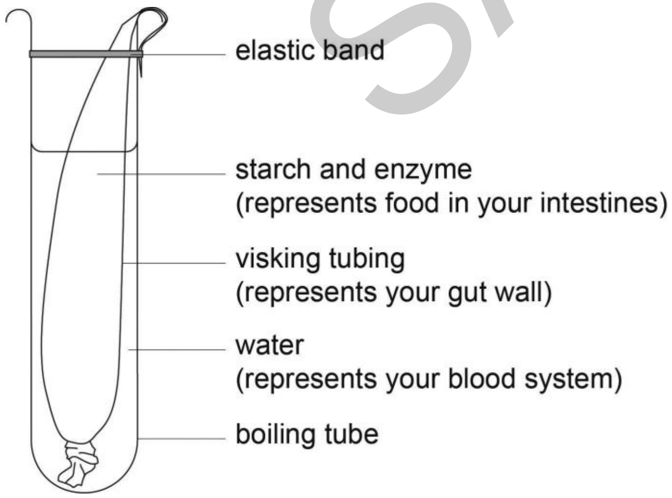
The following resources are needed for the lesson introduction

small building bricks or beads that click together (a range of different colours will be needed so that several different molecules can be modelled)

The following resources are needed for the class practical, for each group

boiling tube
15 cm length of visking tubing
2 % starch solution
2 % diastase solution (enzyme)
iodine solution (to test for starch)
Benedict's solution (to test for reducing sugar)
four test tubes
water bath at 37 °C
safety glasses
elastic band

A model of the gut will be investigated, as shown in the diagram.



4.1 Introduction

When and how to use these pages

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The outcomes, then, will be a recognition of prior learning that can be built on, and interest in finding out more.

There are a number of ways this can be used. You might, for example:

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- Use *Ideas you have met before* as the centre of spider diagrams, to which students can add examples, experiments they might have done previously or what they found interesting.
- Make a note of any unfamiliar/difficult terms and return to these in the relevant lessons.
- Use ideas from *In this chapter you will find out* to ask students questions such as:
  - Why is this important?
  - How could it be used?
  - What might we be doing in this topic?

Overview of the chapter

In this chapter, students will learn about the ideas of atoms, elements and compounds, and ways that scientists represent them using symbols and formulas. They will learn how scientists have developed the Periodic Table and will start to learn about its groups, patterns and trends. Various elements are explored with regard to their different chemical and physical properties. Students will learn how to understand chemical reactions in terms of a rearrangement of atoms and how to represent these using circle diagrams, formulas and equations. They will study metals, non-metals and oxides.

This chapter offers a number of opportunities for students to investigate materials and reactions at first hand and use evidence to construct explanations. They explore evidence that reactions have occurred and how the properties of materials determine their applications.

Obstacles to learning

Students may need extra guidance with the following terms and common misconceptions:

- **Atoms and elements** Misconceptions include: elements were 'invented'; they can all be dug up from the ground; they all have symbols with the same letters as their English names; elements and atoms are different substances; elements are all different, but all atoms are the same; atoms are like cells and of a similar size.
- **Metals and non-metals** Misconceptions include: all metals are silver-coloured, magnetic and strong; all metals can be dug up from the ground; metals all melt at very high temperatures; the melting point and freezing point of a substance are different; non-metals are all solids; gases have no mass (do not weigh anything); air is an element; water is an element; all gases are poisonous.
- **Reactions** Misconceptions include: any elements can combine in any order or quantities; atoms change when compounds form, e.g. H_2O is a new atom; atoms change size; you can only join two atoms together side-by-side, like holding hands (linear); when things burn they disappear or are destroyed forever; heating and burning are the same; dissolving is a chemical change; heating always causes chemical changes.

	Topic title	**Overarching objective**
2	Finding elements and building the Periodic Table	Chemical symbols and formulae for elements and compounds
3	Looking at the Periodic Table of elements	The principles underpinning the Mendeleev Periodic Table The Periodic Table: periods and groups; metals and non-metals
4	Understanding elements and atoms	Differences between atoms, elements and compounds Chemical symbols and formulae for elements and compounds
5	Understanding metals	The varying physical and chemical properties of different elements The properties of metals and non-metals
6	Understanding non-metals	
7	Identifying metalloids	The varying physical and chemical properties of different elements
8	Discovering the origin of metals	The varying physical and chemical properties of different elements The properties of metals and non-metals Chemical symbols and formulae for elements and compounds
9	Choosing elements for a purpose	The varying physical and chemical properties of different elements
11	Combining elements	Differences between atoms, elements and compounds Chemical symbols and formulae for elements and compounds
12	Using models to understand chemistry	
13	Understanding what happens when an element burns	Chemical reactions as the rearrangement of atoms Representing chemical reactions using formulae and using equations Combustion
14	Observing how elements react in different ways	The varying physical and chemical properties of different elements Representing chemical reactions using formulae and using equations The chemical properties of metal and non-metal oxides with respect to acidity
15	Identifying the special features of carbon	The varying physical and chemical properties of different elements
16	Understanding oxidation	Representing chemical reactions using formulae and using equations Oxidation
17	Investigating carbonates	Conservation of mass changes of state and chemical reactions Combustion**,** thermal decomposition, oxidation Chemical symbols and formulae for elements and compounds Thermal decomposition
18	Explaining changes	Differences between atoms, elements and compounds Chemical symbols and formulae for elements and compounds Conservation of mass changes of state and chemical reactions Chemical reactions as the rearrangement of atoms Thermal decomposition, oxidation

4.2 Finding elements and building the Periodic Table

Lesson overview

Learning objectives

- Identify where and how different elements were found.
- Recognise differences between elements.
- Recognise that the Periodic Table has changed over time.

