Oxford International Resources

Revised Edition

8

Science

Student Book

Lower Secondary

OXFORD

Oxford International Resources

8

Science

Student Book

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Contents

Chemistry

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How to use this book

Each topic begins with a set of learning objectives. 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 second question builds on what you have learned.

Stretch zone

3 The third question moves you into the 'stretch zone'. This means you will need to think more deeply about scientific concepts. It is OK if you find this question difficult – doing challenging work is the exercise that your brain needs.

Welcome to your Student Book

This introduction shows you all the different features *Oxford International Science* has to support you on your journey through Lower Secondary Science.

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 answer.

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

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

Working scientifically

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

Scientists use maths to help them solve problems and carry out their investigations. These boxes contain activities and tips to help you practise the maths you need for scientific purposes.

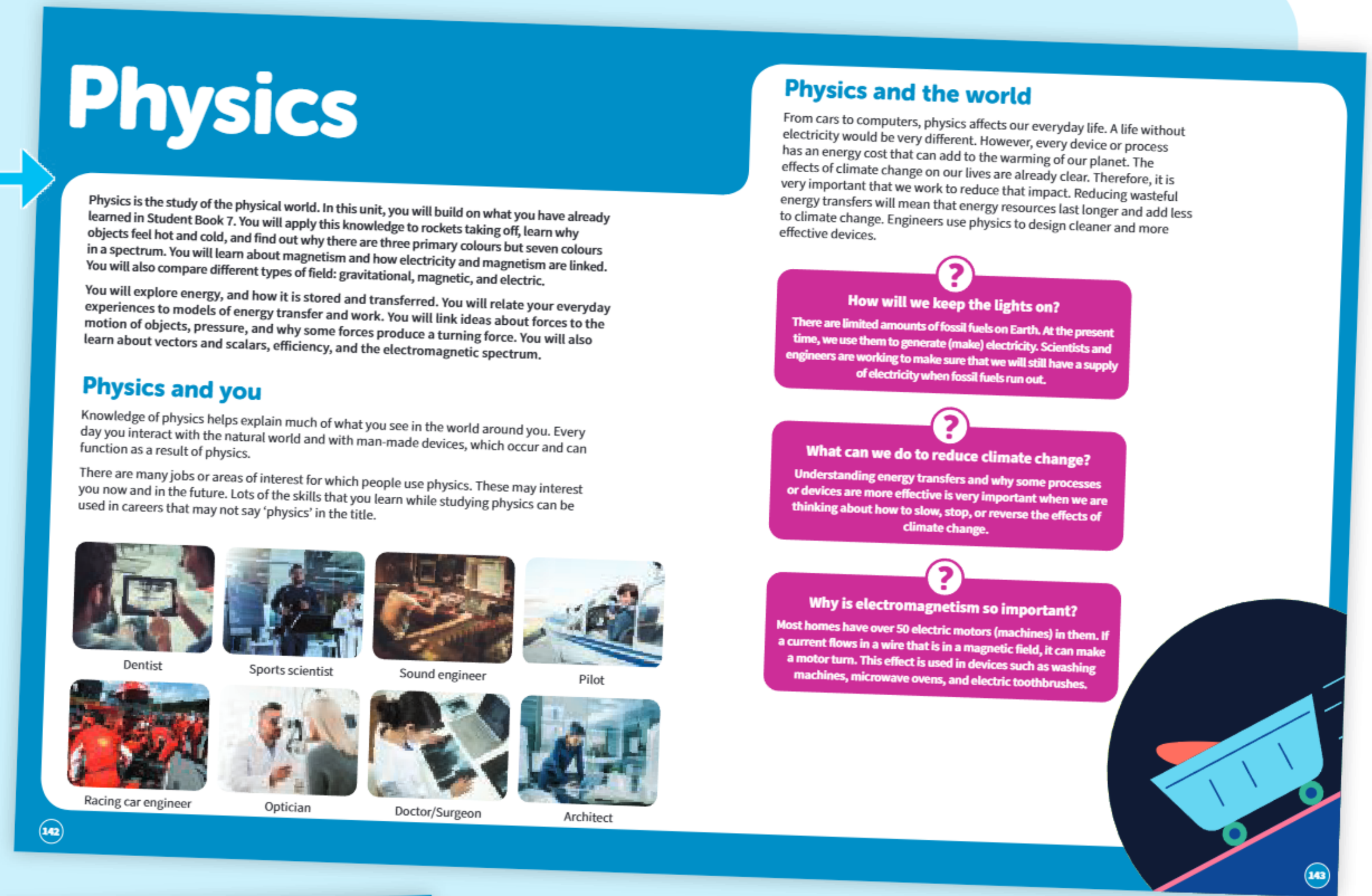
Literacy skills

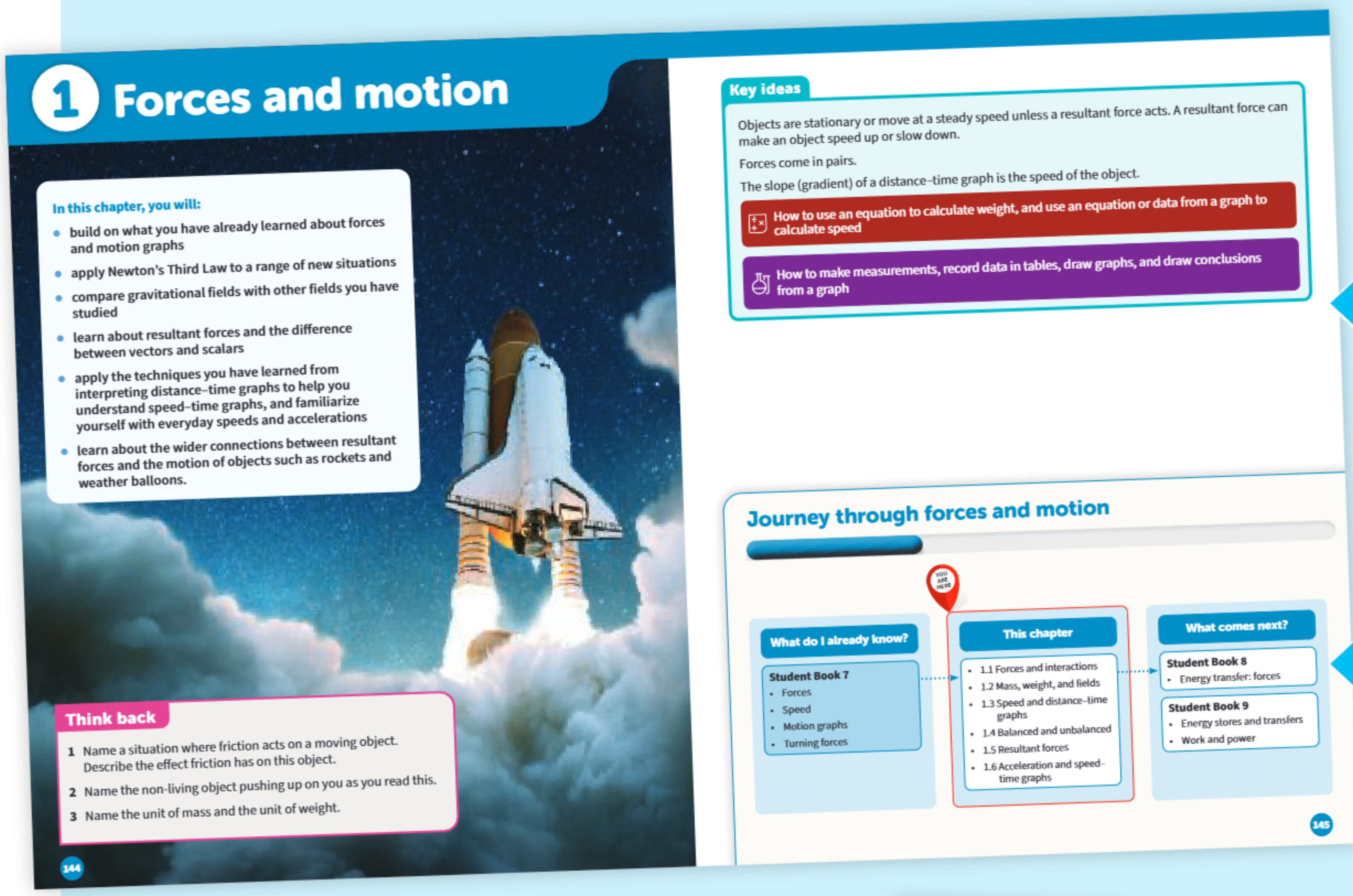
Scientists need to be able to communicate and share their ideas. These boxes contain activities and tips to help develop your reading, writing, listening, and speaking skills.

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.





