Oxford International Resources

Revised Edition

8

Science

Teacher's Guide

Lower Secondary

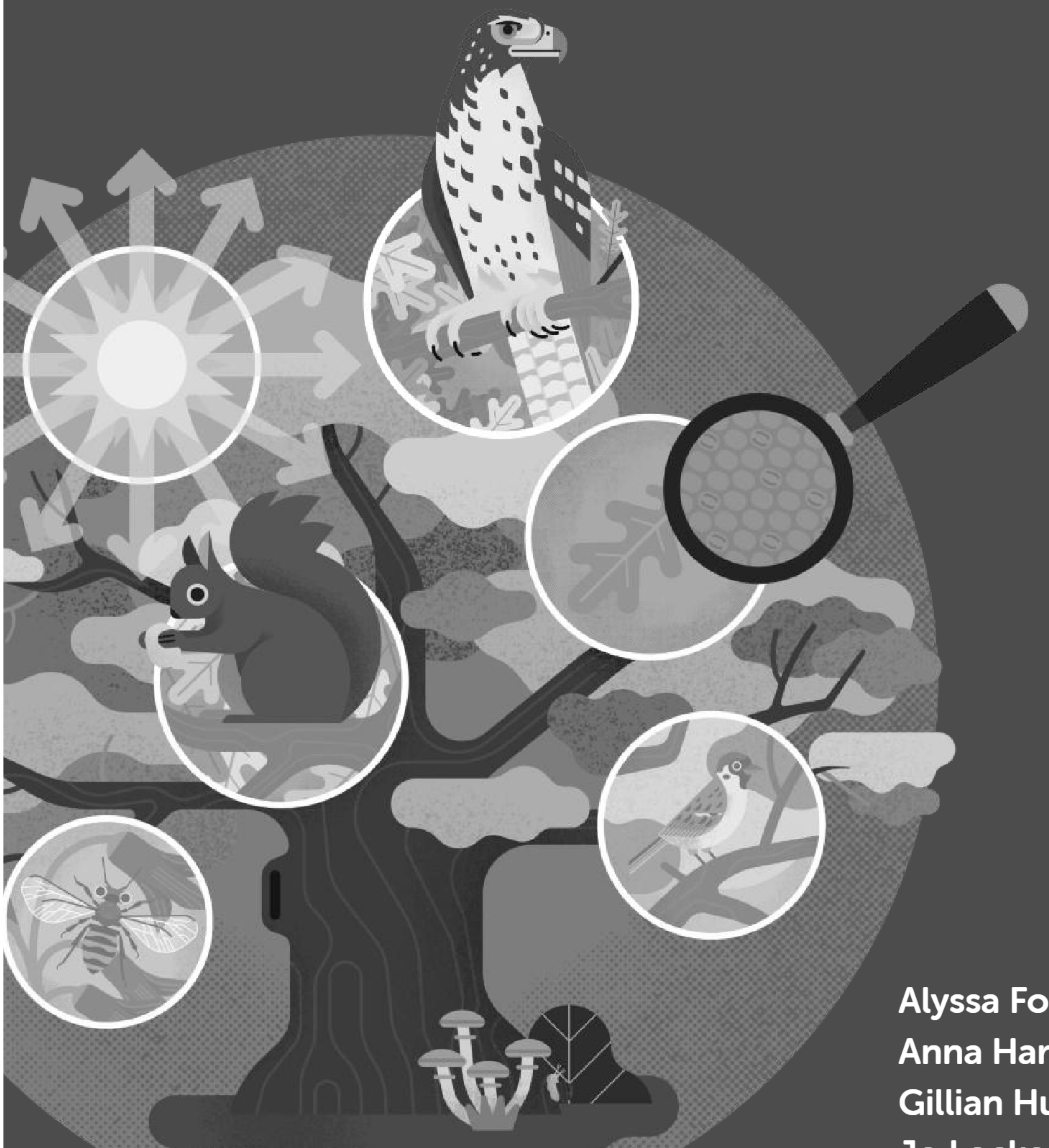
OXFORD

Oxford International Resources

8

Science

Teacher's Guide



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Contents

Chemistry

Physics 142

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 'Working scientifically' 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 outcomes		
Learning objective	**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. Describe how predator and prey popu-lations interact	*State the meaning of predator and prey organisms*	***Describe how predator and prey populations interact***	*Explain the interaction between predator and prey populations*

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
- 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.

