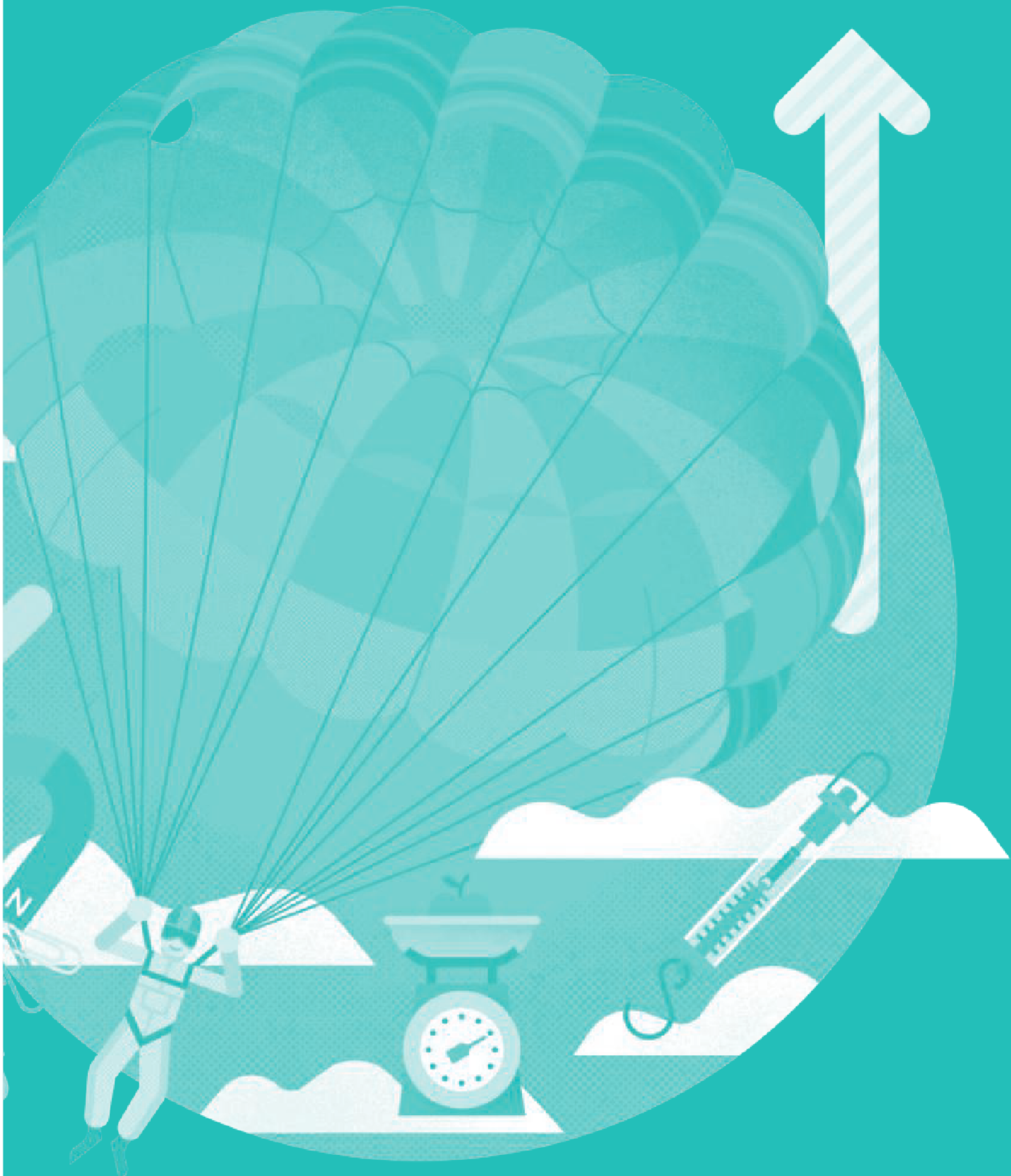
Oxford International Resources

Revised Edition

7

Science

Teacher's Guide



Lower Secondary

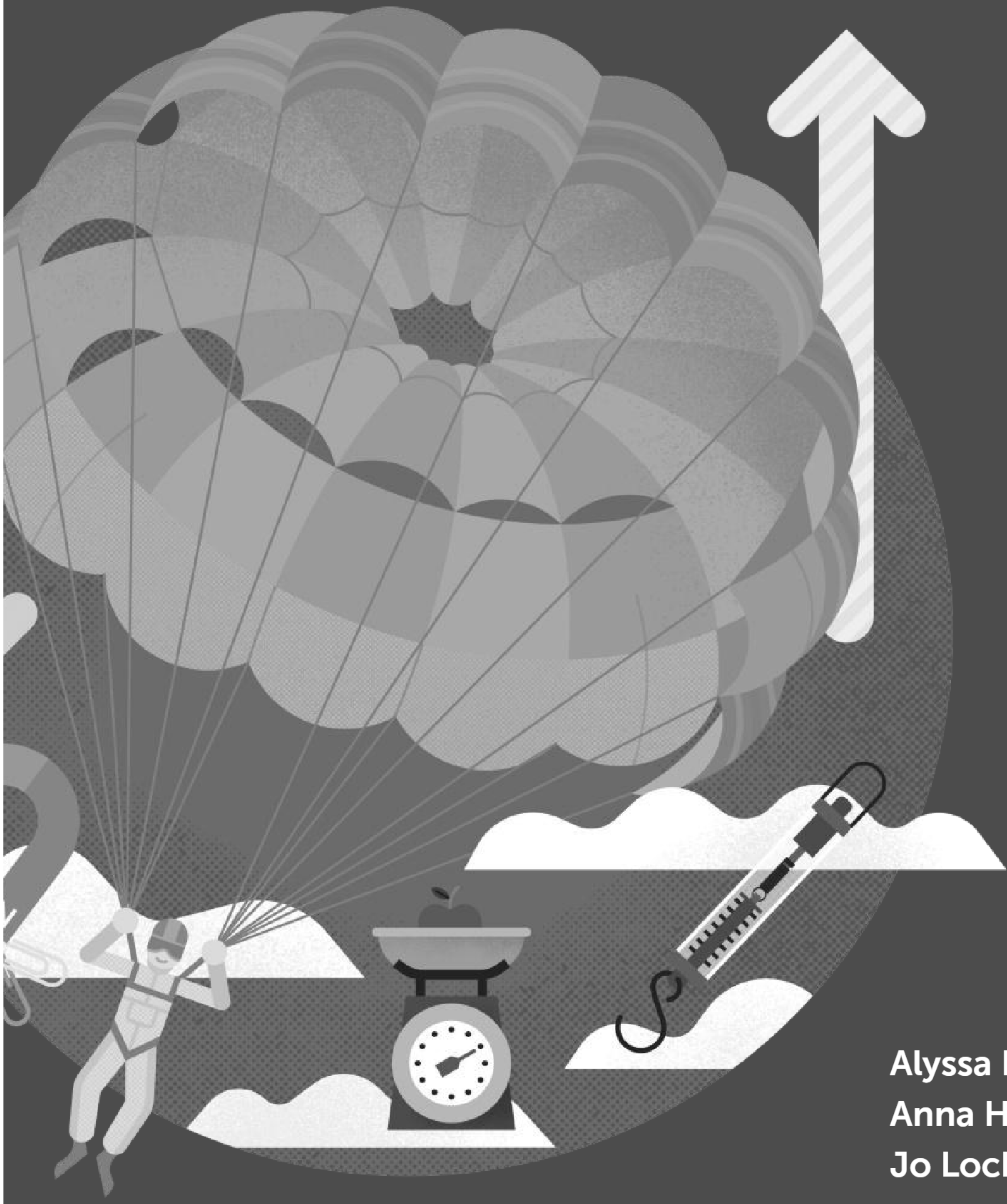
OXFORD

Oxford International Resources

7

Science

Teacher's Guide



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Contents

Introduction

The joy of learning science

We are living in an ever-changing world, where the way we work, live, learn, communicate, and relate to one another is constantly shifting. In this climate, we need to instil in our learners the skills to equip them for every eventuality so they are able to overcome challenges, adapt to change, and have the best chance of success. To do this, we need to evolve beyond traditional teaching approaches and foster an environment where students can start to build lifelong learning skills. Students need to learn how to learn, problem-solve, be agile, and work flexibly. Going hand in hand with this is the development of self-awareness and mindfulness through the promotion of wellbeing to ensure students learn the socio-emotional skills to succeed.

Teaching and learning with *Oxford International Science*

This series is suitable for use alongside the Oxford International Curriculum and the English National Curriculum. The books for each year (or stage) follow the scheme and meet all the learning objectives for both curricula – including Working scientifically. Objectives are written in student-friendly language in the Student Book.

The teaching units in the series are flexible: they can be adapted to meet the needs of your students. Each unit stands alone and can be taught in any order.

The content is designed for students aged 11 to 14. Each year has a **Student Book** and a **Teacher's Guide**. There are also numerous digital resources and sources of support on www.kerboodle.com.

Underpinning the rationale for the series is the strong belief that science provides a way of thinking and working. It helps us make sense of the world and provides intellectual skills that help us in all curriculum areas and in life.

This series has seven main aims:

1 to deliver scientific knowledge and facts

2 to deliver scientific understanding

3 to deliver scientific methods of enquiry

4 to deliver scientific thinking and reasoning

5 to help students understand the development of science and its uses in the world around them

6 to support the wellbeing of students

7 to give students a global outlook.

1 Scientific knowledge and facts

The resources present concepts in a logical sequence and ensure that new ideas are introduced sensitively and explained clearly. Students are then asked to discuss and apply their new knowledge.