Learning outcomes

- Give examples of common elements and suggest where they may be found. [O1]
- Explain why the most ancient elements were found first. [O2]
- Outline a timeline of discovery of the elements. [O3]

Skills development

- Thinking scientifically: understand how theories develop
- Working scientifically: interpret evidence
- Learner development: communicate effectively

Resources needed sample/photo of haematite; timeline for students to add their cards to; Worksheet 1.4.2 – page 2 copied onto card and cut up

Common misconceptions Elements were 'invented' or ‘made’ rather than discovered. Elements can all be dug up from the ground.

Key vocabulary element, native element, compound, atom, Periodic Table

Teaching and learning

Engage

- Ask the students to **interpret the data** in Table 1.4.2 in the Student Book to prepare a bar chart, ordering the top 10 most abundant elements in the Earth’s crust. [O1]
- Extend the task by asking them to **identify the symbols** of the elements – Al, C, H, Fe, Mg, O, K, Si, Na and Ti. [O1]

Challenge and develop

- Explain that most elements cannot simply be dug up in pure form (native metals) and that most are found as combinations of elements – compounds in rocks – that need to be extracted before we can use them (covered in more detail in later lesson). Refer back to the bar chart and clarify that these elements are found in the Earth’s crust, i.e. rocks. Ask students to **suggest** 'Where else might oxygen be found on Earth?', 'How is the oxygen in the atmosphere and that in the rocks different?' (the element is a gas in air and occurs as solid compounds in rocks). [O1&2]
- Show a sample/photo of haematite (iron oxide) and ask groups/pairs of students to **suggest** how life would be different if our ancestors had not learned how to separate the iron from the rock. Gather feedback and reinforce the idea that our lives change as a result of new discoveries in chemistry – e.g. weapons, building materials, transport, silicon chip technology etc. [O2]

Explain

- Give the students a set of element cards from Worksheet 1.4.2 and ask them to **consider**:
  - Which are more likely to be native metals? Why? [O1]
  - What are ‘synthetic’ elements? [O1]

- Reinforce the idea that electricity and technology have made a big difference to what we can do and discover, and that through the work of one scientist, other scientists make further discoveries. [O2]

Consolidate and apply

- Set up a research activity in which the students **investigate the history** of some of the elements (access to the internet will be needed). This could be a card completion activity that is then presented as a Periodic Table by the class – e.g. collect the name, symbol, year of discovery, who/where discovered, how it got its name, its basic properties and uses. (Simplify or extend the detail required to meet the ability of the students.) [O2&3]

Extend

- Ask students able to progress further to **investigate** and outline the classification of elements that were named after people/places/words that have symbols that do not match their English names – e.g. mendelevium, einsteinium, curium; germanium, francium, polonium, americium; lead, tin, gold, silver, potassium, sodium, tungsten. [O3]

Plenary suggestions

Sequence cards Produce a timeline of the discovery of elements. Do this as a group activity and then play 'snap' to compare answers.

Answers to Student Book questions

1. In the Sun the elements are in their natural elemental states; on Earth they are mostly found as compounds.
2. a) water b) earth c) fire d) air – although it is hot, wet and is visible in the air
3. They are native elements that do not have to be extracted from rocks/ores like iron; they are easier to find.
4. Unlike the ancient Greeks, Davy used evidence from experiments that can be repeated to verify his discoveries.
5. They needed electricity to extract them so they could not have been discovered sooner.
6. There are no gaps in the Periodic Table; all the heavy elements (after U) are man-made.
7. They are man-made or produced in the radioactive decay of existing elements.
8. ununpentium – Uup

Worksheet 1.4.2 Finding elements and building the Periodic Table

1 Trump cards >

Play a trump card game with the Element cards from page 2/2.

- Deal out the same number of cards to each player.
- Put them face down and decide who will go first.
- Take the top card from your pile – this is the one you will play first.
- The first player selects a numerical variable, e.g. year of discovery, and announces the element and the value of that variable. Whoever has the highest value of that variable collects all the cards in play and adds them to the bottom of their pile.
- This winning player then leads on the next round, taking the top card and selecting a variable.
- The game continues – either until someone has all the cards or for a set period of time.
- The winner is the player with the most cards.

2 Hunt the application >>

Working in a team, you will need a number of Element cards from page 2/2 and access to reference information such as textbooks and the internet. For each element, find as many applications as you can in a given time of:

a) the element on its own

b) compounds containing that element.

3 Timeline >>>

Working in a group, you will need a set of Element cards from page 2/2 and a timeline. This could be a piece of string with paper clips or you could set the cards out in a row on the table.

- Set the cards out in order of their year of discovery.
- Leave wider gaps for longer intervals of time – remember that dates with BCE refer to the number of years before the year AD 0.

a) Now look at the type of element and see if some types of elements have been discovered earlier than others.

b) Discuss why this might be.

