Oxford International Resources

Revised Edition

9

Science

Teacher's Guide

Lower Secondary

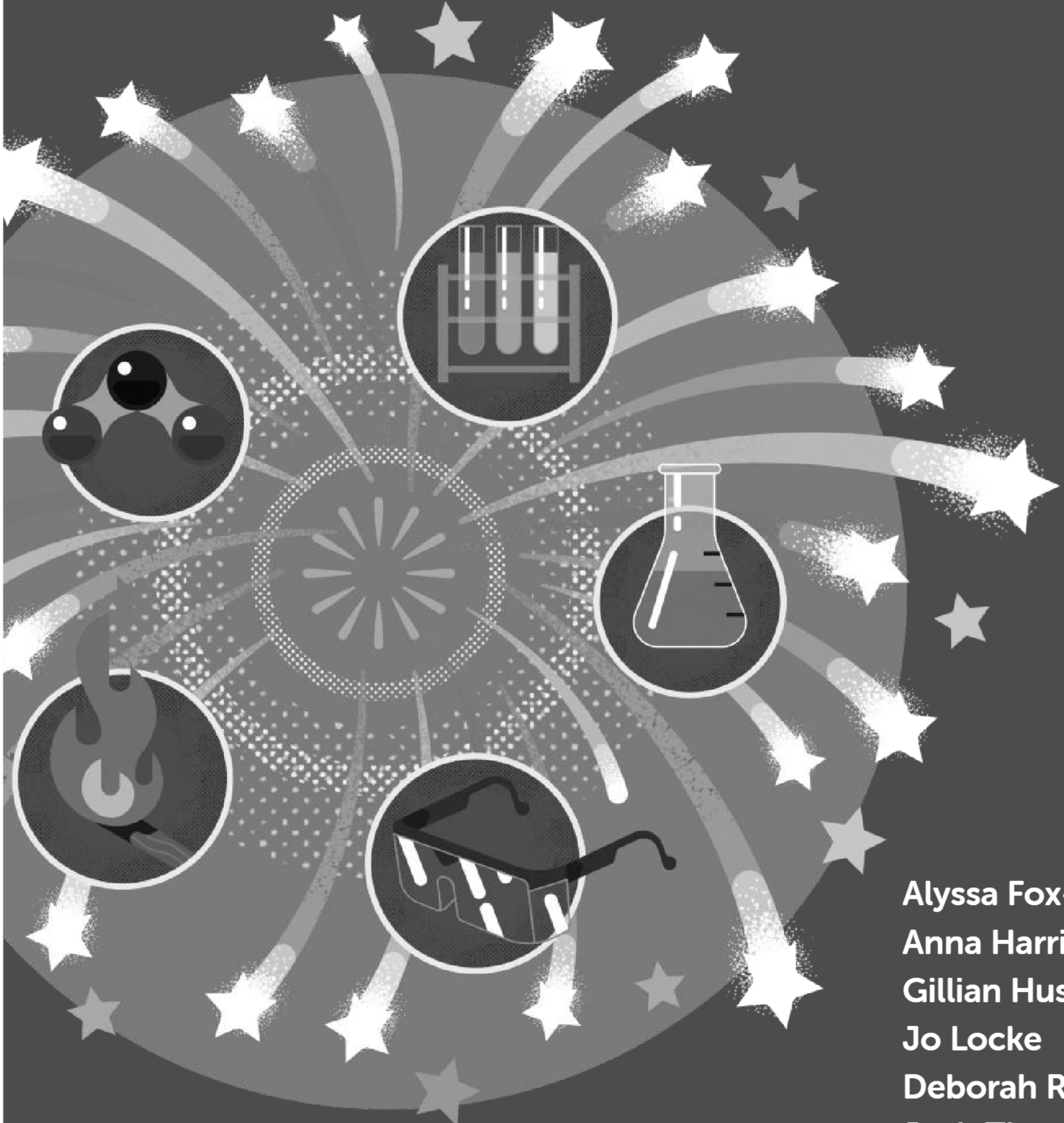
OXFORD

Oxford International Resources

9

Science

Teacher's Guide



Alyssa Fox-Charles
Anna Harris
Gillian Hush
Jo Locke
Deborah Roberts
Josh Thomas

OXFORD

Contents

Chemistry

Physics 134

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

This series encourages 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

This series 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 questions:

- 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'.
- **Differentiation 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. 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 that 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 texts 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 for 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.
- 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 paperbased summative assessment designed to evaluate understanding of the whole chapter.