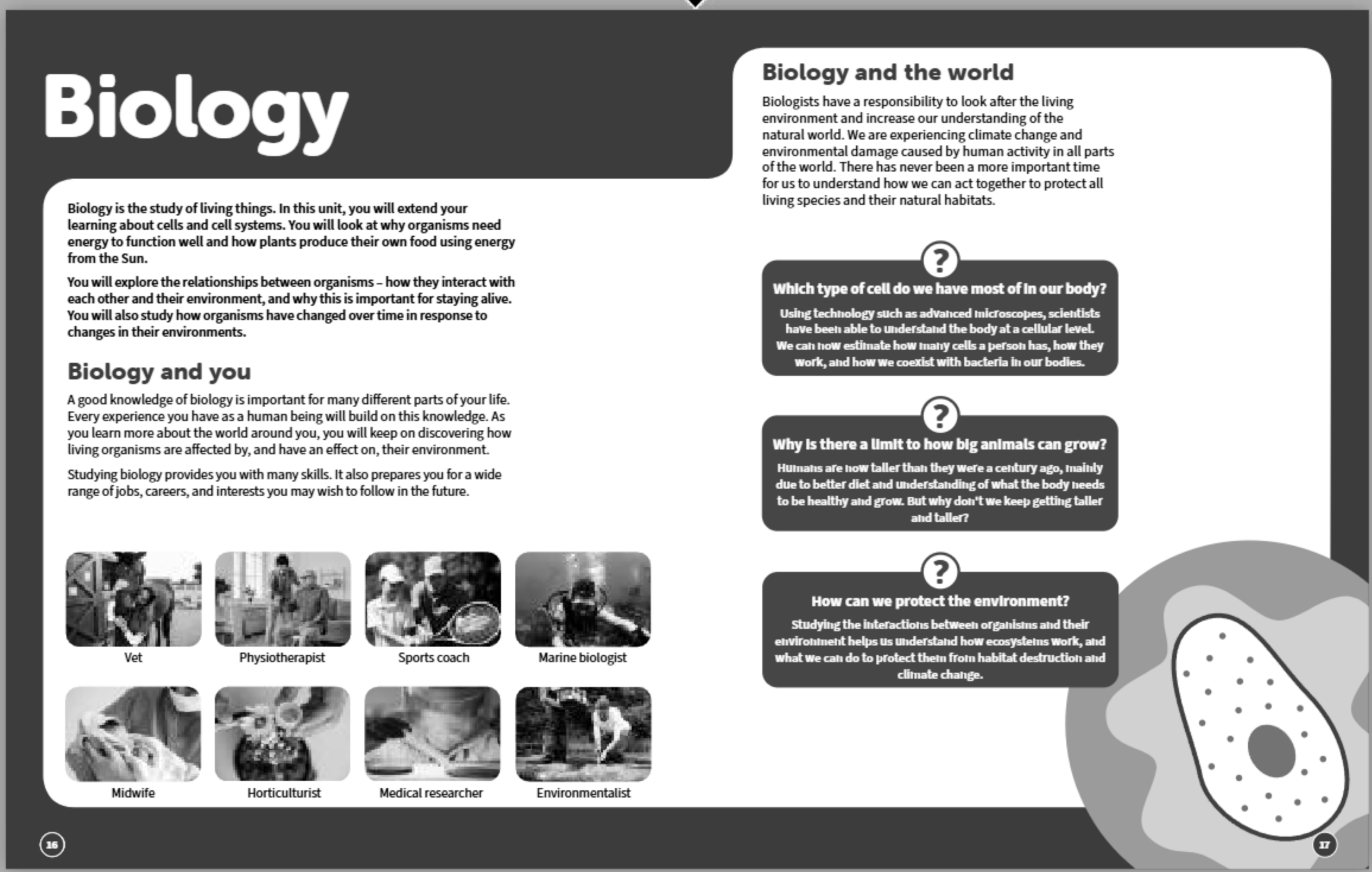
Reporting and insights

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.



Biology

Biology is the study of living things. In this unit, you will extend your learning about cells and cell systems. You will look at why organisms need energy to function well and how plants produce their own food using energy from the Sun.

You will explore the relationships between organisms – how they interact with each other and their environment, and why this is important for staying alive. You will also study how organisms have changed over time in response to changes in their environments.

Biology and you

A good knowledge of biology is important for many different parts of your life. Every experience you have as a human being will build on this knowledge. As you learn more about the world around you, you will keep on discovering how living organisms are affected by, and have an effect on, their environment.

Studying biology provides you with many skills. It also prepares you for a wide range of jobs, careers, and interests you may wish to follow in the future.

Vet
Physiotherapist
Sports coach
Marine biologist
Midwife
Horticulturist
Medical researcher
Environmentalist

16

Biology and the world

Biologists have a responsibility to look after the living environment and increase our understanding of the natural world. We are experiencing climate change and environmental damage caused by human activity in all parts of the world. There has never been a more important time for us to understand how we can act together to protect all living species and their natural habitats.

Which type of cell do we have most of in our body?
Using technology such as advanced microscopes, scientists have been able to understand the body at a cellular level. We can now estimate how many cells a person has, how they work, and how we coexist with bacteria in our bodies.

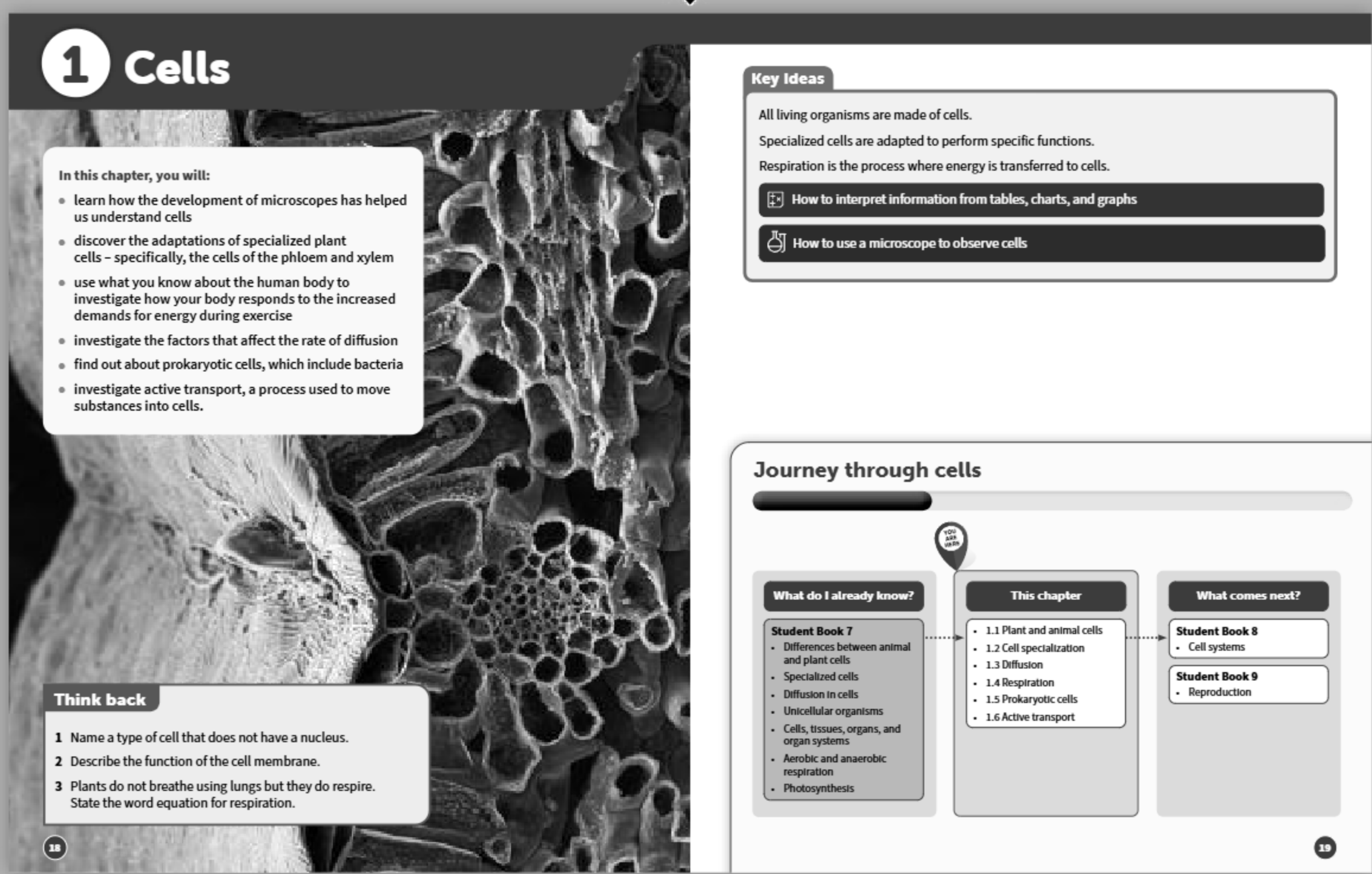
Why is there a limit to how big animals can grow?
Humans are now taller than they were a century ago, mainly due to better diet and understanding of what the body needs to be healthy and grow. But why don't we keep getting taller and taller?

How can we protect the environment?
Studying the interactions between organisms and their environment helps us understand how ecosystems work, and what we can do to protect them from habitat destruction and climate change.

17

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 Cells

In this chapter, you will:

- learn how the development of microscopes has helped us understand cells
- discover the adaptations of specialized plant cells – specifically, the cells of the phloem and xylem
- use what you know about the human body to investigate how your body responds to the increased demands for energy during exercise
- investigate the factors that affect the rate of diffusion
- find out about prokaryotic cells, which include bacteria
- investigate active transport, a process used to move substances into cells.