Worksheet 1.4.2 Finding elements and building the Periodic Table

Name of element	sodium	**Name of element**	potassium	**Name of element**	magnesium
Symbol	Na	**Symbol**	K	**Symbol**	Mg
Type of element	alkali metal	**Type of element**	alkali metal	**Type of element**	alkaline earth metal
Atomic number	11	**Atomic number**	19	**Atomic number**	12
Atomic mass	23	**Atomic mass**	39	**Atomic mass**	24
Melting point	97.8 °C	**Melting point**	63.5 °C	**Melting point**	650 °C
Boiling point	883 °C	**Boiling point**	759 °C	**Boiling point**	1090 °C
Year of discovery	1807	**Year of discovery**	1807	**Year of discovery**	1755
Group number	1	**Group number**	1	**Group number**	2
Name of element	calcium	**Name of element**	iron	**Name of element**	copper
Symbol	Ca	**Symbol**	Fe	**Symbol**	Cu
Type of element	alkaline earth metal	**Type of element**	transition metal	**Type of element**	transition metal
Atomic number	20	**Atomic number**	26	**Atomic number**	29
Atomic mass	40	**Atomic mass**	56	**Atomic mass**	63.5
Melting point	842 °C	**Melting point**	1538 °C	**Melting point**	1085 °C
Boiling point	1484 °C	**Boiling point**	2861 °C	**Boiling point**	2562 °C
Year of discovery	1808	**Year of discovery**	around 5000BCE	**Year of discovery**	around 9000BCE
Group number	2	**Group number**	8	**Group number**	11
Name of element	carbon	**Name of element**	nitrogen	**Name of element**	oxygen
Symbol	C	**Symbol**	N	**Symbol**	O
Type of element	non-metal	**Type of element**	non-metal	**Type of element**	non-metal
Atomic number	6	**Atomic number**	7	**Atomic number**	8
Atomic mass	12	**Atomic mass**	14	**Atomic mass**	16
Melting point	3825 °C	**Melting point**	–210 °C	**Melting point**	–219 °C
Boiling point	4489 °C	**Boiling point**	–196 °C	**Boiling point**	–119 °C
Year of discovery	around 3750BCE	**Year of discovery**	1772	**Year of discovery**	1771
Group number	14	**Group number**	15	**Group number**	16
Name of element	fluorine	**Name of element**	chlorine	**Name of element**	neon
Symbol	F	**Symbol**	Cl	**Symbol**	Ne
Type of element	halogen	**Type of element**	halogen	**Type of element**	inert gas
Atomic number	9	**Atomic number**	17	**Atomic number**	10
Atomic mass	19	**Atomic mass**	35.5	**Atomic mass**	20
Melting point	–220 °C	**Melting point**	–101 °C	**Melting point**	–249 °C
Boiling point	–188 °C	**Boiling point**	–34 °C	**Boiling point**	–246 °C
Year of discovery	1810	**Year of discovery**	1774	**Year of discovery**	1898
Group number	17	**Group number**	17	**Group number**	18

4.6 Understanding non-metals

Lesson overview

Learning objectives

- Identify the uses of common non-metals.
- Describe the properties of non-metals.

Learning outcomes

- Identify elements as non-metals using their properties. [O1]
- Explain why substances are classified as non-metals. [O2]
- Compare and contrast the properties of metals and non-metals. [O3]

Skills development

- Thinking scientifically: ask questions
- Working scientifically: record evidence
- Learner development: collaborate effectively

Resources needed hand lenses; materials and equipment for demonstrations and class practical as detailed in the Technician’s notes; Worksheet 1.4.3a; Worksheet 1.4.6; Practical sheet 1.4.6; Technician's notes 1.4.6

Common misconceptions Non-metals are all solids. Gases have no mass. Air and water are elements. All gases are poisonous.

Key vocabulary halogen, salt, noble gas, inert

Teaching and learning

Engage

- Ask the students to **recall** properties of metals and then **predict** those of non-metals. [O1]

Challenge and develop

- Using the Periodic Table (Worksheet 1.4.3a), ask the students to **identify** some non-metals. The students add information to their predictions and **explain** these additions, supporting the explanation with evidence. [O1]
- Ask the students to **explain** the link between the states of different non-metals at room temperature and their melting/boiling point. [O2]

Explain

- Demonstrate hydrogen burning with a squeaky pop, oxygen relighting a splint and a helium balloon floating. The students can use Practical sheet 1.4.6 to guide them in their observations. They should **identify** similarities and differences between the gases, using appropriate terminology. Ask if this is something that metals could do. Show a video clip or photos of fluorine, chlorine, bromine and iodine before asking the students to **compare** them and **identify** why they are classified as non-metals. [O1, 2&3]
- The students should **observe** the appearance of sulfur, iodine and carbon and **compare** them to each other and to gases and metals, answering the questions on Practical sheet 1.4.6. [O1&3]
- The students can then **research** (using books and the internet) the properties of non-metals, and **identify** the common properties highlighting any odd ones out. [O3]
- Emphasise that carbon is a special element with properties of both metals and non-metals. [O1, 2&3]

  Higher-attaining students may appreciate that both carbon and sulfur exist in different forms called allotropes – e.g. graphite and diamond.

Consolidate and apply

- The students **collaborate** to record all the properties on cards and organise them into lists of metals and non-metals plus any that are common to both. [O1, 2&3]
- They should individually construct a Venn diagram to show the properties of metals and non-metals with carbon in the middle with 'bits of both'. [O1&3]

  It may make it easier for lower-attaining students to **consider** individual elements in order to construct their Venn diagram – e.g. iron, sulfur and carbon.