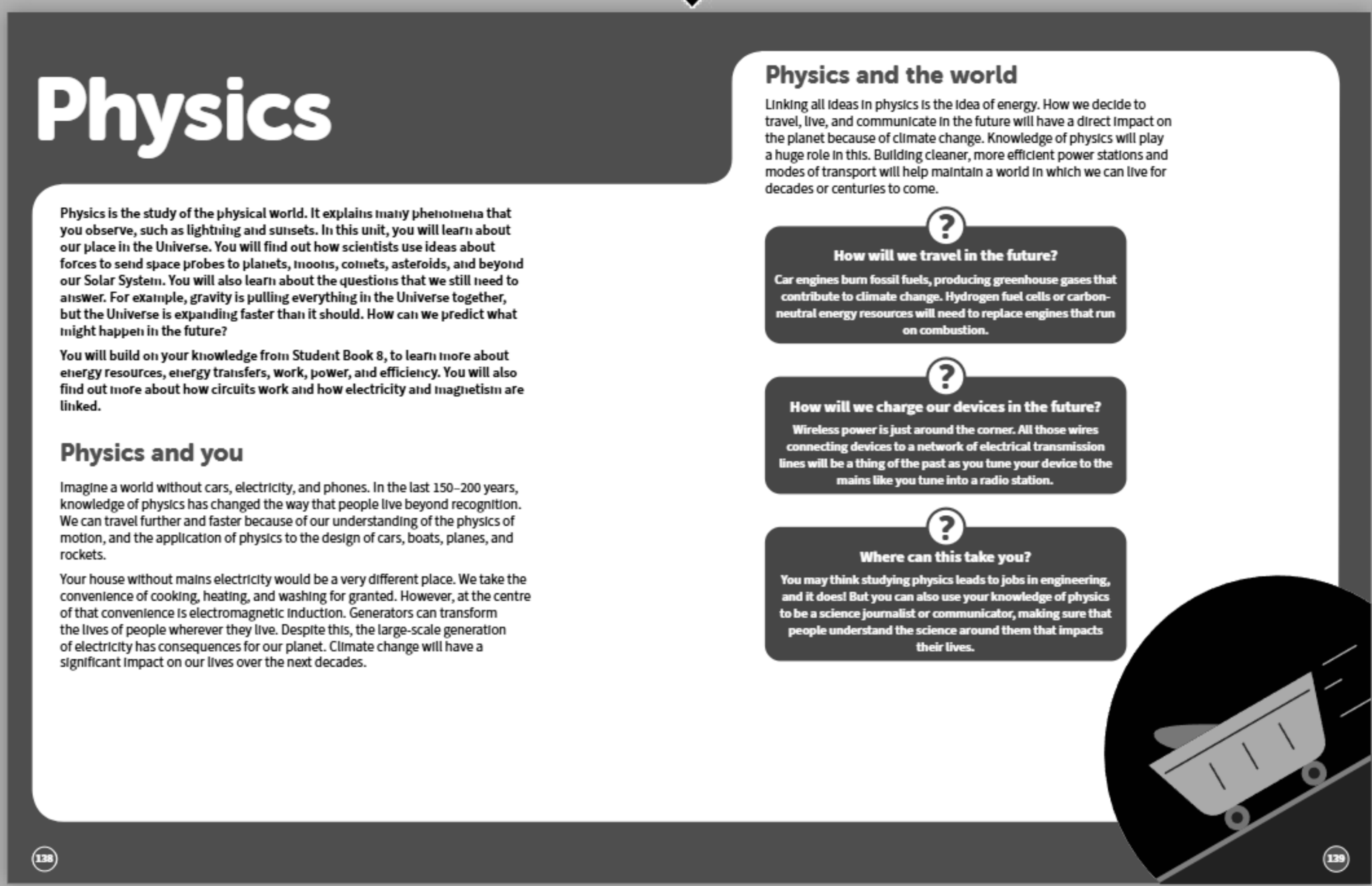
Reporting and insights

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. It explains many phenomena that you observe, such as lightning and sunsets. In this unit, you will learn about our place in the Universe. You will find out how scientists use ideas about forces to send space probes to planets, moons, comets, asteroids, and beyond our Solar System. You will also learn about the questions that we still need to answer. For example, gravity is pulling everything in the Universe together, but the Universe is expanding faster than it should. How can we predict what might happen in the future?

You will build on your knowledge from Student Book 8, to learn more about energy resources, energy transfers, work, power, and efficiency. You will also find out more about how circuits work and how electricity and magnetism are linked.

Physics and you

Imagine a world without cars, electricity, and phones. In the last 150–200 years, knowledge of physics has changed the way that people live beyond recognition. We can travel further and faster because of our understanding of the physics of motion, and the application of physics to the design of cars, boats, planes, and rockets.

Your house without mains electricity would be a very different place. We take the convenience of cooking, heating, and washing for granted. However, at the centre of that convenience is electromagnetic induction. Generators can transform the lives of people wherever they live. Despite this, the large-scale generation of electricity has consequences for our planet. Climate change will have a significant impact on our lives over the next decades.

138

Physics and the world

Linking all ideas in physics is the idea of energy. How we decide to travel, live, and communicate in the future will have a direct impact on the planet because of climate change. Knowledge of physics will play a huge role in this. Building cleaner, more efficient power stations and modes of transport will help maintain a world in which we can live for decades or centuries to come.

How will we travel in the future?

Car engines burn fossil fuels, producing greenhouse gases that contribute to climate change. Hydrogen fuel cells or carbon-neutral energy resources will need to replace engines that run on combustion.

How will we charge our devices in the future?

Wireless power is just around the corner. All those wires connecting devices to a network of electrical transmission lines will be a thing of the past as you tune your device to the mains like you tune into a radio station.

