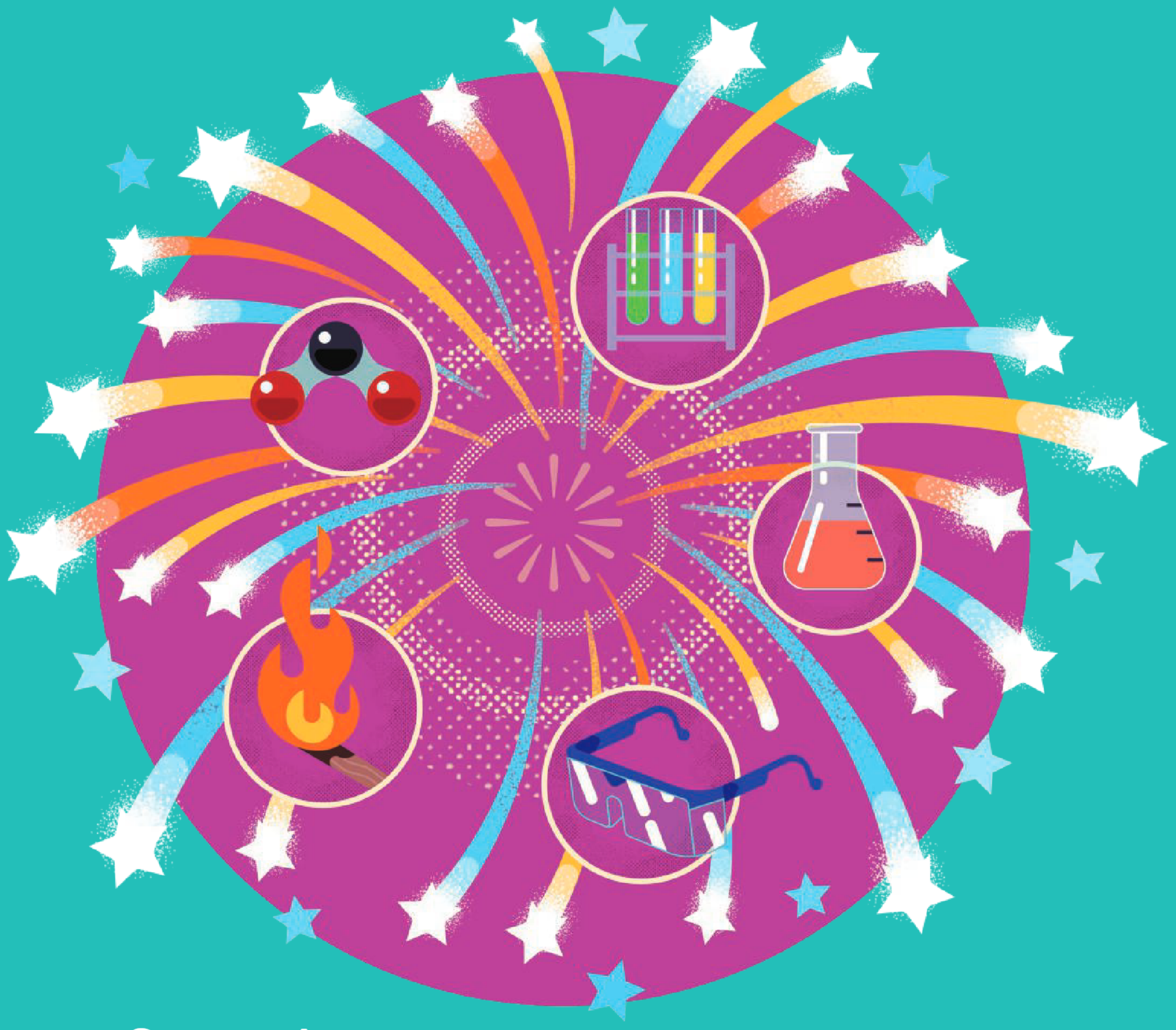
Oxford International Resources

Revised Edition

9

Science

Student Book



Lower Secondary

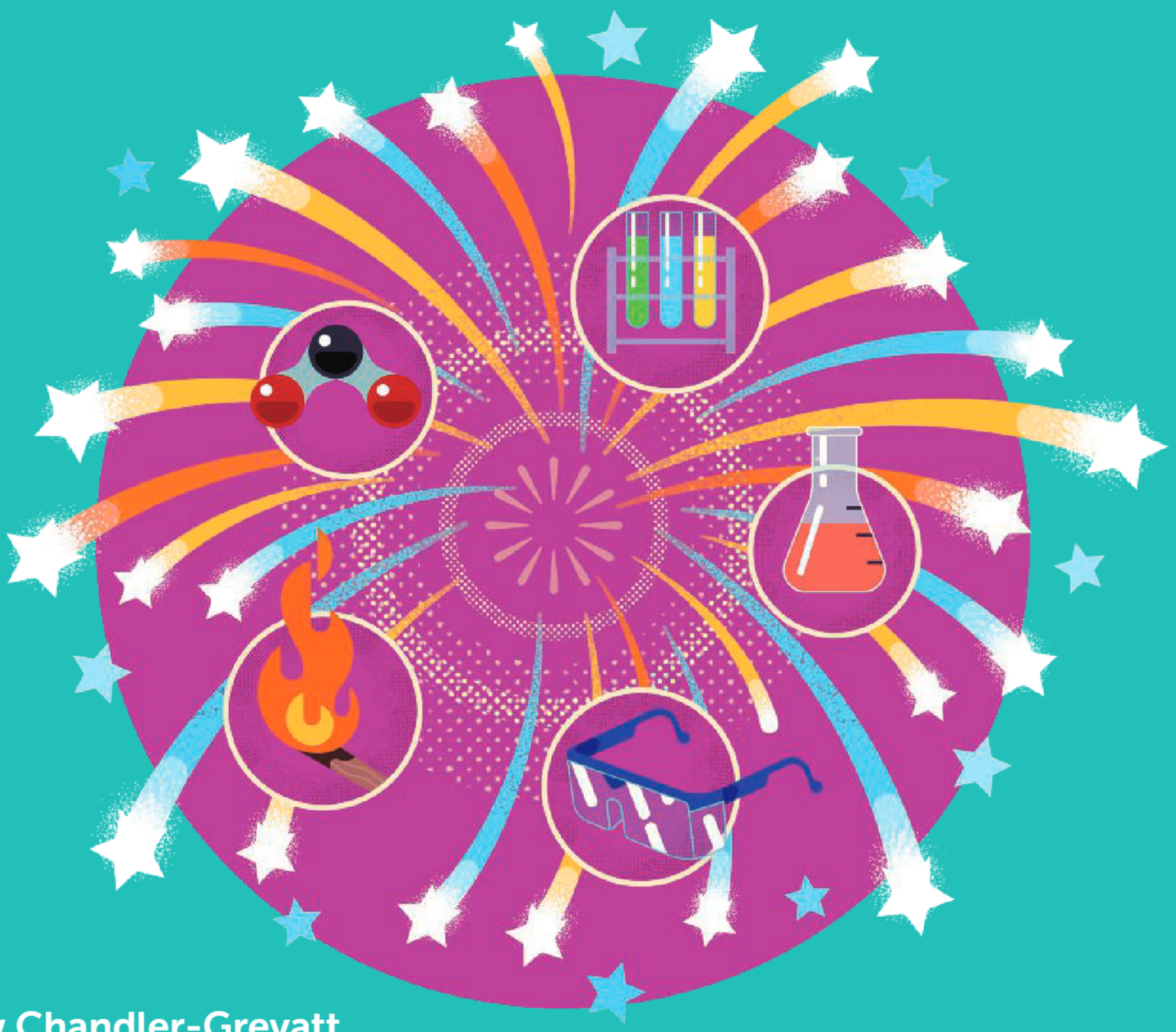
OXFORD

Oxford International Resources

9

Science

Student Book



Dr Andrew Chandler-Grevatt
Jo Locke
Philippa Gardom-Hulme
Helen Reynolds
Deborah Roberts

OXFORD

Contents

Chemistry

Physics 132

How to use this book

Each topic begins with a set of learning objectives, except for in the *Think back* pages. These tell you what you will be able to do by the end of the lesson.

Think back

Here you will find some short questions that will remind you what you already know about a topic.

Key idea

The key idea summarizes the main points of each topic in a few sentences.

Key words

The key words for each topic are highlighted in **bold** in the text. They are also included in order of appearance in this box. You can also find them in the Glossary at the back of your Student Book.

Summary questions

1 The first question asks you to recall information.

2 The following questions build on what you have learned.

Stretch zone

3 The final questions move you into the 'stretch zone'. This means you will need to think more deeply about scientific concepts. It is OK if you find these questions diicult – doing challenging work is the exercise that your brain needs.

Welcome to your Student Book

This introduction shows you all the dierent features *Oxford International Science* has to support you on your journey through Lower Secondary Science, and onwards to higher-level studies.

Being a scientist is great fun. As you work through this Student Book, you will learn how to work as a scientist, and get answers to questions that science can address.

This book is full of activities to help build your confidence and skills in science.

These boxes contain a short question aer each section of text so you can check your understanding of the topic so far.

Working scientically

Scientists work in a particular way to carry out fair and scientific investigations. These boxes contain activities and tips to help you build these skills and understand the process so that you can work scientifically.