Think back

1 Name a type of cell that does not have a nucleus.
2 Describe the function of the cell membrane.
3 Plants do not breathe using lungs but they do respire. State the word equation for respiration.

18

Key Ideas

All living organisms are made of cells.
Specialized cells are adapted to perform specific functions.
Respiration is the process where energy is transferred to cells.

How to interpret information from tables, charts, and graphs

How to use a microscope to observe cells

Journey through cells

What do I already know?
Student Book 7
- Differences between animal and plant cells
- Specialized cells
- Diffusion in cells
- Unicellular organisms
- Cells, tissues, organs, and organ systems
- Aerobic and anaerobic respiration
- Photosynthesis

This chapter
- 1.1 Plant and animal cells
- 1.2 Cell specialization
- 1.3 Diffusion
- 1.4 Respiration
- 1.5 Prokaryotic cells
- 1.6 Active transport

What comes next?
Student Book 8
- Cell systems

Student Book 9
- Reproduction

19

Lesson pages

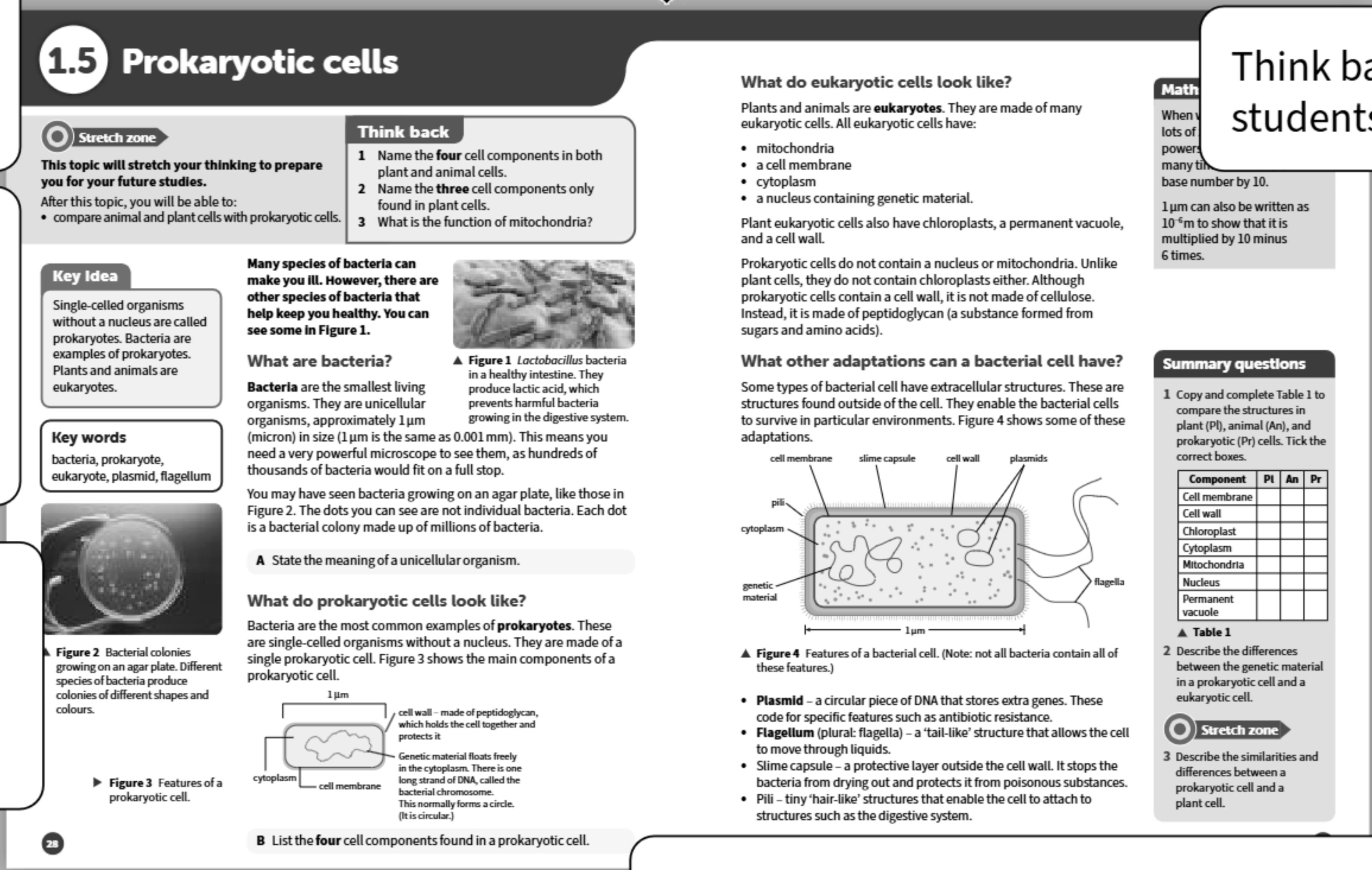
These pages guide students through a particular topic in each chapter. Organized under headings, language is clear and accessible to ensure students' understanding of the key ideas. The key idea and key words in each lesson are presented clearly. Images, tables, and diagrams are included to complement 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.

The 'stretch zone' icon at the beginning of a topic indicates where students will be stretched and challenged learning higher-level topics. This will prepare them for their future studies. Teachers can decide whether students are ready to tackle more advanced scientific concepts.

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

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

Think back boxes remind students of prior learning.