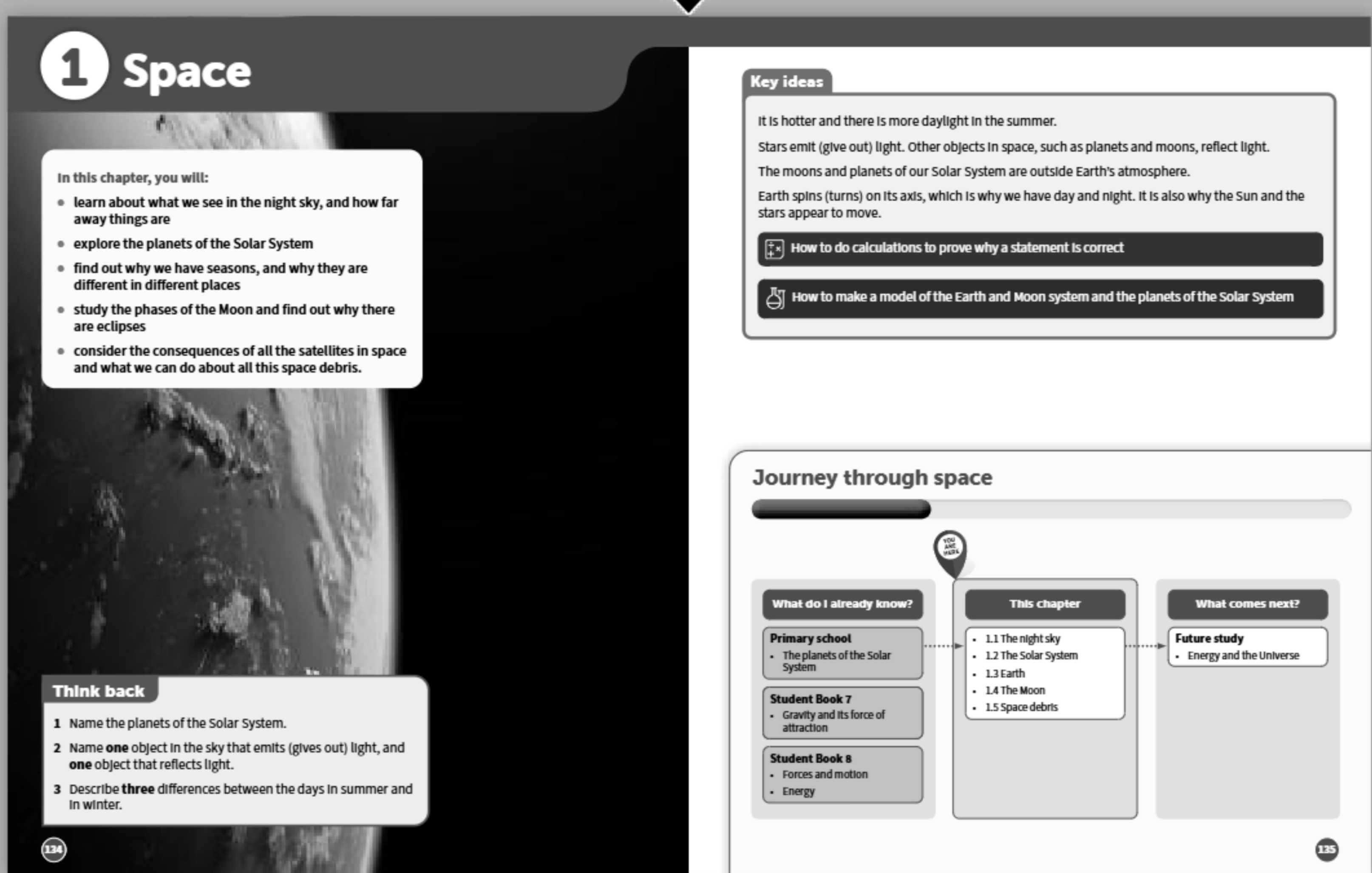
Where can this take you?

You may think studying physics leads to jobs in engineering, and it does! But you can also use your knowledge of physics to be a science journalist or communicator, making sure that people understand the science around them that impacts their lives.

139

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 Space

In this chapter, you will:

- learn about what we see in the night sky, and how far away things are
- explore the planets of the Solar System
- find out why we have seasons, and why they are different in different places
- study the phases of the Moon and find out why there are eclipses
- consider the consequences of all the satellites in space and what we can do about all this space debris.

Think back

1 Name the planets of the Solar System.
2 Name **one** object in the sky that emits (gives out) light, and **one** object that reflects light.
3 Describe **three** differences between the days in summer and in winter.

134

Key ideas

It is hotter and there is more daylight in the summer.

Stars emit (give out) light. Other objects in space, such as planets and moons, reflect light.

The moons and planets of our Solar System are outside Earth's atmosphere.

Earth spins (turns) on its axis, which is why we have day and night. It is also why the Sun and the stars appear to move.

How to do calculations to prove why a statement is correct

How to make a model of the Earth and Moon system and the planets of the Solar System

Journey through space

What do I already know?	This chapter	What comes next?
Primary school • The planets of the Solar System	• 1.1 The night sky • 1.2 The Solar System • 1.3 Earth • 1.4 The Moon • 1.5 Space debris	**Future study** • Energy and the Universe
Student Book 7 • Gravity and its force of attraction		
Student Book 8 • Forces and motion • Energy		