Maths skills

These boxes contain activities and tips to help you practise the maths you need for scientific purposes.

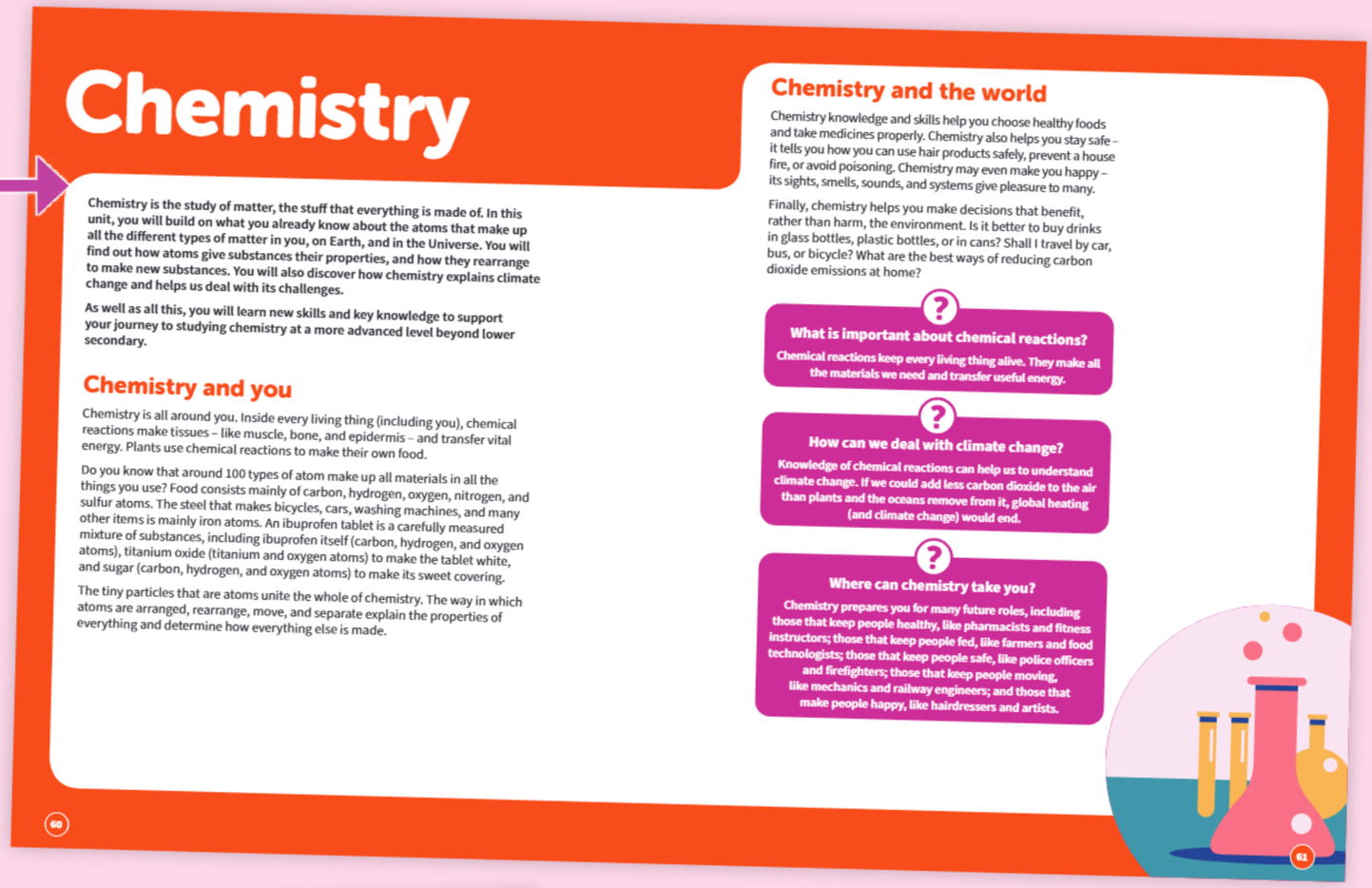
Literacy skills

Scientists need to be able to communicate and share their ideas. These boxes contain activities and tips to help develop your reading, writing, listening, and speaking skills.

Unit opener

Each unit begins with an introduction. This introduces you to the awe and wonder of science and helps you understand your place in the scientific world.

It asks some important questions that you will find the answers to in the unit.



Chemistry

Chemistry is the study of matter, the stuff that everything is made of. In this unit, you will build on what you already know about the atoms that make up all the different types of matter in you, on Earth, and in the Universe. You will find out how atoms give substances their properties, and how they rearrange to make new substances. You will also discover how chemistry explains climate change and helps us deal with its challenges.

As well as all this, you will learn new skills and key knowledge to support your journey to studying chemistry at a more advanced level beyond lower secondary.

Chemistry and you

Chemistry is all around you. Inside every living thing (including you), chemical reactions make tissues – like muscle, bone, and epidermis – and transfer vital energy. Plants use chemical reactions to make their own food.

Do you know that around 100 types of atom make up all materials in all the things you use? Food consists mainly of carbon, hydrogen, oxygen, nitrogen, and sulfur atoms. The steel that makes bicycles, cars, washing machines, and many other items is mainly iron atoms. An ibuprofen tablet is a carefully measured mixture of substances, including ibuprofen itself (carbon, hydrogen, and oxygen atoms), titanium oxide (titanium and oxygen atoms) to make the tablet white, and sugar (carbon, hydrogen, and oxygen atoms) to make its sweet covering.

The tiny particles that are atoms unite the whole of chemistry. The way in which atoms are arranged, rearrange, move, and separate explain the properties of everything and determine how everything else is made.

Chemistry and the world

Chemistry knowledge and skills help you choose healthy foods and take medicines properly. Chemistry also helps you stay safe – it tells you how you can use hair products safely, prevent a house fire, or avoid poisoning. Chemistry may even make you happy – its sights, smells, sounds, and systems give pleasure to many.

Finally, chemistry helps you make decisions that benefit, rather than harm, the environment. Is it better to buy drinks in glass bottles, plastic bottles, or in cans? Shall I travel by car, bus, or bicycle? What are the best ways of reducing carbon dioxide emissions at home?

What is important about chemical reactions?

Chemical reactions keep every living thing alive. They make all the materials we need and transfer useful energy.

How can we deal with climate change?

Knowledge of chemical reactions can help us to understand climate change. If we could add less carbon dioxide to the air than plants and the oceans remove from it, global heating (and climate change) would end.

Where can chemistry take you?

Chemistry prepares you for many future roles, including those that keep people healthy, like pharmacists and fitness instructors; those that keep people fed, like farmers and food technologists; those that keep people safe, like police officers and firefighters; those that keep people moving, like mechanics and railway engineers; and those that make people happy, like hairdressers and artists.

Chapter opener

Each chapter begins with an introduction. This reminds you what you already know and shows you what is coming up in the chapter. It also shows you the Working scientifically and Maths skills that you will learn.

2 Reactions

In this chapter, you will:

- explore the chemical reactions that make the substances we need and the fuels we use
- compare physical changes and chemical reactions, including those involved in cooking and baking
- learn to write chemical equations, classify chemical reactions, and use ratios
- investigate how different catalysts are used to speed up reactions.

Think back

1 Describe what you can see before, during, and after wood burns.

2 When wood has burnt, you cannot get the wood back again. In other words, burning wood is not reversible. Explain whether baking a cake is reversible or not.

3 Give the number of different types of atom in: a piece of copper, oxygen gas, a piece of copper oxide.

Key ideas

A chemical reaction makes new substances, but a physical change does not.

Compounds are substances made up of atoms of two or more elements, strongly joined together.

Catalysts are used in many chemical reactions to speed them up.

A word equation shows the reactants (starting substances) on the left of the arrow and the products (substances that are made) on the right of the arrow.

A balanced formula equation shows the reactants and products and their formulae, as well as the ratios of the amounts of the reactants and products.

How to present and simplify ratios

How to make observations in experiments

Journey through reactions

What do I already know?

Student Book 7
- Elements, atoms, and compounds
- Neutralization and making salts
- Changes of state

Student Book 8
- Mixtures
- Bonding
- Metals and non-metals
- Metal displacement reactions

This chapter
- 2.1 Chemical reactions
- 2.2 Chemical reactions and physical changes
- 2.3 Word equations
- 2.4 Oxidation reactions
- 2.5 Combustion reactions
- 2.6 Decomposition reactions
- 2.7 Using ratios
- 2.8 Balanced formula equations
- 2.9 Conservation of mass
- 2.10 Energy in chemical reactions
- 2.11 Exothermic and endothermic reactions
- 2.12 Speeding up reactions

What comes next?