2 Scientific understanding

This series promotes an understanding of the principles and practice of science through effective learning. Knowledge without understanding is only useful for recall. Understanding moves to a deeper intellectual level and enables students to think and apply that knowledge.

Effective learning requires students to develop appropriate attitudes, skills, and enthusiasm, and this can be encouraged by good teaching and exciting resources.

Active learning is an approach in which students are encouraged to engage with material through activities that promote participation and interaction. The table opposite shows a variety of approaches to promote active learning.

3 Scientific methods of enquiry

This series promotes scientific enquiry and closely follows the Working scientifically objectives in the English National Curriculum. Students are encouraged to use and reflect on the different ways that scientists work and think, which have produced the knowledge, theories, and laws of science over the last 1000 years. It is based on 'empiricism' – arriving at knowledge and understanding through observation and experiment.

Scientists progress through observation and questioning what they see and already know. From this, they make hypotheses, which they test in experiments, and develop new knowledge. This will be further explored in the 'Being a scientist' pages in this Teacher's Guide and in the Student Books.

4 Scientific thinking and reasoning

These resources encourage students to think and reason for themselves. Their ability to think, reason, and research will make them independent learners who can interpret and understand new ideas quickly.

Scientists use logical thinking to make sound inferences, taking them from the known to discover the unknown. They use reason and argument based on fact and evidence to prove their case. By experiencing these processes through 'discovery learning', students will similarly experience the thrill of finding out.

Teacher-centred learning	Student-centred learning
Teacher exposition	Group work
Accent on competition	Accent on cooperation
Whole-class teaching	Resource-based learning
Teacher responsible for learning	Students more responsible for learning
Teacher providing knowledge	Teacher as guide/facilitator
Students seen as empty vessels which need filling	Students have ownership of ideas and work
Subject knowledge valued	Process skills are valued
Teacher-imposed discipline	Self-discipline
Teacher and student roles emphasized	Students seen as source of knowledge and ideas
Teacher decides the curriculum	Students involved in curriculum planning
Passive student roles	Students actively involved in learning
Limited range of learning styles and activities	Wide range of learning styles employed

Select a variety of approaches to promote active learning.

5 Science in context

This series links what students learn in the classroom to the real world. This makes their learning relevant and helps them relate new ideas to their own experience.

Explain that science theories develop when a person or a team puts forward new ideas. If other scientists test these ideas and agree, then the idea becomes a part of science theory. It could change later with new evidence. This is how ideas develop.

The activities in each lesson provide you with many opportunities to relate the science content and processes to the real world.

6 Wellbeing of students

The content provides opportunities for you to consider the vital importance of wellbeing and to weave this into your teaching. The enquiry-based approach encourages curiosity and helps students explore the world around them. Wellbeing does not mean feeling happy all of the time. Making mistakes, feeling challenged, and even being confused at times can help to develop resilience.

This series supports wellbeing directly by:

- **Providing questions** This challenges and engages students. They can reflect on prior learning and apply new skills.
- **Promoting group work** This gives students the opportunity to develop their collaborative skills. Growth through practice builds confidence.
- **Presenting stretch zone challenges** This encourages students to develop thinking skills and welcome challenge. In each chapter of the Student Book, the 'stretch zone' icons in the 'Summary questions' sections signpost where students will be stretched and challenged to think more deeply and apply their understanding of the topic. This kind of practice will support students to move away from their comfort zone into the stretch zone without worrying.
- **Offering mindful moments** This provides opportunities for students to pause and re-focus their attention. In the Student Book, the 'What have I learned?' pages promote metacognition (students' ability to think about their own thought processes). These pages empower students to quietly reflect on their learning so far and how they learn best.

7 A global outlook

This series is designed to address the idea that academic lifelong success is the result of both academic performance and emotional wellbeing. As educators, we want to prepare our students for a workplace that is unknown to us. Ideas and activities identify areas where students can develop real-world skills while feeling safe and confident enough to apply themselves to the content of the lessons.

Teaching techniques for this series

Asking effective questions

Research tells us that teachers ask up to 400 questions per day, which can amount to 30 per cent of teaching time. Improving questioning techniques will therefore have an important impact on learning.

Consider your own practice:

- why you are asking a question
- what type of questions you ask
- when you ask questions
- how you ask questions

- who you ask questions to
- how you expect questions to be answered
- how you respond if a student does not understand the question
- how you react to an inappropriate or wrong answer
- how you react to an appropriate answer
- how long you wait for an answer.

Consider your reason for asking the question:

- to get attention
- to check students are paying attention
- to check understanding
- to reinforce or revise a topic
- to increase understanding
- to encourage thinking
- to develop a discussion.

Bloom describes six levels of thought process:

1 Knowledge

2 Comprehension

3 Application

4 Analysis

5 Synthesis

6 Evaluation

Closed questions

These tend to have only one or a limited range of correct answers. They require factual recall. They are useful for whole-group question and answer sessions, to quickly check learning or refresh memory, or as a link to new work. For example:

Question: What is the boiling point of water?

Answer: 100 °C.

Closed questions are very good for knowledge recall but are generally non-productive regarding anything else.

Open questions

These may have several possible answers, making it difficult to decide which are correct. They are used to develop understanding and encourage students to think about issues and ideas. We are not looking for a single right answer; we are looking for what the student thinks may be the right answer. Once you get the student thinking, you can use this information to move the learning on towards the right answer, while promoting understanding at the same time. For example:

Question: Where do you think the water in rain clouds comes from?

Answer: Any answer will have a little 'rightness' in it that the teacher can use. The student may answer 'From the sea'.

You can then follow several lines of enquiry to extend the learning. For example, 'Do you know of any other places the water might have come from?' or 'How do you think that the water got into the clouds?'.

These follow-up 'how' and 'why' questions encourage students to think more deeply about key scientific ideas and principles.

Differentiation

Differentiation is closely linked to inclusion: ensuring all students have access to the curriculum. This means that learning and teaching approaches must consider individual needs. Not all students will learn at the same pace or in the same ways.

This series supports the following approaches:

- **Differentiation by task** Content can be adjusted for some students to provide sufficient support or adequate challenge. The Summary questions in the Student Book are ramped, starting with questions aimed at less able students and finishing with 'stretch zone' questions. The latter are designed to extend more confident students and challenge them to think more deeply. For less able students, prioritize the in-text questions after each section of text. They will be able to find the correct answers in the text they have just read.
- **Differentiation by outcome** This allows all students to tackle the same tasks, but with differentiated learning outcomes. There are three bands of differentiation for each learning objective: developing, secure, or extending. The differentiated outcomes are provided for each lesson in this Teacher's Guide. 'Secure' indicates that students have a secure grasp of the knowledge or skills specified. The band working towards 'secure' is 'developing', and the band moving past 'secure' is 'extending'.
- **Differentiating by support** This means providing more or less support as students are carrying out a task. Advice on this is provided for each lesson in this Teacher's Guide. For additional practice, support handouts are available on Kerboodle to give less able students further opportunities to reach a secure understanding of new or challenging concepts in their own time. These handouts can be tackled independently or used in adult-led, small-group sessions.

Learning objective	Learning outcomes: Developing	Secure	Extending
Learners at this stage...	...are working towards secure knowledge and understanding but need more support to achieve this.	...have a secure knowledge and understanding.	...are working beyond expectations, and their knowledge and understanding can be stretched and challenged.
e.g. Compare the parts of plant and animal cells	*Label the parts of plant and animal cells*	*Compare the parts of plant and animal cells*	*Explain the differences between plant and animal cells*

Assessment

Assessment is an essential part of learning. Without being able to check progress, teachers and students will not be able to identify areas of strength and areas in need of development.

Each activity – group and individual – can be assessed through observation, questioning, and progress notes. Written or drawn responses for each activity can be assessed/marked using the school's marking policy; and unit, end-of-term, and end-of-year judgements made about individual and class progress.

Feedback is a crucial aspect of assessment. This should be as positive and encouraging as possible, in which clear targets are identified. Involve students in assessment and target setting – assessment is done *with* learners not done *to* learners.

Formative assessment

This takes place during learning and is used to address issues as they arise. This means learning and teaching can be modified during lessons to better meet students' needs. Feedback is ongoing.

Each activity within the Student Book provides opportunities for formative assessment and feedback. You can do this by listening to discussions or presentations; observing the outputs of investigations; and assessing outcomes such as posters, reports, and leaflets. Individual questions in discussion tasks can be used to monitor understanding and identify misconceptions. These can be addressed as they are noted. Questions are suggested for each lesson in the 'Review and reflect' sections in this Teacher's Guide.

Summative assessment

This is used to measure or evaluate student progress at the end of a process – for example, when a unit is completed or at the end of a year. Summative assessment compares students' attainment against a standard or benchmark.

The 'What have I learned?' pages at the end of each chapter can be used for summative assessment. You can record which questions each student is answering correctly and use this to measure individual attainment. It can also indicate how well the class is progressing though the work. In this way, the assessment can inform individual interventions (extra support for a student) or whole-class interventions (reviewing work that is not well understood).

How to support non-native English speakers

Ministries of Education at both local and national level are increasingly adopting the policy of English Medium Instruction (EMI), for either one or two subjects or across the whole curriculum.

In international schools, it is likely that students do not share a mother tongue with each other or perhaps the teacher. English is chosen as the medium of instruction to level the playing field and to provide the opportunity to develop proficiency in an international language.

This does not mean that the science teacher is expected to replace the English teacher, or to have the same skills or knowledge of English. However, they do need to become more language aware. This raises significant challenges, including:

- the teacher's knowledge of English
- students' level of English (which may vary considerably in international schools)
- resources that provide appropriate language support
- assessment tools which ensure that it is the content and not the language being tested
- differentiation that acknowledges different levels of proficiency in both language and content.