Chapter opener

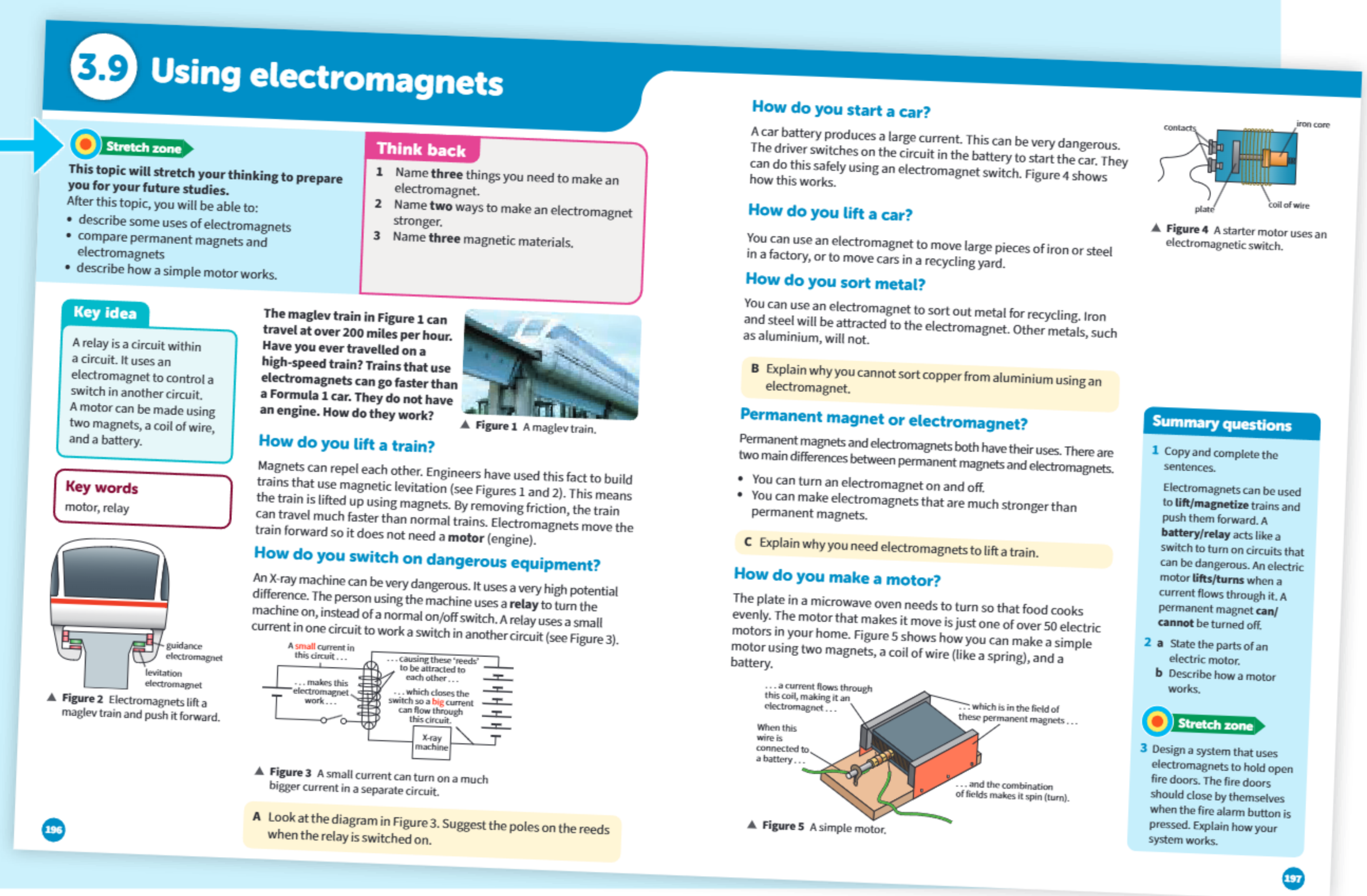
Each chapter begins with an introduction. This reminds you what you already know and shows you what is coming up in the chapter. It also shows you the Working scientifically and Maths skills that you will learn.

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.



Strategies for effective learning

Throughout your time in school, your teachers will teach you different strategies to help you be an effective learner. Sometimes these strategies are useful for specific subject skills, and sometimes they are useful for independent learning. To be an effective learner, it is important that you have a good understanding of <u>what</u> strategies you have available, <u>how</u> you should use them, and <u>why</u> they are useful.

The EVERY method for calculations

What: The EVERY method is an approach you can use to do calculations in science. Each letter in EVERY represents a different step in the process. You should follow this process every time.

EVERY

Equations
Values
Enter values
Rearrange
Your answer and units

How: You can use the EVERY method any time you need to do a calculation in science.

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

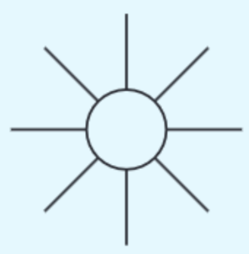
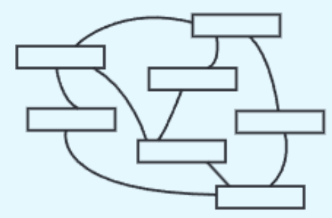
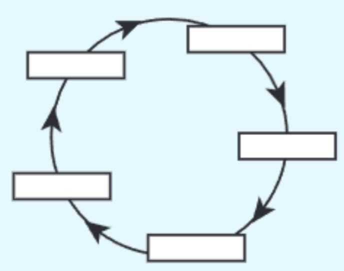
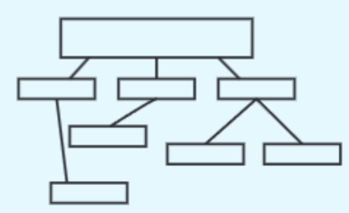
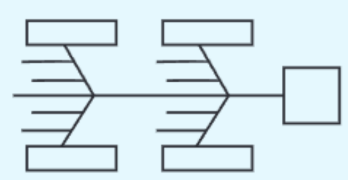
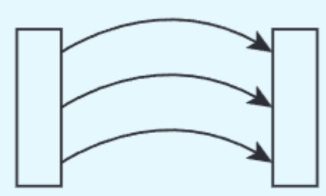
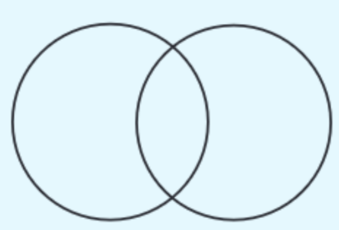
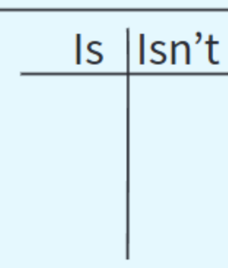
A bike is travelling at 5 m/s for 100 s. Calculate the <u>distance</u> the bike has travelled.

E	s = d ÷ t
V	s = 5 m/s d = ? t = 100 s
E	5 m/s = d ÷ 100 s
R	(×100 s) 5 m/s = d ÷ 100 s (×100 s)
	(×100 s) 5 m/s = d ÷ ~~100 s (×100 s)~~
	d = 5 m/s × 100 s
Y	d = 500 m

Why: Students often find calculations challenging in science. This strategy is something you can use to make it easier. Remember that putting units next to your numbers helps you check that your calculation is correct. Following this method will also be helpful in exams because it is common to receive marks for showing your working.

Graphic organizers

What: A graphic organizer is a great way to turn key ideas into simple visual summaries. They are particularly useful for showing the stages in a process, or the links between key ideas. **Table 1** shows examples of graphic organizers and their uses.

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

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

How: You first need to decide which graphic organizer is best. Once you have done this, you need to identify the key words, equations, and ideas from your chosen topic. It is important to remember that this needs to be a simple and clear summary. Don't write lots of information on it. Finally, start to fill in your graphic organizer.

Why: Although a completed graphic organizer is useful for revising for a test, the process of filling one in is beneficial too. By thinking carefully about what information to include, you are reviewing the content, making links between everything you have learned, evaluating what information is necessary, and summarizing it. All of these are very important skills that an effective learner has.

Talk about ...

Discuss with a partner what type of graphic organizer you can use to compare:

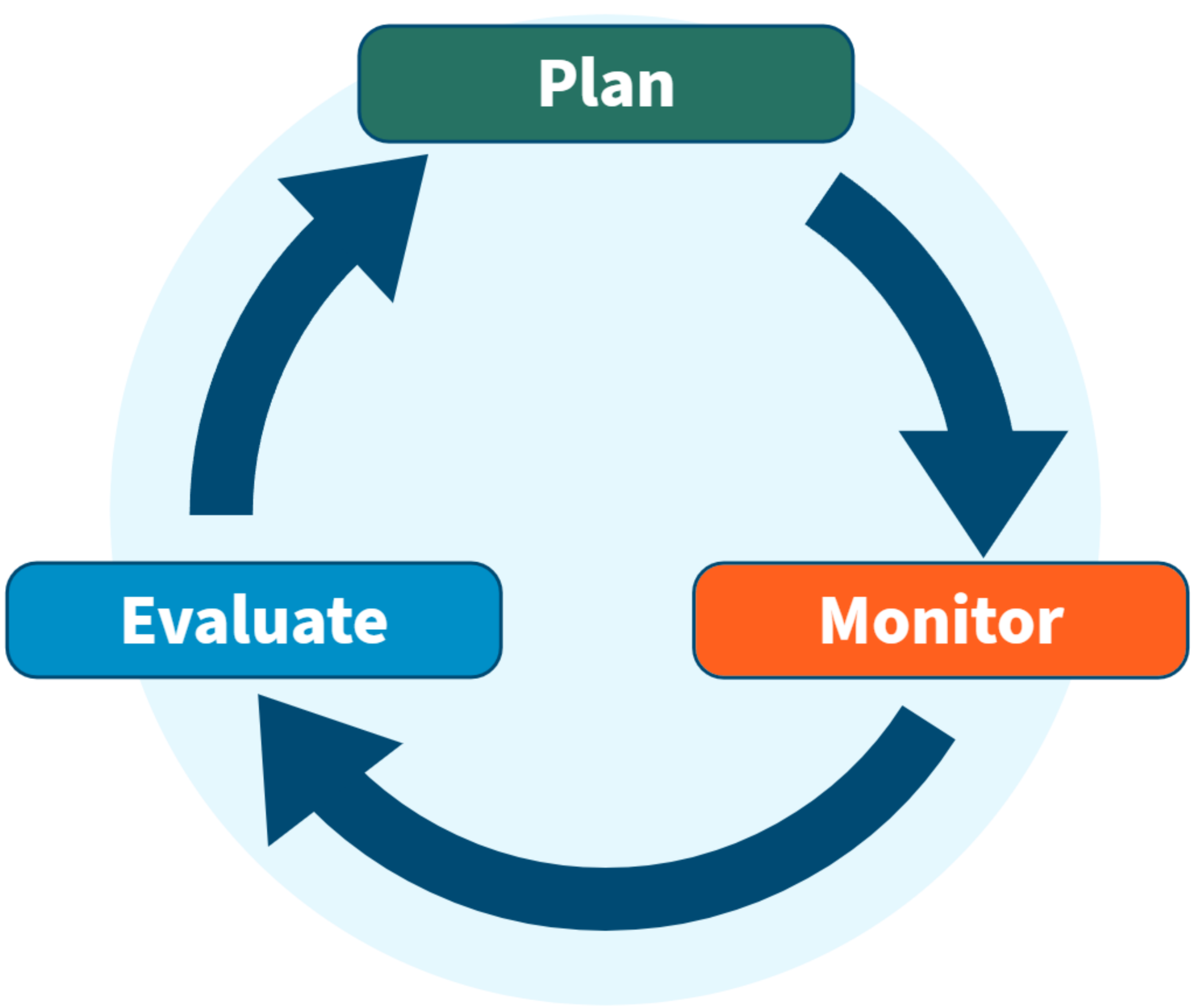
- the features of a plant cell and an animal cell
- the relative sizes of the organisms in an ecosystem.