135

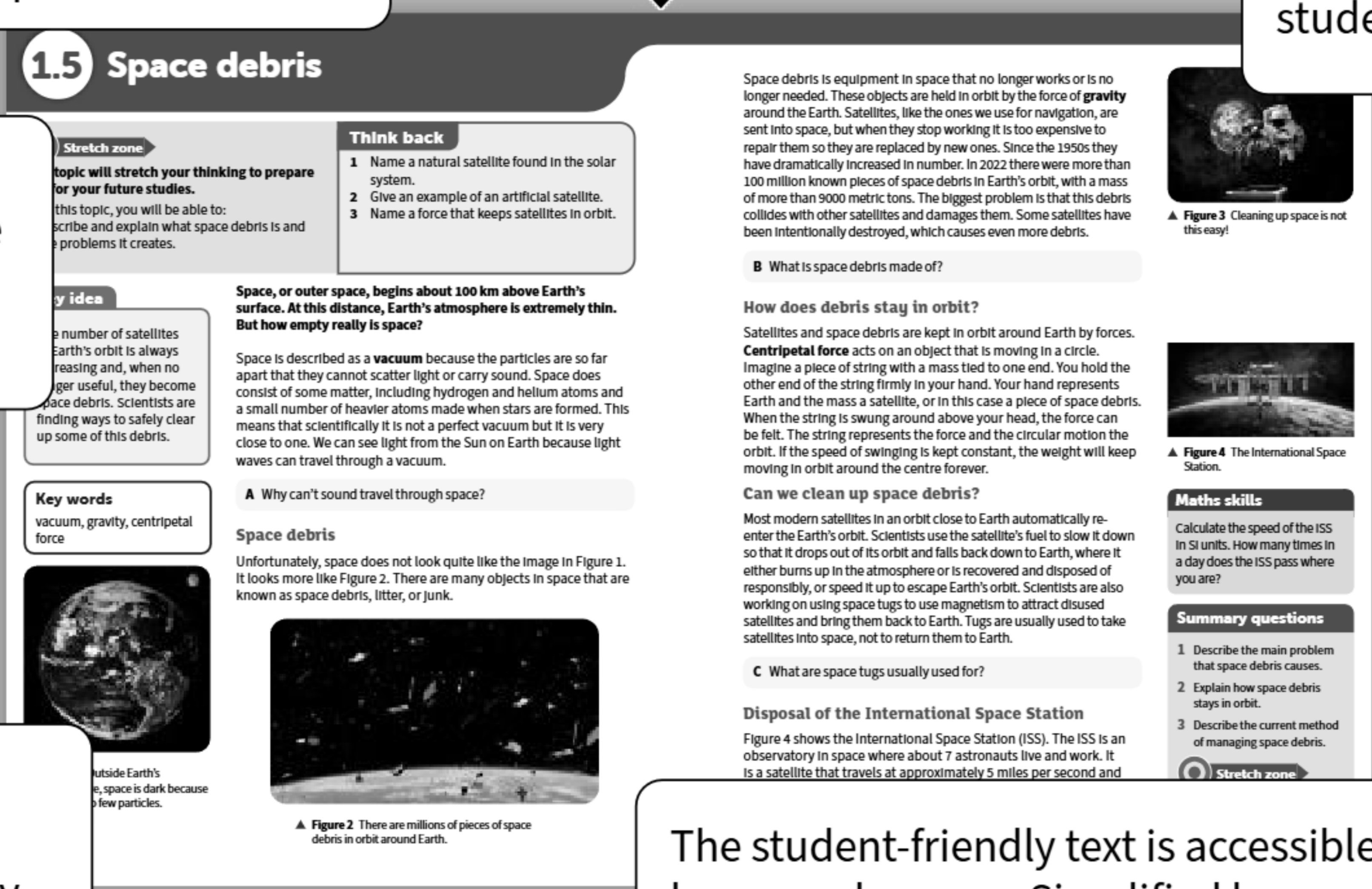
Lesson pages

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.

Think back boxes remind students of prior learning.

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



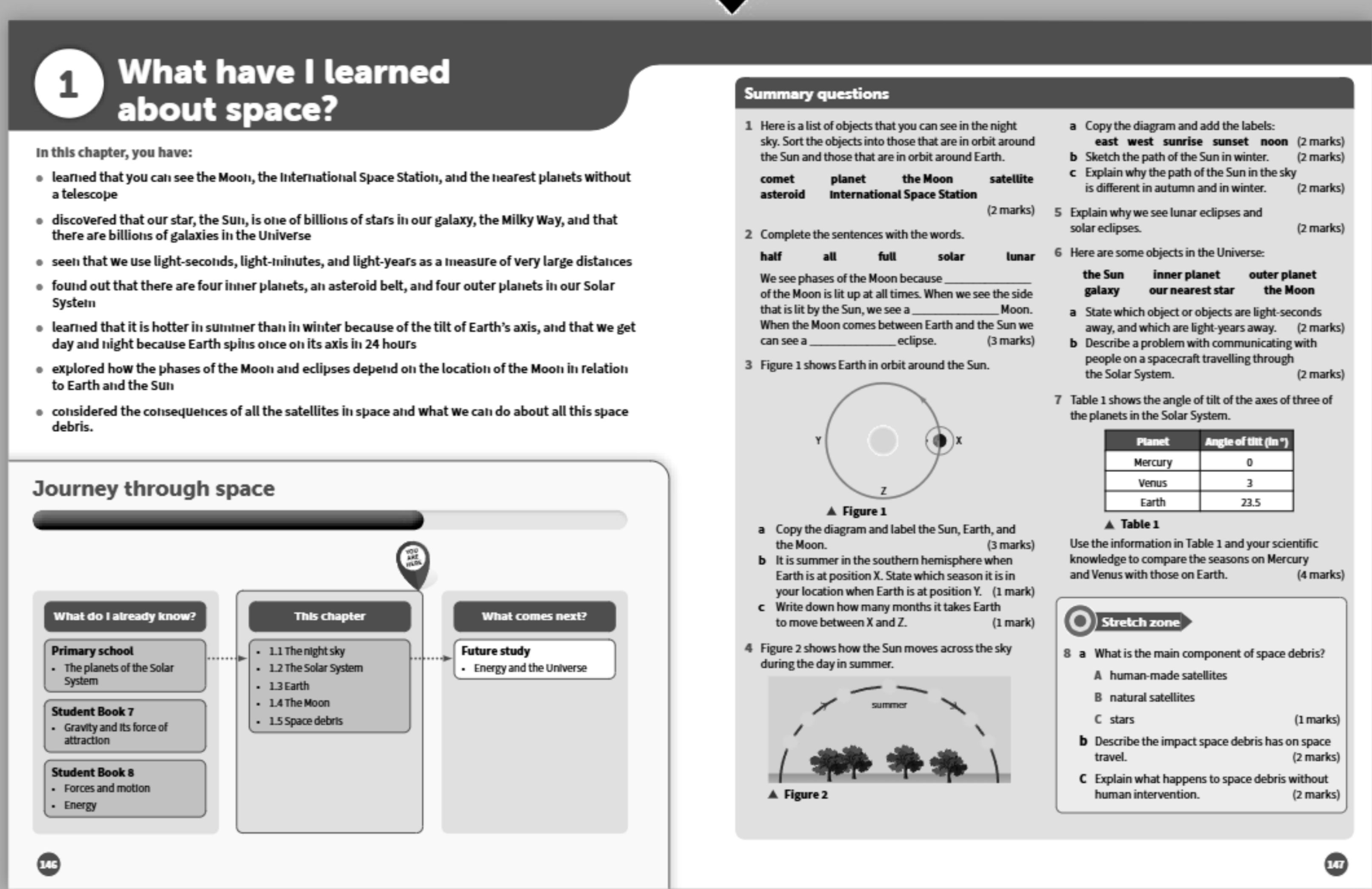
Key words boxes show the main science vocabulary for the lesson.

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.

Preparing for and approaching assessments

What does 'learning' really mean?