Language in the classroom

Using English in the classroom is very important as it provides exposure to an additional language (often a student's second or third), which plays a valuable role in language acquisition. The 'teacher talk' for purposes such as checking attendance and collecting homework does not have to be totally accurate or accessible to students. However, when teaching scientific concepts it is essential that the 'teacher talk' is comprehensible. The following strategies can help:

- simplify your language
- use short, simple sentences and project your voice
- paraphrase as necessary
- use visuals, the board, gestures, and body language to clarify meaning
- repeat as necessary
- plan before the lesson
- prepare clear instructions and check understanding.

Creating a language-rich environment

Providing a colourful and visually stimulating environment for students becomes even more important in the EMI classroom. Posters, lists of key words and structures, displays of students' work, and signs and notices in English all maximize students' exposure to English and, in big or small ways, contribute to their language acquisition.

Planning

In your planning, identify each language demand (LD). You will need to think about what language students will need to understand or produce, and decide how best to scaffold the learning to ensure that language does not become an obstacle to understanding the concept. This kind of language support (LS) goes beyond the familiar strategy of identifying key vocabulary.

Support for listening and reading

Listening and reading are receptive skills, requiring understanding rather than production of language.

If students need to listen to or read in English, ask yourself the following questions:

1 Do I need to teach any vocabulary before they listen/read?

2 How can I prepare them for the content of the text so that they are not listening 'cold'?

3 Can I provide visual support to help them understand the key content?

4 How many times should I ask them to listen/read?

5 What simple question can I set before they listen/read for the first time to focus their attention?

6 How can I check more detailed understanding of the text? Can I use a graphic organizer (e.g. tables, charts, or diagrams) or a gap-fill task?

7 Do I need to differentiate the task to support or challenge students?

8 Can I make the tasks interactive through group work or games?

9 How can I check their answers and give feedback?

Support for speaking and writing

Speaking and writing are productive skills and may need more language input from the teacher. You will need to think in detail about what language the task requires (language demands, LD) and what strategies you will use to help students use English to perform the task (language support, LS).

Ask yourself the following questions:

1 What vocabulary does the task require? (LD)

2 Do I need to teach this before they start? How? (LS)

3 What phrases/sentences will they need?
Think about the language for learning science (e.g. predicting and comparing). What structures do they need for these language functions? (LD)

4 While I am monitoring this task, is there any way I can provide further support to less confident students? (LS)

5 What language will students need to use at the feedback stage (e.g. when they present their task)? Do I need to scaffold this? (LD, LS)

Teaching vocabulary and structures

Vocabulary

Learning key science vocabulary is central to EMI, and 'learning' means more than simply understanding the meaning. Knowing a word also involves being able to pronounce it accurately and use it appropriately. Aim to adopt the following strategies:

- Avoid writing a vocabulary list on the board at the start of the topic and 'explaining' it. The vocabulary should be introduced as and when it arises. This helps students associate the word or phrase with the concept and context.
- Record the vocabulary clearly on the board. Check your pronunciation and spelling beforehand.
- Give students a chance to say the word once they have understood it. The most efficient way to do this is through repetition drilling.
- Use visuals whenever possible to reinforce students' understanding of the word or scientific concept.
- Advise students to record the vocabulary systematically in their glossaries under chapter or topic headings.
- Remember to recycle and revise the vocabulary.

Structures

Students will need to use phrases and sentence frames to discuss or write about their learning in science, including these structures:

I predict that X will happen.

If X happens, then Y happens.

The next step is …

Build up these banks of common science phrases and remind students to record them. You do not have to focus on grammar here as the language can be taught as 'chunks' rather than specific grammatical structures.

Component overview

Student Books

The Student Books are textbooks for students to read and use. They include everything you need to deliver the course to your students, guide their activities, and assess their progress.

Student Book	Typical student age range
Student Book 7	Age 11–12
Student Book 8	Age 12–13
Student Book 9	Age 13–14

Teacher's Guides

There are three Teacher's Guides, corresponding to the three Student Books. Each Teacher's Guide includes:

- an introduction with advice about delivering science and using the Student Books.
- guidance on teaching each Student Book topic, including student learning objectives and outcomes, recommended scaffolding, and answer keys.
- model answers to the activities and investigations, and answers to the assessment activities.

Digital

Kerboodle online learning (www.kerboodle.com) provides engaging digital books, lesson resources, and a comprehensive assessment package.

Digital books

- **For the teacher:** You can access the Student Books and Teacher's Guides as digital books. The digital books show the course content on screen, making it easier for you to deliver engaging lessons. A set of tools (e.g. sticky notes, bookmarks, pen features, zoom in, and spotlight text) allows you to personalize your digital book and make notes. You can share your notes or hide them from view.
- **For the students:** Students can access the Student Books as digital books for use at home.

Resources

- Videos – on each topic, also integrated into students' adaptive learning journey
- Activity and practical handouts – useful visual aids and additional scaffolding for the lesson content
- Support handouts – for students at developing level who need more support during the activities and practicals
- Vocabulary quizzes – for each chapter, to assess students' understanding of key terms
- Curriculum mapping to the English National Curriculum, Cambridge International curriculum, and Oxford International Curriculum
- Guidance on how the series supports progression to further study at iGCSE
- Letters to parents/carers to introduce the course and offer guidance on home learning.

Assessment and adaptive learning journey

Our assessment model combines formative and summative practices. An additional element is regular, low-stakes quizzing aimed at helping students retain new concepts. The formative assessment comprises:

- **My self-study quizzes** at the end of each topic, which ask students questions that are relevant to the learning objectives they have just covered. Students' scores will generate either a 'developing to secure' or a 'secure to extending' next-step intervention. The teacher will also see a breakdown of how students are performing against each of the learning objectives.
- **Formative tests** which cover content from the whole chapter. Similarly, students will be assigned a next-step intervention according to their score.

Quizzes and tests are auto-marked. Following either assessment type, students are offered personalized next steps. They can consolidate their knowledge if they are at a developing level, or challenge themselves if they have demonstrated secure knowledge.

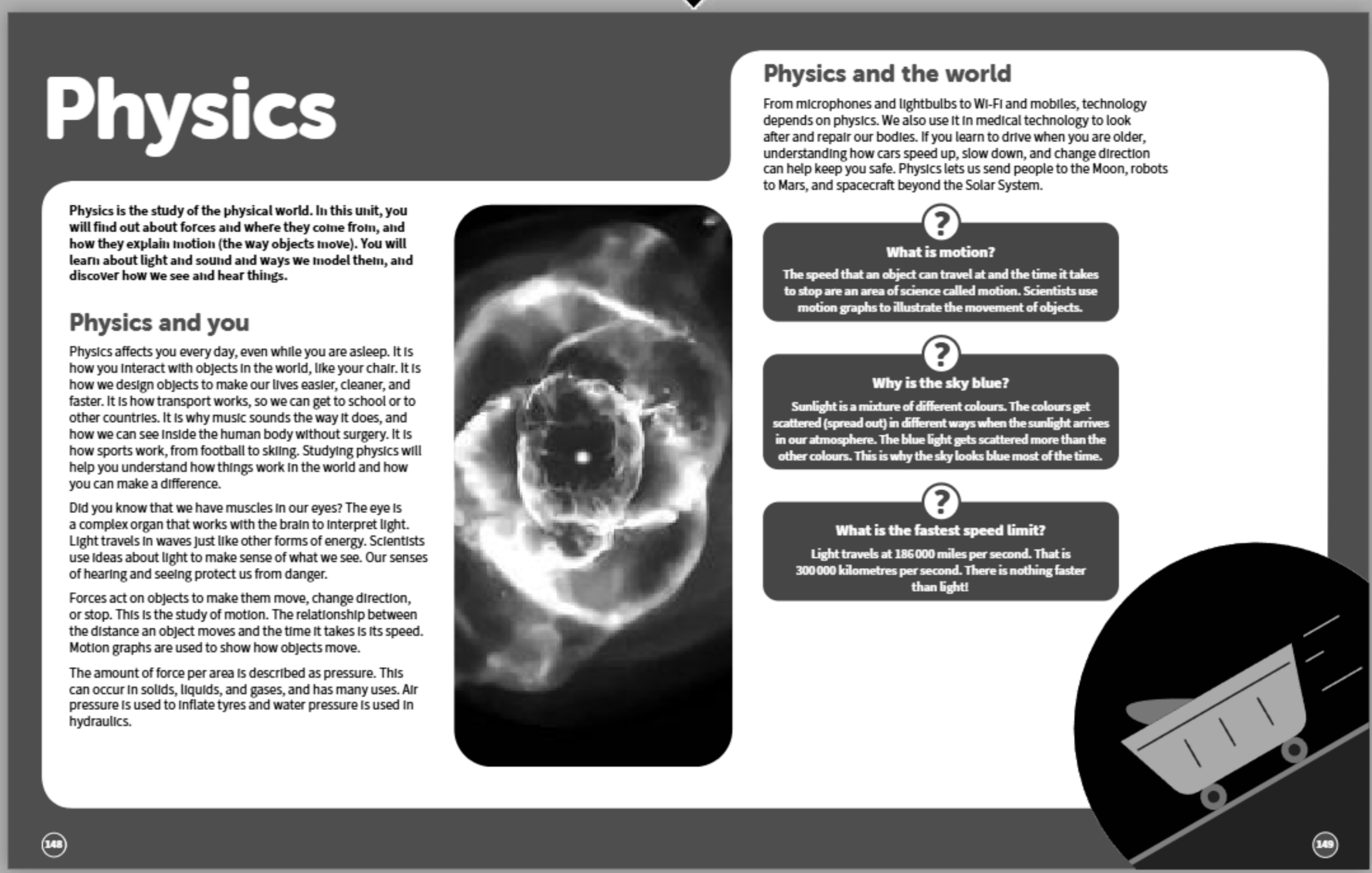
At the end of each chapter, there is also a paper-based summative assessment designed to evaluate understanding of the whole chapter.