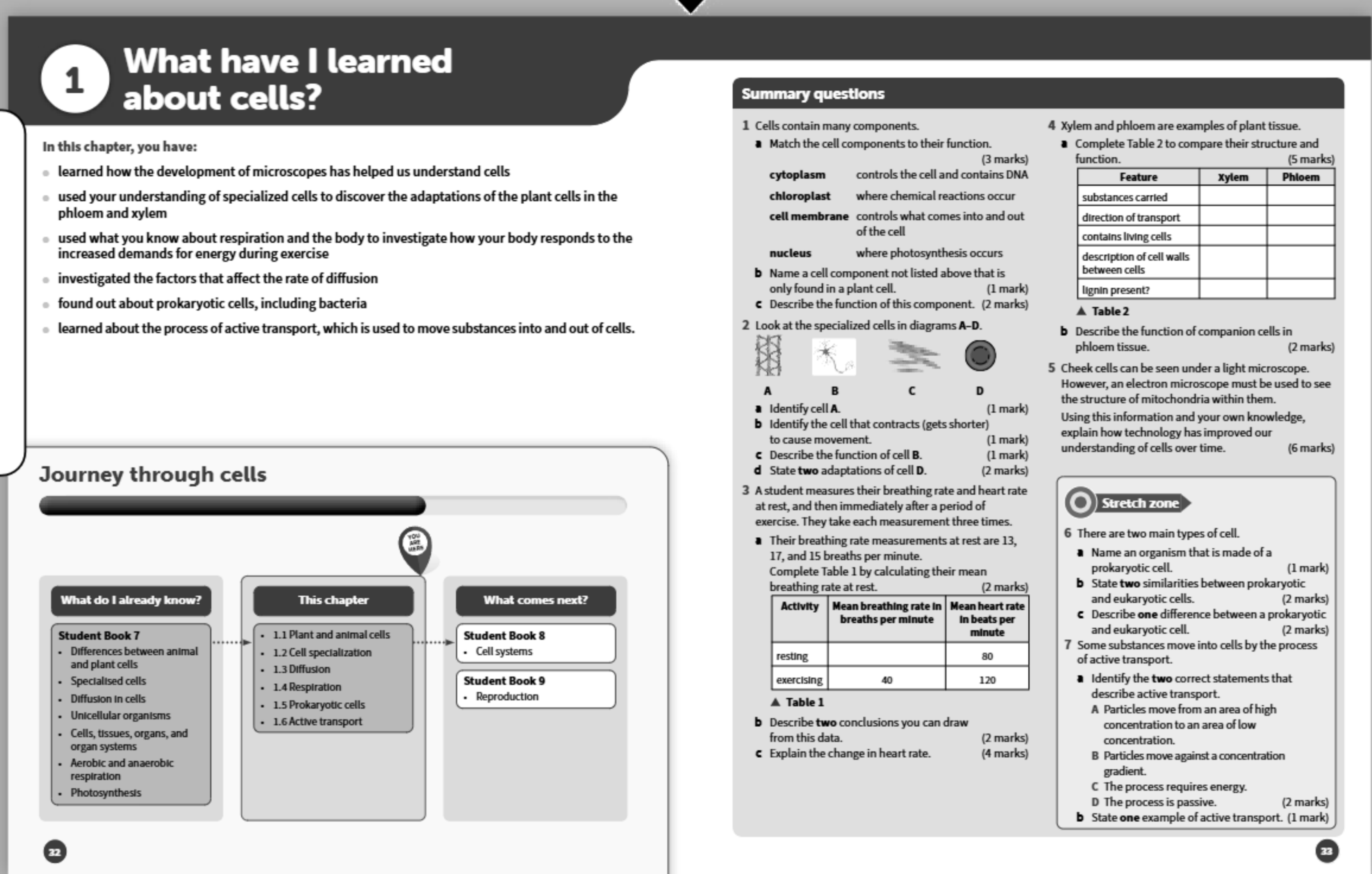


The student-friendly text is accessible for English language learners. Simplified language guides students through scientific concepts without difficulty. Where complex scientific words are needed, a brief explanation or synonym is included in parentheses.

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.

Strategies for effective learning

Metacognition: A review

Metacognition refers to the understanding a student has about their own learning processes. This includes their knowledge of tasks that they may face and the strategies they have available to use, as well as knowledge of themselves as a learner.

The seven-step approach

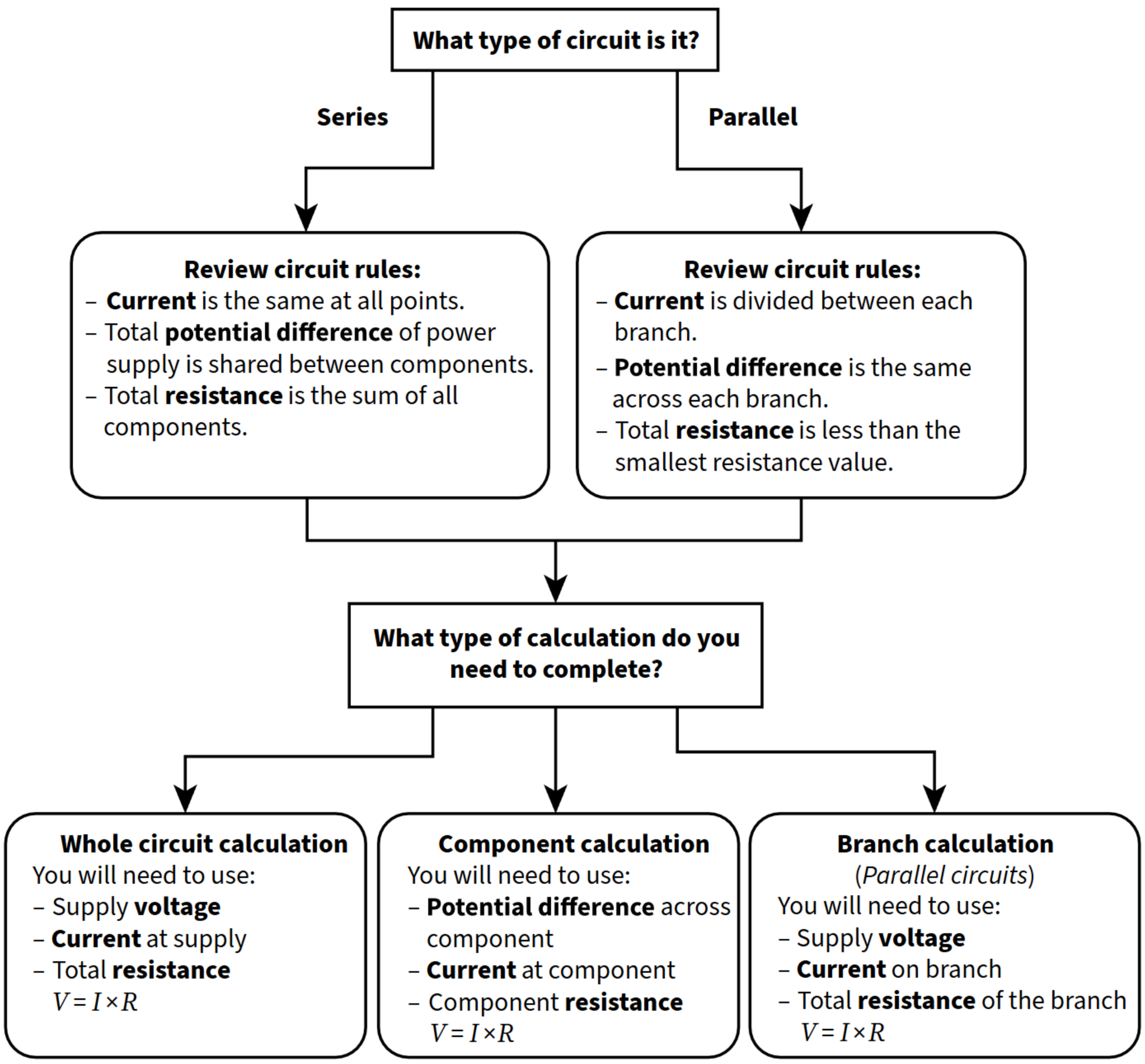
The following seven-step approach helps teach metacognitive skills.

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

This approach allows students to learn about a strategy in relative isolation. If introducing students to the EVERY method outlined in the Student Book, you would do it in the context of a very simple calculation. You would also use an example that they are very familiar with. This removes the extra cognitive load of unfamiliar science content.