Using strategies effectively

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

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

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



Talk about ...

Discuss with a partner your answers to these questions:

- How should you plan your approach to a question?
- What are some examples of monitoring your progress?
- Why is the evaluation phase important?

Plan

Before you start a new task, whether it is revision at home or a science question in class, you need to plan your approach. This includes deciding what scientific content needs to be included, choosing an appropriate strategy to use, and then checking previous work to see what success looks like.

What does this look like in practice?

When completing revision, it may be appropriate to summarize a process using a graphic organizer. Before you start, plan your approach by reflecting on the different types of graphic organizer and seeing which one suits the process you need to summarize. Next, remind yourself of the last time you created a graphic organizer and see what success looks like. Finally, carefully review your notes to identify what information you need to include.

Monitor

Monitoring your progress is when you pause and check again that your chosen strategy is correct, and that you are including everything that is needed. Sometimes you may need to stop and change your approach.

What does this look like in practice?

When using the **EVERY** method to do a calculation, pause and re-read the question to check the values given. Make sure you have put the values in the right place in the equation. Remember to check that you have converted the units correctly before carrying on and finishing the question.

Evaluate

When you have completed the task, you need to evaluate how you have done. During this phase, look at what you have done, and decide what was successful and what you could improve next time. Then make a brief plan of what you would change if you were to carry out the task again.

What does this look like in practice?

When you have completed an extended answer, and your teacher has marked your work, evaluate your performance. To do this, look at what you have done correctly and what areas you need to improve. After this, note down what you would do differently next time. This is very useful – it will help you plan your approach the next time you complete a similar task.

Working scientifically

In this unit, you will look further at planning investigations, making sure that data is precise and reproducible. You will also produce risk assessments so that you and others around you are safe.

You will analyse data in more detail, exploring the different types of relationship that exist between variables. You will use secondary data to improve the confidence in your conclusions. You will also begin to analyse sources to check for their reliability.

You will study how our understanding of science develops over time, the importance of the peer-review process in research, and how scientists communicate information with different audiences.

Working scientifically and you

Scientists work in lots of different fields. You can find them in universities, hospitals, and the government. No matter what career a scientist chooses, their goal is to add knowledge and understanding to the wider scientific community, to support future discoveries, and to help ignite interest and enthusiasm in the next generation of scientists – you!

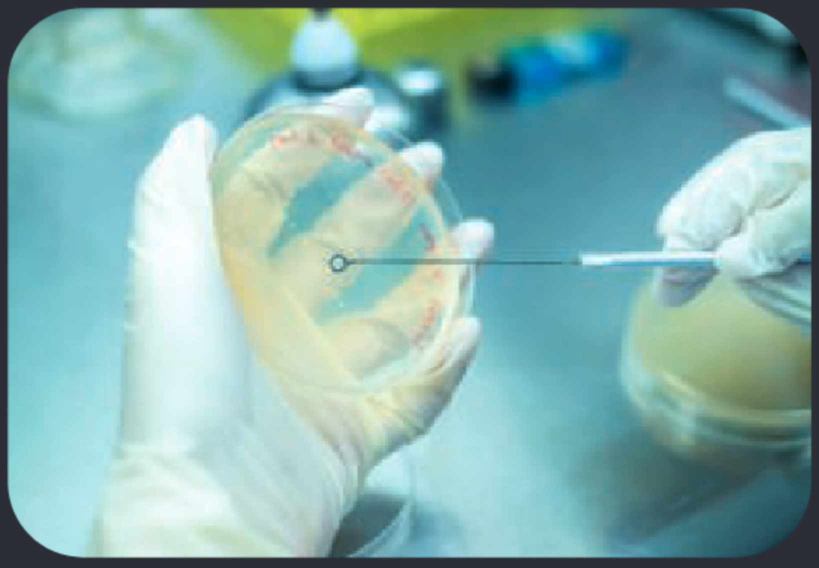
Being able to work scientifically provides you with many skills. It also prepares you for a wide range of jobs, careers, and interests you may wish to follow in the future.


Engineer


Meteorologist


Astronaut


Nutritionist


Microbiologist


Geologist

Working scientifically and the world

We all have a responsibility to protect and strengthen the living world, and the physical environment in which we live. The ability to think like a scientist is important to make sure that we all listen to scientific evidence – for example, about climate change – and understand what it is telling us. We must then act in a way which is best for the planet. Together, the actions of many people make an enormous difference. These actions are critical in providing a stable, sustainable future not only for human beings, but for all species on Earth.

How do scientists stay safe?

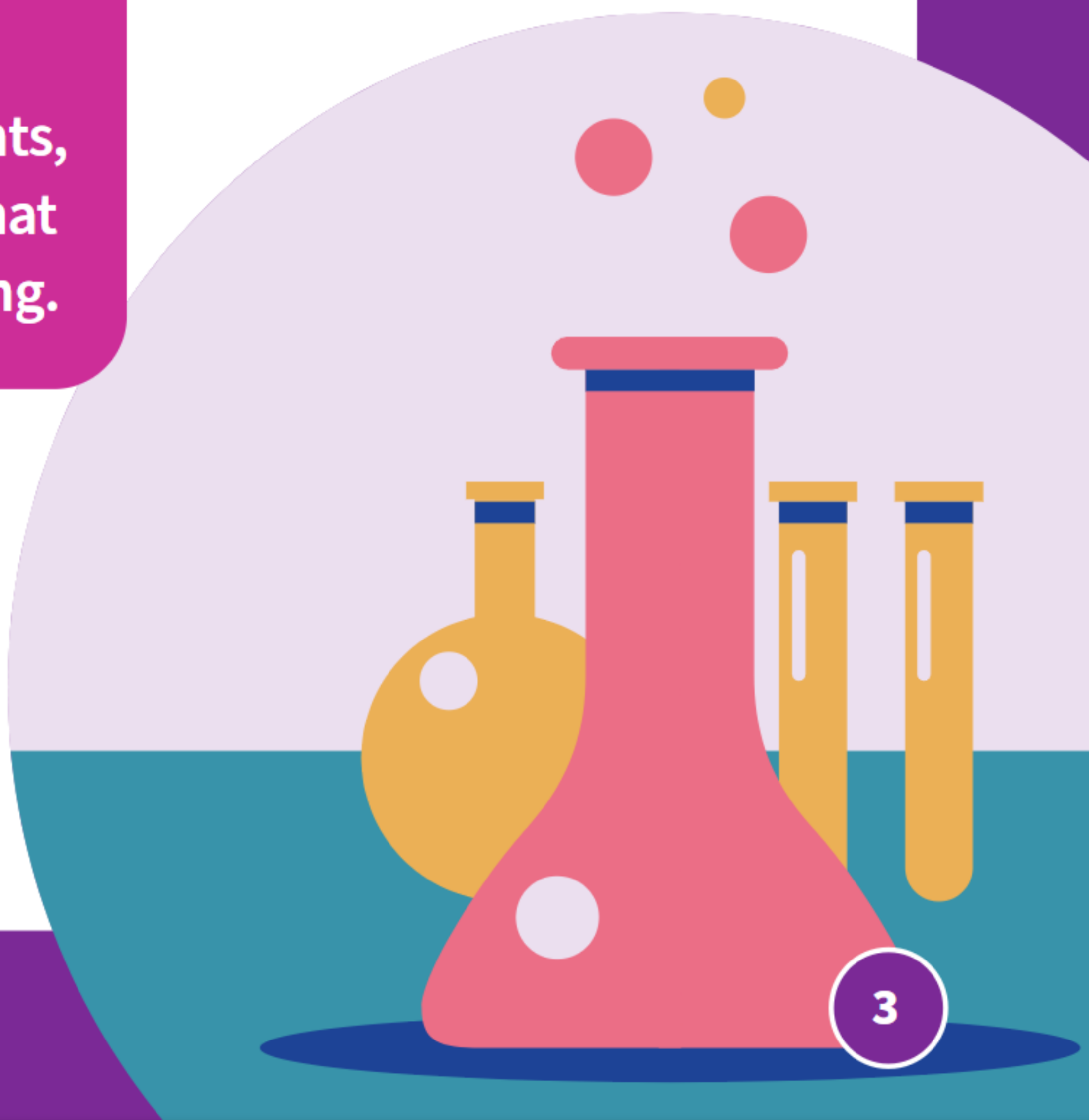
Scientists complete a risk assessment (a kind of safety review) before carrying out any scientific investigation. This identifies any hazards (something that can cause harm), and the control measures that must be followed to make sure no one is injured.

How can you trust a scientific 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 minds 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 Planning investigations

After this topic, you will be able to:
- write a hypothesis for a scientific investigation
- describe the difference between precise and accurate data
- write a risk assessment for a scientific investigation.