For students to 'learn' a piece of information, they need to be able to store it in their long-term memory and recall it when needed.

The multi-store model of memory outlines how information can be transferred between different memory stores. Our sensory memory is where information that is first detected through our senses is stored. By paying attention to the information, it is then transferred to our short-term memory store. If we need to use the information, we then use our working memory to complete a task.

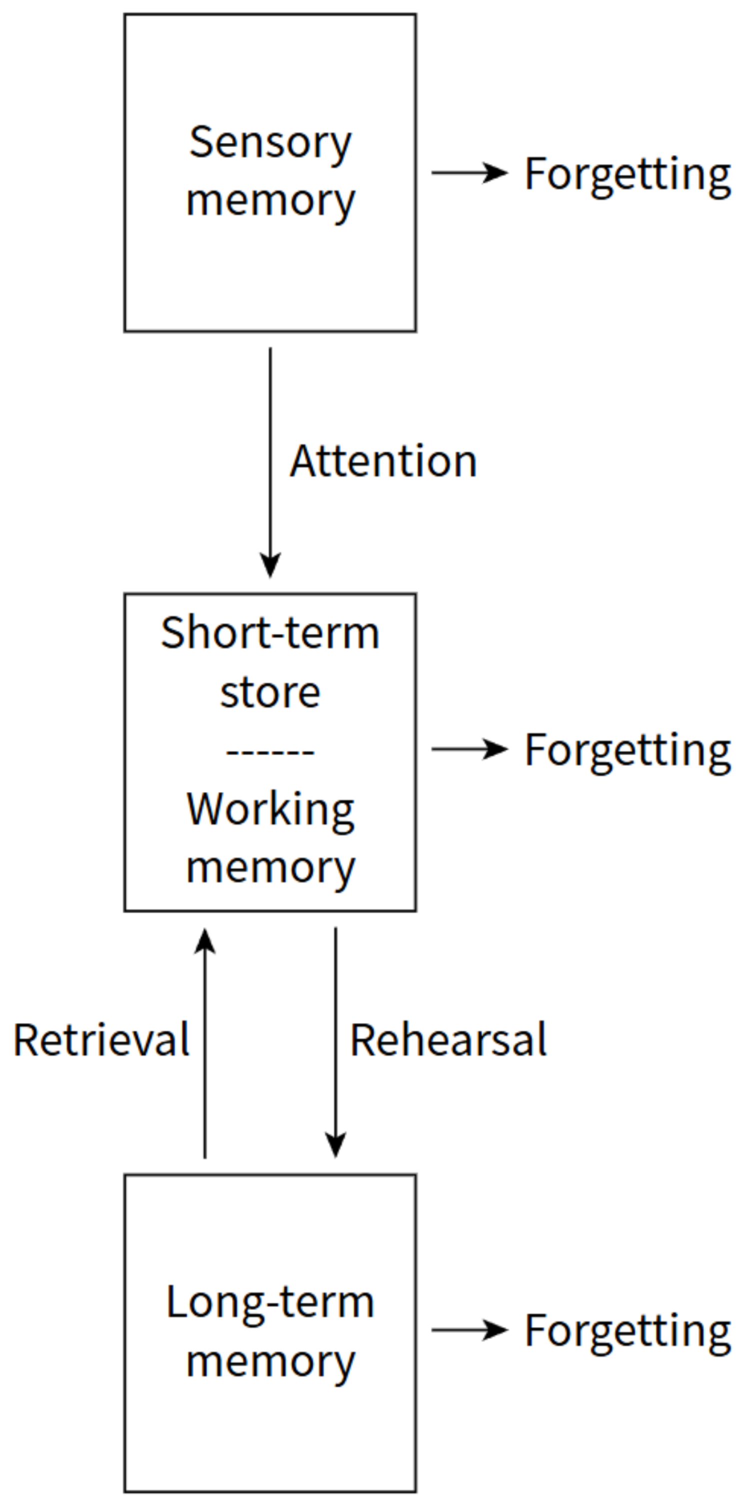
When we conduct a new or complicated task, we sometimes find that our working memory becomes quickly overloaded. This hinders the chances of the information being transferred to long-term memory, and therefore the information can be easily forgotten. However, information can be transferred to our long-term memory through *rehearsal*, and transferred back to our working memory by *retrieval*. The more we rehearse and retrieve information, the stronger the memory becomes.

In the next section, several effective revision strategies grounded in retrieval are outlined.

Effective revision strategies

John Dunlosky, in *Strengthening the Student Toolbox*[1] (2013), identifies the following strategies as highly effective for learning:

- **Practice testing:** Students repeatedly carry out tests, quizzes, and practice exam questions to recall and apply information.
- **Distributed practice:** Students spread out their revision topics over a period of time rather than spending lots of time revising one thing. This helps them recall the content over time.
- **Interleaved practice:** Students swap around the order of topics when they are revising so that they are covering each topic little and often.
- **Elaborative interrogation:** Students delve deeper into content and start to make connections between topics, or attempt to explain why a process takes place.