Student Book 9
- Useful chemical reactions
- Displacement reactions
- Relative mass
- Calculating yield

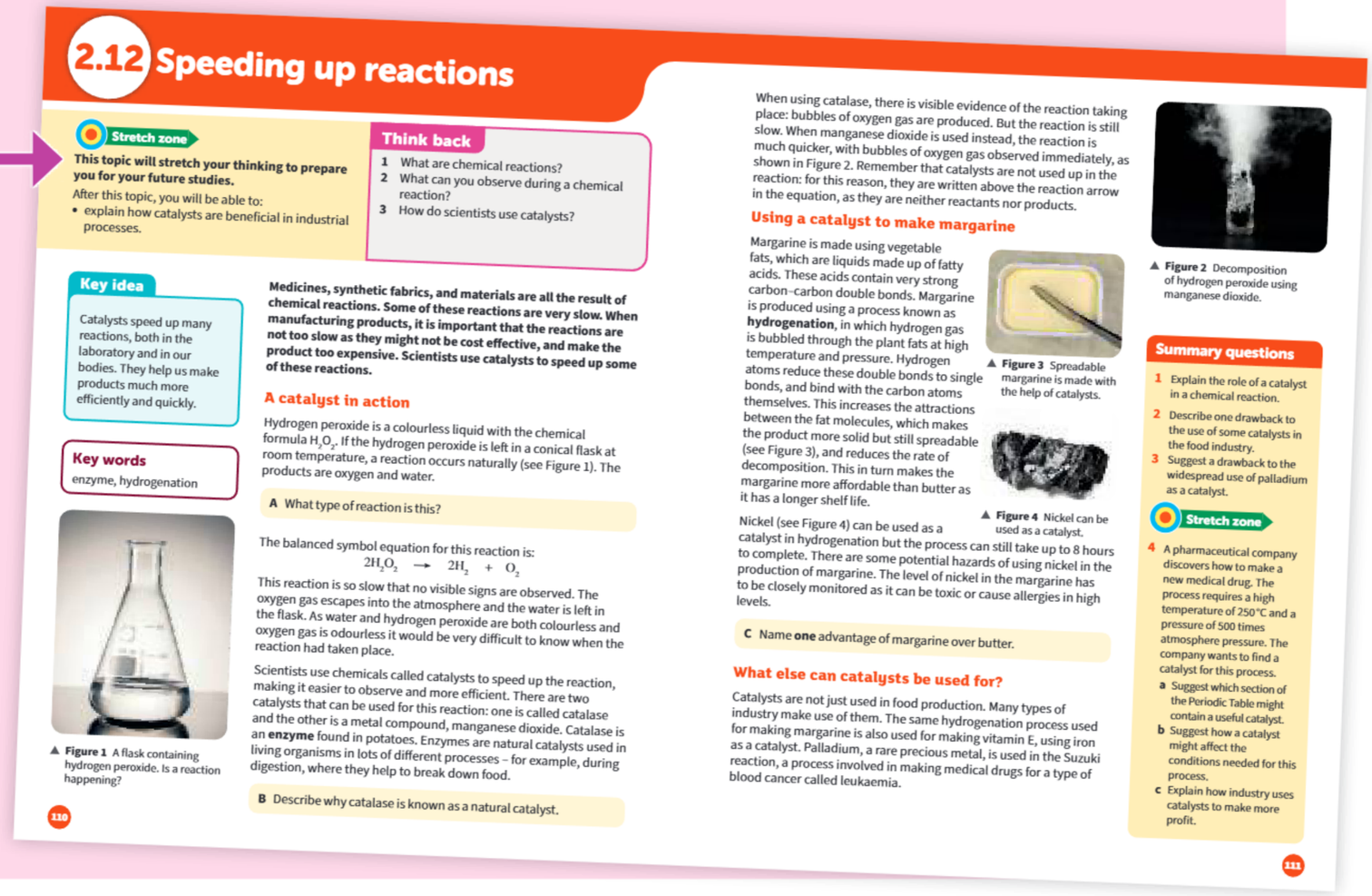
Learning journey

This shows clearly what science you already know, the new topics you will study in this chapter, and the next steps in your science learning.

Stretch

These pages will guide you through some higher-level ideas, building on what you already know.

This section can be challenging, so check with your teacher if you are ready to study these topics.



2.12 Speeding up reactions

Stretch zone

This topic will stretch your thinking to prepare you for your future studies.

After this topic, you will be able to:
- explain how catalysts are beneficial in industrial processes.

Think back

1 What are chemical reactions?
2 What can you observe during a chemical reaction?
3 How do scientists use catalysts?

Key idea

Catalysts speed up many reactions, both in the laboratory and in our bodies. They help us make products much more efficiently and quickly.

Key words

enzyme, hydrogenation

▲ **Figure 1** A flask containing hydrogen peroxide. Is a reaction happening?

Medicines, synthetic fabrics, and materials are all the result of chemical reactions. Some of these reactions are very slow. When manufacturing products, it is important that the reactions are not too slow as they might not be cost effective, and make the product too expensive. Scientists use catalysts to speed up some of these reactions.

A catalyst in action

Hydrogen peroxide is a colourless liquid with the chemical formula H_2O_2. If the hydrogen peroxide is left in a conical flask at room temperature, a reaction occurs naturally (see Figure 1). The products are oxygen and water.

A What type of reaction is this?

The balanced symbol equation for this reaction is:

$$2H_2O_2 \rightarrow 2H_2 + O_2$$

This reaction is so slow that no visible signs are observed. The oxygen gas escapes into the atmosphere and the water is left in the flask. As water and hydrogen peroxide are both colourless and oxygen gas is odourless it would be very difficult to know when the reaction had taken place.

Scientists use chemicals called catalysts to speed up the reaction, making it easier to observe and more efficient. There are two catalysts that can be used for this reaction: one is called catalase and the other is a metal compound, manganese dioxide. Catalase is an **enzyme** found in potatoes. Enzymes are natural catalysts used in living organisms in lots of different processes – for example, during digestion, where they help to break down food.

B Describe why catalase is known as a natural catalyst.

When using catalase, there is visible evidence of the reaction taking place: bubbles of oxygen gas are produced. But the reaction is still slow. When manganese dioxide is used instead, the reaction is much quicker, with bubbles of oxygen gas observed immediately, as shown in Figure 2. Remember that catalysts are not used up in the reaction: for this reason, they are written above the reaction arrow in the equation, as they are neither reactants nor products.

▲ **Figure 2** Decomposition of hydrogen peroxide using manganese dioxide.

Using a catalyst to make margarine

Margarine is made using vegetable fats, which are liquids made up of fatty acids. These acids contain very strong carbon–carbon double bonds. Margarine is produced using a process known as **hydrogenation**, in which hydrogen gas is bubbled through the plant fats at high temperature and pressure. Hydrogen atoms reduce these double bonds to single bonds, and bind with the carbon atoms themselves. This increases the attractions between the fat molecules, which makes the product more solid but still spreadable (see Figure 3), and reduces the rate of decomposition. This in turn makes the margarine more affordable than butter as it has a longer shelf life.

▲ **Figure 3** Spreadable margarine is made with the help of catalysts.

▲ **Figure 4** Nickel can be used as a catalyst.

Nickel (see Figure 4) can be used as a catalyst in hydrogenation but the process can still take up to 8 hours to complete. There are some potential hazards of using nickel in the production of margarine. The level of nickel in the margarine has to be closely monitored as it can be toxic or cause allergies in high levels.

C Name **one** advantage of margarine over butter.

What else can catalysts be used for?

Catalysts are not just used in food production. Many types of industry make use of them. The same hydrogenation process used for making margarine is also used for making vitamin E, using iron as a catalyst. Palladium, a rare precious metal, is used in the Suzuki reaction, a process involved in making medical drugs for a type of blood cancer called leukaemia.

Summary questions

1 Explain the role of a catalyst in a chemical reaction.

2 Describe one drawback to the use of some catalysts in the food industry.

3 Suggest a drawback to the widespread use of palladium as a catalyst.

Stretch zone

4 A pharmaceutical company discovers how to make a new medical drug. The process requires a high temperature of 250 °C and a pressure of 500 times atmosphere pressure. The company wants to find a catalyst for this process.
- **a** Suggest which section of the Periodic Table might contain a useful catalyst.
- **b** Suggest how a catalyst might affect the conditions needed for this process.
- **c** Explain how industry uses catalysts to make more profit.

Preparing for an assessment

When you have an assessment coming up, it is important to prepare well. Sometimes it is tempting to just read over or rewrite your notes. However, this is not very eective.

The most eective way to revise is to recall as much information as possible and practise applying it to questions. This will put you in a situation similar to the one you will face in the assessment. At rst, it may feel like you cannot remember very much at all. However, if you persevere (keep trying), you will nd that over time you will remember more and more, and your condence will grow.

Eective revision strategies

Table 1 lists some of the most eective revision strategies that you can use to put your brain to work.

