CURRICULUM FOR WALES

SCIENCE AND TECHNOLOGY

Science

FOR 11–14 YEARS

Michelle Austin, Andrea Coates, Richard Grimmer

Sample Booklet

IN COLLABORATION WITH
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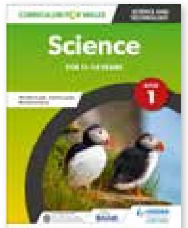

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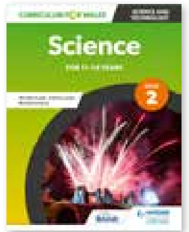

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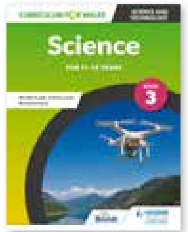

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- Improve working scientifically skills and prepare students for future lab work with practical skills and activities highlighted throughout
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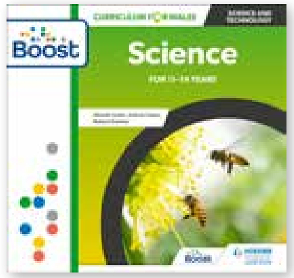

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Meet the team behind our books

Michelle Austin

Michelle Austin has been a chemistry teacher for 17 years in a wide range of schools including grammar, faith and comprehensive. During this time she has been a Head of Department and Science Outreach Coordinator, working alongside the Science Learning Centres (now STEM learning) and the RSC to offer training across the county.

Dr Simon Broadley

Dr Simon Broadley has been a teacher of Biology, Science and Applied Science for 25 years, teaching from years 7 to 13 at all abilities. He is currently Head of Biology at St Joseph's R.C. High School in Newport and is also a mentor for PGCE students in the science department, external mentor, form tutor, and a BTEC internal verifier.

Andrea Coates

Andrea Coates has a wealth of examining experience across GCSE Science papers for a major awarding body. Previously Teacher in charge of Science at a PRS, and before that Head of Science at a comprehensive school, she has also contributed to various KS3 and KS4 publications in the past, including Science Progress, Biology for All, Exploring Science and more.

Mark Edwards

Mark Edwards has been a KS3–5 Physics teacher for almost 30 years. He is currently a Head of Science and also works one day a week as a School Physics Coach for STEM Learning offering training across the country as a Lead Facilitator. He has written a number of books across KS3–5 including textbooks, revision guides and practice examination papers.

Richard Grimmer

Richard Grimmer was a Physics Network Coordinator for the Institute of Physics (IoP) for 10 years, running twilight workshops for teachers in Surrey and SW London. For the past 4 years he has been organising CPD days for the IoP, in the South Region, including the Ivybridge, Bristol, Abingdon and Bath days, plus online alternatives. He has 25 years' teaching experience.

Jim Lewis

Jim Lewis has 16 years' experience teaching Science, specialising in teaching KS3-5 Physics. He is also currently the Director of Raising Standards at Ysgol Maesydderwen. He studied at the Dept of Materials Science and Technology, University of Wales Swansea (undergrad) and University of Wales Swansea Interdisciplinary Research Centre and University of Cambridge Rolls Royce University Technology Centre (postgrad). Before teaching he worked/studied in the field of metallurgy for 9 years.

Dr Mark Matthews

Dr Mark Matthews has been a teacher of Biology, Science and Applied Science for approximately 30 years, teaching students from years 7 to 13, across all ability ranges, and is currently at St Joseph's R.C. High school in Newport. He has also been a BTEC internal verifier, and school BTEC Quality nominee, as well as an A-level examiner.

In collaboration with University of Wales Press

We have worked in collaboration with University of Wales Press on our Curriculum for Wales resources. They have reviewed content to make sure it is tailored to the new curriculum and explores Welsh culture and heritage in an authentic way. Find out more about UWP and their resources in Welsh and English languages: visit **www.uwp.co.uk / www.gwasgprifysgolcymru.org**

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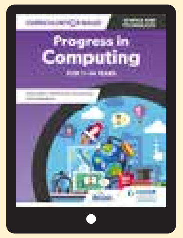

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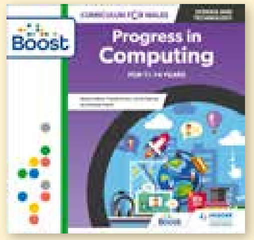

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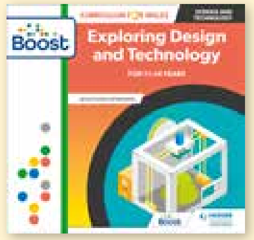

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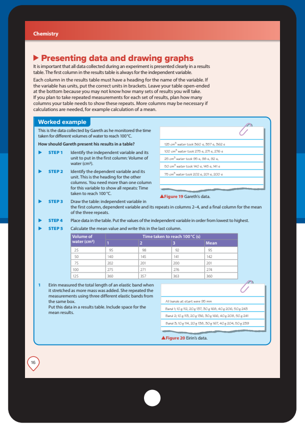