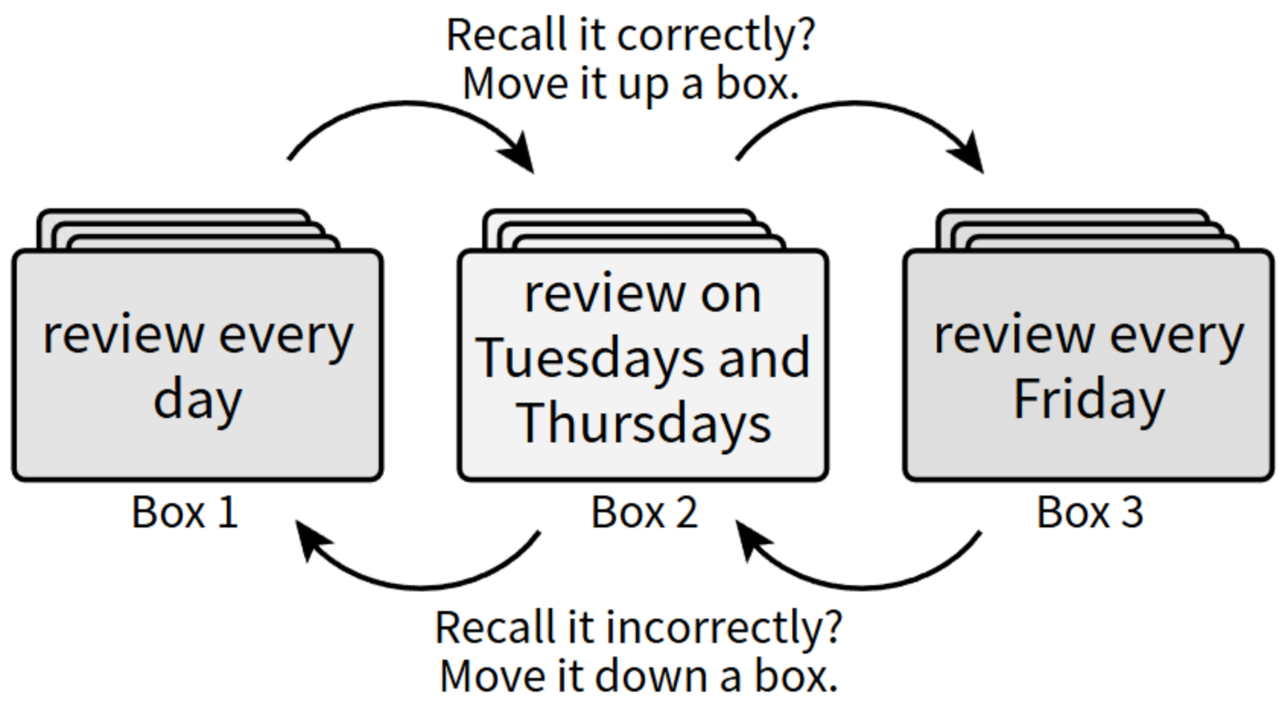


◀ **Figure 1** The multi-store model of memory.

Students need to understand **why** strategies are useful as well as how to use them. Deliberately planning a series of revision sessions that follow these strategies, combined with sharing the explanation of **why** they are so effective, will give students greater metacognitive awareness and improve their self-regulation of their learning.

The Leitner method

One of the strategies outlined in the Student Book is the Leitner method for using flashcards.



▲ **Figure 2** The Leitner method.

Table 1 shows how to introduce this method with students following the seven-step approach.

1 J. Dunlosky (2013), *Strengthening the Student Toolbox*, American Educator

1. Activate prior knowledge	The teacher reviews key content relating to the topic using low-stakes quizzes, topic maps, and some independent reading.
2. Explicit strategy instruction	The teacher explores what makes a good flashcard, then introduces the Leitner method to students. Each step of the method is explained by linking to the theory of why recall activities like this are so important for learning.
3. Modelling of learned strategy	The teacher models the Leitner method to students, reiterating the previous explanation of the steps.
4. Memorization of strategy	Students note down the strategy. The teacher circulates the room and questions students to see if they understand how to use it and why it is effective.
5. Guided practice	The class is given a selection of premade flashcards to practise the Leitner method.
6. Independent practice	Students create a few of their own flashcards to practise the Leitner method.
7. Structured reflection	The class reflects on how effective the Leitner method was in comparison to simple quizzing. They can also reflect on how it can be used for other topics or subjects.

▲ **Table 1** A seven-step approach to the Leitner method.

Exam technique

Often students are able to recall subject knowledge well, but fall at the final hurdle of being able to apply it to a particular question. Answering exam questions is a skill and needs to be explicitly taught, just like teaching other skills in science.

When a student first comes across an exam question, it can be overwhelming and easily overload their working memory. Teaching a specific technique can be really beneficial, and the BUG method is a particularly easy one to follow.

BUG

Box the command word
Underline any key information
Go over the question and your answer

The seven-step approach outlined above can be used to introduce and embed the BUG method.

A key aspect of this approach is modelling. Modelling metacognitively focuses on demonstrating how an expert learner would approach the task by verbalizing their inner thought processes. The teacher can show this by completing an exam paper 'live' in front of students, using the BUG technique. Students can then mirror the strategy and thought processes themselves when answering questions.

After the exam: evaluating performance

An exam wrapper is a document that scaffolds the post-exam review process by using questions and prompts to guide students through identifying subject content and skills that they need to review. It also helps students reflect on their preparation by asking them when and how they revised, and provides an opportunity to plan how they will move their own learning forward by asking them to write 'next steps'.

Key questions would include:

- **Which topic(s) will be your key area(s) of focus moving forward?**
- **Are these old or new topics?**
- **Are there any procedural skills you need to focus on?**
- **How did you prepare for this assessment? How much time did you spend using each strategy?**
- **Next steps:** Before your next assessment, review the topics you have chosen. Make sure that you are using effective revision techniques and address the procedural skills you need to work on. Plan and write down your next steps.

After the exam: feedback

Here are two examples of activities that can get students actively engaging with feedback.

Find and fix

Collate common mistakes into one document when marking the assessment. Students are then asked to find and correct mistakes, before reviewing their own answers to make improvements.

Three questions

Write three targeted questions for each student that delve into their misconceptions and mistakes. Asking students to focus on answering these, rather than reviewing the whole test paper, focuses their attention on the areas that they most need to improve upon.

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.

Many lessons will involve some risks that should be managed responsibly. Students in Year 9 should now be able to recognize risks and begin to manage them effectively with support. 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 had planned. Make sure that you can respond safely, calmly, and efficiently to any changes to your plan. Demonstrate that it is acceptable to make mistakes as long as you act responsibly to avoid any hazardous situations.