A key aspect of this approach is modelling. Metacognitive modelling is where the focus is on demonstrating how an expert learner would approach a task by verbalizing your inner thought processes. For example, you could answer a question 'live' in front of the class. This helps students because they are learning about how an expert learner plans, monitors, and evaluates their own learning.

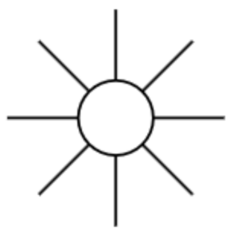
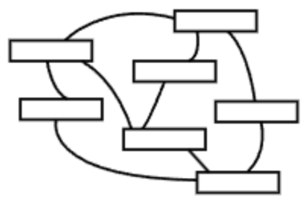
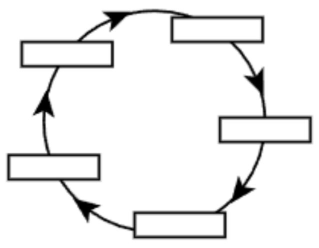
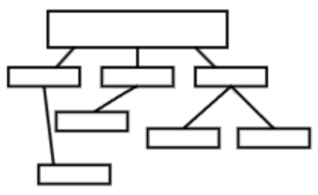
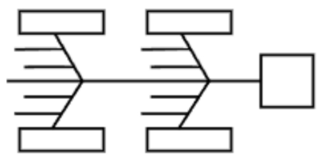
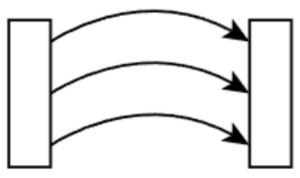
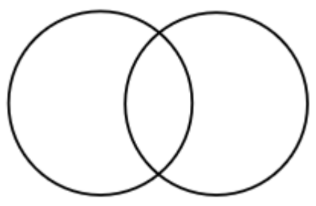
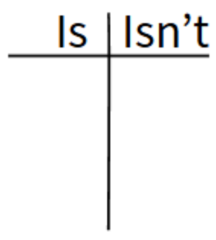
A question tree (see Figure 1) is a tool that can complement the modelling process. For example, when completing circuit calculations, it is common for values to be placed on a circuit diagram. Then students need to choose which values are needed for a calculation. The question tree in Figure 1 summarizes how students should approach the task.



▲ **Figure 1** A question tree for completing circuit calculations.

What does this look like in practice?

Scenario: You would like to introduce some independent study strategies and think graphic organizers would be appropriate.

Task	Suggested graphic organizers	
grouping, classifying, or summarizing your ideas	 spider diagram	 concept map
sequencing events or ordering ideas	 cycle circle	 flowchart
making links between ideas	 fishbone	 bridge
making comparisons	 Venn diagram	 T chart

▲ **Table 1** Different types of graphic organizer and when to use them.

Seven-step approach: Table 2 illustrates how the seven-step approach can be used to introduce independent study strategies.

1. Activate prior knowledge	The teacher reviews key content relating to the topic with the class, using low-stakes quizzes, topic maps, and some independent reading.
2. Explicit strategy instruction	The teacher explores the different types of graphic organizer and examples of when each would be used. They talk through the table in the Student Book and ask students what scientific content each one could be useful for. They explore why graphic organizers are useful in each case.
3. Modelling of learned strategy	The teacher identifies a topic to translate into a graphic organizer, and models how they approach condensing the information and selecting the key information. At all stages, the teacher is explicitly explaining why they are doing what they are doing.
4. Memorization of strategy	The students are given time to note down the strategy. The teacher moves around the room, questioning students to see if they understand how to use the strategy and why it is effective.
5. Guided practice	The teacher hands out a partially completed graphic organizer and some topic information to fill it with. When finished, the class compares it to a WAGOLL (what a good one looks like) on the board.
6. Independent practice	In the next lesson, students are given time to create a different type of graphic organizer. This will allow them to practise the skill of translating scientific content into the simplified structure.
7. Structured reflection	At the end of the lesson, the class reflects on whether the graphic organizers they have made are effective. They also reflect on their use of the graphic organizers and how they can use them for revision.

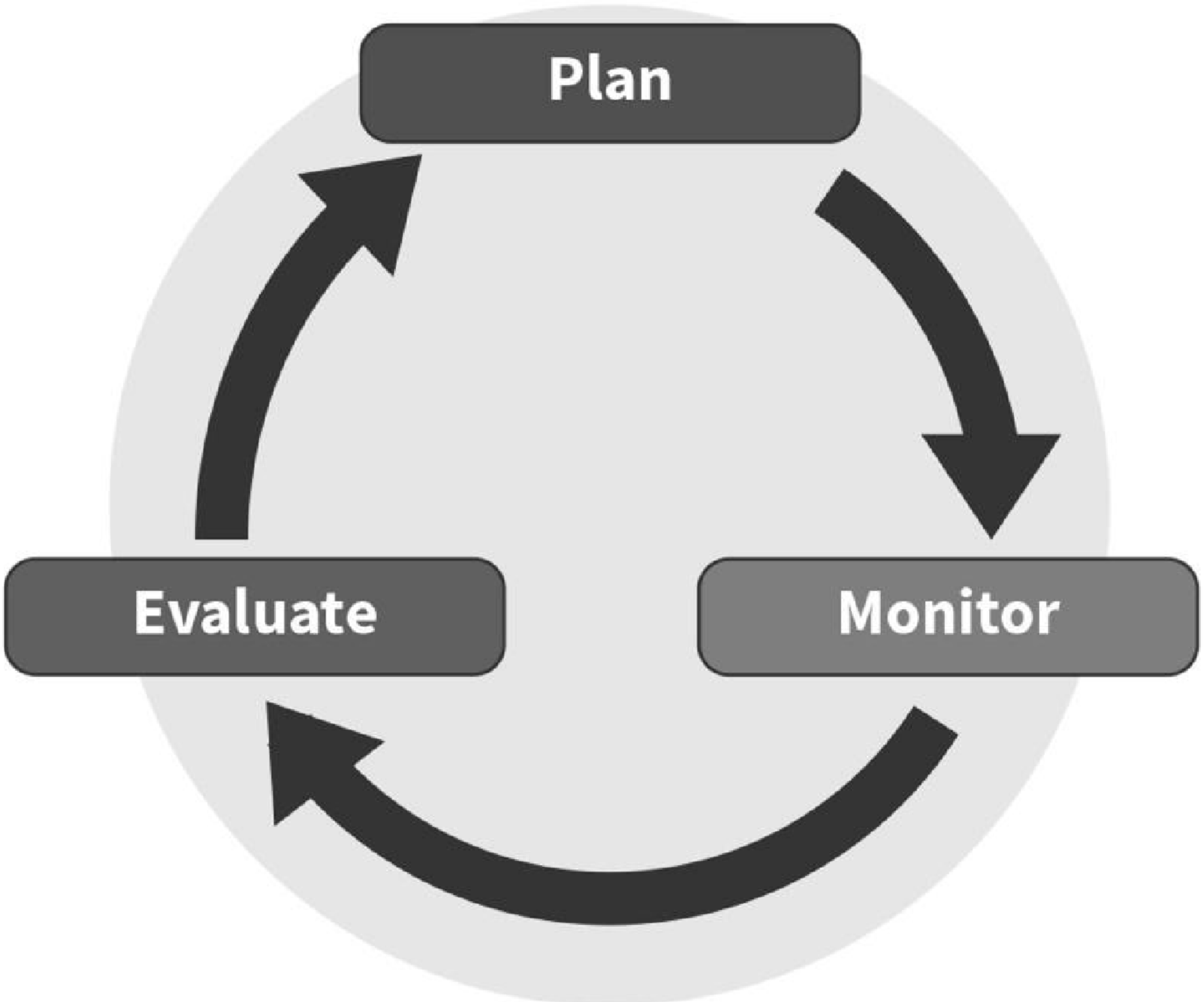
▲ **Table 2** A seven-step approach for introducing independent study strategies.