Reporting and insights

The formative assessment data will feed reporting on Kerboodle and give insights into strengths and areas for development. The data is broken down into learning objectives, and will support you in diagnosing learner needs and focusing your intervention accordingly.

Tour of a Student Book

Unit opener
This asks some important questions that students will find the answers to in the unit, and shows students the key topics they will study.



Physics

Physics is the study of the physical world. In this unit, you will find out about forces and where they come from, and how they explain motion (the way objects move). You will learn about light and sound and ways we model them, and discover how we see and hear things.

Physics and you

Physics affects you every day, even while you are asleep. It is how you interact with objects in the world, like your chair. It is how we design objects to make our lives easier, cleaner, and faster. It is how transport works, so we can get to school or to other countries. It is why music sounds the way it does, and how we can see inside the human body without surgery. It is how sports work, from football to skiing. Studying physics will help you understand how things work in the world and how you can make a difference.

Did you know that we have muscles in our eyes? The eye is a complex organ that works with the brain to interpret light. Light travels in waves just like other forms of energy. Scientists use ideas about light to make sense of what we see. Our senses of hearing and seeing protect us from danger.

Forces act on objects to make them move, change direction, or stop. This is the study of motion. The relationship between the distance an object moves and the time it takes is its speed. Motion graphs are used to show how objects move.

The amount of force per area is described as pressure. This can occur in solids, liquids, and gases, and has many uses. Air pressure is used to inflate tyres and water pressure is used in hydraulics.

Physics and the world

From microphones and lightbulbs to Wi-Fi and mobiles, technology depends on physics. We also use it in medical technology to look after and repair our bodies. If you learn to drive when you are older, understanding how cars speed up, slow down, and change direction can help keep you safe. Physics lets us send people to the Moon, robots to Mars, and spacecraft beyond the Solar System.

What is motion?
The speed that an object can travel at and the time it takes to stop are an area of science called motion. Scientists use motion graphs to illustrate the movement of objects.

Why is the sky blue?
Sunlight is a mixture of different colours. The colours get scattered (spread out) in different ways when the sunlight arrives in our atmosphere. The blue light gets scattered more than the other colours. This is why the sky looks blue most of the time.

What is the fastest speed limit?
Light travels at 186 000 miles per second. That is 300 000 kilometres per second. There is nothing faster than light!

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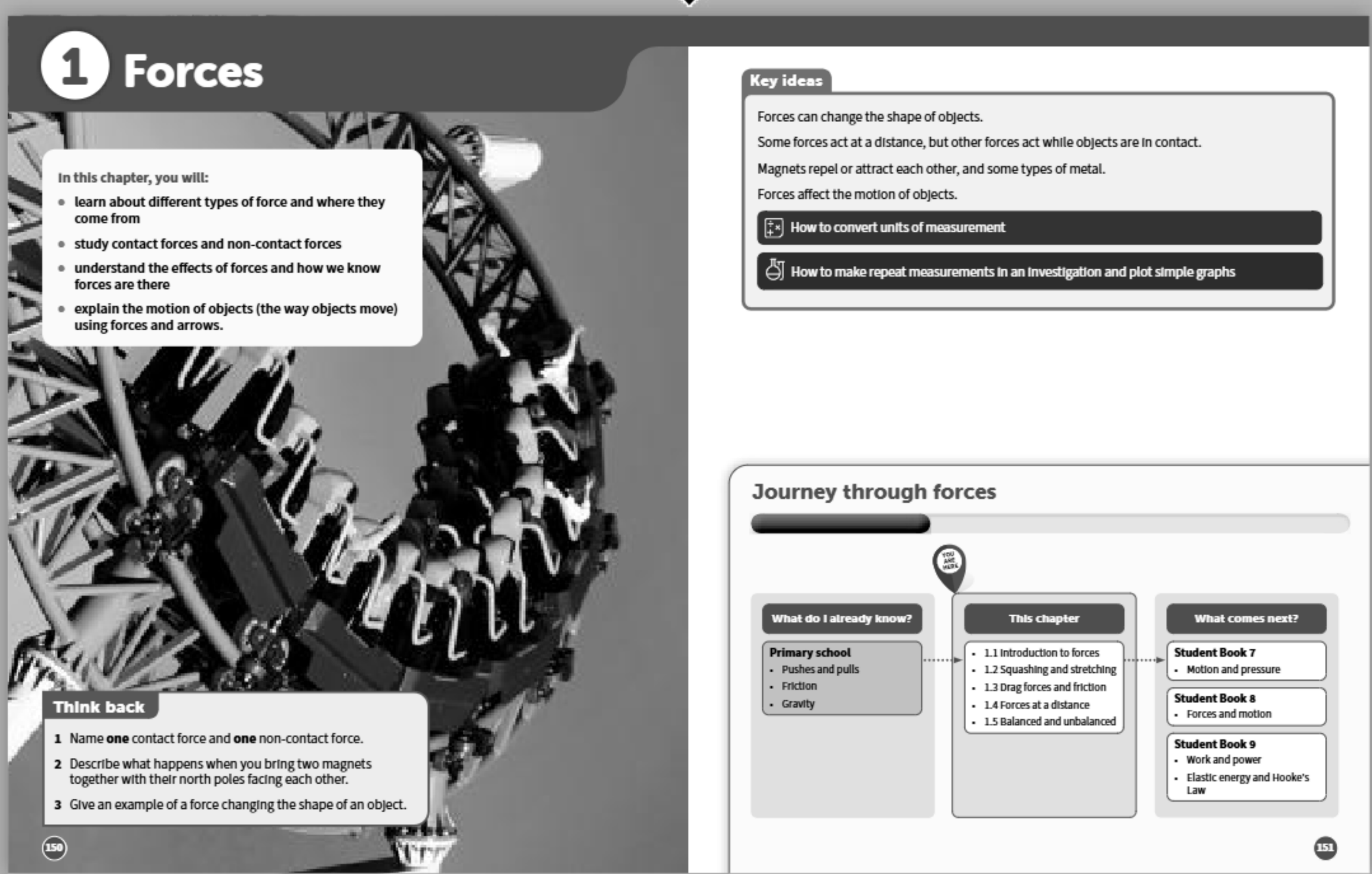
Chapter opener
This reminds students what they already know, and shows them what is coming up in the chapter. It also shows students the Working scientifically and Maths skills that they will learn. The 'Journey' map shows what students are learning in each chapter, the knowledge being built on, and what comes next.



1 Forces

In this chapter, you will:
- learn about different types of force and where they come from
- study contact forces and non-contact forces
- understand the effects of forces and how we know forces are there
- explain the motion of objects (the way objects move) using forces and arrows.

Think back
1 Name **one** contact force and **one** non-contact force.
2 Describe what happens when you bring two magnets together with their north poles facing each other.
3 Give an example of a force changing the shape of an object.

Key ideas
Forces can change the shape of objects.
Some forces act at a distance, but other forces act while objects are in contact.
Magnets repel or attract each other, and some types of metal.
Forces affect the motion of objects.
How to convert units of measurement
How to make repeat measurements in an investigation and plot simple graphs

Journey through forces

What do I already know?	This chapter	What comes next?
Primary school • Pushes and pulls • Friction • Gravity	• 1.1 Introduction to forces • 1.2 Squashing and stretching • 1.3 Drag forces and friction • 1.4 Forces at a distance • 1.5 Balanced and unbalanced	**Student Book 7** • Motion and pressure **Student Book 8** • Forces and motion **Student Book 9** • Work and power • Elastic energy and Hooke's Law