  Higher-attaining students could increase the complexity of their diagram by creating additional sections – e.g. solid/liquid/gas, magnetic; then **identify elements** that fit the categories. Alternatively they could create a key to identify an element.
- Ask the students to **compare** and **contrast** sodium, chlorine and sodium chloride (see Technician's notes 1.4.6). They can answer the questons in sections 1 and 2 of Worksheet 1.4.6. Point out the fact that the elements sodium and chlorine are not very useful and are dangerous in their element form – but as a salt/compound, sodium chloride is one of the safest and most useful chemicals we have. [O1&3]

Extend

- Students able to progress further could **research** the uses of non-metal elements and of their compounds with metals. Introduce the idea that non-metals change their names when in a compound, e.g. sulfur – sulfide, oxygen – oxide etc. The students can do task 3 on Worksheet 1.4.6. [O2&3]

Plenary suggestions

What am I? Read out the properties of a substance and challenge the students to **predict** what it could be. [O1]

Answers to Student Book questions

1. Metals tend to be stronger, shinier, denser and better conductors. Many non-metals are unreactive gases at room temperature; some have special properties and some are vital to life.
2. salts
3. It sublimes; it appears not to melt; just turns straight from a solid to a gas
4. *Helpful*: rubber; gunpowder; sulfuric acid; essential to life *Harmful*: toxic gas; acid rain
5. a different form of the same element; different arrangement of the same atoms
6. It produces sulfur dioxide; a choking gas that attacks lungs and throat.
7. It is brittle; can be crushed into a powder; it doesn't conduct electricity or heat.
8. they are inert; don't react or form compounds
9. Reward any reasonable comparison and challenge higher-attaining students to use the Periodic Table.

   a) Both are gases; helium is lighter and inert; chlorine is harmful and forms compounds.

   b) Both are halogens and kill bacteria; iodine is a solid at room temperature and chlorine is a gas.

   c) Bromine is a liquid at room temperature and forms compounds. It's atoms are twice as heavy as argon, which is an inert noble gas. Both non-metals are used in making light bulbs.

   d) Metals are shiny and are good conductors of heat and electricity; most are sonorous and ductile. They are found towards the left of the Periodic Table. Non-metals are on the right; they are less dense.

Worksheet 1.4.6 Understanding non-metals

1 Looking at elements >

You will need access to sources of information, such as textbooks or the internet.

a) Write a short description of sodium.
b) List some of the properties of sodium.
c) Write a short description of chlorine.
d) List some of the properties of chlorine.
e) Identify three key differences between the elements sodium and chlorine.

2 Looking at a compound >>

You will need some sodium chloride and a hand lens.

a) Look at the crystals of sodium chloride and see if you can sketch the shapes.
b) What do the shapes have in common?
c) How do they vary?
d) How does this compare with the results of your research on sodium and chlorine?

3 Finding out about salts >>>

We are used to calling sodium chloride 'salt' – if you buy a packet of salt in a shop, what you get is sodium chloride. However, scientists use the term 'salt' to refer to a whole group of chemicals – magnesium chloride is another one; copper sulfide is another.

a) Find another three examples of salts and list their chemical names.
b) Now look at their chemical names and see what they have in common. In particular, what is true about all of the first words in their names? How does this rule apply to the second words?

Practical 1.4.6 Comparing non-metals

1 Testing oxygen

Your teacher is going to show you a test – make sure that you wear eye protection.

Apparatus

Draw a diagram of the apparatus used in the test.

Method

1. A glowing splint is put inside the test tube.
2. Observe what happens to the splint.
3. Record what you have observed.

2 Testing hydrogen

Your teacher is going to show you a test – make sure that you wear eye protection.

Apparatus

Draw a diagram of the apparatus used in the test.

Method

1. A lighted splint is put inside the test tube.
2. Observe what happens.
3. Record what you have observed.

3 Looking at helium

a) Look at the balloon, which contains helium.

b) What conclusion can you make about helium?

c) List similarities and differences between the three gases oxygen, hydrogen and helium.

4 Looking at iodine, sulfur and carbon

a) Look at the samples of iodine, sulfur and carbon.

b) Describe the appearance of each.

c) How are these non-metal elements different from each other?

5 Comparisons

a) How are iodine, sulfur and carbon different from the gases you have observed?

b) In what ways are all of these non-metal elements similar to each other?

c) How are they different from metals?

Technician's notes 1.4.6 Understanding non-metals

Be sure to check the latest CLEAPSS safety notes before proceeding.

Introduction

This is a teacher demonstration of hydrogen burning with a squeaky pop and of oxygen relighting a splint.

The students also observe a helium balloon floating, samples of carbon, sulfur and iodine, and also of sodium, chlorine and sodium chloride.

The following resources are needed for the demonstrations

two test tubes in a rack, each containing hydrogen with a bung
two test tubes in the same rack, each containing oxygen with a bung
balloon filled with helium
Bunsen burner
splints

The following resources are needed for student observations

samples of sulfur, carbon and iodine
sample of sodium
gas jar of chlorine
sodium chloride in a beaker
hand lenses

Safety

Remind the students to wear eye protection.

5.1 Introduction

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- Make a note of any unfamiliar/difficult terms and return to these in the relevant lessons.
- Use ideas from *In this chapter you will find out* to ask students questions such as:
  - Why is this important?
  - How could it be used?
  - What might we be doing in this topic?

Overview of the chapter

In this chapter, students will learn about ideas of forces, friction, movement and speed. They will learn how to represent the location, size and direction of forces using arrows. They will meet situations in which forces are balanced and others in which they are unbalanced. They will also learn to identify reaction forces.

The students will consider the effects that forces have – stretching, compressing, turning around a fulcrum, causing changes in speed or direction. They will learn that movement continues at the same speed and in the same direction unless a force acts. In analysing the force of friction they will consider where it is desirable, where it is unwanted and how it can be increased or reduced. They will have the opportunity to investigate the effect of streamlining in order to develop their understanding of water and air resistance.