Think back

1 What is a prediction?
2 What information helps you stay safe during an investigation?
3 What is accurate data?

Key idea

To plan an investigation well, you must come up with a hypothesis, think about how to collect accurate and precise data, and write a risk assessment.

Key words

prediction, hypothesis, independent variable, dependent variable, accurate, precise, spread, repeatable, reproducible, hazard, risk, control measure

▲ **Figure 1** Scientists collect data about bungee ropes. This information is then used each time a person jumps.

The person in Figure 1 is bungee jumping. This activity gives people a huge adrenaline rush as they fall through the air, but is it safe?

A detailed risk assessment must be completed. This makes sure all risks are reduced. You also need to write a risk assessment for a scientific investigation. This step comes after coming up with a hypothesis and a way of collecting accurate and precise data.

What is a hypothesis?

You should be used to making **predictions** about your investigations. Scientists back up their predictions with reasons why they think something will happen, using scientific knowledge. This is known as a **hypothesis**.

Katie and Rahim decide to investigate the link between the thickness of a piece of elastic and how much it stretches. Their hypothesis is:

The thicker the piece of elastic, the lower the extension will be when a force is applied. This is because a thicker piece of elastic contains more bonds. These bonds all need to be stretched to make the elastic get longer.

▲ **Figure 2** Katie and Rahim discuss their hypothesis.

They make a list of variables. In their plan, they:

- identify the **independent variable** – the thickness of the elastic
- identify the **dependent variable** – the extension of the elastic
- identify all the variables they need to control, and say how they will control them.

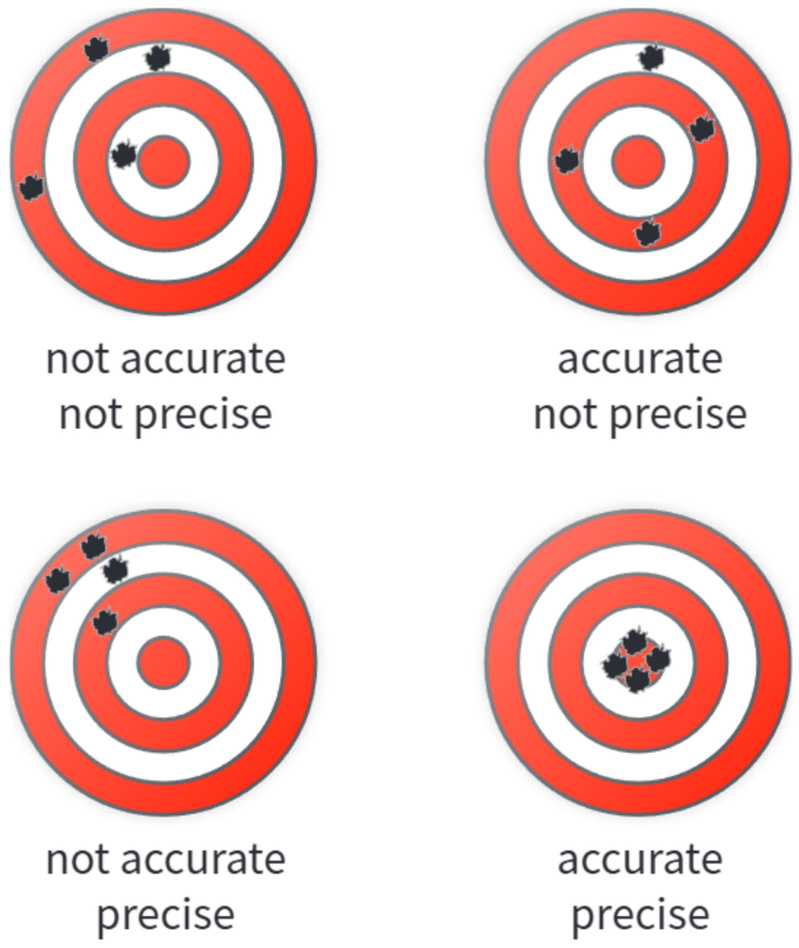
A Write down **one** variable Katie and Rahim need to control.

Collecting accurate and precise data

It is important to collect data that is both **accurate** and **precise**. Figure 3 illustrates the meaning of these words. Accurate data is close to the true value of what you are trying to measure. This means you have taken steps to reduce the effect of random and systematic errors. Precise data means getting similar results if you repeat a measurement. This means that precise data has a very small **spread**.

If Katie and Rahim repeat their investigation several times, their data should be similar. The data is then said to be **repeatable**. Therefore, repeatable data is also referred to as being precise.

Sometimes the same experiment is repeated by other students, or by using a different method or equipment. If these experiments produce similar data, the data is said to be **reproducible**.



▲ **Figure 3** Be aware that sometimes readings can be precise but not accurate. These are often the most misleading.

Writing a risk assessment

You may need to complete a risk assessment for an investigation before you carry it out. A risk assessment usually consists of three sections: **hazard**, **risk**, and **control measure**. Figure 4 shows an example of a risk assessment.

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

▲ **Figure 4** A risk assessment table.

B State a risk associated with using a lit Bunsen burner.

Summary questions

1 Match the words to the definitions.

accurate data	the chance someone could be hurt
precise data	close to the true value
hazard	repeat measurements with a small spread
risk	something that could hurt you or anybody else

2 Describe the difference between repeatable data and reproducible data.

Stretch zone

3 A group of students heat a beaker of water up to boiling point. Complete a risk assessment for this investigation. Identify **two** hazards.

1.2 Presenting data

After this topic, you will be able to:
- select an appropriate graph to display data
- present data as a pie chart or a histogram
- calculate the mean, mode, and median of a set of data.

Think back

1 What is continuous data?
2 What is discrete data?
3 What are some different ways data can be presented?

Key idea

You can present your data in a bar chart or a pie chart (discrete or categorical), or in a line graph or a histogram (continuous). Scientists often calculate the average of a data set. Types of average include mean, mode, and median.

Key words

discrete, categorical, bar chart, pie chart, continuous, line graph, histogram, mean, mode, median

▲ **Figure 1** Data can be presented in a number of different ways.

Scientists use graphs and charts to share information. How do they know which type of chart to use?

Which chart should you choose?

The chart you decide to use depends on the type of data you have collected. If you have **discrete** or **categorical** data, you should choose a **bar chart** or a **pie chart**. If you have **continuous** data, you should plot a **line graph** or a **histogram**.

A State the type of chart you would use to display the method of transport students use to get to school.

Plotting a pie chart

Pie charts show percentages, or proportions, of a total. The whole pie chart represents 100%. It is then divided into sections to represent the data values. To work out the size of each section, you must:

1 calculate the total of the values to be plotted

2 calculate the angle of each section of the pie chart using the below formula.

$$\frac{\text{data value}}{\text{total value}} \times 360$$

Katie and Rahim collected data on the ages of 90 people who completed a bungee jump. Figure 2 shows their results in a pie chart.

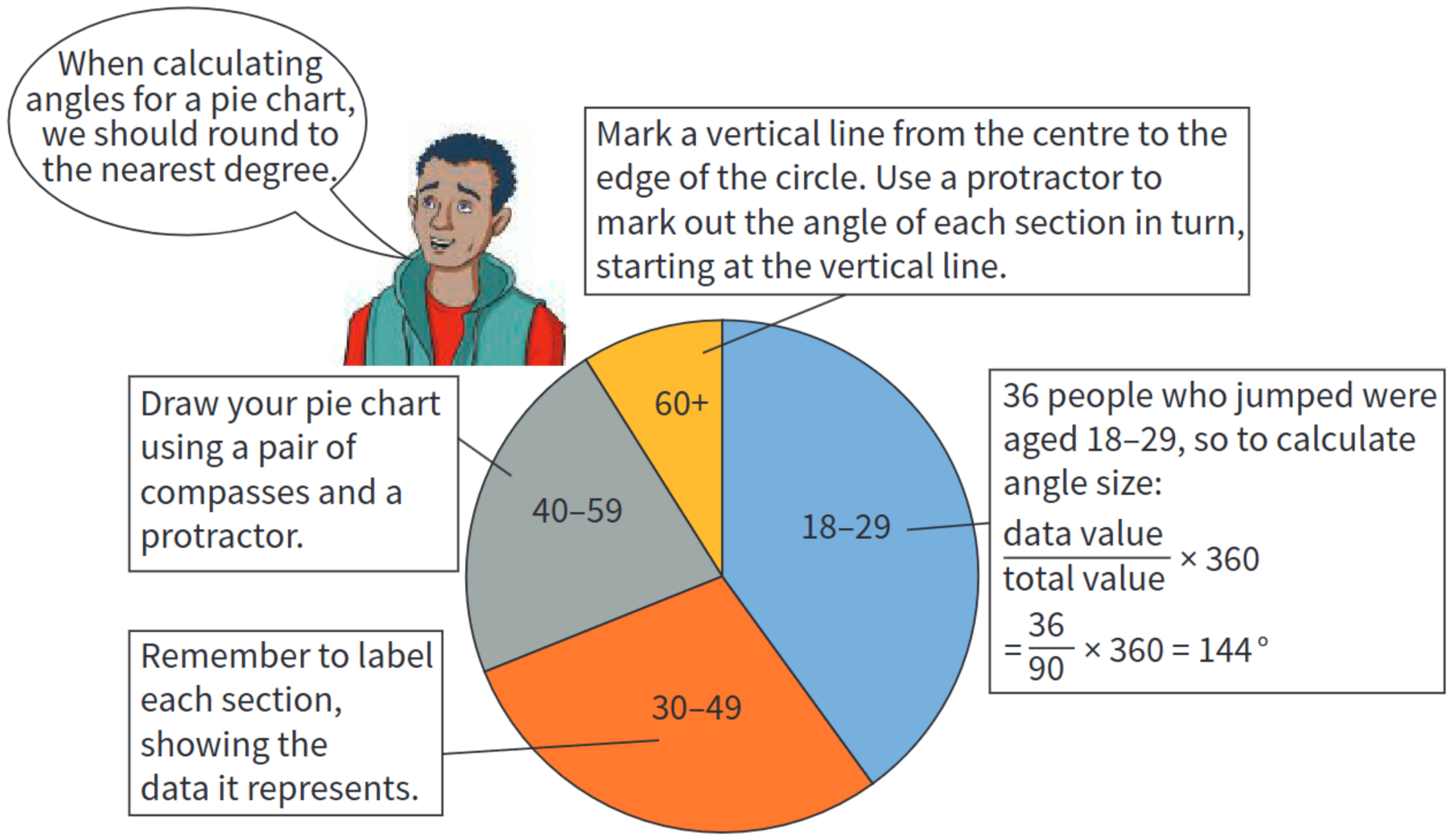
B State which age range contained the fewest bungee jumpers.