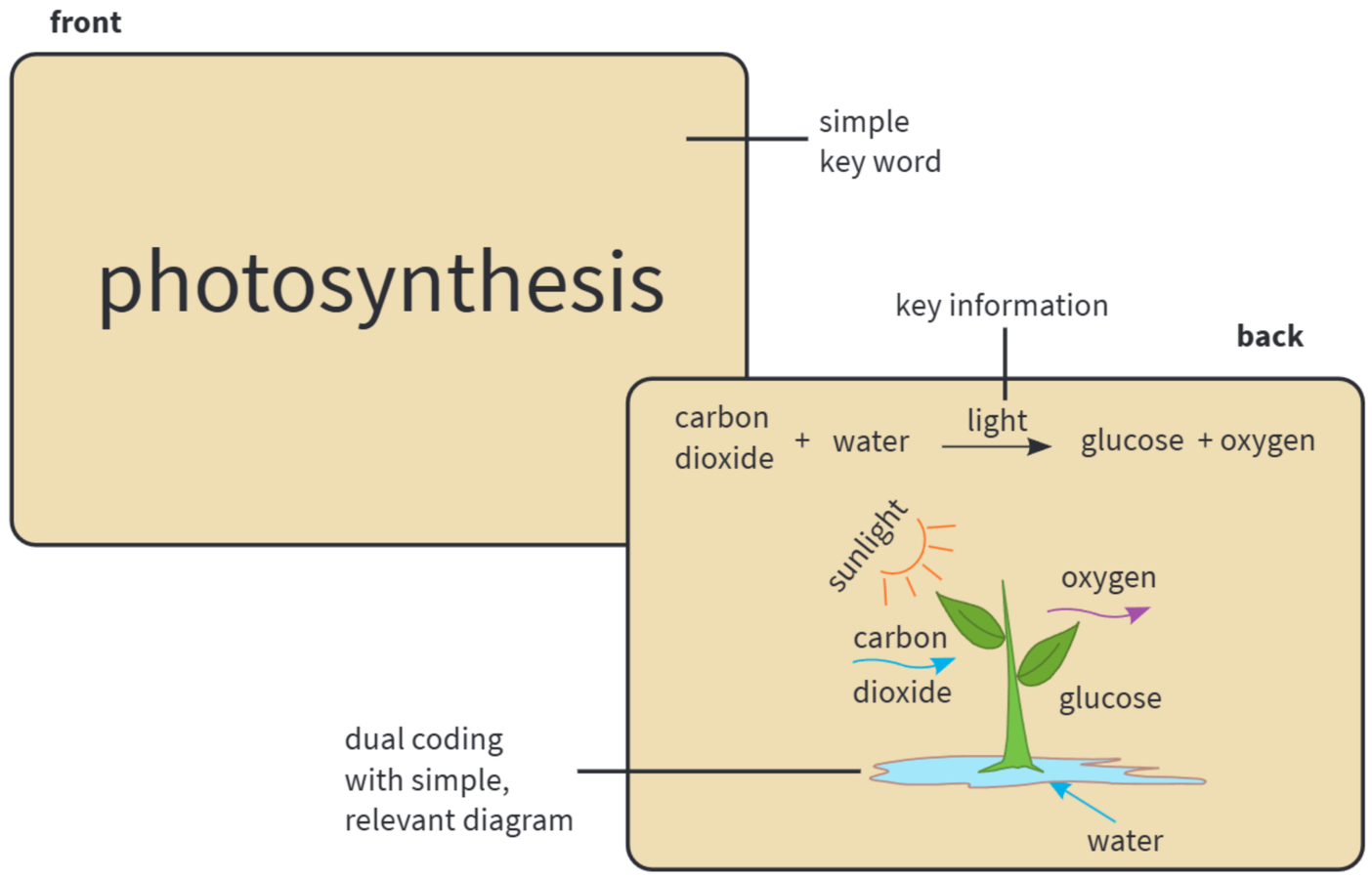
Strategy	What this looks like
Retrieval practice	This is where you try to remember as much information as possible. This could be through doing online quizzes, getting your friends to quiz you, writing everything that you know down on a mind map, or using flashcards.
Spaced practice	This is where you space out your studying over time. When you create a revision plan, it is important that you spread out your topics and have a variety of tasks to complete.
Elaboration	This is where you try to describe and explain as many details about a topic as possible. Doing this from memory also acts as a recall task.
Dual coding	This is where you combine words and visuals to help you remember information. You could use a knowledge organizer to summarize key information or use small diagrams to add alongside the definitions of key words.
Interleaving	This is where you mix up the order of the topics that you are revising. For example, if you have Topics A, B, and C, you could structure your revision over three days in the following way:

Time of day	Day 1	Day 2	Day 3
Morning	A	B	A
Aernoon	B	C	C
Evening	C	A	B

▲ **Table 1** Revision strategies and examples of how to use them.

What makes a good ashcard?

Flashcards can be used to test how much knowledge you can recall. It is important that you create them in the right way. Sometimes you will see flashcards with lots of in-depth information written on them, but this can be hard to self-quiz and remember. It is more eective to keep the information to a minimum with key facts, definitions, and diagrams.



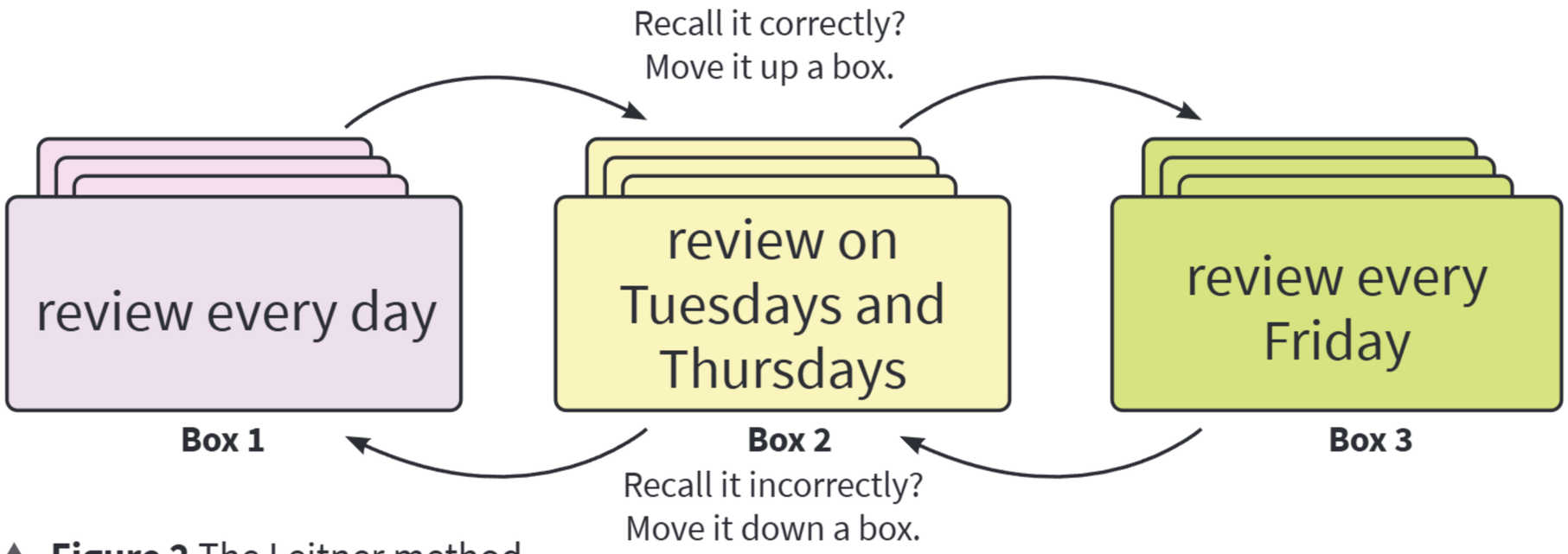
▲ **Figure 1** An example of a well-designed flashcard.

The Leitner method

Once you have made your flashcards, you can use the Leitner method. The method involves moving cards between boxes depending on whether you can recall the information correctly. In **Box 1** are the cards with the concepts you find most challenging – you should work through these every day until you are confident enough that you can move them into the next box. **Box 2** is for the cards with concepts you feel confident about, but were a little challenging to remember. **Box 3** is for the cards with concepts that you can easily recall. The aim is to move all your cards out of **Box 1**.

Talk about ...

Discuss with a partner/group what strategies you know that will help you with your revision.



▲ **Figure 2** The Leitner method.

Approaching assessments like an expert learner

Expert learners approach an assessment in a methodical and thorough way. They prepare for the assessment using eective revision techniques and have a good understanding of all the strategies that they can use during the test.

Aer the assessment, expert learners take the time to reect on their approach and evaluate their own strengths and weaknesses. This allows them to learn from their mistakes and do better next time.

Eective assessment technique

The first step in succeeding in assessments is being able to understand exam command words. These are the words that tell you how you need to answer the question.

Here are some examples of common command words:

- **Calculate –** You need to use the numbers in the question to do a calculation.
- **Describe –** You need to recall some facts, events, or processes in an accurate way.
- **Explain –** You need to say *why* a process happens. Oen an 'explain' answer will include the word 'because' in it.

The BUG method is an approach you can use to help you understand what the question is asking for. Each letter in BUG represents a dierent step in the process. You should follow this process every time.

BUG

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

Here is an example of how to use the BUG method:

Describe the similarities and differences between a plant and an animal cell.

Aer you have finished the assessment, it is important to check your answers by rereading the question and then checking what you have written. This is to make sure that you have addressed everything the question is asking of you, so that you do not miss any easy marks.

Evaluating your performance

The greatest learning gains are made when you have a good understanding of your mistakes. This allows you to improve next time and drive your own learning forward.

One way you can do this is by choosing the topics and skills from the assessment where you gained and lost marks. By doing this, you can make sure that these topics are addressed in your revision plan for your next assessment.

Table 1 suggests some questions to consider the next time you are reviewing an assessment.

Strengths	Areas for improvement
• What part of the exam was your greatest success and that you are most proud of? • What topic areas did you gain the most marks in? • What maths and working scientifically skills did you gain marks in? • Was there anything that you revised that was not in the test?	• What topic areas did you struggle with? • What topic areas did you think you did OK with but actually lost marks in? • What maths and working scientifically skills did you lose marks in? • Were there any questions where you were unsure what the question was asking?