The concept of speed will be explored and students will learn and practise the method for calculating it.

This chapter offers a number of opportunities for students to relate hands-on experience to slightly more abstract ideas. They will use a range of thinking and personal skills to help their learning and support their peers.

Obstacles to learning

The students may need extra guidance with the following terms and misconceptions:

- **Forces** Students may think that moving objects always have forces acting on them. Their experience makes it hard to accept the idea that an object which is moving will continue with the same speed and direction unless a force acts (Newton's First Law), because on Earth the forces of friction and gravity are always present.
- **Weight and mass** Students need to grasp the idea that weight is a force with the unit newton, yet when people talk about weight they often mean mass.
- **Elasticity** Students may think that elastic simply means stretchy; elasticity means an object or material returns to its original shape.

- **Free fall** On film, free-fall parachutists can appear to fly upwards when they open their parachute. Students may need help to realise that this is only a dramatic slowing in relation to the camera (which is still in free fall). At terminal velocity all forces are in balance so the object won't get faster.

	Topic title	**Overarching objective**
2	Discovering forces	Forces as pushes or pulls arising from the interaction between two objects Using force arrows in diagrams
3	Measuring forces	Forces measured in newtons
4	Understanding weight on other planets	Gravity forces acting at a distance on Earth and in space
5	Exploring the effects of forces	Forces being needed to cause objects to stop or start moving, or to change their speed or direction of motion
6	Understanding stretch and compression	Forces associated with deforming objects Measurements of stretch or compression as force is changed
7	Investigating Hooke's Law	Forces associated with deforming objects; stretching and squashing – springs Measurements of stretch or compression as force is changed Force–extension linear relation; Hooke's Law as a special case
8	Understanding friction	Rubbing and friction forces between surfaces
9	Exploring the benefits of friction	
10	Understanding air and water resistance	Forces: pushing things out of the way; resistance to motion of air and water
11	Discovering streamlining	
13	Exploring forces and motion	Forces being needed to cause objects to stop or start moving, or to change their speed or direction Balanced and unbalanced forces
14	Exploring how forces affect speed and direction	Change depending on direction of force and its size
15	Understanding speed calculations	Change depending on direction of force and its size Speed and the quantitative relationship between average speed, distance and time (speed = distance ÷ time)
16	Understanding turning forces	Moment as the turning effect of a force
17	Discovering moments	
18	Understanding the application of moments	

5.2 Discovering forces

Lesson overview

Learning objectives

- Recognise different examples of forces.
- List the main types of force.
- Represent forces using arrows.

Learning outcomes

- List some types of force and label diagrams to show the direction of forces. [O1]
- State the main types of force and draw force diagrams to show the size and direction of forces. [O2]
- Describe the main types of force and accurately draw force diagrams to explain the relative size and direction of applied forces and their effects. [O3]

Skills development

- Thinking scientifically: understand how theories develop
- Working scientifically: develop explanations
- Learner development: collaborate effectively

Resources needed pictures of e.g. tennis player, plane or bird taking off, roller coaster, vehicle on tow; suction jumper; wind-up mechanical toy; ball floating in a bowl of water; pendulum, large mass; air track and glider; toy car on a ramp; Worksheet 1.5.2

Common misconceptions When an object is stationary, no forces are acting on it. When an object is moving there must be a force acting on it.

Key vocabulary pushing force, pulling force, turning force

Teaching and learning

Engage

- Identify the students' experience of forces from KS2 by displaying a range of images that show different situations in which forces are in action. They have two minutes to **identify** some of the forces. Collect feedback, drawing out a range of descriptions and key words. Make a note of some ideas (incorrect and incomplete as well as correct), so that they can be displayed and revisited later. [O1]

Challenge and develop

- Explain how to represent forces using arrows (see the Student Book for examples). The direction of an arrow shows the direction that the force is acting. Force arrows should be labelled so they are not confused with any arrows showing direction of movement. The length of the arrow can represent how big the force is. [O1&2]

  Higher-attaining students may be able to draw force arrows to scale.

- Challenge the students, by examining a range of objects and equipment (see *Resources needed*), to **draw force diagrams** with arrows showing the direction, location and size of forces. [O1, O2]
- Ask the students to **consider** these three questions:
  - Are forces always present?
  - Can you have movement without forces?
  - Can forces be present even when there is no movement?

  Encourage students to present tentative ideas as well as those they are sure about. [O3]

- Students **discuss** the forces that they have identified. Encourage them to **identify** evidence and observations that support or contradict their answers to the questions. Feedback should give the opportunity to highlight where new ideas or evidence can lead to scientists modifying their views, and should ensure that all students have drawn the force arrows correctly. [O1, 2&3]

Explain

- **Pair talk** The students produce verbal or written **explanations** in relation to the three questions in *Challenge and develop*. Appropriate answers include:
  - Forces are present in most/all examples; gravity is exerting a pulling force in most cases.
  - Once an object is moving it will keep going even if no forces are acting (e.g. a spacecraft in outer space).
  - When forces are in balance there is no change in movement.
- The students can then complete the first two tasks of Worksheet 1.5.2. [O1, 2&3]

Consolidate and apply

- **Listening triads** Working in groups of three, the students revisit the images and ideas in the starter activity. Each student takes on a role – talker, questioner or recorder. The talker **explains** something; the questioner **asks for clarification**; the recorder **makes notes and gives a report** at the end of the conversation. Then the roles can be changed. [O1, 2&3]

Extend

- Students who are able to progress further can complete the third task on Worksheet 1.5.2. [O3]

Plenary suggestions

Learning triangle Students draw a large triangle with a smaller inverted triangle inside it. In the three outer triangles they write something they have seen, something they've done and something they've discussed. Then they add in the central triangle something they have learned.