Maths skills

A group of five students scored the following marks on their biology test:

17 11 14 17 16

Calculate the mean, mode, and median scores.

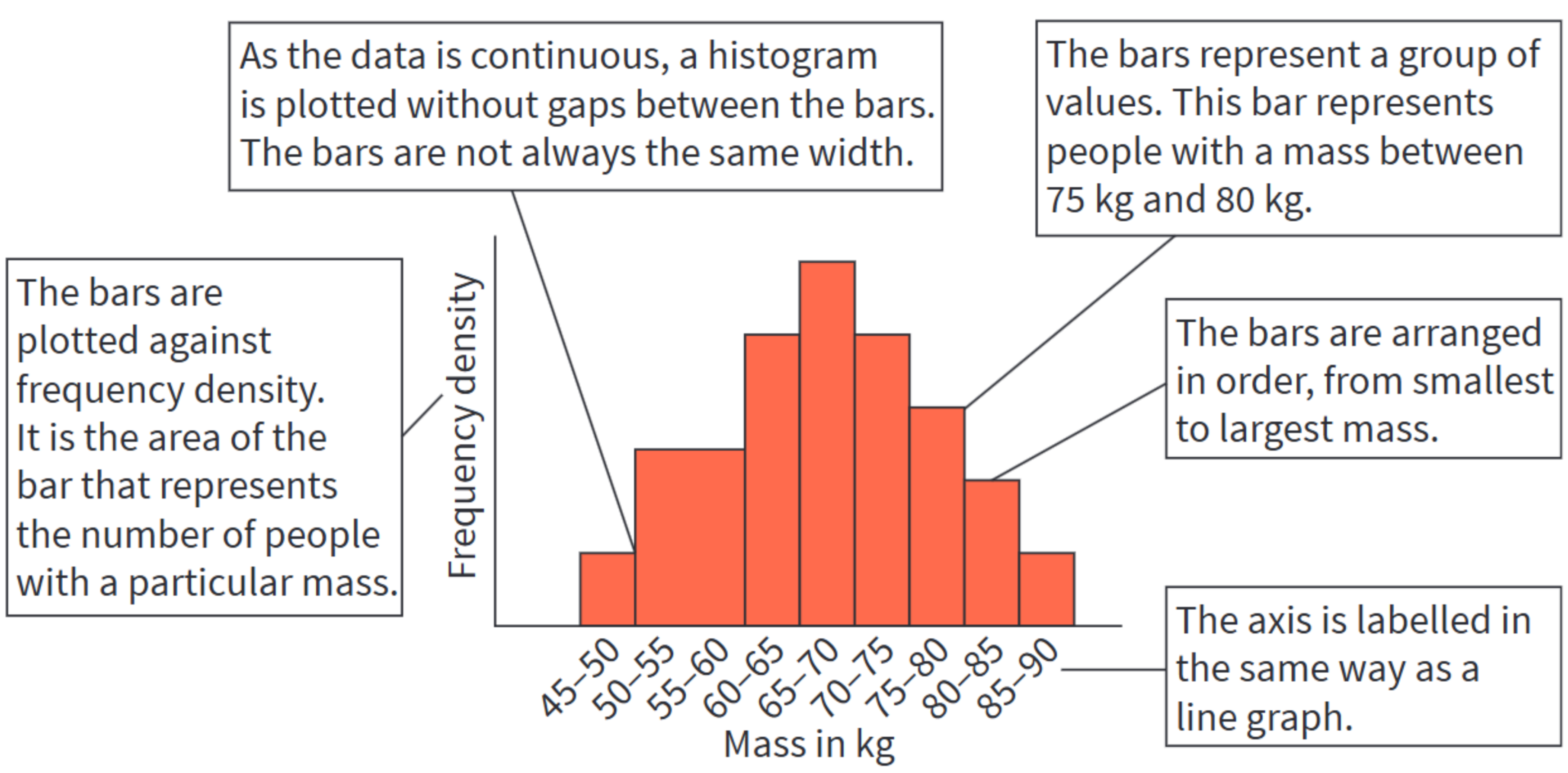


▲ **Figure 2** A pie chart of Katie and Rahim's results.

Plotting a histogram

A histogram is a chart that is used to picture the shape of a set of data. It presents continuous data in groups. This makes it easier to see certain information. For example, the most common value.

To make sure that bungee jumps are safe, measurements are taken of the mass of the people who are jumping (the jumpers). Figure 3 shows the mass of the jumpers in the past month as a histogram.



▲ **Figure 3** A histogram of Katie and Rahim's results.

What are the different types of average?

When looking at a data set, scientists often calculate averages. There are three different types of average:

- **Mean** – calculated by adding up all of the values, then dividing by the number of results
- **Mode** – the most common value or group (modal group)
- **Median** – the middle value, when the data are placed in numerical order.

Summary questions

1 Match the types of average measure to the methods of calculation.

mean place numbers from smallest to biggest, then find the middle one

mode add up values, then divide by number of values

median identify the value that occurs most

2 Table 1 gives data on the eye colour of a group of students.

Eye colour	Number of students
blue	4
brown	6
green	3
hazel	7

▲ **Table 1**

Use the data to calculate the angle for each section of a pie chart.

Stretch zone

3 Table 2 gives data on the students' height.

Student	Height in cm
1	121
2	122
3	162
4	156
5	149
6	164
7	160
8	122
9	158
10	154

▲ **Table 2**

a Calculate the mean, mode, and median height.

b Explain which average would give the best measure of the average height of students.

1.3 Analysing and evaluating

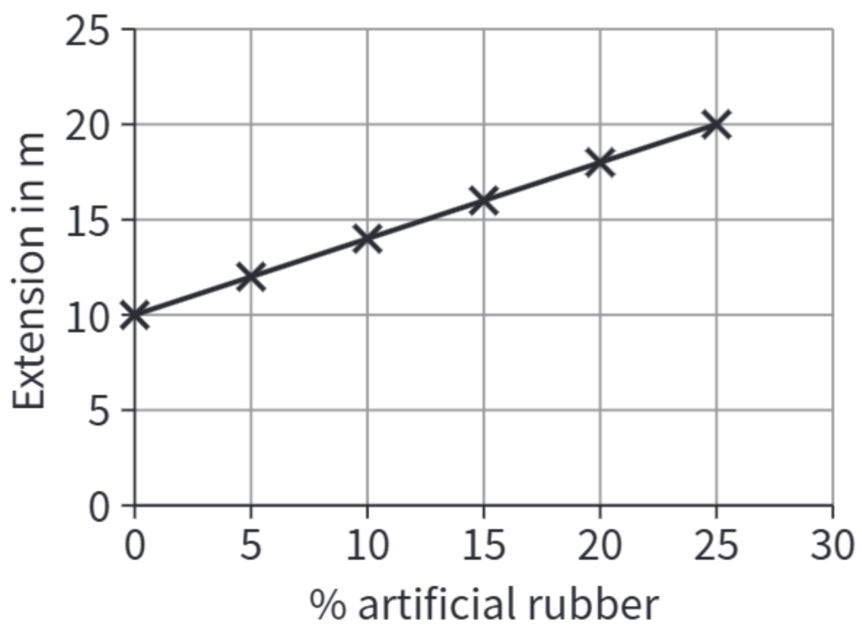
After this topic, you will be able to:

- identify linear and directly proportional relationships
- take readings from a graph using a line of best fit
- describe how to improve confidence in a conclusion.

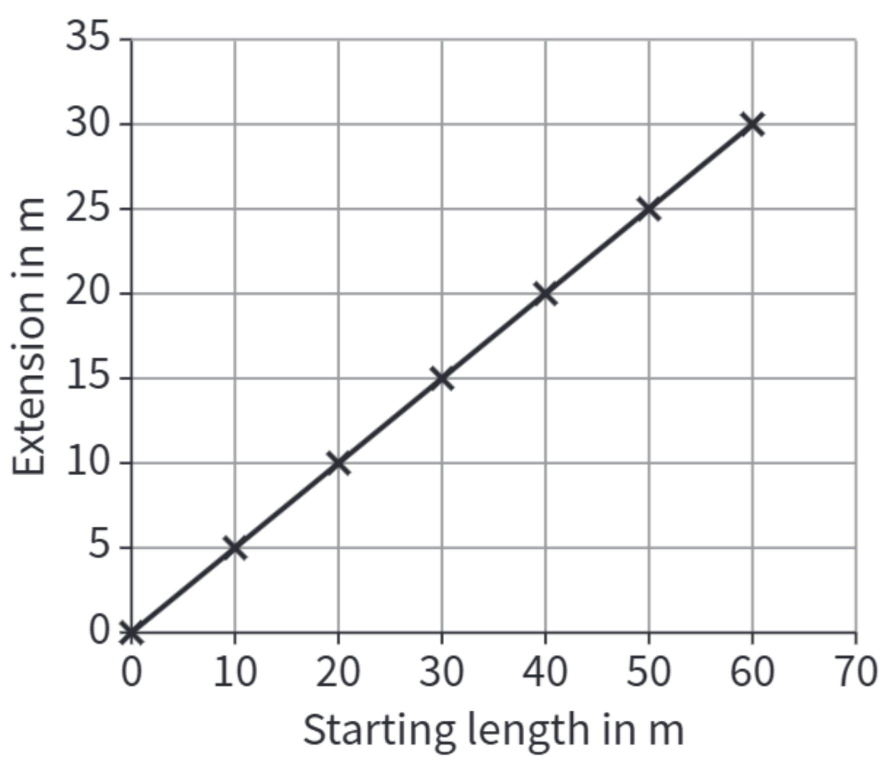
Think back

1. What does a line of best fit show?
2. What shape should a line of best fit be?
3. Which type of average finds the middle value in a data set?