▲ **Table 1** Useful questions for evaluating your performance in an assessment.

Talk about ...

Discuss with a partner/group what strategies you know that will help you answer an exam question.

List any questions you have tried to answer recently where some of these strategies may have been helpful. Practise answering some practice questions using one of your strategies.

Working scientifically

In this unit, you will look again at the main stages of a scientific investigation. You will start with identifying variables (things you can change or measure), producing a plan to create valid data, and performing a risk assessment.

You will practise calculating averages. You will then practise presenting data on a range of charts, including bar charts, pie charts, and histograms.

Finally, you will analyse data to draw conclusions. You will carry out evaluations to identify any sources of error and suggest improvements to your methods.

Working scientifically and you

Humans are naturally curious and wonder ‘How? Why? What?’ about the world in which we live. By learning to work scientifically, you will be able to ask scientific questions based on observations you make. You will also start to make sense of the answers you find by carrying out practical investigations and doing experiments.

Being able to work scientifically equips you with many skills. These skills will prepare you for a wide range of jobs, careers, and interests you may wish to follow in the future.

Understanding the scientific process and how to interpret data is also important for your everyday life. It can help you make important, informed choices and decisions about things like your health, lifestyle, money, and relationships.

It can also help you be more sustainable. If you know how to analyse and evaluate problems and solutions, you can find ways to repair, reuse, and recycle things as you move through the world.

Working scientifically and the world

We all have a responsibility to protect and enhance the living world, and the physical environment in which we live. The ability to think like a scientist is important to ensure that we listen to, understand, and act on scientific evidence. Together, the actions of many people make an enormous difference. They are critical in ensuring a stable, sustainable future not only for human beings but for all species on Earth.

How do scientists stay safe?

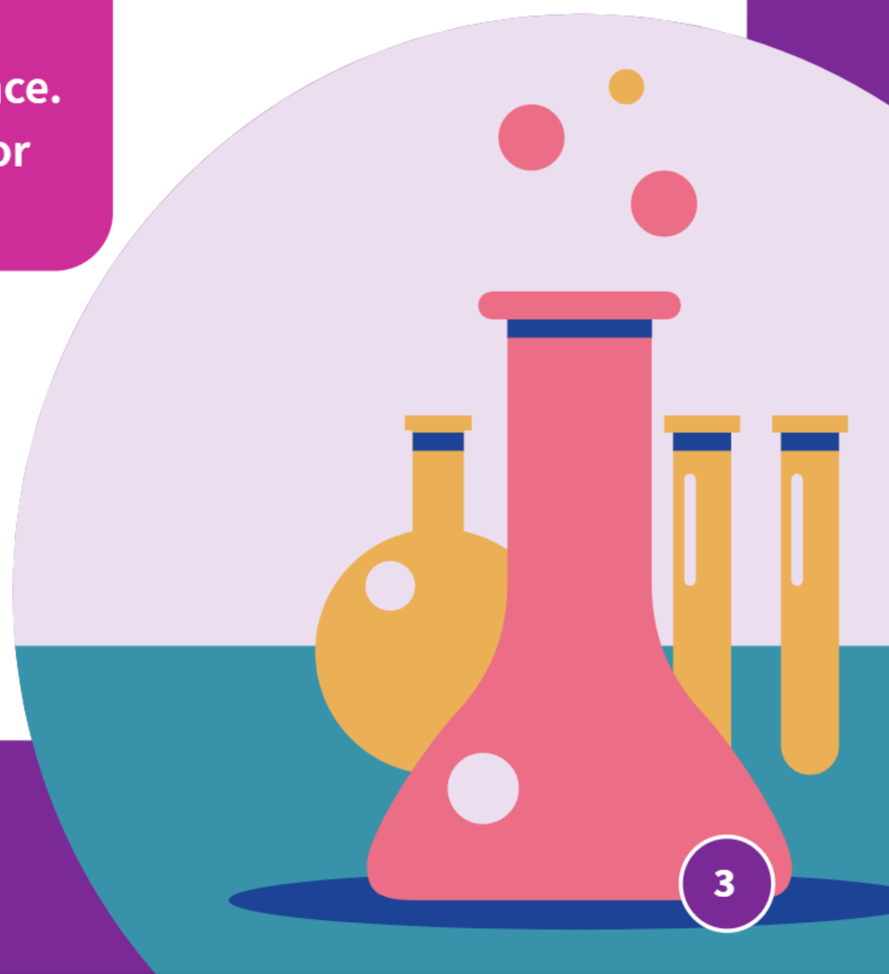
Scientists complete a risk assessment (a kind of safety review) before carrying out any scientific investigation. This identifies any hazards (things that can cause harm), and the control measures that must be followed to make sure no one is injured.

How can you trust a scientic claim?

One of the key skills of a scientist is to think critically: what is the basis for the claim, who wrote it, and why? Only when we know the answers to these questions can we make a reasoned decision on whether to believe a piece of information, or not.

Why do scientists change their mind about how things happen?

The development of new technology, carrying out different experiments, and new ways of thinking can all provide new evidence. This means that scientists might need to amend a previous idea or change their thinking.



1.1 Think back
Planning investigations

Plan

Scientific investigations are experiments where you collect **data** (**observations** or measurements) to answer a scientific question.

A scientific **plan** includes:

- the scientific question that you are trying to answer
- the independent and dependent variables
- a **prediction** or **hypothesis**
- a list of **variables** you will control, and how you will do this
- a list of the equipment you will need, sometimes including a diagram
- a step-by-step method of how you will collect your data or observations
- any safety measures you should take.

Hypothesis

Scientists back up their predictions with reasons why they think something will happen, using scientific knowledge. This is called a hypothesis.

Variables

Anything that can change during an investigation is called a variable.

- **Independent variable** – this is the variable you change.
- **Dependent variable** – this variable changes as you change the independent variable.
- **Control variables** – these are the variables you need to keep the same.

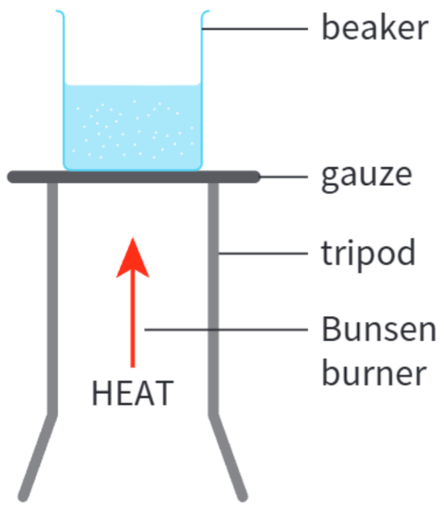
Equipment

Your equipment should be able to produce measurements or observations to help you answer your scientific question. You need to choose equipment to measure both the independent and dependent variables.

Drawing equipment

Symbols are oen used to draw standard laboratory equipment.

Using symbols helps others understand what you have drawn.



Answering a scientic question

To answer a scientific question, you should take several measurements to see a pattern or trend.

You will need to choose:

- the biggest and smallest values of the independent variable (this is called the **range**)
- the number of dierent values for the independent variable (usually five, or more)
- the interval (gap) you will use between values of the independent variable.

If possible, you should also take each measurement three times.

Risk assessments

You may need to complete a risk assessment for an investigation before you carry it out. A risk assessment usually has three sections: **hazard**, **risk**, and **control measure**.

A risk assessment will help you stay safe.

Something that could hurt you or anybody else	How you could hurt yourself	How you can reduce the risk
Hazard	**Risk**	**Control measure**
broken glass	cut yourself when clearing it up	Use a dustpan and brush, and place glass in a glass bin.

Hazard symbols

Hazard symbols warn people of dangers and help them work safely.

Oxidizing | Flammable | Corrosive

Compressed gas | Toxic | Irritant

These symbols will help you stay safe in a lab.

Accurate and precise data

It is important to collect data that is both **accurate** and **precise**.

- Accurate data is close to the true value of what you are trying to measure.
- Precise data means getting similar results if you repeat measurements.

To help ensure your data is accurate and precise, you should know how to use scientific equipment correctly, and follow the plan carefully.

Errors in data

There are two types of error in scientific data.

- **Random errors** – these are errors that vary between one result and another. They may be caused by not keeping all the control variables constant in an investigation.
- **Systematic errors** – these are a consistent set of errors in data. They are oen caused by measuring equipment that has not been calibrated (set) correctly.