Answers to Student Book questions

1. pulling force 2. gravity 3. pushing force from the engines; lift force from the wings
4. The downward pulling force of gravity; air resistance causing drag against forward motion.
5. The pushing force from the engines.
6. The increased team would produce a bigger force. The forces from each team would no longer be balanced, and there would be movement in the direction of the larger force – the stronger team would pull the weaker team forwards.
7. The forward pushing force should be bigger than any other forces; and should be in the direction that the car will move.
8. In each situation the students should show at least two forces – e.g. for the sailing boat they could show the pushing force of the wind and the resistance of the water. Challenge the students to think about the relative sizes of the forces.

Answers to Worksheet 1.5.2

1. a) i) two arrows acting along the rope, pointing outwards, equal in size and opposite in direction; no movement

   ii) right-hand force arrow larger than left-hand force arrow; movement arrow to the right

   iii) left-hand force arrow larger than right-hand force arrow; movement arrow to the left

   b) The first diagram is drawn as for (a)(iii). The second diagram has the left-hand force arrow unchanged, the right-hand force arrow larger, and the movement arrow to the right.

   c) i) There is no movement (or, if already moving, movement continues at the same speed and in the same direction).

   ii) The teams move in the direction of the larger force (or resultant force).
2. a) It will continue at the same speed and in the same direction unless another (unbalanced) force acts.

   b) air resistance; weight/gravity c) weight of the ball (gravity); upwards supporting force from ground
3. The burning produces a pushing force (due to the expansion of gases) that propels the firework upwards into the air. The pushing force is larger than the weight/gravity force. Air resistance acts to slow the rocket down. When the burning stops, the force of weight/gravity pulls the rocket back to Earth.

5.3 Measuring forces

Lesson overview

Learning objectives

- Measure forces using newtonmeters.
- Use the correct unit for force.
- Explain the difference between mass and weight.

Learning outcomes

- Recognise that a newtonmeter can be used to measure a force, and know that mass and weight are not the same. [O1]
- Use newtonmeters, have a basic understanding of mass and explain simply how gravitational force affects weight. [O2]
- Use newtonmeters with skill to measure a range of everyday forces, and correctly use scientific concepts to explain effectively the difference between mass and weight. [O3]

Skills development

- Thinking scientifically: use units and nomenclature
- Working scientifically: record evidence
- Learner development: communicate effectively

Resources needed newtonmeters with different ranges and scales; a variety of objects to weigh and drag, including a sports shoe for each group; Worksheet 1.5.3; Practical sheet 1.5.3

Common misconceptions Mass and weight have the same meaning.

Key vocabulary newton, newtonmeter, precision, weight, gravity, mass

Teaching and learning

Engage

- Identify the students' ideas about measuring force by demonstrating opening a door against the force from the closure mechanism. Ask how we could compare the force needed to open different doors. Follow this up by demonstrating using a newtonmeter to pull the door open steadily. [O1, 2&3]

Challenge and develop

- Show the students the newtonmeters (many may already have used them at KS2) and check that they know that they are used to measure force and that the unit is the newton (N). [O1]
- Give the students practice at using the newtonmeters to **measure** and **record** different forces. This should include the weights of objects as well as actions such as dragging objects and opening doors. They should **record** their evidence on Practical sheet 1.5.3. [O1&2]
- Ask the students to **explain** why they think the choice of newtonmeter is important. They should mention the need for an appropriate range and how finer divisions on the scale allow greater precision. [O1&2]
- Explain the definitions of mass and weight to the students: [O3]
  - mass – the amount of material (number and type of particles); the unit is the kilogram (kg) or the gram (g).
  - weight – a force due to the pull of gravity; the unit is the newton (N). The larger the mass of an object, the bigger the force of gravity acting on it.
- Discuss the confusion that exists with measuring mass and weight. When a person stands on some bathroom scales, they are measuring weight – the force with which gravity is pulling them down. However, the scales are calibrated in kg rather than N, which is technically incorrect. When they are manufactured, the

scales are calibrated for use on Earth to display mass. This works because the Earth's force of gravity per unit mass is (fairly) constant from place to place. [O3]

Higher-attaining students may be able to **explain** objects with the same size but with different masses, using the particle model.

Explain

- **Pairs to fours** The students **discuss** and note down their ideas in answer to Student Book questions 6, 7 and 8. They then join with another pair and **communicate their ideas**. Encourage the pairs to question each other and to modify their own ideas if necessary. During the activity, circulate and gather examples of the best explanations and any enduring misconceptions, so that whole-class feedback can be given. [O3]

  Students not progressing to O3 can produce an A4 guide with a diagram and an **explanation** of how to choose and use a newtonmeter.