▲ **Figure 1** Scientific measurements are used to make changes to the bungee rope before every jump.



▲ **Figure 2** A graph showing how the bungee rope material affects its extension.



▲ **Figure 3** A graph showing how the starting length of the bungee rope affects its extension.

Safety is the most important thing to consider when you want to do a bungee jump. How do the organizers use data to make sure you do not hit the ground when you jump?

Identifying a linear relationship

Bungee jump organizers need to think about both the type and length of a bungee rope when deciding how to make changes to the rope for a jumper. A group of scientists completed two investigations to collect this data for a group of jump organizers. Figures 2 and 3 show their results.

These graphs show a **linear relationship**. They are straight-line graphs. In this type of relationship, increasing the independent variable causes an increase in the dependent variable. So, in Figure 2, the more artificial rubber the bungee rope contains, the more the rope extends.

A Use Figure 2 to state the extension for a bungee rope made of 25% artificial rubber.

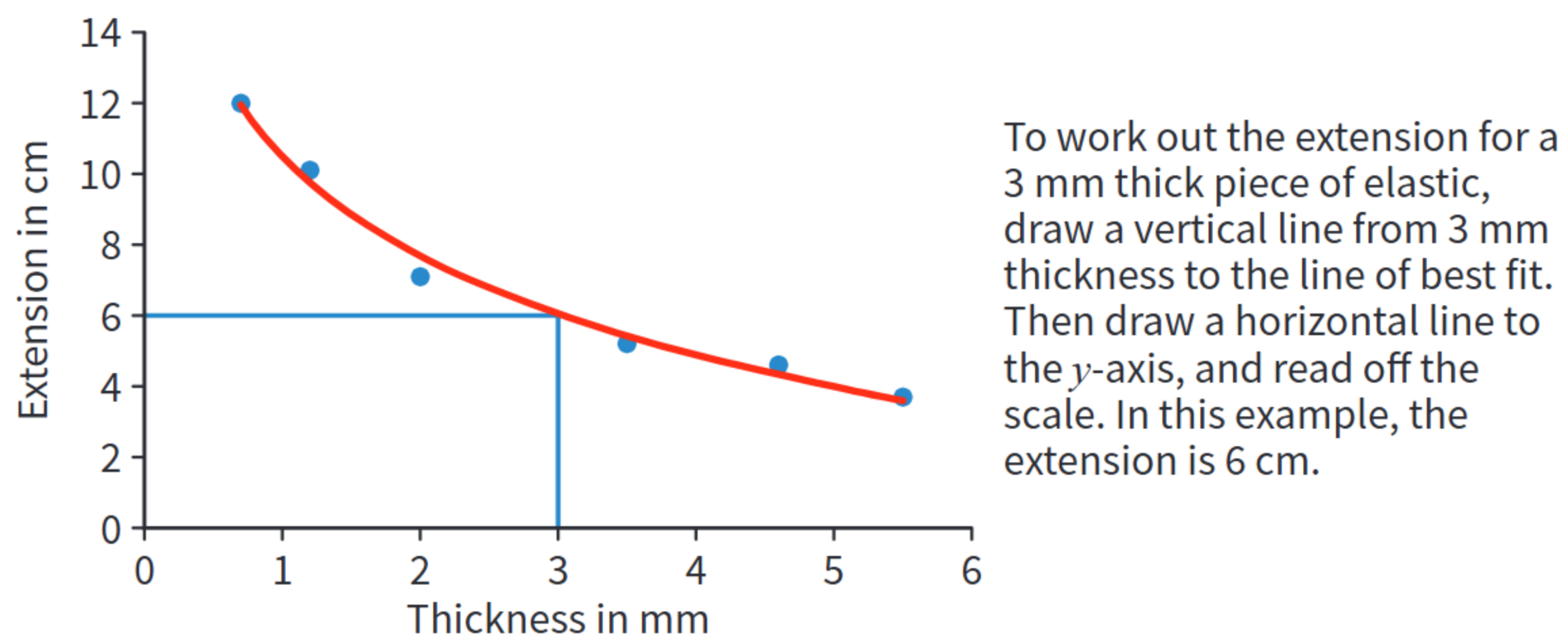
The graph in Figure 3 shows a special type of linear relationship, called a **directly proportional relationship**. It is a straight-line graph that passes through the origin (0,0).

In this type of relationship, doubling the independent variable causes the dependent variable to double. So, in this example, doubling the starting length doubles the extension.

B State how you can tell if a straight-line graph shows a directly proportional relationship.

Analysing data using a graph

Bungee jump organizers do not have to measure each jumper's mass to make changes to a bungee rope. They can work out this information from a graph. They read the **line of best fit** based on earlier experiments.



▲ **Figure 4** Katie and Rahim draw a curved line of best fit. A straight line does not fit their data.

The graph in Figure 4 shows the data Rahim and Katie collected on how the thickness of a piece of elastic affected how far it stretched.

C Use Figure 4 to work out how long the extension of a piece of elastic will be if it has a thickness of 5 mm.

Conclusions and limitations

Katie and Rahim correctly predicted that a thicker piece of elastic would stretch less when a force is applied. However, Katie and Rahim can only draw a limited conclusion. This is because they can only be certain that the pattern is true for the thicknesses of elastic they investigated.

The greater the range of the independent variable, the more certain you can be that a pattern is true for all values. The range and interval for the variables that you use can depend on the equipment available, the measuring instruments, or the time available.

Improving confidence in a conclusion

Katie wondered what real bungee ropes were like. She looked up some data on the internet and found a graph showing how the thickness of bungee ropes affected how much they stretch. Graphs or data that someone else has collected is known as **secondary data**. The data Katie found show the same pattern as their graph. This allowed Katie and Rahim to have more confidence in their conclusion. Repeating an experiment several times also helps improve your confidence in a conclusion.

Key idea

When analysing and evaluating data, you might identify a linear relationship: the dependent variable increases when the independent variable increases. A line of best fit helps show a trend in your data.

Key words

linear relationship, directly proportional relationship, line of best fit, secondary data

Summary questions

1 Copy and complete the sentences.

Patterns in data can be shown by adding a line of **best fit/worst fit** to your graph. Data that forms a straight-line graph shows a **linear/non-linear** relationship. Data that forms a straight-line graph that passes through the origin shows a **directly proportional/indirectly proportional** relationship. Data collected from other sources, such as the internet, is called **primary/secondary** data.

2 Describe **three** ways you can increase your confidence in a conclusion.

Stretch zone

3 Using data from Figure 3, explain why the relationship between the length of a bungee rope and its extension is described as directly proportional.

1.4 Communicating scientific information

After this topic, you will be able to:

- describe the key features of effective communication
- describe how to adapt communication for different audiences.

Think back

1. How can you display data visually?
2. What should you include in observational drawings?
3. Name **three** sections which should be included in a scientific investigation.

Key idea

Scientists write scientific investigation reports to share what they have discovered with different audiences.

Key words

communication, audience, purpose, concise, coherent

▲ **Figure 1** Scientists publish their research in journals, which are read by other scientists. Articles about science are also published in newspapers and magazines.

When scientists carry out research, they often need to share their discoveries with a wide range of audiences. During a global pandemic, for example, scientists will appear regularly on the TV, on social media, and in newspapers to explain their most recent findings to the public.

Planning your communication

When planning your **communication**, you need to think about how you are going to do it. Here are some questions that you should think about each time:

- Who is the **audience**?
- What is the **purpose**?
- What is the best structure?
- How can I make it clear, **concise**, correct, and **coherent**?

Concise writing means that you describe or explain as much as possible using as few words as possible.

Coherent writing is logical (sensible), well-organized, and easy to understand.

A Write down **two** different audiences you may need to communicate with.

Writing effectively

Good communication should be used for all styles of writing, for example, when writing an article or preparing a presentation. To make sure your communication is effective, you should:

- use clear language and well-formed sentences
- read any source material carefully, and rewrite anything that is not clear

- check there are no mistakes in spelling, punctuation, or grammar
- put paragraphs in a sensible order to 'tell your story'
- use linking words to help the reader connect sentences and paragraphs
- use diagrams, charts, and graphs to communicate data (see Figure 2).

All of these ideas help the audience understand what you are saying and why you are saying it.

Writing for a scientific audience

When you write up an investigation, you are probably writing for your teacher or other students. A scientific investigation report should include:

- a hypothesis or prediction
- a method, written in the third person, with a labelled diagram of your equipment
- a risk assessment
- your results table and graph
- your conclusions and evaluation.

You should take care to use the correct scientific vocabulary. Words often have a different meaning in science than in everyday life.

Writing for different audiences

You must also adapt your writing to suit the audience. Table 1 gives some examples.