Review any safety rules that the students have developed in previous years. Discuss specific risks in the science laboratory or classroom before delivering practical lessons. Remind students to wash their hands after handling any samples or science equipment. Be aware of any health issues including respiratory issues and allergies. Remind students never to eat in the science classroom. Some students might have allergies to compost so handle with care. Find out the correct procedure in the school for reporting any accidents. Follow this protocol and record everything as soon as possible to allow the accurate reporting of any incidents.

You might need to deliver some practicals as demonstrations, due to a shortage of resources or the equipment or materials are too dangerous for students to handle. Encourage students 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.

General rules

Always ask students to prepare the workspace for investigations by tidying loose items and bags away from the area. Items on the floor can be trip hazards. Encourage students to tie up long hair, and remove 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 or toppling Bunsen burners and 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. Keep a dustpan and brush 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 saltwater can irritate the eye if it is not washed out immediately. Clean 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. Students should always tell an adult if they have hurt themselves in any way in the lesson. Encourage students to wear goggles or protective eyewear during all investigations in the science classroom. Students will work in a darkened space during some investigations in Year 9. Minimize the movement needed during these times to avoid trips and falls.

Heavy equipment

When using magnets and suspended masses, students should position them over the desk or bench. Always demonstrate how to attach masses securely to avoid them dropping on fingers. Students should wear safety goggles when using springs and masses and observing bouncing balls or falling objects. Sand bags and bean bags should be 20 N or less. Check that they are in good condition so they do not break during the lesson. Scales, test tube racks, and retort stands should be used away from the edge of the desk to avoid them falling over and spilling their contents. Where possible these should be clamped into position. Oscilloscopes can be very heavy, so lift them with care.

Sharp items

Scissors, forceps, tweezers, sharp knives, and scalpels should be used and stored sensibly. Remind students not to walk around with them in their hands but to keep them in small working trays. Check that any metal samples or materials do not have any rough edges. When using steel needles, pins, or nails make sure they are blunt.

Glassware

Beakers, conical flasks, test tubes, and boiling tubes can be a hazard. Students should know how to deal with breakages safely. Instruct them that they should report any breakages to an adult and warn everyone in the workspace. Clean up any broken glass using a dustpan and brush. Always keep a breakages bucket or container for safe disposal. Advise students to wear safety goggles when working with glass to protect their eyes. When working with microscopes, remind students of the fragility of slides and coverslips. Instruct them never to use any that are damaged. When using lenses and telescopes students should never look directly at the Sun or any other source of light. The light on a microscope should never be directed into the eyepiece.

Chemicals

Most of the chemicals used in Year 9 are not hazardous if managed correctly. The following chemicals have some risk attached.

Methylene blue, citric acid, and limewater are irritants and can stain clothing and the skin. Calcium chloride and rooting hormones are irritants. Contact with the eyes and skin should be avoided. Magnesium sulfate, dilute hydrochloric acid, 36.5 g/dm^3, are low-hazard but harmful; and acid is corrosive. Acids at concentrations greater than 0.4 mol/dm^3 should not be used. The reaction between iron and sulfuric acid produces an irritant gas, and should take place in a well-ventilated lab. Sodium hydroxide is corrosive. Magnesium chloride and magnesium carbonate are non-hazardous. Sodium carbonate solution is weakly alkaline. Magnesium ribbon, hydrogen gas, and calcium are flammable. Magnesium ribbon burns with a bright white flame so never look at the flame directly. Air fresheners containing 1,4-dichlorobenzene (para-dichlorobenzene), $C_6H_4Cl_2(s)$, should be handled with tongs in a fume cupboard. Para-dichlorobenzene and anhydrous copper (II) sulfate (VI) are harmful, and cobalt chloride paper is toxic; all are dangerous to the environment. These and calcium should be handled using tongs.

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

Biohazards

When using food or drink samples or packaging, remind students to never consume anything in a science workspace as everything could be contaminated with substances used in previous experiments. Check for any poisonous or other hazardous plants when investigating potted plants and natural ones outside. Wash hands after use.

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.

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. Do not provide high-voltage power supplies (in excess of 28 V) as they can cause the wires to overheat. Bulbs or wires may become hot during experiments so encourage students to only switch circuits on when taking readings. Use low-voltage bulbs but still handle with care as they can get hot if left connected in a circuit.

Use the Van der Graaf generator away from any electrical circuits. Discharge the student volunteers carefully by asking them to touch a wooden metre ruler. Anyone with a heart condition must be kept at a safe distance, and the Van der Graaf generator cannot be operated by a person wearing a pacemaker.

Flames and heat

Take care using lit splints and dispose of them responsibly. When pouring hot liquids into test tubes place them in a test tube rack to avoids spills.

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.