Quick quiz

Question	Answer
1 What is an independent variable?	the variable you change in an investigation
2 What is a dependent variable?	the variable that changes by changing the independent variable
3 What is the meaning of a hazard?	something that can cause harm
4 What is the meaning of precise data?	data that is similar when repeating a measurement

Put paper here

Put paper here

1.2 Think back
Recording and presenting data 1

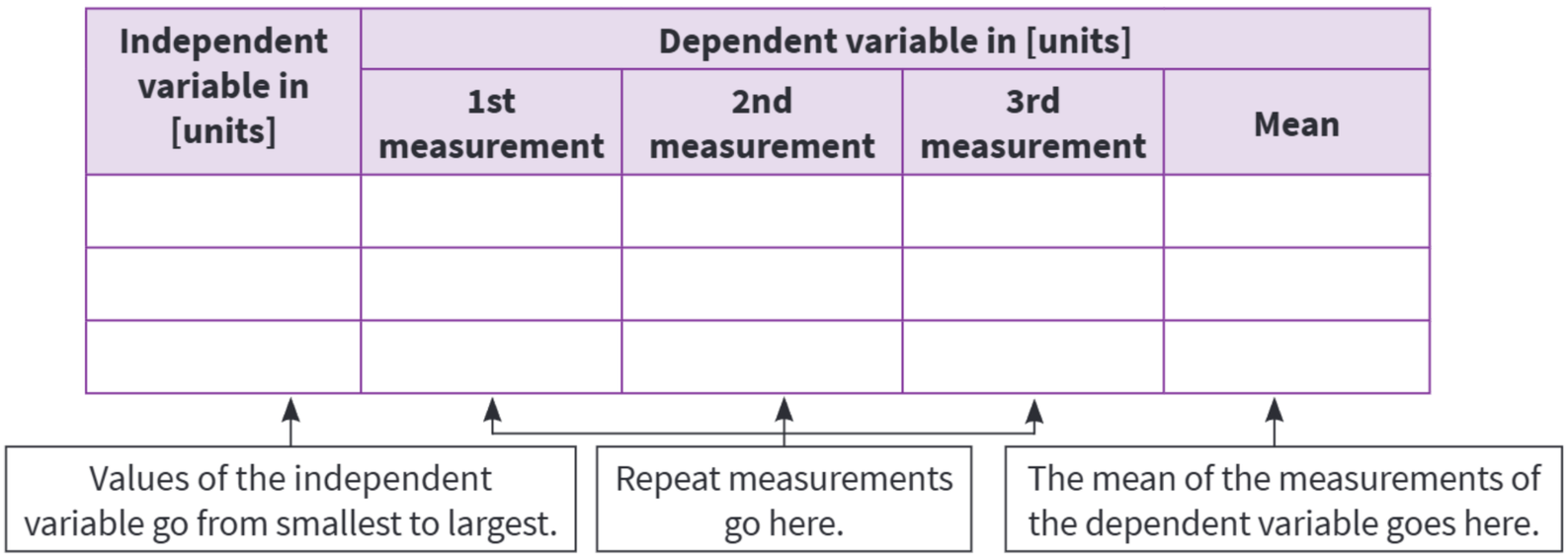
Results table

A results table helps you organize your data.

Use a results table to record what you have measured or observed.

Not all data are numbers. Sometimes you need to use words to record observations.

Results tables for repeat measurements



Repeat measurements help you check your data for anomalies. An **anomalous result** (also called an **anomaly**) is a result that is very dierent from the others when repeating a measurement. Anomalous results should not be included when calculating a mean result.

Mean average

$$\textbf{Mean (average)} = \frac{\text{result 1} + \text{result 2} + \text{result 3} + \ldots}{\text{number of results}}$$

For example, a student collects leaf length measurements of 13 cm, 14 cm, and 18 cm. The mean leaf length is:

$$\text{Mean (average)} = \frac{13 + 14 + 18}{3} = \frac{45}{3} = 15\,\text{cm}$$

Median and mode averages

Sometimes it is useful to use a dierent type of average:

- **mode** – the most common value or group in the data
- **median** – the middle value, when the data are placed in numerical order.

Types of data

The data you collect in an investigation can be:

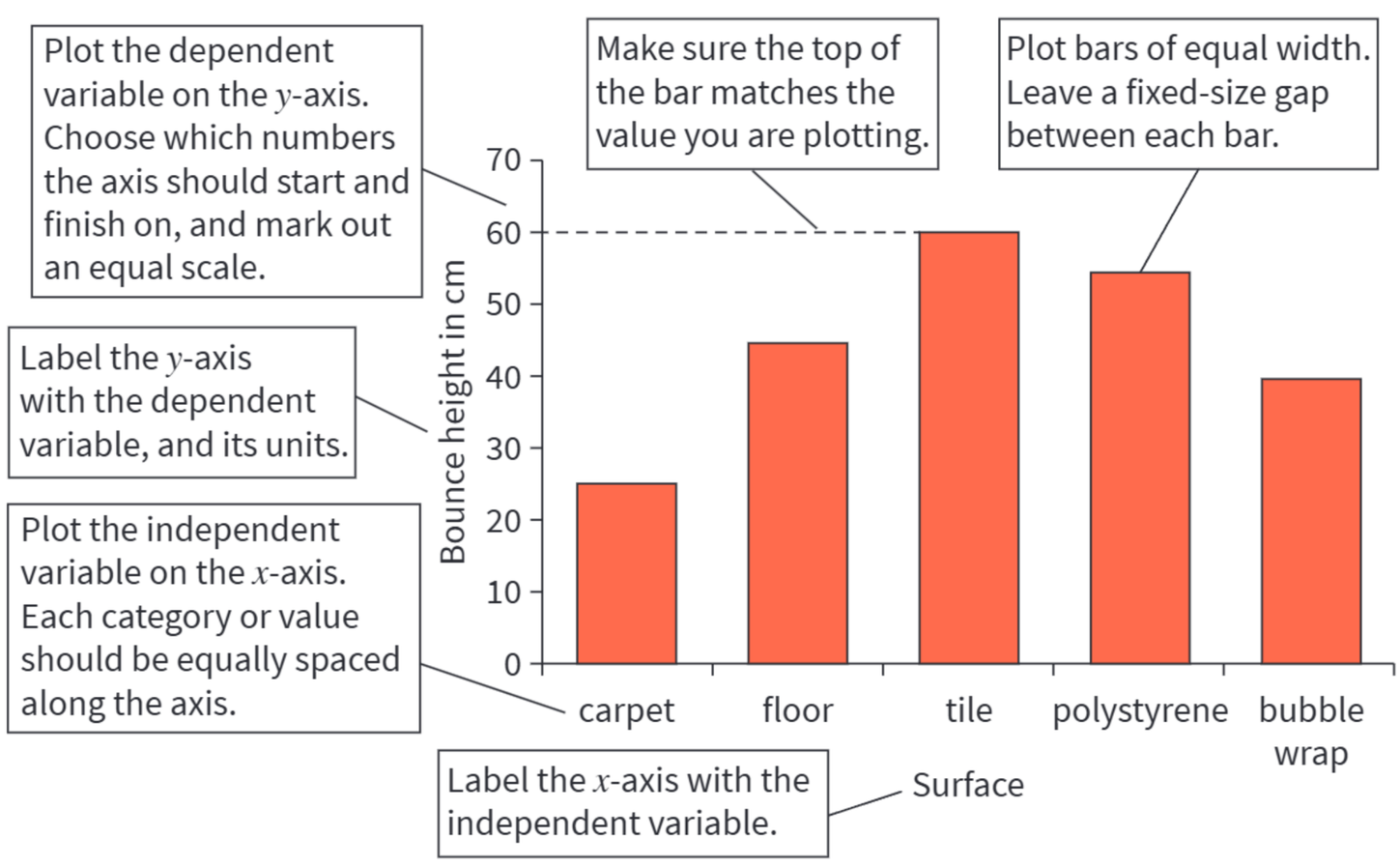
- **continuous** – the data can have any value within a range, such as temperature
- **discrete** – the data can have only whole-number values, such as shoe size
- **categorical** – the value is a word, such as 'blue'.

Choosing a chart or graph type

Dierent types of data are displayed in dierent charts:

- **bar chart** – used to plot discrete and categorical data
- **line graph** – used when both the independent and dependent variables are continuous
- **pie chart** – used to plot discrete and categorical data
- **histogram** – used to plot grouped, continuous data.

Bar chart



Bar charts are used to plot discrete and categorical data. Think about what type of data you have when choosing your chart or graph.

Quick quiz

Question	Answer
1 Which variable goes in the first column of a results table?	independent variable
2 What is an anomalous result?	a result that is very dierent from the others when repeating a measurement
3 What are the **three** types of average?	mean, mode, and median
4 What is categorical data?	data where the value is a word
5 Which variable goes on the y-axis?	dependent variable