Using strategies effectively

Expert learners approach new and unfamiliar tasks in a structured way. Often they will start by studying the question or task, thinking carefully about what subject knowledge they are going to need or whether they have seen something similar before.

During a task, an expert learner will keep checking to make sure they are focusing on the right thing by regularly looking back at the question. Sometimes they may even decide to start the task again and choose a different approach. After they have finished, an expert learner will reflect on their work by thinking about any areas of improvement and what they would do differently next time.

The Plan, Monitor, Evaluate cycle is a structure that students can follow to help them to approach a new task like an expert learner. The cycle should be used every time they complete a task.



Talk about ...

Encourage students to discuss with a partner their answers to these questions:

- When does the planning phase take place?
- How can you monitor your progress during the monitoring phase?
- Why is the evaluation phase important?

Supporting students to plan, monitor, and evaluate

Once students are familiar with the strategies they have available to them, this part of the Student Book aims to help them use these strategies effectively. It outlines what they should be doing when planning, monitoring, and evaluating their learning. But what does this look like in the classroom?

When introducing a new strategy using the seven-step approach, students will have an opportunity to complete independent practice. At this stage, they could use a checklist to help them regulate their learning. This is a series of questions that guide students through each of the plan, monitor, and evaluate phases. When first introducing the checklists, it may be more appropriate to focus on one of these phases rather than the whole checklist. Or it may be appropriate to have the whole class reflect on the questions as a group when completing their independent practice, rather than reflecting on the questions individually.

If we take the example of using the seven-step approach to teach the use of graphic organizers, here are some examples of the types of regulatory checklist that you could use with students:

Plan

- How do you feel about completing this task? Confident or unsure?
- Do you have a good understanding of the scientific content you are reviewing? If not, what can you do to change this?
- Which type of graphic organizer suits the information you need to summarize?
- Have you used a graphic organizer like this before? What did success look like?
- Have you identified the key information that needs to be included in your graphic organizer?

Monitor

- Are you doing well?
- Do you still think the graphic organizer you have chosen is the correct one?
- If not, which one would be more appropriate?
- Do you need to make any changes to what you have done? Do you need to start again?
- Is there any information you are unsure how to summarize? If so, what resources do you have to help you work it out?

Evaluate

- How do you feel now that you have completed the task? Confident or unsure?
- Did you summarize all of the correct information? If not, what did you miss?
- What were your strengths when completing this task?
- What would you do differently next time?

Although this is just one example of how teachers can use a regulatory checklist to help students plan, monitor, and evaluate their learning, any of these questions can be adapted to suit any task that they complete. Over time, the need for a structured checklist will reduce and these types of question will naturally form the thoughts and discussions students will have when completing a new task.

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. Students must record their observations accurately and clearly, using suitable methods that they have designed independently or that have been provided for them.

Investigations rarely involve 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 the cause of most accidents in the science classroom in Year 8. 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, and be aware that different authorities have different requirements. 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 and make sure that you can respond safely, calmly, and efficiently to any changes to your plan. Students learn from the behaviour of others so demonstrate that it is acceptable to make mistakes as long as you act responsibly to avoid any hazardous situations as far as possible.

Allow students time to review any safety rules that they developed in Year 7, according to what they have experienced. Discuss general risks in the science laboratory or classroom before delivering practical lessons.

Remind students to wash their hands after handling any samples, chemicals, or equipment. Be aware of any health issues including respiratory issues or allergies to substances such as pollen or nuts.

Find out the correct procedure in the school for reporting 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.

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 (e.g. vacuum pumps or collapsible bottles). Research alternatives but if there is no safer option where students can have a hands-on experience, encourage them to ask questions throughout and be prepared to repeat the demonstration. Where necessary, use safety screens, fume cupboards, or outdoor spaces and arrange the students about 2 metres back from any demonstrations.

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. Items on the floor can be trip hazards that are dangerous in themselves but more so when using glassware or naked flames. 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

When using suspended masses, students should position the masses over the desk or bench. This reduces the distance that the masses may fall and should prevent them from landing on students' feet. Always demonstrate how to attach weights securely to any fixtures to avoid them dropping on hands or fingers. Scales, test tube racks, and retort stands should be used away from the edge of the desk to prevent them falling over or spilling the contents onto the user or others working close by. Students should not be allowed to swing pendulums too far as they could detach.

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. Students may grate chocolate or wax; remind them that graters can be very sharp and should be handled with care.

Glassware

Beakers, conical flasks, test tubes, and boiling tubes can be a hazard. Inform students that, if they are using glassware on a regular basis, there will certainly be breakages and so they should know how to deal with this safely. Explain that the broken glass is only a problem if it is not cleaned up efficiently. Discuss how they should report any breakages to an adult and warn everyone in the workspace that there could be shards of glass in the surrounding area. Clean up any broken glass using a dustpan and brush. Always keep a breakages bucket or container to hand for safe disposal. Advise students to wear safety goggles when working with glass to protect their eyes in case of breakages.

Chemicals

Zinc, copper, and iron are low-hazard but it is advisable to handle them with care and wear goggles when handling them. Wax is low-hazard but some types have manufacturers' warnings regarding allergies associated with certain ingredients. Magnesium sulfate is low-hazard.

Iron sulfate solution, 1% carbohydrase (diastase) solution, and universal indicator are irritants. Diastase should be prepared in a fume cupboard as the dust should not be inhaled. Silver nitrate solution is an irritant and will stain skin and clothing. Iron sulfate solution, some fertilizers, and limewater are irritants. Zinc sulfate solution is corrosive and an irritant. Silver nitrate solution and iodine are irritants and will stain skin and clothing. Benedict's solution and biuret solution are irritants and harmful. Copper sulfate solution is harmful. When in contact with water, calcium and magnesium produce gases that catch fire easily.

Protective clothing, gloves, and safety goggles should be worn when using these chemicals. Rinse any skin that comes into contact with any of the chemicals.

Biohazards

When using food or drink samples, remind students never to consume anything in a science workspace as it could be contaminated with substances used in previous experiments. Students may use chocolate when investigating rocks. It is important to remind them not to eat it. Some seeds might be coated with a fungicide so encourage hand-washing after handling them.