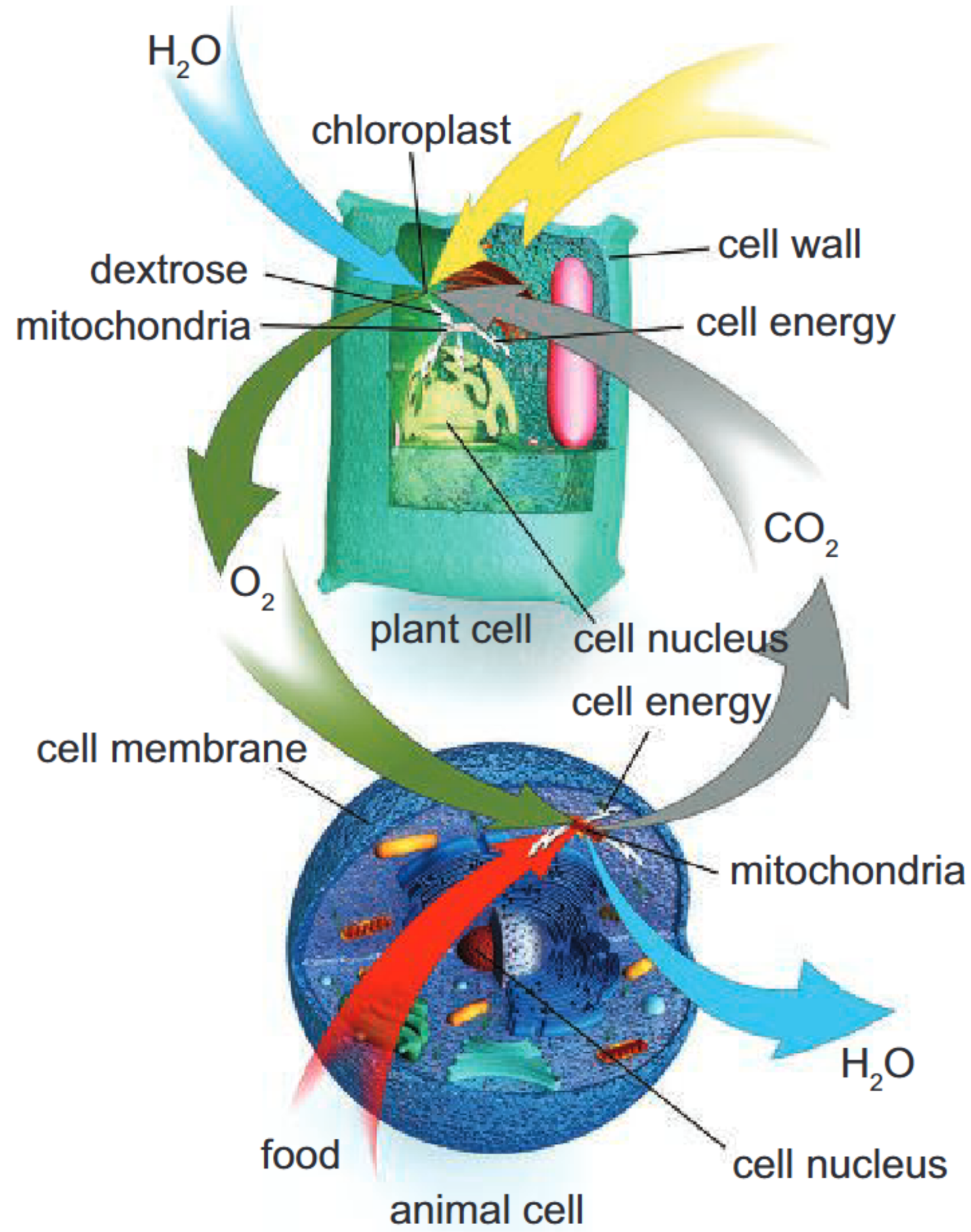
What you are writing	How to adapt your writing
an information leaflet for primary school children	• use simple words • use short sentences
a newspaper article for the general public	• illustrate ideas with real-life examples • use vivid words, describing real things • if you are making a claim, make sure that you clearly state the evidence that you are using • make a list of the points and cover one in each paragraph
a scientific article	• use diagrams to make the meaning clear • use scientific vocabulary, units, and chemical symbols accurately

▲ **Table 1** How to write for different audiences.

B Write down **one** thing that you should include in a newspaper article but not in a scientific article.

Literacy skills

It is difficult to work and share information when your own writing is not clear. Next time you write something, ask someone else to read it and underline sections that they do not understand.



▲ **Figure 2** Scientific diagrams.

Summary questions

1 List **four** strategies to use when you are writing about a scientific investigation.

2 Compare writing for a science journal with writing for the general public.

Stretch zone

3 Write a leaflet for primary school children based on Katie and Rahim's investigation into pieces of elastic. Explain how your writing is suitable for the audience.

1.5 Using evidence and sources

After this topic, you will be able to:

- describe the peer review process
- describe how to assess sources of evidence
- identify possible sources of bias.

Think back

1 How do you collect data?
2 What is repeatable data?
3 What is reproducible data?

Key idea

Scientific evidence must be accurate and reliable. Peer review is a process where other scientists in the field check the work of another scientist. These scientists cannot be biased or unfair.

Key words

evidence, anecdotal, journal, peer review, research, bias

▲ **Figure 1** Scientists collect a range of evidence through observations, chemical tests, and measurements.

▲ **Figure 2** Science magazines often include peer-reviewed articles.

Historians use evidence to make conclusions about the past. Police need evidence to convict people of crimes. Scientists collect evidence through data. However, scientific evidence has to be checked before it is accepted as true.

Evaluating evidence

Not all **evidence** carries equal weight. For example, you may hear someone say:

I know what they say about sugar, but my grandfather ate chocolate every day for 50 years and he didn't get Type 2 diabetes.

This is not scientific evidence. It is called **anecdotal** evidence. You cannot reason from this one example that smoking doesn't cause cancer. Scientific evidence is checked by other scientists.

What is a peer review?

Scientists make hypotheses, come up with ways to test their hypotheses, collect evidence, and write up their investigation. This is not the end of their work. They then send their work to a scientific **journal**. The editor of the journal sends it to other scientists working in the field who judge whether the work is correct. This is called **peer review**.

Peer review is a checking system. It makes sure that the work is accurate, and that you can believe the conclusions made. Work that has not gone through this process is not scientific evidence.

A State where scientists publish their results.

Checking that sources are reliable

How do you know if an information source can be trusted? To judge the reliability of evidence, you need to consider the answers to a range of questions, like those in Table 1. The more reliable the source, the more valuable the information.

What to look for	Questions to ask
Who are the authors?	• Are they qualified scientists? • Is this their field of study?
Where is the **research** published?	• Has it been published in a peer-reviewed journal?
When was the research published?	• Are the data still up to date?
What were the findings of the research?	• Does it agree with current scientific thinking? • Did the author give a scientific explanation of the findings?
Does the scientist have a personal interest in the results?	• Who is funding (giving money to) the research? • Does the scientist work for a company that would like the conclusion to be a certain way?
Were there enough data to justify the conclusion?	• How many data points were collected? • What was the range and interval of measurements? • Was the sample big enough? • Were all the categories (of age/gender, etc.) involved that should be?
What does other research into this area say?	• Are the findings backed up by other research? Who did that research?

▲ **Table 1** Questions to check the reliability of evidence.

B Write down **three** things you need to comment on when you judge the reliability of a source.

Who funds scientific research?

- Governments – scientists write grant proposals to get money to do research (e.g. for universities to develop vaccines).
- Companies – for example, a car company might fund research into how to reduce vehicle emissions.
- Non-profit organizations, such as charities – for example, a heart charity might research the effect of a particular diet on the risk of heart disease.

What is bias?

If someone has a **bias** it means that they have a preference for something, which can be unfair. Biased information may be:

- a personal opinion – for example, a scientist developing a health product may claim it tastes sweeter even though it has less sugar
- a statement that is not based on facts – for example, a vitamin supplement may claim to 'help manage stress levels' but not be backed up by scientific evidence
- prejudiced towards or against another person, product, situation, or idea – for example, a scientist researching the impact of a new drug may focus on the health benefits, rather than highlight any side effects, if they work for the drug company.

Summary questions

1 Copy and complete the sentences.

biased **funding** **peer reviewed** **reliable**

When a scientist checks another scientist's work, we say it has been ______ ______.

This makes the evidence in the work more ______.

Evidence may be ______ if the person doing the research could benefit from it, or if the person ______ the research could make money from the results.

2 In 1972, John Sawyer, a meteorologist, published evidence in the scientific journal *Nature*. It said there is a link between manufactured CO_2 and a rise in global temperatures.

a Explain why this evidence is probably reliable.

b Explain why a journalist may be biased in their reporting of this claim.

Stretch zone

3 A food company produces a new low-fat dessert. It claims the dessert is 'the after-dinner treat that keeps your heart healthy'. The claim is based on research completed by the company's own team of scientists.

Suggest some possible reasons for the research being biased, and how this may affect the reliability of the company's health claims.

1.6 Development of scientific understanding

After this topic, you will be able to:

- describe the scientific method
- describe the difference between a theory, a law, and a model
- describe how our understanding of science changes over time.

Think back

1 Give some examples of scientific evidence.
2 What is a hypothesis?
3 Where do scientists publish the results of their research?

Key idea

It is important to understand what the scientific method is, and how theory, law, and models have helped us develop scientific research.