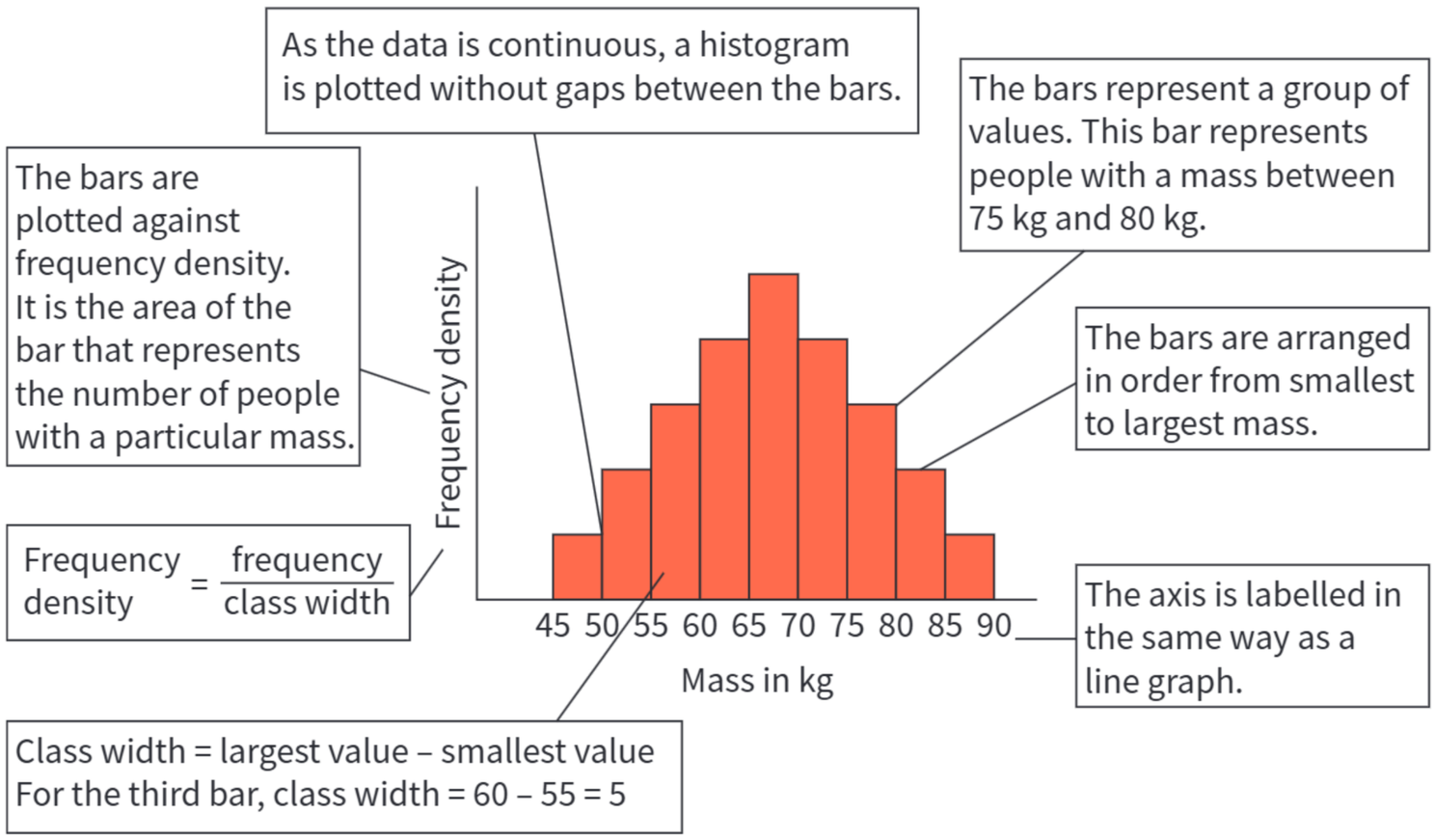
Put paper here

Put paper here

1.3 Think back
Recording and presenting data 2

Histogram

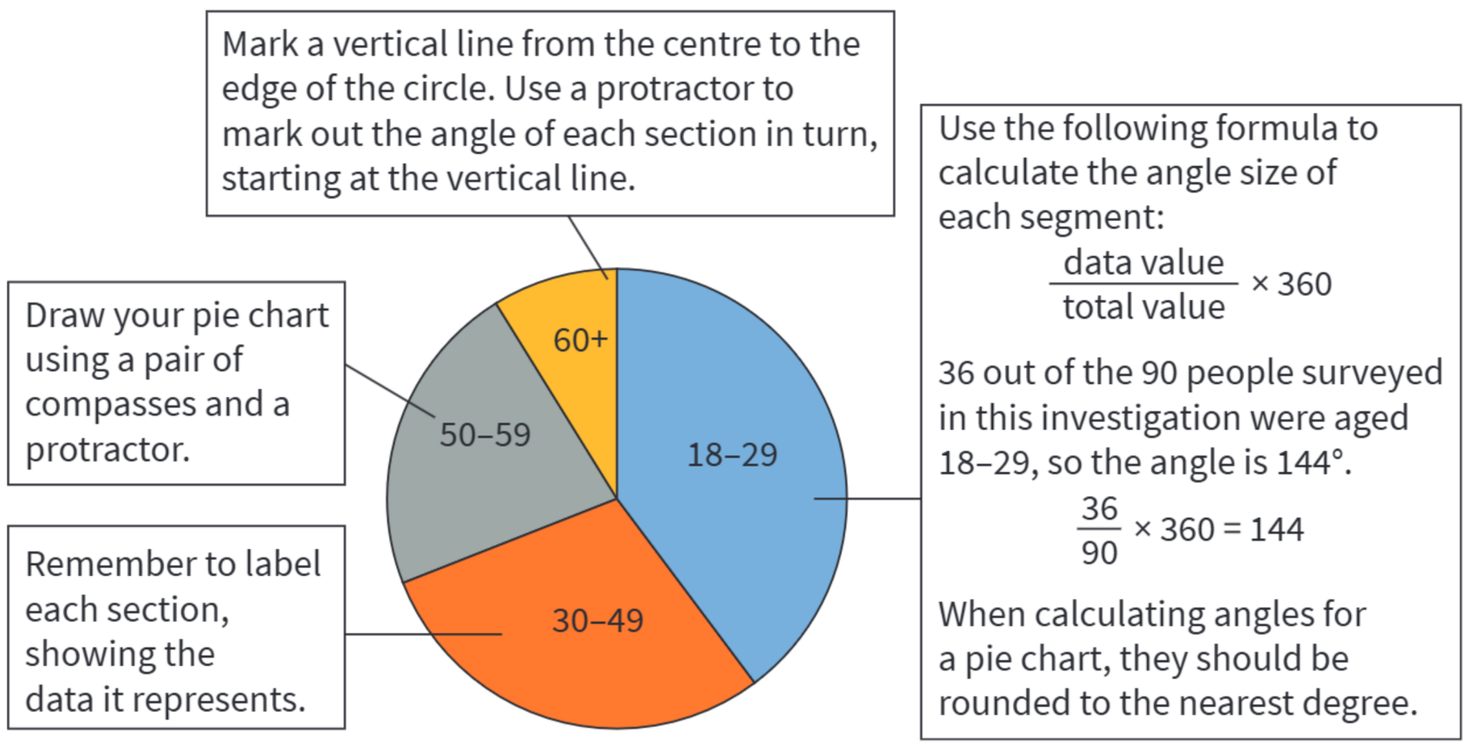
Histograms are used to show the shape of a set of data. They present continuous data in groups.



Histograms look like bar charts, but they have no gaps between the bars because the data is continuous.

Pie chart

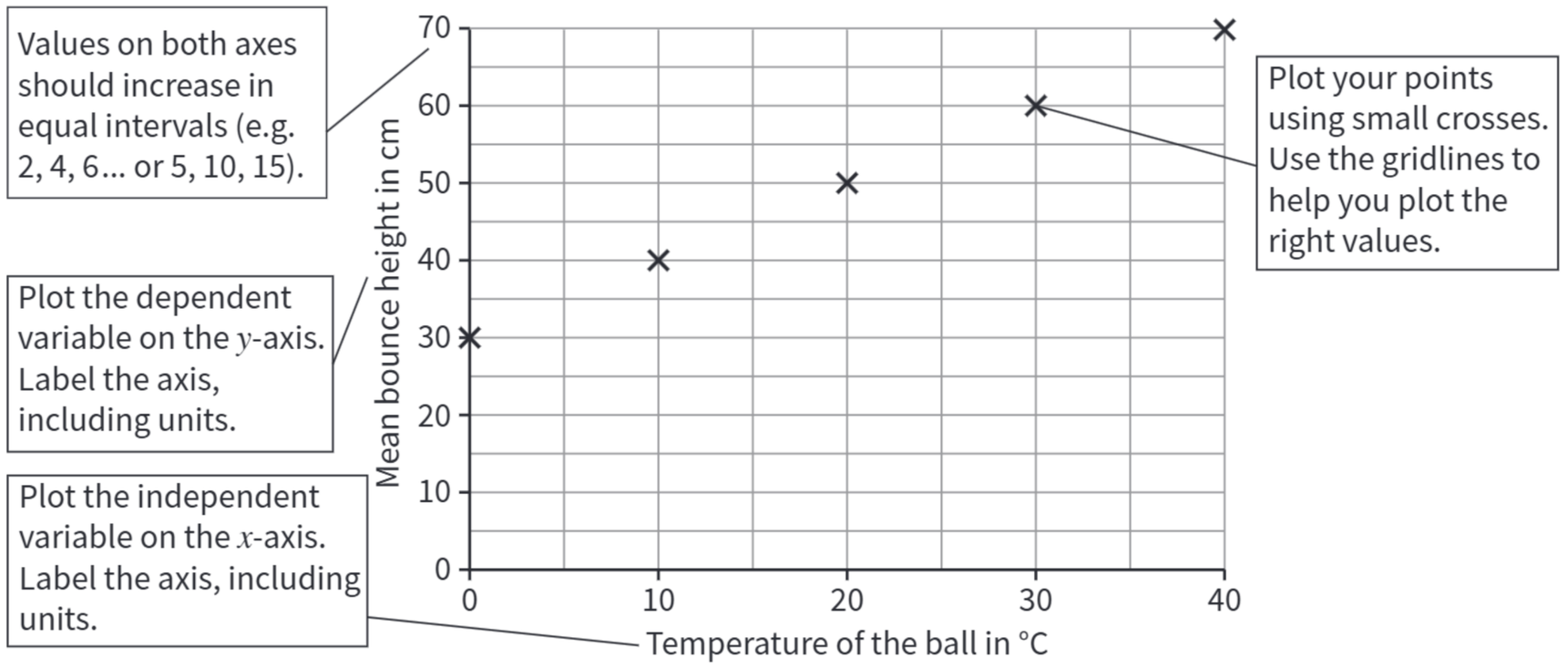
Pie charts are used to plot discrete and categorical data. The segments in the circle represent data.