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-voltage bulbs but still handle with care as these can get hot if left connected in a circuit. 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 them off when not in use.

Check all batteries are disconnected from circuits before storing. 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 it away responsibly. Separate a wire from the insulation and expose the copper wire inside; show how fragile and brittle this is to demonstrate the importance of coiling wires and not scrunching them or folding them away. Do not provide high-voltage power supplies as they can cause the wires to overheat.

Flames and heat

When heating samples, use equipment designed to withstand high temperatures such as boiling tubes, and tongs to handle them. In Year 8, students will observe the combustion of some Group 1 metals. Using a Bunsen burner to start these reactions is the safest method. When demonstrating any of the metals other than magnesium, do so behind a safety screen. Open windows or use the AC to properly ventilate the room before the demonstration. Instruct students to stand 2 to 3 metres back from the screen and make sure they can exit the space easily. Magnesium ribbon is highly flammable and the flame produced is very bright. Students should never look directly at the flame produced. Lithium, sodium, and potassium are all highly flammable and corrosive. Never use samples that show signs of being old, yellow, or crusty. You should never cut potassium as it is highly reactive. At the end of practicals involving Group 1 metals, all of the used equipment should be placed in a water trough, to ensure there are no unreacted metals left on the equipment. Store these metals in brown containers to prevent the energy from the sun igniting them.

Hot wax can cause burns so it should be handled with care. Never pour heated wax down the sink as this can cause a 'chip pan' fire which will need to be extinguished using a fire blanket or damp cloth. Students should use tongs or heatproof gloves in addition to safety goggles. Ethanol is highly flammable and should not be used near a naked flame or disposed of down the sink. When burning food, ensure students carry out the experiment with the food sample attached to a pin at arm's length from the flame when igniting. Check that kettles and containers are cool and empty before storage.

Working scientifically

Introduction to unit

In this unit, students revisit the planning of investigations, focusing on collecting precise and reproducible data, and writing risk assessments to ensure their safety and the safety of those around them.

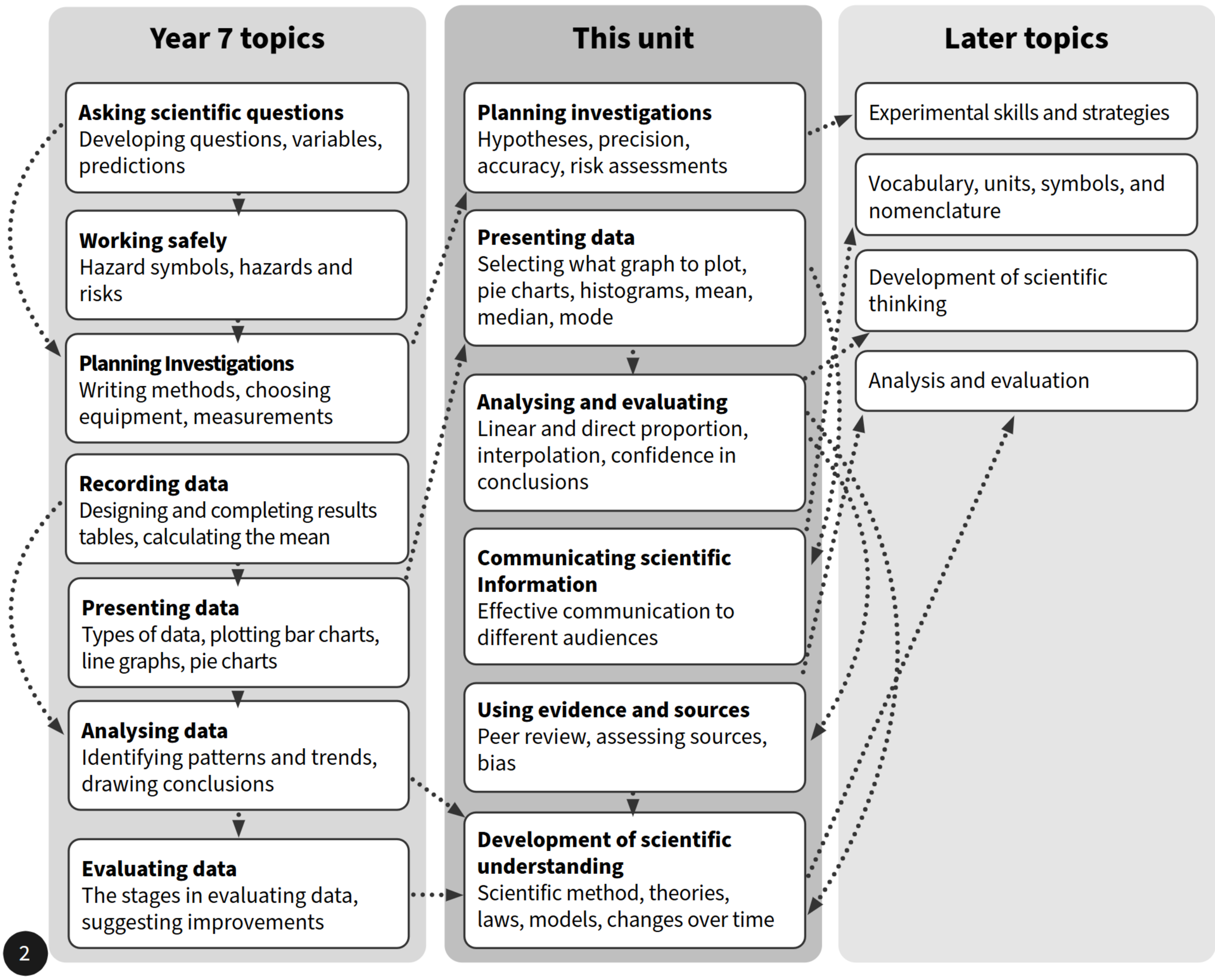
They will extend their focus on analysing data by looking at how to plot a pie chart and a histogram, along with how to identify the median and mode averages in a data set. They will identify linear and directly proportional relationships, and use lines of best fit to interpolate and extrapolate data. Students will also use secondary data to improve confidence in their conclusions.

Finally, students will study how our understanding of science develops over time, the importance of peer review, and how scientists communicate information to different audiences.

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



Working scientifically and you

Working scientifically skills are essential for a wide range of occupations, as well as wider interests. In the Student Book, a few careers that use these skills are listed:

- Microbiologist – being able to write and follow a risk assessment is essential when working with bacteria and viruses.
- Astronaut – being able carry out experiments independently is essential when doing research in space.
- Engineer – engineers need practical skills in the workplace and knowledge of how to analyse data.
- Meteorologist – communication skills are required when explaining scientific phenomena to the public about weather forecasts.
- Nutritionist – understanding possible bias in health claims about food is essential when advising on diet.
- Geologist – an understanding of staying safe is required when monitoring tectonic activity.

Working scientifically and the world

Regularly remind students that we are all responsible for protecting and enhancing the living world and the physical environment. The ability to think like a scientist is critical to ensure that we can listen to the evidence (e.g. about climate change), take account of what it says, and then act in a way that is the most beneficial to the planet.