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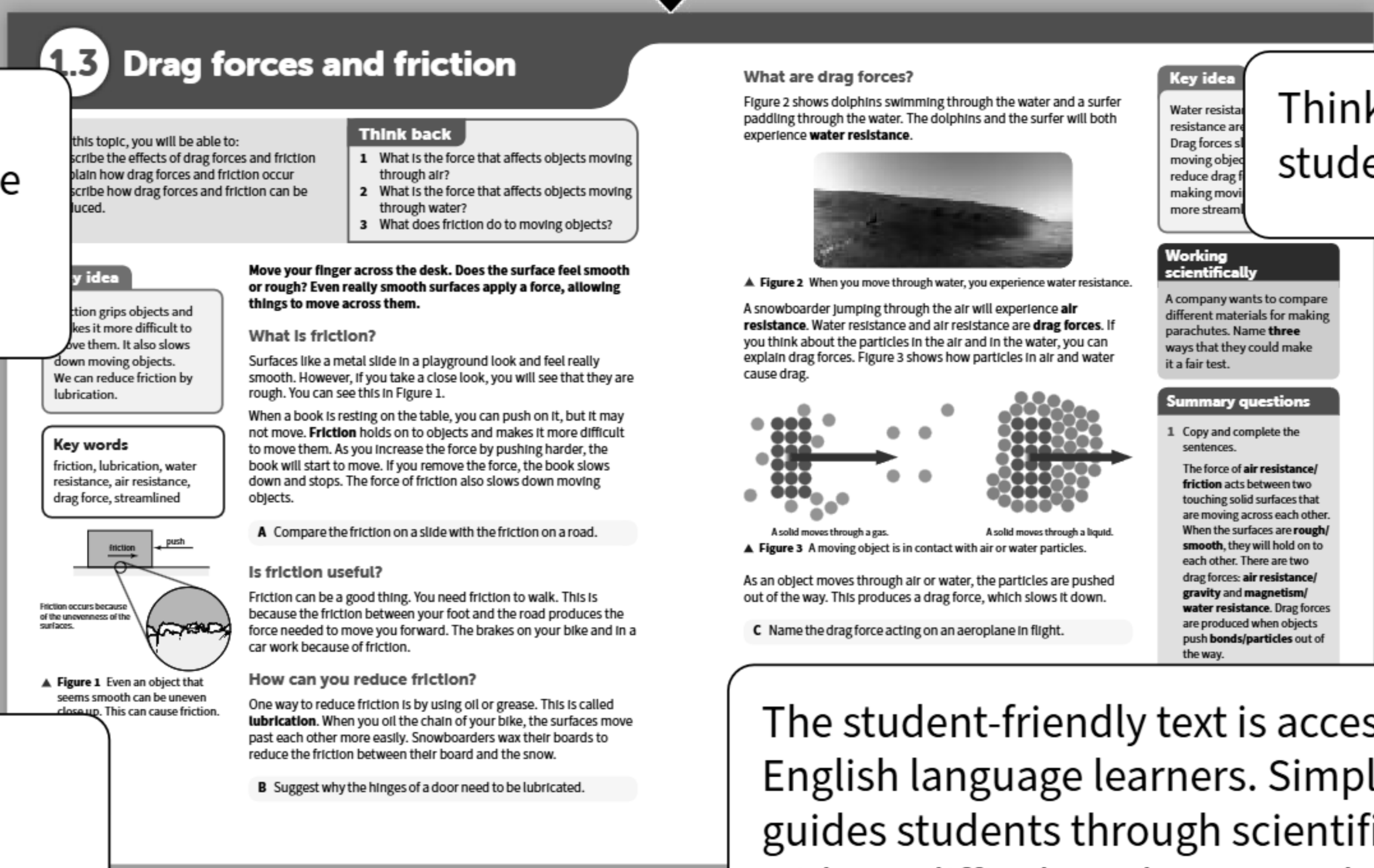
Lesson pages

These pages guide students through a particular topic in each chapter. Organized under headings, language is clear and accessible to ensure students' understanding of the key ideas. The key idea and key words in each lesson are presented clearly. Images, tables, and diagrams are included to complement the text and to support visual learners to grasp the scientific concepts. Skills boxes, in-text questions, and 'Summary questions' can then be used to check students' understanding of what they have just read and to stretch their thinking further.

Learning objectives for the lesson are clearly set out at the start and summarized in the Key idea box.

Think back boxes remind students of prior learning.



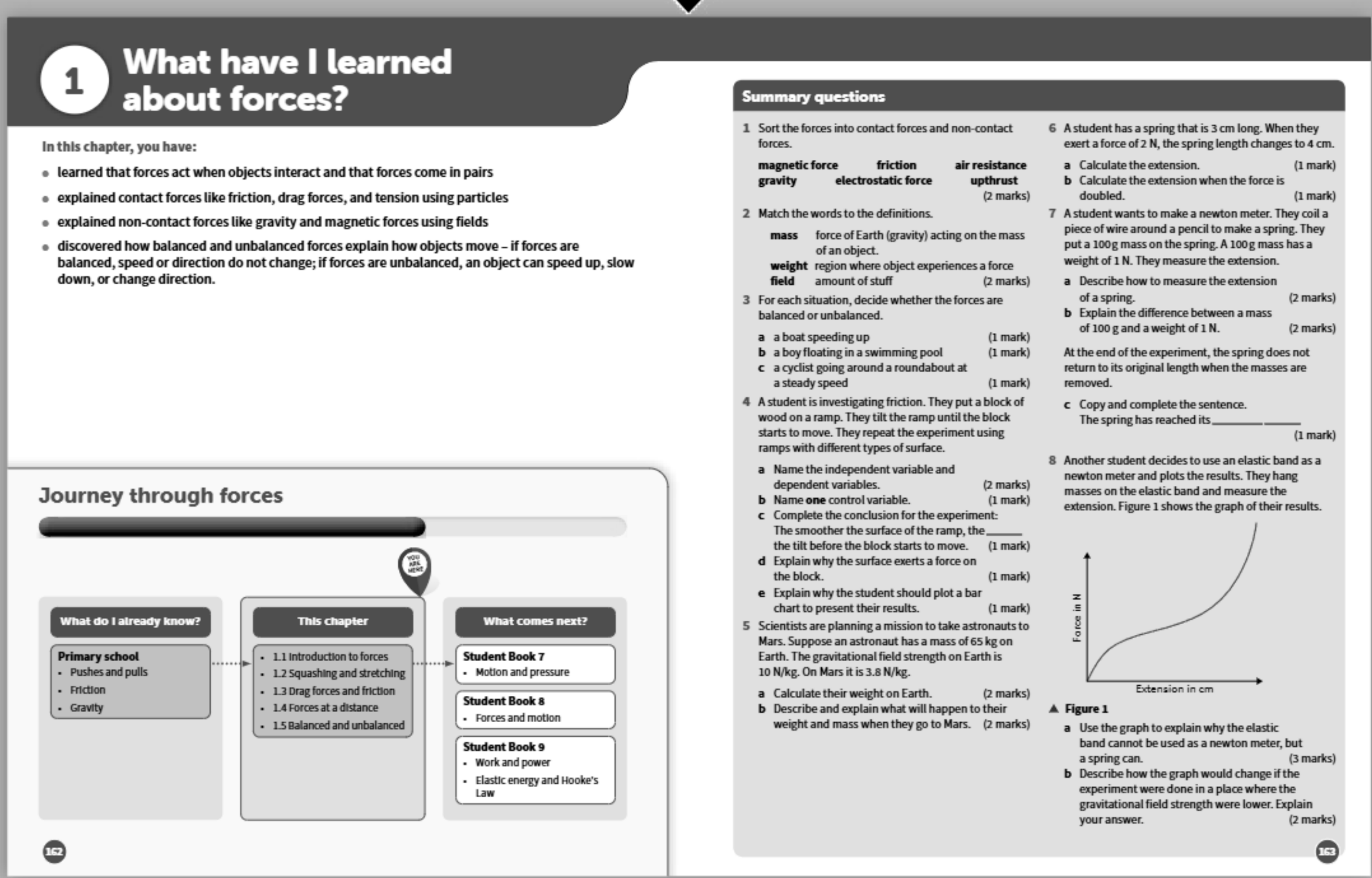
Key words boxes show the main science vocabulary for the lesson.

The student-friendly text is accessible for English language learners. Simplified language guides students through scientific concepts without difficulty. Where complex scientific words are needed, a brief explanation or synonym is included in parentheses.

What have I learned? pages

These pages summarize the content that students have learned so far and show their progress through the unit. Each chapter concludes with exam-style questions to test how well students have learned and understood the topics.

Allow students time to reflect on how confident they feel about each topic. Remind them to use the learning objectives for guidance.



Students' progress is assessed through the questions at the end of each chapter. Students can answer the questions one at a time after each topic, or as a single summative activity. This could be done as a whole-class or group activity, or set as an independent task. The questions are designed to give you and students feedback about progress and identify targets for development.

Being a scientist

What is metacognition?

Metacognition refers to the knowledge a student has about their own learning processes. It is commonly referred to as 'learning about learning' and covers both subject-specific learning and wider independent study skills. Metacognition can be broken down further. Firstly, there is metacognitive knowledge, which is where students have a good understanding of the tasks they need to complete and the strategies that they have available to them. Students also have knowledge of themselves as a learner. Secondly, there is metacognitive regulation, which is where students are able to regulate themselves by planning, monitoring, and evaluating their own learning.

Why 'being a scientist'?

Metacognition applies to all aspects of learning, whether that be subject-specific knowledge or other wider study skills. This means that we need to develop our students' metacognitive skills in all aspects of their learning.

One way to teach metacognitive skills is to explicitly teach students how to be a secondary school learner. These could be be subject-specific skills like rearranging equations or writing a method. Or they could be general skills like how to complete independent study tasks. Explicit instruction on how to complete these tasks successfully helps build metacognitive skills in our students.

One particular area that students struggle with is what to do when they need help. A large part of metacognition is students having a good understanding of the strategies they have available to them. Usually this is thought of in terms of subject-specific strategies, such as using acronyms to help structure extended writing. However, it also applies to general study skills, including what to do when they get stuck in a lesson and when completing home learning tasks. The Student Book asks students to think about what resources they have available in their own school to help them when they are stuck.