Key words

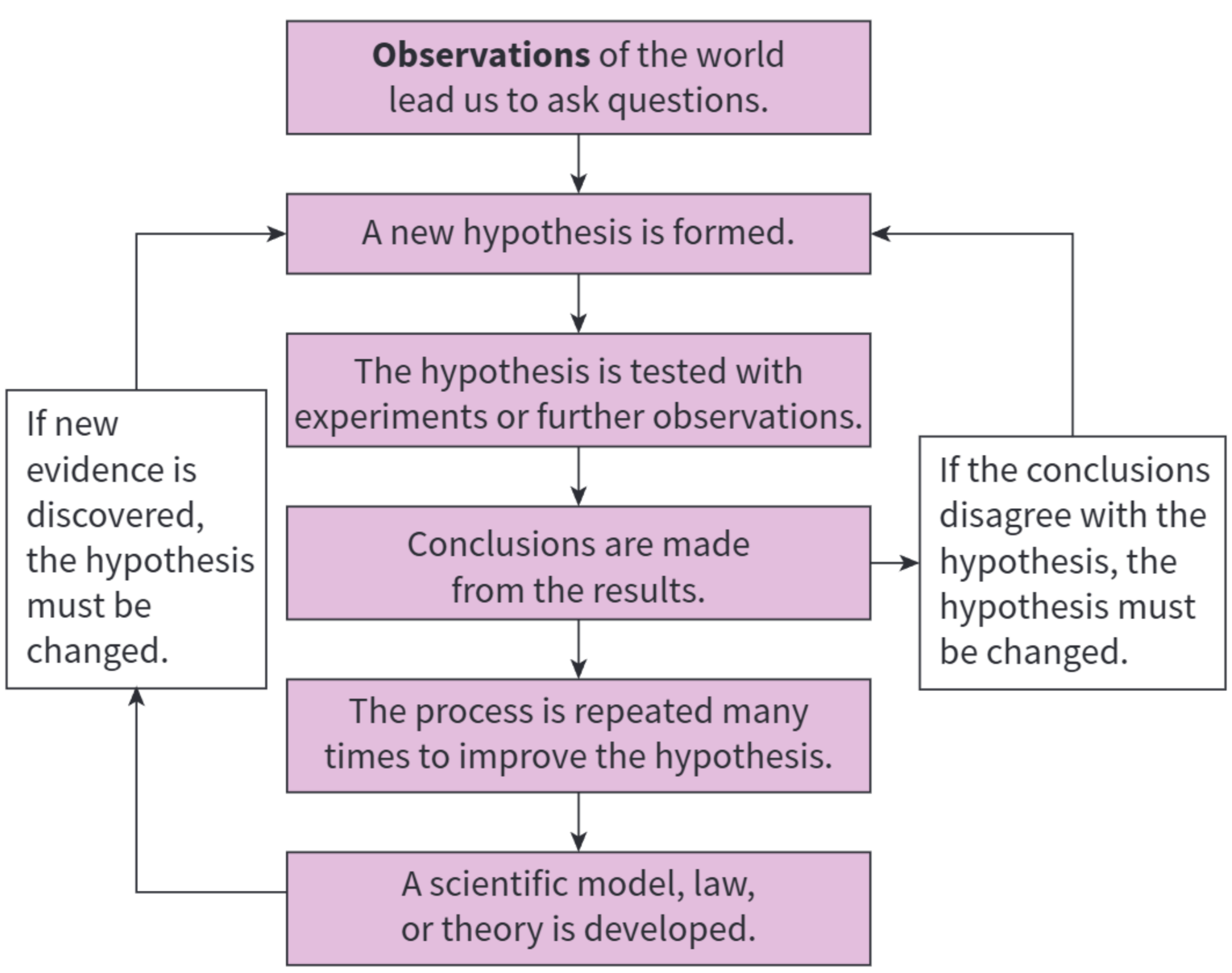
scientific method, observation, model, law, theory

A very long time ago, most people thought that disease was caused by a poisonous vapour that came from decaying matter. How did scientists change our thinking?

The scientific method

Throughout your work in science, you are using the **scientific method**. This is an evidence-based way of developing our understanding of the world around us. Figure 1 shows the steps involved in the scientific method.

A **model** is a way of representing something that is too difficult to display because it is too big, too small, or too complicated. The mental image it gives you allows you to explain or predict the results of experiments.



▲ **Figure 1** The scientific method is a cyclical (circular) process of forming and testing hypotheses.

A **law** is a scientific rule that is supported by evidence, such as 'energy cannot be created or destroyed'. Scientific laws do not explain why something happens.

A scientific **theory** is an explanation of the world around us, based on evidence produced using the scientific method. This evidence must also be peer reviewed.

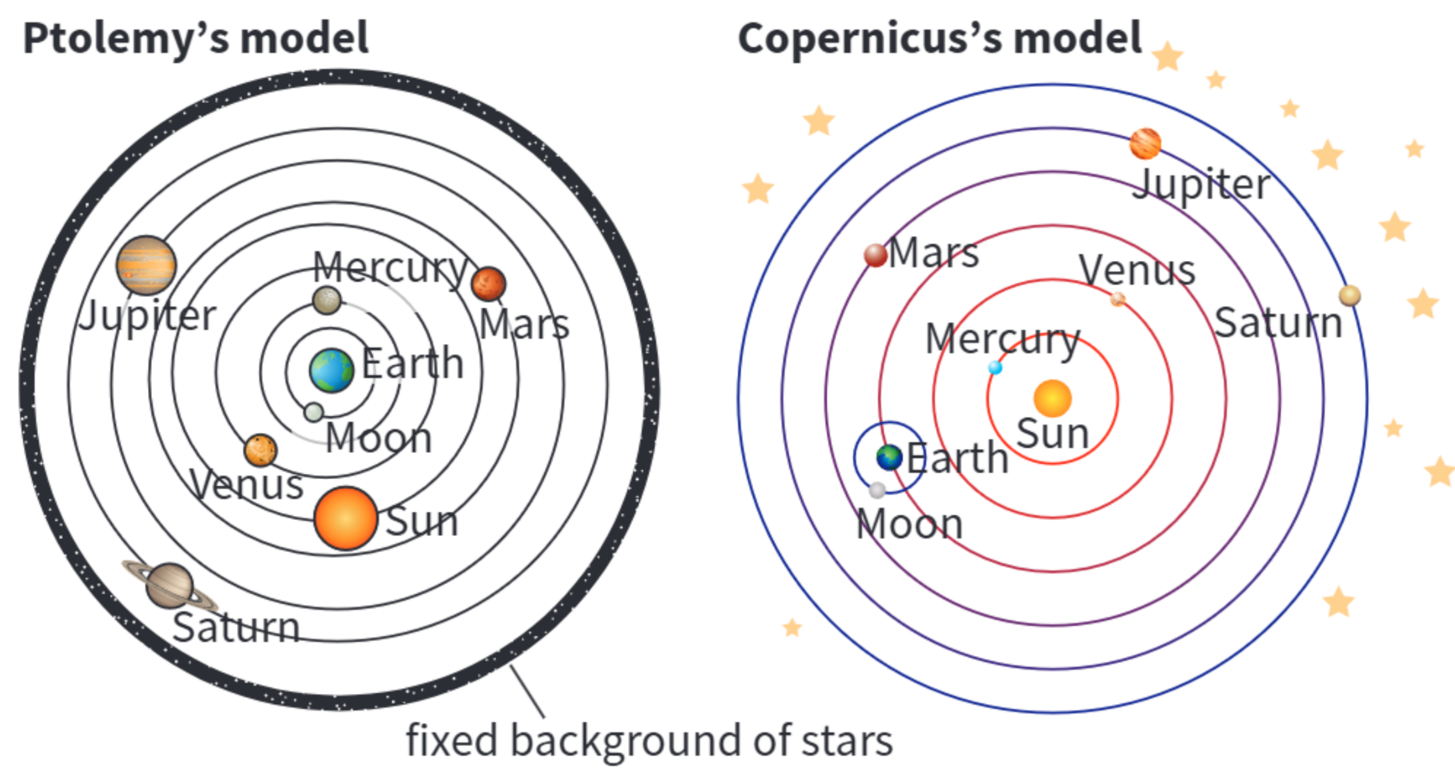
A State the difference between a theory and a law.

Why do scientific ideas develop over time?

Although scientific models, laws, and theories are supported by experimental evidence, sometimes a new piece of information is discovered as a result of new technology or another scientist thinking differently.

This might mean that the scientific idea is:

- improved, because the new evidence tells us new information
- completely changed, because the new evidence proves that the existing idea cannot be true.



▲ **Figure 2** Ptolemy's (left) and Copernicus's (right) models of the Solar System.

How did our understanding of the Solar System develop?

Since ancient times, humans have studied the night sky. A model of the Solar System was developed by Ptolemy in around 150 CE. It is called the geocentric model. Ptolemy believed Earth was at the centre of the Solar System (see Figure 2).

Ptolemy's model was based on careful observations of the movement of planets through the night sky. However, it did not always accurately predict the planets' positions.

B Which parts of the Solar System did Ptolemy get correct in his geocentric model?

Almost 1500 years later, Nicolaus Copernicus developed a new model of the Solar System – the heliocentric (Sun-centred) model. Through observation, he discovered that Earth rotates (turns) on its axis. In this model, the planets orbit (travel around) the Sun in perfectly circular orbits (see Figure 2).

In 1609, Johannes Kepler improved the Solar System model after studying data on the planets' positions. Kepler realized that the orbits were not perfectly circular. This improved Copernicus's model. It also led more astronomers to support the heliocentric model.

At around the same time, Galileo Galilei developed the first telescope. This allowed him to look at some of the moons orbiting Jupiter. He realized these moons were like the planets orbiting the Sun. This development provided further evidence for the heliocentric model.

Summary questions

1 Copy and complete the sentences.

method **model** **evidence** **explanation** **law**

A scientific theory is a well-thought-out _______ of a scientific event. It is backed up by _______ that has been collected using the scientific _______. A scientific _______ describes how a system will behave, but does not explain why. A _______ visually represents a complicated concept.

2 Describe **two** reasons why a scientist may change a hypothesis.

Stretch zone

3 Suggest **three** reasons why most astronomers in the 1600s did not agree with the heliocentric model, even after the work of Kepler and Galileo was published.