Discuss with students that the collective actions of many people make an enormous difference, and are critical in ensuring a stable, sustainable future – not only for human beings, but for all species on Earth.

At the same time, explore with students the idea of misinformation and 'fake news', which is often shared via social media. Compare this with the rigorous process of peer review prior to scientific research being released. Reinforce to students that they should always interrogate information in the following way: Who does this information come from? Why was it published? What is the basis for any claims made?

Big questions

How do scientists stay safe?

Before carrying out a scientific investigation, a risk assessment is performed. This identifies the hazard (something that can cause harm), the risk (how likely it will harm you), and control measures to ensure no one is harmed. By thinking about risk before an activity is started, scientists ensure that their work is safe, even when working with hazardous substances and equipment.

How can you trust a scientific claim?

Scientists learn how to identify bias and check the reliability of a source. For a piece of research to be valid, it should be produced without bias. Students should be aware that scientific research is often funded by business, which may lead to an undue focus on the positive aspects of a product, potentially ignoring or sidelining any negative impacts.

Why do scientists change their minds about how things happen?

The development of new technology (including artificial intelligence), carrying out different experiments, and new ways of thinking can all provide new evidence. This can result in scientists amending a previous idea or changing their thinking entirely. Science is an ever-evolving subject. For example, some teachers may be teaching science to students that was not even known when they started their teaching career!

1.1 Planning investigations

Working scientifically links

- pay attention to objectivity and concern for accuracy, precision, repeatability, and reproducibility
- make predictions using scientific knowledge and understanding
- select, plan, and carry out the most appropriate types of scientific enquiry to test predictions, including identifying independent, dependent, and control variables
- use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety

	Learning outcomes		
Learning objectives	**Developing**	**Secure**	**Extending**
Write a hypothesis for a scientific investigation	Write a prediction for a scientific investigation	**Write a hypothesis for a scientific investigation**	Write a hypothesis using detailed scientific knowledge
Describe the difference between precise and accurate data	State the meaning of accurate data	**Describe the difference between precise and accurate data**	Categorize data into being accurate and/or precise
Write a risk assessment for a scientific investigation	State the meaning of hazard and risk	**Write a risk assessment for a scientific investigation**	Write a detailed risk assessment that identifies and controls all possible hazards

Tier 2 vocabulary	Tier 3 vocabulary
accurate, hazard, precise, prediction, risk, spread	control measure, dependent variable, hypothesis, independent variable, repeatable, reproducible

Digital resources

Practical: *Investigating bungee cords* (Practical handout, Support handout)
Video: *Planning investigations 2*

Student Book answers

Think back 1 what you think will happen in an investigation **2** risk assessment **3** data that is close to the true value

In-text questions A force applied/original length of elastic/material of elastic **B** burns/setting hair alight

Summary questions 1 accurate data – close to the true value; precise data – repeat measurements with a small spread; hazard – something that could hurt you or anybody else; risk – the chance someone could be hurt **2** repeatable – similar results/small spread/precise data when you repeat an investigation; reproducible – similar results when different people carry out the same investigation, or when you repeat an investigation using a different method or equipment **3** for example: hazard – boiling water, risk – scalding, control measure – leave to cool before moving; hazard – lit Bunsen burner, risk – hair catching fire, control measure – tie hair back

Getting started

Show students Figure 1 in the Student Book of the person bungee jumping. How do they think the person could be injured? What safety equipment can they see? What safety precautions may have been taken that they cannot see?

Use students' answers to introduce the three main parts of a risk assessment – hazard, risk, and control measure – using the example of broken glass in Figure 4. Ask students to create a risk assessment for using bleach (hazardous chemical, could damage skin/eyes, wear gloves/goggles).

Ask students to explain the meaning of *accurate* data (data that is close to the true value of what you are trying to measure). Then introduce *precise* data (getting similar results if you repeat a measurement). You may need to remind students that the spread of data refers to the difference between the smallest and largest results. Precise data therefore has a small spread. Illustrate the difference between accurate and precise data using the images of archery targets in Figure 3.

Explain that precise data is also referred to as repeatable. Discuss the difference between repeatable and reproducible data. (Reproducible data: when similar results are achieved by other people carrying out the same experiment, or through using different equipment.)

Main activity

Practical: Investigating bungee cords Tell students they will investigate the relationship between the thickness of an elastic band and how much it stretches.

Discuss with students the factors they think are important when choosing which bungee cord to use in a jump. Explain that in today's activity they are going to look at how the thickness of elastic affects how much it stretches. Ask them to predict what they think will happen. Then introduce the difference between a hypothesis and a prediction by asking them to explain their prediction. This can be repeated for a range of questions if required.

Before they complete the practical, have students write a hypothesis and complete a risk assessment. Once they have collected their data, they need to decide if their data is repeatable, and whether it is reproducible by looking at other students' results. (Students need to keep their data for the activity in *1.5 Using evidence and sources* for further analysis. See page 13 in this Teacher's Guide.)

Support developing students with a partly completed hypothesis and risk assessment to complete.

Review and reflect

State a number of different hazards, such as worn carpet, heating a test tube, or using a sharp knife.

Students record the risk and control measures on their whiteboards and hold them up.

Language support

Ask students what a risk is. Explain, using examples, that a risk is how likely it is that a hazard (e.g. a corrosive chemical) can cause harm or put you in danger.

1.2 Presenting data

Working scientifically links

- apply mathematical concepts and calculate results
- present observations and data using appropriate methods, including tables and graphs
- undertake basic data analysis, including simple statistical techniques

	Learning outcomes		
Learning objectives	**Developing**	**Secure**	**Extending**
Select an appropriate graph to display data	Describe the difference between discrete, categorical, and continuous data	**Select an appropriate graph to display data**	Justify the graph chosen to display a set or sets of data
Present data as a pie chart or a histogram	Draw a pie chart when given section angles	**Present data as a pie chart or a histogram**	Draw a histogram using different class widths
Calculate the mean, mode, and median of a set of data	Calculate the mean	**Calculate the mean, mode, and median of a set of data**	Identify which is the most appropriate average to calculate for a set of data

Tier 2 vocabulary	Tier 3 vocabulary
bar chart, categorical, continuous, discrete, line graph, mean, median, mode, pie chart	histogram

Digital resources

Activity: *Pie charts and histograms* (Activity handout, Support handout)
Video: *Presenting data 2*

Student Book answers

Think back 1 data that can have any value within a range **2** data that can have only whole-number values **3** bar chart, line graph, pie chart

In-text questions A bar chart or pie chart **B** 60+

Maths skills: mean = 15, mode = 17, median = 16

Summary questions 1 mean – add up values, then divide by number of values; mode – identify the value that occurs most; median – place numbers from smallest to biggest, then find the middle one **2** blue 72°, brown 108°, green 54°, hazel 126° **3 a** mean = 146.8 cm, mode = 122 cm, median = 155 cm **b** The mean is affected by anomalies (the three shorter students). The mode finds the most common height, which is low in this example. The median is the best measure, as it ignores the anomalies.