How to teach metacognitive strategies

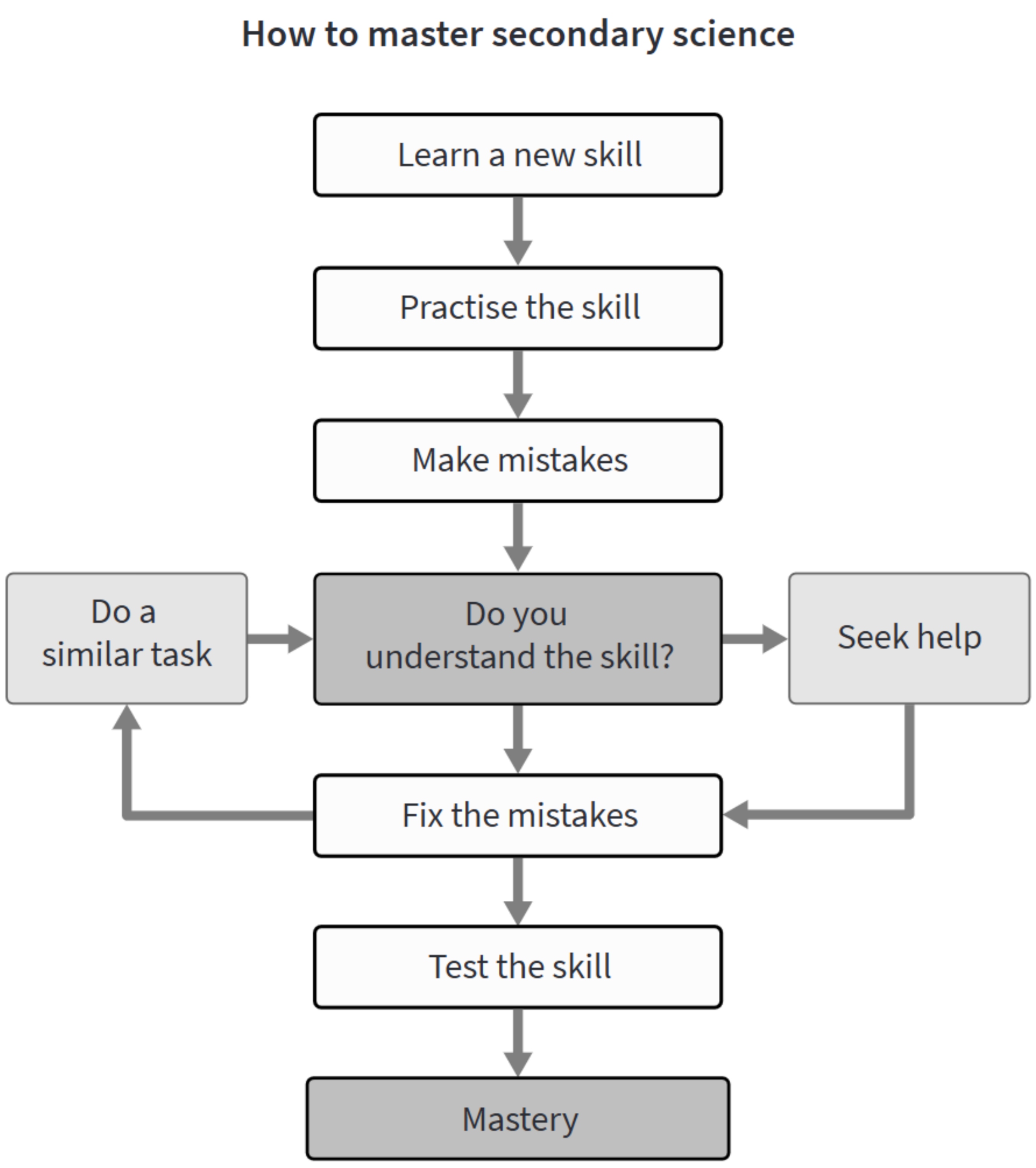
The following seven-step approach can be used as a planning tool to support the delivery of any new skill or strategy, and can be used in all aspects of learning.

1. Activate prior knowledge
2. Explicit strategy instruction
3. Modelling of learned strategy
4. Memorization of strategy
5. Guided practice
6. Independent practice
7. Structured reflection

What are some metacognition strategies students could use?

There are many different metacognition strategies students could use. Here are some explanations of metacognition strategies that could be particularly useful when learning science.

Mastering secondary school science



Why: This flowchart shows the learning journey and is designed so that students can follow a series of steps when learning new material.

How: Modelling is the best way to introduce this strategy. Showing students how you, as an expert learner, navigate the stages will help them adopt the practice themselves. It is also best to revisit the flowchart when studying different topics so that students start to see the variety of ways it can be used.

When: This could be integrated into any transition unit.

Where: This could be placed on the wall in a classroom so that it is easy to refer to in lessons.

Reading scientific texts

Why: It can be a challenge for students to read the text while also interpreting equations, diagrams, and data. All of this combined with the high-level language and subject-specific vocabulary means that students often struggle to access the textbooks and resources we supply them with.

How: It is important that new strategies are delivered in a simple context so that students are focused on the strategy and not on learning new scientific content at the same time.

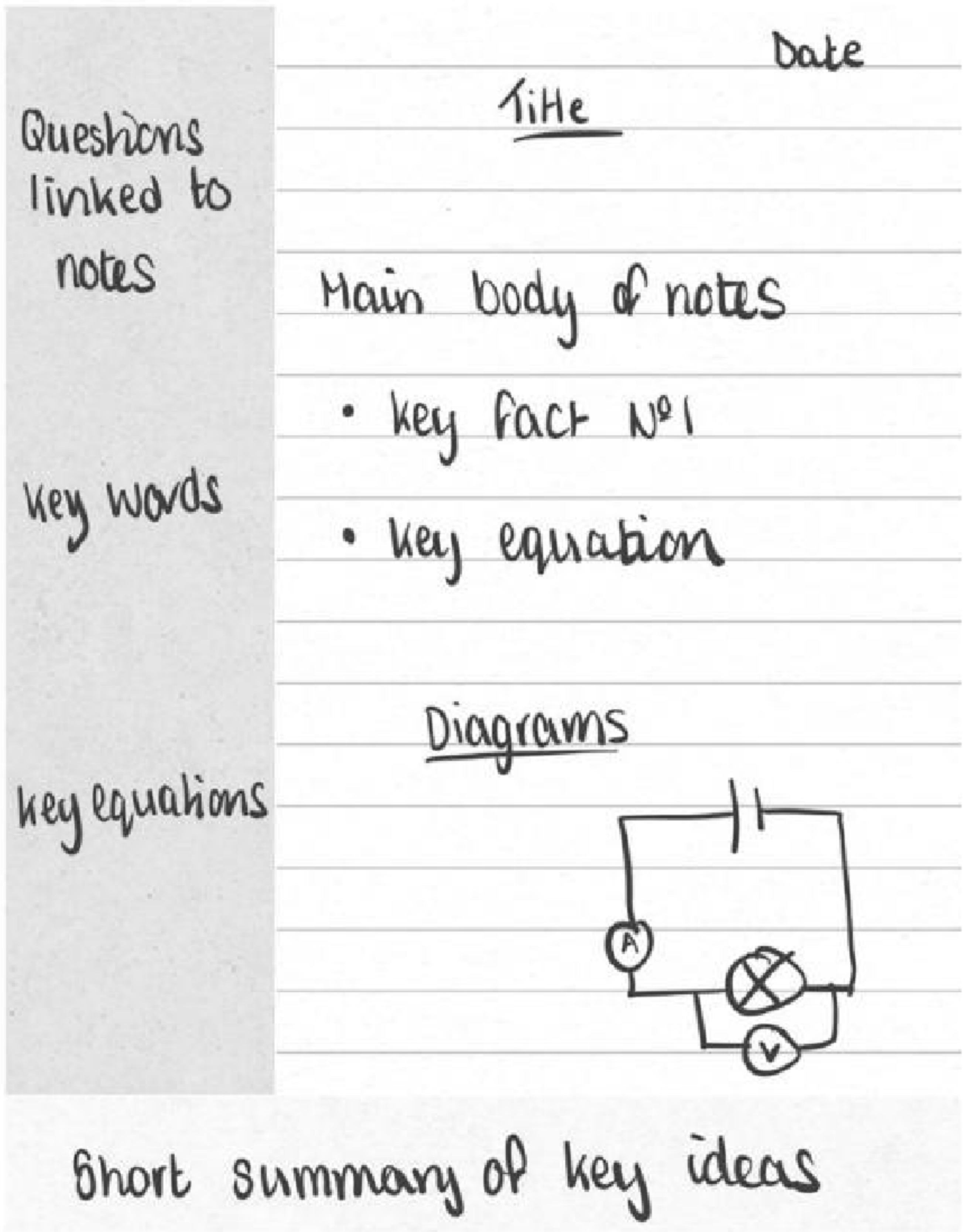
When: This could be integrated into a transition unit early on in Lower Secondary.

SURE

Skim the text
Underline and understand
Reread
Extract information

Finish with a one-sentence summary

Cornell notes method



Why: Teaching the Cornell notes method helps students to understand how classroom notes can be used to help with long-term learning.

How: This strategy can be delivered alongside the SURE approach or on its own. The seven-step approach to teaching metacognitive skills can be used to introduce and embed this strategy.

When: This could be integrated into a transition unit early on in Lower Secondary.

Working safely

Enquiry-based learning

Enquiry-based learning in science can only be achieved by investigating and experimenting. Questions should lead to predictions and then hypotheses that can be tested and investigated using scientific methods. This rarely involves chemicals that are not found in a common kitchen but will almost always involve some risks that should be managed responsibly.

Glassware, spills, and sharp equipment are probably the cause of most accidents in the science classroom in Year 7. The teacher should be able to assess and manage such risks but it is the responsibility of the students to keep themselves and everyone around them (including you) safe. Assess all practical work that you plan yourself for risk, as different authorities have different views. Make sure your classroom is as safe as it can be for your students. Be prepared for things not to go the way that you have planned. Discuss general risks in the science laboratory or classroom before delivering practical lessons.

Allow students to work in small groups to plan safety rules. Encourage them to share their rules and explain why they think they are important. Then vote on which rules are the most important and display them clearly in the working space. Refer to this display at the start of all practical lessons and remind students that they agreed on these rules for everyone's safety. Give clear safety instructions at the beginning of practical lessons.

Find out the correct procedure in the school for reporting any accidents. Follow this protocol and record everything as soon as possible to allow accurate reporting of any event, regardless of how minor it may appear.

Remind students to wash their hands after handling any samples, chemicals, or even science equipment in the laboratory. Be aware of any health issues including allergies and respiratory issues when working with pollen or flowers.

You might need to deliver some practical tasks as a demonstration, due to a shortage of resources or because the equipment or materials are too dangerous for students to handle.