Pie charts can help show how a group of samples is divided up.

Line graph

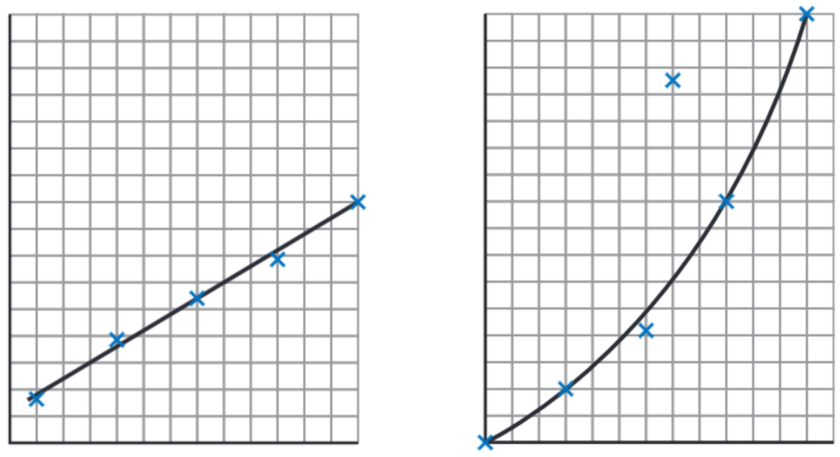
Line graphs are used when both the independent and dependent variables are continuous.



Line graphs can show trends in your results.

Line of best t

To make the trend easier to see on a graph, add a **line of best t** . This is a straight line or a smooth curve that goes through, or very close to, as many points as possible.



Quick quiz

Question	Answer
1 What data is displayed in a histogram?	grouped, continuous data
2 Which variable is plotted on the x-axis of a graph?	independent variable
3 How do you calculate the angle of a pie chart segment?	divide segment value by total value, then multiply by 360
4 What is a line of best fit?	a smooth line that goes through, or close to, as many points as possible, showing the trend
5 How do you calculate frequency density?	frequency divided by class width
6 What should you include on a graph axis?	name of variable, units, appropriate scale

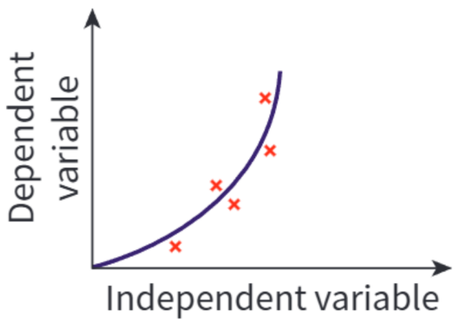
Put paper here

Put paper here

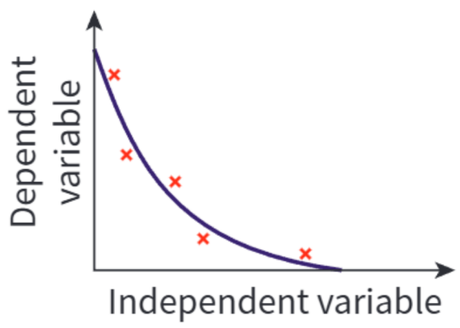
1.4 Think back
Analysing and evaluating data

Trends

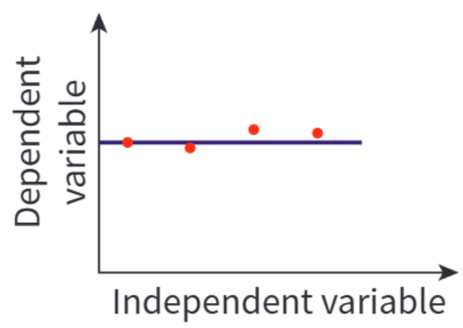
The line of best fit tells you about the **trend** in the data.



If the line slopes up (straight or curved), it means that as the independent variable increases, the dependent variable increases too.



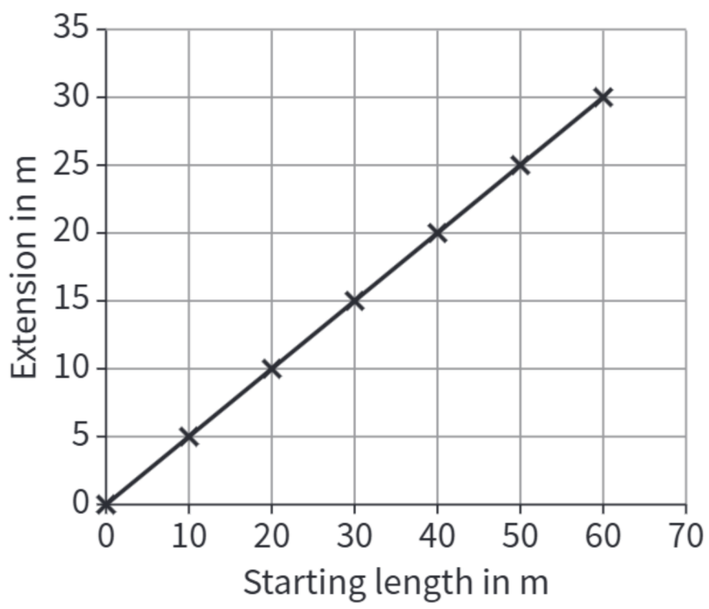
If the line slopes down, (straight or curved), it means that as the independent variable increases, the dependent variable decreases.



If the line is horizontal, it means that as the independent variable increases, the dependent variable does not change.

Linear relationships

Straight-line graphs show **linear relationships**. This is where an increase in the independent variable causes the dependent variable to increase or decrease at a constant rate.



A straight-line graph that passes through the origin is a special type of linear relationship, called a **directly proportional** relationship. In a directly proportional relationship, doubling the independent variable doubles the dependent variable.

Conclusions

A **conclusion** outlines what you have found out in an investigation. You should:

1. start by describing the pattern in your data, or the relationship you can see between the two variables from your graph or chart
2. where possible, use scientific knowledge to explain the pattern or trend
3. compare your results with your prediction.

Evaluations

Writing an **evaluation** is the final step in an investigation. You should:

1. identify the strengths and weaknesses in your results
2. decide how confident you are in your conclusion
3. suggest and explain improvements to your method, so you can collect data of better quality if you do the investigation again.

Strengths and weaknesses

To identify strengths and weaknesses:

1. identify anomalies
2. look at the **spread** of data – the spread is the dierence between the highest and the lowest readings in a set of repeat measurements
3. check for errors.

Condence in a conclusion

You can be confident in your data if:

- there are few anomalies. This means your data was unlikely to contain errors.
- there is a small spread in the data, so your method is **repeatable**.

You could also look at **secondary data** – data that someone else has collected.

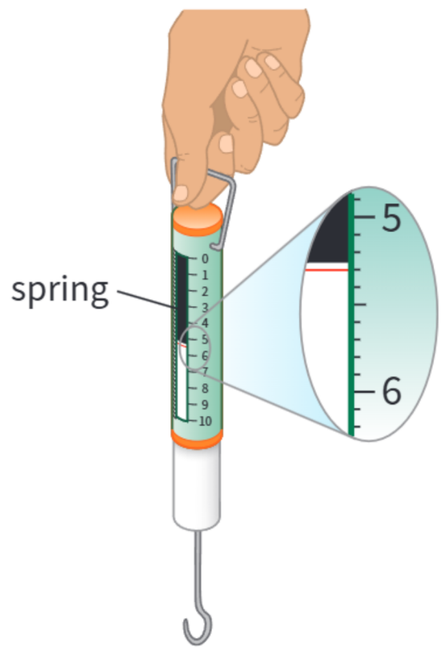
Peer review

For the results of an investigation to be accepted as scientific evidence, it must be **peer reviewed**. The data and conclusions are checked by other scientists working in the same field.

Types of error

A random error is where an unexpected change aects your results, such as the temperature of the room changing because someone opens a door.

A systematic error is where something consistently aects all of your results. These are oen caused by faulty equipment, such as a newton meter showing a reading without a load attached.



Check equipment is working as expected before using it.

Improvements

You can improve an investigation in **three** ways.

1. Use a bigger range of results. This means using larger or smaller values of the independent variable. The wider the range, the more certain you can be that your conclusion is always true.
2. Take more repeat measurements. You should always take at least three repeat measurements for each value of the independent variable.
3. Use dierent equipment. If you had anomalies, or a large spread of data, you could use dierent equipment to collect your measurements.

Quick quiz

Question	Answer
1 What type of graph shows a linear relationship?	a straight-line graph
2 What is a conclusion?	a description of what you found out
3 What causes a random error?	an unexpected change in conditions
4 What is secondary data?	data that has been collected by someone else

Put paper here

Put paper here