Consolidate and apply

- Ask selected students to **present** their explanations from the 'pairs to fours' discussions to the rest of the class. [O3]

Extend

- Ask students who are able to progress further to try weighing a mass in air and then in water and then to speculate why the readings are not the same. They can do an internet search for 'upthrust in water' for ideas to help. [O3]

Plenary suggestions

Quick quiz Use mini-whiteboards, or similar, to quickly check the students' **recall** of the key learning – the equipment for measuring mass and weight; the units for mass and weight; matching mass and weight to definitions provided. Alternatively, Worksheet 1.5.3 can be used. [O1&2]

Answers to Student Book questions

1. newton
2. N
3. newtonmeter (or forcemeter)
4. left-hand meter: 1.0 N; right-hand meter: 10 N
5. The left-hand meter; because its scale divisions are of smaller value.
6. Ideas such as: people do not understand the scientific use of the terms; we say 'weigh' something when we mean measure its mass; when we weigh ourselves on bathroom scales the unit is kg, but it should be N.
7. The mass would be the same on both; because the number and type of particles do not change. The weight would be bigger on the bigger planet; because the force of gravity would be greater.
8. Damage is caused by the impact between the two cars. The mass of the two cars is the same on the Moon as on the Earth. Only the weight differs and this is a force acting downwards, which is not relevant in the impact.

Answers to Worksheet 1.5.3

1. a) 5000 N b) 100 N c) 2000 N d) 20 N e) 5 N
2. a) true b) partly true; the unit of force is the newton (N) c) false; weight (or force) is measured with a newtonmeter

   d) partly true; a door needs a pushing force or a pulling force to open it

   e) false; if no forces are acting on a stationary object it will not move, and if no forces are acting on a moving object it continues at the same speed in the same direction
3. a) A newtonmeter with a small range is suitable for a relatively light object, such as a pencil case. A relatively heavy object, such as a bag of books, would need a newtonmeter with a larger range.

   b) The fine divisions on a newtonmeter with a small range allow a reading to be more precise. The reading on the newtonmeter with the large range would be less precise because the value of each division is larger.

Worksheet 1.5.3 Measuring forces

1 Comparing forces >

The results in the table have been mixed up. Match each description to the correct size of force.

	Description of force	Size of force
a)	Push of a rugby scrum (8 large adult males)	100 N
b)	Opening a fire door	2000 N
c)	Towing a small trailer	5 N
d)	Weight of a laptop computer	5000 N
e)	Opening a book	20 N

2 Statements about forces >>

Decide if each of these statements is true, partly true or false. For the partly true and false statements, change each statement into a true one using as few changes as possible.

a) Forces can act in any direction.

b) The unit for force is the newton (n).

c) Mass is measured with a newtonmeter.

d) A door needs a pushing force to open it.

e) If no forces are acting on an object it cannot be moving.

3 Choosing a newtonmeter >>>

Newtonmeters are available that have different ranges and different divisions on the scales.

a) Explain why you might choose different newtonmeters to measure the weight of a pencil case and the weight of a bag of books.

b) Compare the precision of the readings you would obtain.

Practical 1.5.3 Using a newtonmeter

In this practical you will measure forces in different situations and practise choosing the correct newtonmeter for each situation.

Apparatus

different newtonmeters covering a variety of ranges
different objects to weigh and drag

SAFETY INFORMATION

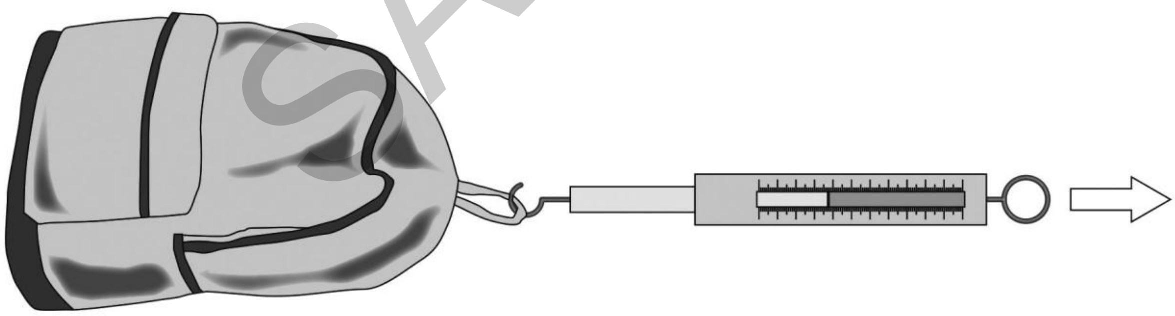
Ensure that no-one traps their fingers in the door.

Method and results

1. Weigh different objects. You need to decide which newtonmeter is the best to use for each object. Record the weights in a table like this one.

Description of object	Measurement range of newtonmeter chosen (N)	Weight (N)
school bag		
bunch of keys		

2. Measure the minimum force needed to drag various objects along the bench or floor, and to open different doors. Again, decide which newtonmeter is the best to use in each case. Record the results in a table like the one shown.



Description of force	Measurement range of newtonmeter chosen (N)	Size of force (N)
opening the classroom door		
dragging a school bag		

Evaluate method

Explain how you chose the newtonmeter with the best range in each case.

5.19 Checking students' progress

The *Checking your progress* section in the Student Book indicates the key ideas developed in this chapter and shows how students progress to more complex levels. It is provided to support students in:

- identifying the key ideas
- developing a sense of their current level of understanding
- developing a sense of what the next steps in their learning are.

It is designed either to be used at the end of a chapter to support an overall view of progress, or alternatively during the teaching of the chapter. Students can self-assess or peer-assess using this as a basis.

It would be helpful if students can be encouraged to provide evidence from their understanding or their notes to support their judgments. In some cases it may be useful to explore the difference in the descriptors for a particular idea so that students can see what makes for a 'higher outcome'.