Research all options but if there is no safer alternative where students can have a hands-on experience, encourage the students to ask questions throughout and be prepared to repeat the demonstration. For example, you might demonstrate how to use equipment such as a vacuum pump or collapsible bottles. Use safety screens, fume cupboards, or outdoor spaces and arrange the students about 2 metres back from any demonstrations as necessary.

General rules

Always ask students to prepare the workspace for investigations by tidying loose items and bags away from the area and keeping the floor clear. Encourage students to take responsibility for their own safety by tying back long hair and removing ties, scarves, or loose items such as bracelets or earrings. Students should place their stools or chairs under the desk or work bench when experimenting. They should always be standing up so that spills and toppling Bunsen burners or spirit burners are less likely to fall onto their torso and more likely to fall on the floor.

Remind students that if they spill any liquids or break glassware, they should report this to you straight away. Ask the students to stand well back while you clear up the hazard. Keep a dustpan and a bucket to hand to enable fast, efficient clean-up.

Make sure there is access to clean running water or an eye wash in case any chemicals are splashed into the eyes. Even salt water can irritate the eye if it is not washed out immediately. Clean running water or a bottle of water is also useful for mild burns. Never apply any creams or administer any form of medication to students unless you are a qualified practitioner.

Demonstrate how to use tongs or heatproof gloves when working with any equipment that has been heated. Even glass that has been heated in hot water or over a chemical burner or candle can burn the skin. Students should always tell an adult if they hurt themselves in any way during a lesson.

Heavy equipment

Microscopes should be carried and used correctly; they are much heavier than some students think they are. Demonstrate how to hold the handle with one hand and place the other hand under the base.

When using weights and magnets, students should hold them over the desk or bench to avoid them dropping on feet. Always demonstrate how to attach weights securely to any attachments to avoid them dropping on fingers. Scales and retort stands should be used away from the edge of the desk to avoid them falling over or spilling their contents onto the user.

Even water is heavy. Show students how 1 litre of water has a mass of 1 kg. Allow them to explore this for themselves.

Sharp items

Scissors, forceps, tweezers, and scalpels should be used and stored sensibly. Remind students not to walk around with them in their hands but to keep them on small working trays so that they can be transported safely.

Glassware

Microscope slides and coverslips can also be a hazard if they are broken. Demonstrate how to hold slides between the fingers and add a cover slip using forceps. When the slide is placed on the stage, wind the stage up to the lens before looking through the eyepiece and then wind it away from you until the specimen is in focus. When using higher-powered lenses, it is possible to wind the slide too close to the lens and crack the glass of the coverslip or slide.

Chemicals

Methylene blue, Benedict's solution, biuret solution, limewater, hydrochloric acid, sodium hydroxide, sodium carbonate, and sulfuric acid are all irritants. Students should always wear safety glasses/goggles and disposable gloves and wash hands thoroughly after use. Rinse skin that has come into contact with any of the chemicals. 0.1 M ethanoic acid is not currently listed as hazardous but it is advisable to take care when using it and when diluting acids/alkalis. Some fertilizers can be irritants and harmful and should be used with caution. Iodine solution is low hazard at 1 M or less but it is still an irritant so you should avoid contact with skin and eyes.

Some seeds may be covered in a fungicide so remind students to wash their hands after handling them. Salts made in science experiments are not safe to eat.

Biohazards

Check that all equipment that will come into contact with the mouth, such as tubing in a pooter or when testing exhaled breath, is sterile.

Mouth swabs or other biological samples that could be contaminated with microorganisms should be disposed of responsibly in sealed bags or a container of disinfectant. Students should always use their own swabs and never share them with others. This also applies to samples on microscope slides or in other containers. When using food or drink samples or packaging, remind students never to consume anything in a science workspace as everything could be contaminated with substances used in previous experiments.

Electrical

Students should never use any electrical equipment near a water source or spills. Remind students not to put their fingers or any objects such as scissors or pencils into an electrical socket as these are all good conductors of electricity. Use low-energy bulbs in lamps or torches to avoid damage to the eye if they are looked at directly. When using ray boxes, remind students that the ray of light can damage the eye and the box can get very hot. Ask students to turn these boxes off when not in use.

Check wires and electrical equipment before the lesson to ensure that the insulation material is not damaged. Encourage students to check their own equipment for breaks and to tidy away all equipment responsibly. Separate a wire from the insulation and expose the copper wire inside. Show students how fragile and brittle this is to demonstrate the importance of coiling wires and not scrunching them or folding them away.

Flames and heat

Demonstrate how to light Bunsen burners safely. Safety glasses must be worn when using a Bunsen burner or any other heating equipment. Allow students to explore how the adjustment of the collar regulates the flow of oxygen and the effect this has on the flame. Show how the hottest flame is very difficult to see in daylight. Then show the safety flame and explain why it is called this. This is the coolest flame as complete combustion of the gas has not taken place, so it is also called the dirty flame. Hold a boiling tube over the flame and observe the carbon residue, which is evidence of incomplete combustion. Remind students that the safety flame should always be used between parts of an investigation.

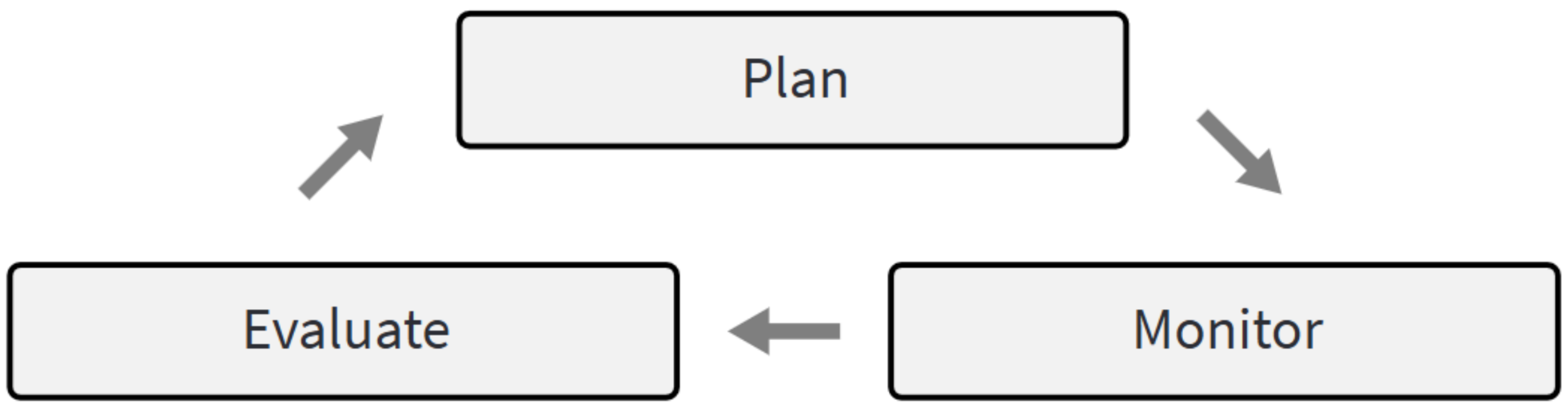
When heating samples, use equipment designed to withstand high temperatures such as boiling tubes, and tongs to handle them. Containers of heated chemicals should always face away from the user to prevent inhalation of toxic fumes. Ethanol, universal indicator, red litmus, lithium, sodium, potassium, and magnesium, and all alcohol-based products, are flammable and should be used with care and not disposed of down a sink. Remind students never to look directly at the flame produced when burning magnesium. Potassium is also corrosive; never use samples that show signs of being old, such as a yellow and crusty. You should never cut potassium as it is highly reactive.

Plan, monitor, evaluate

Metacognitive regulation

A key part of metacognition is metacognitive regulation. This is where students are able to regulate themselves through planning, monitoring, and evaluating their own learning.

An expert learner would naturally follow a cycle like this when they tackle a new task. By explicitly teaching students about this cycle, they will adopt a similar thought process. This will help students build confidence when completing new and challenging activities.



The planning phase

This takes place before the task. An expert learner would plan their approach carefully by thinking about what strategies they could use and what scientific knowledge is relevant. They would also reflect on whether they have completed something similar before and apply this experience to the new task.

The monitoring phase

This takes place during the task. An expert learner would regularly pause and check back to make sure their chosen approach is still right. They would also have the confidence to stop and start again if needed.

The evaluation phase

This takes place at the end of the task. An expert learner would reflect on their performance and carefully consider any areas for improvement. They would think about how they would use their learning in the future to achieve success in similar tasks.

What does this look like in practice?

An effective way to teach the plan, monitor, and evaluate cycle is to use a list of reflective questions to get students to target their thinking correctly in each phase. Students will start adopting the thought process of an expert learner and, if carefully chosen, the questions will explicitly show them what they should be thinking at each phase.

As with all metacognitive strategies, the seven-step approach is a good structure to follow when introducing the plan, monitor, and evaluate cycle. However, at first it may be more appropriate to start with modelling one phase, and then building in the other two over time.

Another good way to introduce this cycle is to create a regulatory check list. This is a set group of questions for each phase which students refer to when completing a task. For example, a check list could be created to help students plan, monitor, and evaluate their learning when tackling an extended writing task.

Here are a few examples of the types of question you could use in a regulatory checklist.

Example 1: Exam question practice

The planning phase

- How do I feel when I read this question? Confident or unsure?
- How many marks can I get for this question?
- What scientific knowledge do I need to answer this question?
- Is there any data in the question that I need to use?
- Have I answered anything like this before?

The monitoring phase

- How do I feel now that I am answering this question? Confident or unsure?
- Have I included enough detail for the number of marks in this question?
- Do I need to review any of my notes to make sure the scientific content is correct?
- If there is data in the question, have I used the data correctly in my answer?