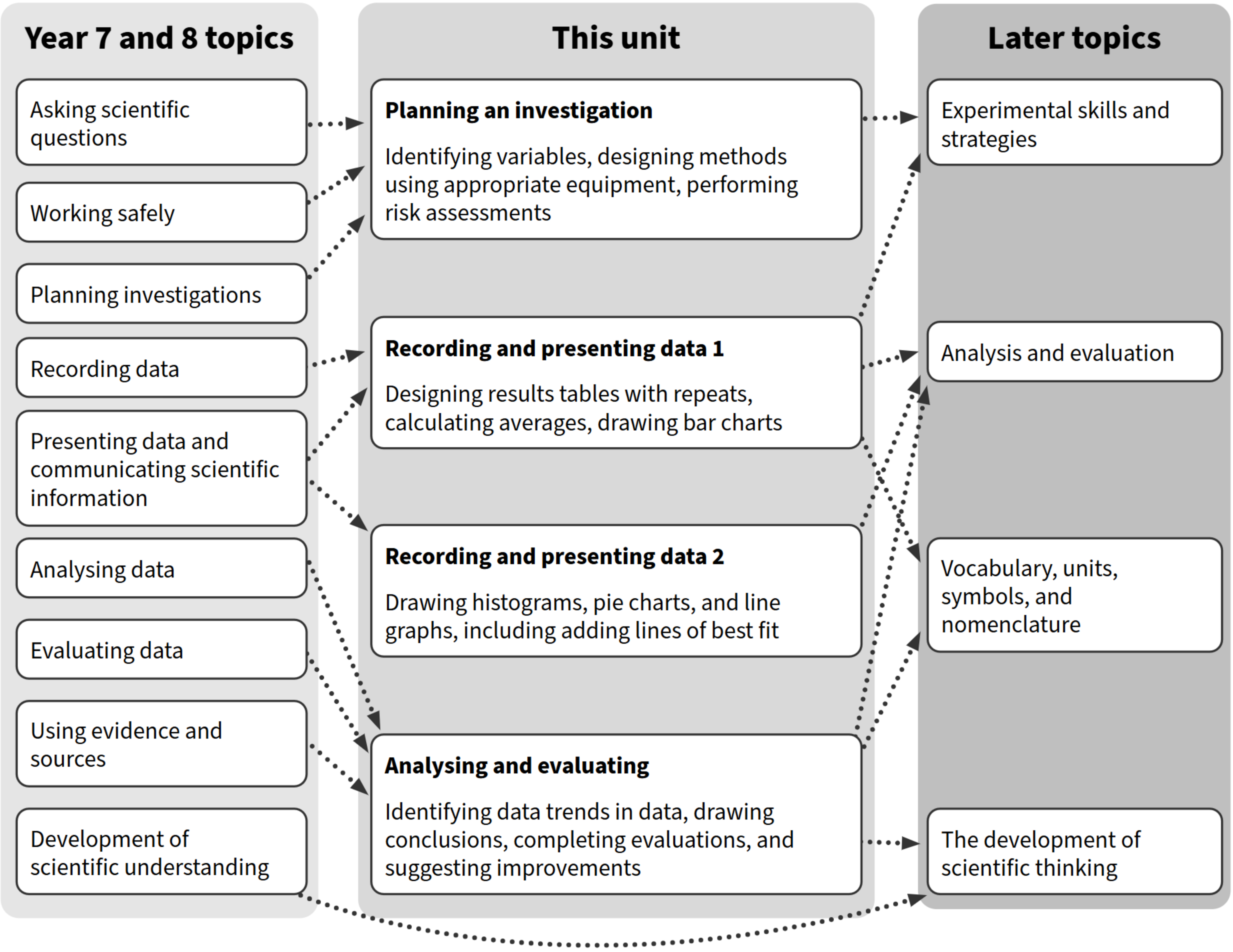
Working scientifically

Introduction to unit

In this unit, students will look again at the main stages of a scientific investigation, starting with identifying variables, producing a plan to create valid data, and performing a risk assessment. They will practise calculating averages as well as presenting data on a range of charts, including bar charts, pie charts, and histograms. Finally, they will analyse data to draw conclusions, carry out evaluations to identify any sources of errors, and suggest improvements to their methods.

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

Learning journey



Working scientifically and you

Discuss the fact that humans are naturally scientific. We are born with inquisitive minds, constantly asking questions to make sense of the world in which we live. By carrying out scientific investigations based on the observations they make, people can start to find reasons for why things occur or predict what will happen in a situation.

Understanding the scientific process and how to interpret data is an important skill for everyday life. It allows people to make informed choices and decisions about things like their health and lifestyle.

Discuss that by knowing how to analyse and evaluate problems and solutions, it can make people live more sustainably, as they can find ways to repair, reuse, and recycle things.

Working scientifically and the world

It is important to stress that there are still many things that we cannot explain fully and new problems arise, which scientists endeavour to solve, so scientific research is constantly occurring. This happens in the laboratory, in the field, and even in space. Due to advances in technology and improvements in communications, many research projects are now global, as illustrated by the fight against COVID-19. This is increasingly important with the shared stand against climate change and its wide-ranging effects.

Scientists also have a key role in exposing 'fake news', making sure that the population is well informed using authentic scientific information. They also provide data to governments to enable them to make decisions based on evidence.

Big questions

How do scientists stay safe?

Discuss with students the role of risk assessments when carrying out an investigation in order to protect both the scientist and others working around them. These identify the hazards and steps that can be taken to minimize the risk of these hazards causing harm. It is important that students are aware that most investigations involve a degree of risk. However, many safety measures are employed to minimize it.

How can you trust a scientific claim?

Explain to students that one of the key skills of a scientist is to think critically. When looking at a claim, they should think about what evidence there is for a claim, what the basis is for the claim, who wrote it, and why. Only when they know the answers to these questions can they make a reasoned decision on whether to believe a piece of information, or not.

Why do scientists change their mind about why things happen?

Explain that scientists are constantly questioning the work of scientists who have come before them. Technology is constantly developing – for example, the development of electron microscopes from the single glass magnifying lens, or the ability to sequence DNA. New technology combined with carrying out different experiments and new ways of thinking can all provide new evidence. This can result in scientists having to amend a previous idea or change their thinking entirely.

1.1 Think back: Planning investigations

Working scientifically links

- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- 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, where appropriate

Learning objective

- Recall and organize key knowledge about planning an investigation

Year 7 learning objectives

- Develop an idea into a question that can be investigated
- Identify independent, dependent, and control variables
- Make a scientific prediction
- Recognize commonly used hazard symbols
- Identify possible hazards in practical work
- Understand the purpose of a risk assessment
- Write a plan for a scientific investigation

Year 8 learning objectives

- Write a hypothesis for a scientific investigation
- Describe the difference between precise and accurate data
- Write a risk assessment for a scientific investigation

Tier 2 vocabulary	Tier 3 vocabulary
accurate, data, hazard, observation, plan, precise, prediction, range, risk, variable	control measure, control variable, dependent variable, hypothesis, independent variable, random error, systematic error

Digital resources

Activity: *Investigating candle burn time (planning)* (Activity handout, Support handout)
Video: *Planning investigations*