It may be useful with some descriptors to provide examples from the specific work done, such as an experiment undertaken or an explanation developed and recorded. If marking and feedback use similar ideas and phrases this will enable students to relate specific marking to a more general sense of progress.

To make good progress in understanding science students need to focus on these ideas and skills:

Students who are making modest progress will be able to:	**Students who are making good progress will be able to:**	**Students who are making excellent progress will be able to:**
List types of force and represent forces using force diagrams; use newtonmeters.	Describe the size and direction of forces using force diagrams.	Explain the how the size and direction of forces determines their effects.
Identify gravity as a pulling force and distinguish between mass and weight.	Describe what is meant by mass, explain how gravity forces affect weight, explain why weight varies from planet to planet and explain the term 'weightless'.	Explain weight as a gravitational attraction between masses which decreases with distance; use scientific concepts to explain the difference between mass and weight.
Know that forces can lead to changes in shape and investigate the change of shape of a spring.	Explain the relationship between the amount of change in shape and the size of the force, and use data to state Hooke's Law.	Collect accurate data about forces changing the shape of an object, recognise when shape changes regularly with force size, and explain behaviour when the elastic limit is exceeded.
Identify some situations where forces are balanced and recognise that unbalanced forces are needed for a change to take place.	Identify forces acting in pairs, and apply an understanding of forces to explain how a force can cause a change in speed and direction.	Identify different examples of forces and reaction forces, and predict the changes of speed and direction that different forces can cause.
Recognise that friction is a force that slows objects down or stops them from moving.	Explain that friction is a contact force opposing the direction of movement.	Provide a detailed explanation of friction between surfaces.
List examples where friction is useful and when it is unwanted, recognise that drag forces slow things down, and recognise that streamlining helps objects move through air or water.	Compare contrasting situations involving friction, explain how friction can be increased or reduced, explain air and water resistance, and explain how streamlining reduces such resistance.	Explain air and water resistance in terms of frictional drag, explain the forces on flying or falling objects, and explain streamlining using scientific vocabulary.
Explain how to find the speed of an object.	Explain the concept of speed and use understanding of speed to explain how the equation for speed is derived.	Independently derive the equation for speed and use understanding of the speed equation to explain how speed cameras work.
Describe the balancing of a see-saw with different loads, recognise situations where balance is important, and describe the effect of increasing the length of a lever.	Explain how a fulcrum allows a turning motion, explain the effect of changing the size of a force or its distance from the fulcrum, and use and apply the law of moments.	Explain moments using force diagrams and the law of moments, explain how levers can act as force multipliers, and explain and demonstrate the design principles of a crane.

5.20 Answers to Student Book Questions

This table provides answers to the Questions section at the end of Chapter 5 of the Student Book. It also shows how different questions assess attainment in terms of the focus and style of a question as well as the context. Question level analysis can indicate students' proficiency in approaching different aspects of scientific understanding and different types of answer.

Q	Answer		Focus			Style			Context			
		Marks available	Knowledge & understanding	Application	Evaluation of evidence	Objective test question	Short written answer	Longer written answer	Forces and gravity	Friction	Turning forces	Speed
1	b	1	x			x			x			
2	c	1	x			x						x
3	c	1	x			x			x			
4	d	1	x			x			x			
5	Gravity (or weight) pulling downwards	1	x				x		x			
	Friction (and air resistance) resisting movement	1	x				x		x			
6	It gives it a higher top speed	1	x				x			x		
	It reduces the amount of fuel (or energy) needed	1	x				x			x		
7	Gravity (or weight) produces downward forces	1	x					x			x	
	The fulcrum causes the downward forces to act as turning forces	1	x					x			x	
	One person creates an anticlockwise turning effect, the other a clockwise turning effect	1	x					x			x	
	For balance, the larger force (weight) needs to be closer to the fulcrum than the smaller one, so that the turning effects (moments)are equal	1	x					x			x	
8	a	1		x		x					x	
9	d	1		x		x			x			
10	c	1		x		x						x
11	d	1		x		x			x			

Q	Answer		Focus			Style			Context			
		Marks available	Knowledge & understanding	Application	Evaluation of evidence	Objective test question	Short written answer	Longer written answer	Forces and gravity	Friction	Turning forces	Speed
12	Downward-pointing force arrow from the object, labelled 'weight' Smaller upward arrow on the object labelled 'drag' or 'air resistance' (Arrows correct, not correct labels: 1 mark)	2		x			x		x			
13	Downward weight arrow equal and opposite to upward air resistance arrow	1		x			x		x			
	Statement that forces of weight and air resistance are balanced so speed does not change	1		x			x			x		
14	Elastic means that an object returns to its original shape when a force which deformed it is removed	1		x				x	x			
	The soles do not become permanently compressed	1		x				x	x			
	so they can continue to cushon the feet	1		x				x	x			
	Shoe can bend, straighten and be undamaged	1		x				x	x			
15	May be true depending on:											
	• the leverage (position of fulcrum, length of lever)	1			x		x				x	
	• the strength of the components	1			x		x				x	
16	Padding A compresses progressively but at higher forces (or higher impact speeds) becomes 'solid' and so stops cushioning	1			x			x	x			
	Padding B compresses progressively, even with large forces	1			x			x	x			
	Padding C is fully compressed by small forces so only protects at low forces (impacts at low speeds)	1			x			x	x			
	Padding B is best because it works for the widest range of forces (or impacts at the widest range of speeds)	1			x			x	x			
	Total possible:	**30**	**12**	**12**	**6**	**8**	**10**	**12**	**18**	**3**	**7**	**2**