The evaluation phase

- How many marks did I get?
- What did I miss out in my answer?
- Did any of my peers answer the question differently?
- What were my strengths when completing this task?
- What areas do I need to improve?

Example 2: Practical activity

The planning phase

- How do I feel about this activity? Confident or unsure?
- Have I followed the lab safety protocol?
- Do I have all of my equipment?
- Do I understand the method I need to follow? If not, what can I do to check this?
- Have I drawn my data table correctly so that I am ready to complete the practical?
- Do I need to plan how to control any variables?

The monitoring phase

- How do I feel now that I am doing this activity? Confident or unsure?
- Am I doing the experiment safely?
- Am I certain about the next steps that I need to take?
- Are my results as I expected?
- Am I controlling any variables that I have identified as control variables?

The evaluation phase

- Did I collect enough data?
- Did I find what I expected?
- Did I control all of the correct variables?
- Are there ways to improve my method?
- What were my strengths when completing this task?
- What areas do I need to improve?

Example 3: Doing a calculation

The planning phase

- How do I feel when I read this question? Confident or unsure?
- Do I need to convert any units in this question?
- What equations do I need?
- Do I need to rearrange an equation?
- Have I answered anything like this before?

The monitoring phase

- How do I feel now that I am answering this question? Confident or unsure?
- Have I converted the units correctly?
- Have I shown all my working?
- Do I need to review any of my notes to make sure I am using any equation correctly?

The evaluation phase

- How many marks did I get?
- What did I miss out in my answer?
- Did any of my peers answer the question differently?
- What were my strengths when completing this task?
- What areas do I need to improve?

Working scientifically

Introduction to unit

In this unit, students learn how to take an idea and turn it into a scientific question which can be tested. They will start to develop their own plans and use a range of scientific equipment to collect and record measurements and observations in a suitable results table. Students will begin to analyse their data through drawing graphs and calculating the mean to form simple conclusions.

Throughout their practical work, students will develop the skills to work safely and independently. They will also begin to evaluate their work to identify random and systematic errors, and suggest improvements.

The Working scientifically skills have been sequenced to ensure effective development for learners and to accompany the course's scientific knowledge.

In addition to this unit, Working scientifically skills are embedded within lessons. Each lesson spread includes the relevant Working scientifically links.

Learning journey

Primary topics

- Setting up fair tests
- Taking measurements
- Drawing bar charts and line graphs
- Writing a conclusion

This unit

- **Asking scientific questions** Developing questions, variables, predictions
- **Working safely** Hazard symbols, hazards and risks
- **Planning investigations** Writing methods, choosing equipment, measurements
- **Recording data** Designing and completing results tables, calculating the mean
- **Presenting data** Types of data, plotting bar charts, line graphs, pie charts
- **Analysing data** Identifying patterns and trends, drawing conclusions
- **Evaluating data** The stages in evaluating data, suggesting improvements

Later topics

- **Planning investigations** Hypotheses, precision, accuracy, risk assessments
- **Communicating scientific information** Effective communication to different audiences
- **Presenting data** Selecting what graph to plot, pie charts, histograms, mean, median, mode
- **Development of scientific understanding** Scientific method, theories, laws, models, changes over time
- **Analysing and evaluating** Linear and direct proportion, interpolation, confidence in conclusions
- **Using evidence and sources** Peer review, assessing sources, bias

Working scientifically and you

Discuss the fact that everyone is born a scientist. Young children in particular ask hundreds of questions every day as they discover the world in which they live. Being a scientist means that you continue to question the world around you. Why does something happen? How can you improve something? How can you find out about a problem or issue?

Explain that scientific research is going on all the time. In 2020, scientists from all over the world came together to develop vaccines, drugs, and testing kits in the fight against COVID-19. But explain to students that research does not just occur in a laboratory. It is happening at the tops of mountains, at the bottom of the ocean, and even on Mars! Can they think of any other places where research may be occurring right now?

Working scientifically and the world

Explain to students that it is important for all scientists to develop the right skills for working scientifically. These skills ensure that scientific research is carried out in a careful, methodical way. They also ensure that scientists understand the importance of checking the data they collect through their research, so that it is accurate and correct. Scientists' work needs to be checked by fellow scientists before it is accepted.

Beyond working in a scientific environment, explain that it is important for all of us to understand the processes of how science works. We hear and read new information every day. We therefore need scientific knowledge to understand the information, and to decide whether the information is reliable and believable. Scientists keep us well-informed using accurate information.

Big questions

How do scientists find out how things happen?

Scientists make observations of the world around them, which lead to questions about how or why something happens. They then investigate the question to try to find the answer. For example, scientists have observed that Earth's climate is warming over time. They have asked the questions: What has caused this change? Is it human activity?

How do you carry out an investigation?

All investigations work in the same way. You need to choose equipment and carefully follow a method to collect results. Scientists working on climate change data have carried out many experiments to try to understand what is causing global warming. They must carry out their experiments methodically and check them many times to ensure that their results can be trusted.

How do scientists use data to answer their questions?

Scientists carefully examine the results of an investigation to see if there are any patterns or trends. These patterns allow us to understand the world around us. Climate change data has revealed the cause of the changes we are experiencing: human activity and, in particular, our use of fossil fuels to generate energy.

1.1 Asking scientific questions

Working scientifically links

- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- select, plan, and carry out the most appropriate types of scientific enquiry to test predictions, including identifying independent, dependent, and control variables, where appropriate

	Learning outcomes		
Learning objectives	**Developing**	**Secure**	**Extending**
Develop an idea into a question that can be investigated	Ask a simple question based on observations	**Develop an idea into a question that can be investigated**	Use scientific knowledge to ask a question that can be answered scientifically
Identify independent, dependent, and control variables	Identify a variable that may affect the outcome of an investigation	**Identify independent, dependent, and control variables**	Identify a range of control variables for an investigation
Make a scientific prediction	Make a prediction without using scientific language	**Make a scientific prediction**	Justify the prediction using scientific knowledge

Tier 2 vocabulary	Tier 3 vocabulary
data, investigation, observation, prediction, variable	control variable, dependent variable, independent variable

Digital resources

Activity: *Asking scientific questions* (Activity handout, Support handout)
Video: *Asking scientific questions*

Student Book answers

Think back 1 data (or results) **2** a test that keeps everything the same, except for the variable (thing) being tested **3** for example: books, the internet, other people

In-text questions A brightness of torch **B** for example: material ball is made from, hardness of ball

Working scientifically a dependent: how high the ball bounces; independent: size of ball **b** for example: material ball is made from; height ball is dropped from; floor surface; temperature of ball

Summary questions 1 independent, control, dependent **2 a** for example: How does the temperature of the surroundings affect how long it takes the ice cube to melt? **b** It is a question that you can collect data for by measuring the temperature and the time. **3 a** length of the leaf **b** time taken for leaf to fall to the ground **c** any three from: leaf width, leaf surface area, leaf mass, type of leaf, height of leaf from the ground, wind speed

Getting started

Show students the image of the polar bear from the Student Book. Discuss what it shows and some questions that scientists can ask.

Explain that they are scientific questions if they can be answered through a scientific investigation.

Ask students to make lists of questions they could ask if they were given something to investigate, for example: 'melting ice-cream' or 'floating or sinking'. Choose examples of questions that can be investigated (scientific questions) and examples that cannot, for example: *What is the best flavour of ice cream?* (This question is subjective as different people will like different flavours; the word 'best' can be interpreted in different ways.)

Introduce Katie and Rahim's investigation from the Student Book into how high balls of different temperatures can bounce. Can students think of any other scientific questions Katie and Rahim could have investigated, for example: *Does the surface the ball lands on affect bounce height?*

Introduce the word 'variable', and the different types of variable. Most students should have some prior knowledge of this concept through fair tests that they have carried out previously.

Use Katie and Rahim's investigation to illustrate these words. Then, as a class, identify the variables for the other question Katie and Rahim came up with – *Are the balls harder if they are kept in the dark?*

Explain the meaning of a prediction using Katie and Rahim's investigation to illustrate the concept. Do students agree? What would they predict? (At this stage, students do not need to turn their predictions into hypotheses. However, where relevant, students could be asked to give reasons for their prediction.)

Main activity

Activity: Asking scientific questions Place different objects at stations around the classroom. Example objects include: pile of paper, beaker of water, toy car, magnet, rubber band, tuning fork. Do not set up an experiment; just lay out single items for students to be creative.

Divide students into groups of 3 or 4. Send one group to each station, allowing approximately 5 minutes for students to think of three questions they might like to find out about the object. Ask them to choose one question, and identify the independent, dependent, and control variables. Then tell them to move on to the next station.

Point out that any one of the control variables can be chosen as a new independent variable to investigate.

Model this, if necessary, by showing how you can rephrase a question and change the variable to investigate. In the investigation, *How does the starting temperature of a hot drink affect how quickly it cools down?*, water volume is a control variable. A new question could therefore be derived, as: *How does the volume of a hot drink affect how quickly it cools down?*

When students have been round four stations, ask them to choose one of their scientific questions and turn it into a prediction, using Katie and Rahim's example as a guide.

Support students with a model answer to allow them to focus on ideas, questions, and variables, and on two stations instead of four.

Review and reflect

Provide a list of variables and a scientific question. Challenge students to identify which variables are independent, dependent, and control.

Language support

Elicit from students what the word 'observation' means. Some students might notice that it comes from the verb 'observe', which means to look at something carefully. In science, an observation also includes looking carefully at results and data collected from investigations and experiments.

When discussing independent, dependent, and control variables, find out if the word 'variable' reminds students of any other words. They might suggest 'vary', 'varied', or 'variety'. A variable is something that *varies* (changes).