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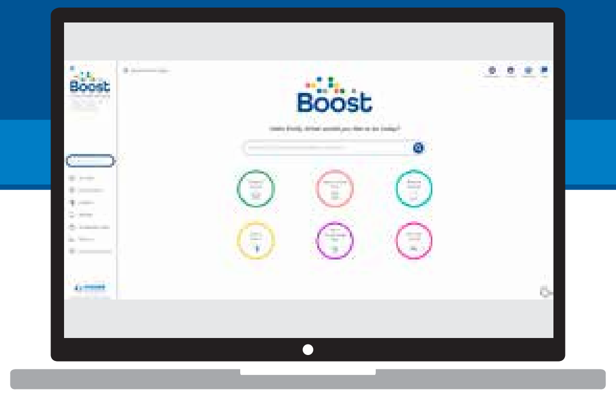

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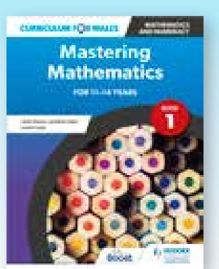

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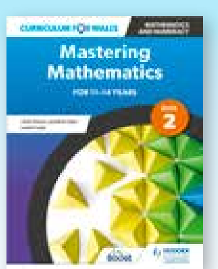

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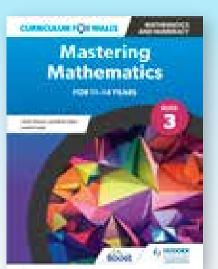

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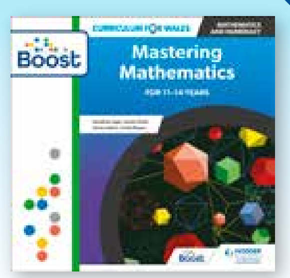

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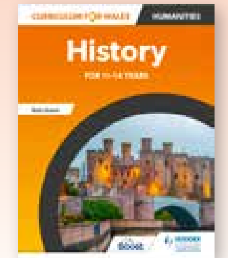

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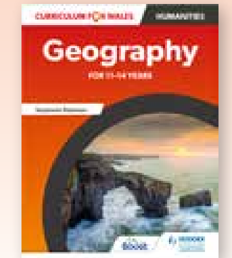

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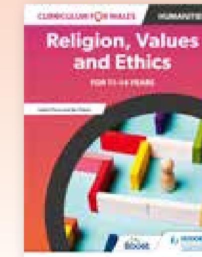

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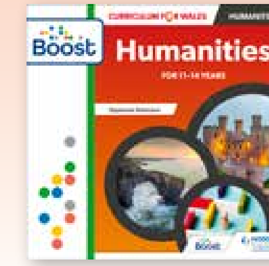

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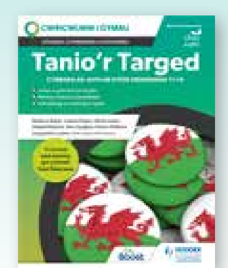

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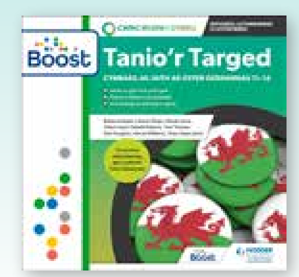

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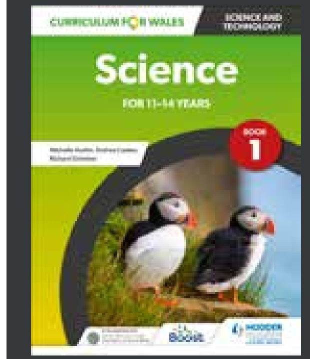
Curriculum for Wales: Science for 11–14 years Book 1

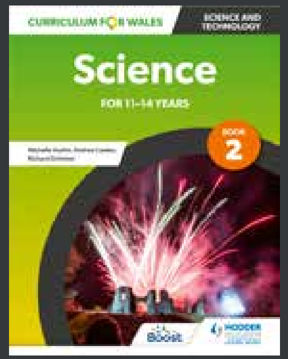
Contents

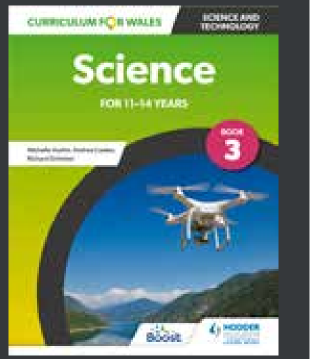
What's inside this booklet?

The sample pages in this booklet are from *Curriculum for Wales: Science for 11–14 years Book 1.*

To see the Contents Lists from Books 2 and 3 turn to the inside back cover of this booklet.







Key terms are highlighted and explained clearly to boost students' scientific vocabulary.

Presenting data and drawing graphs

It is important that all data collected during an experiment is presented clearly in a results table. The first column in the results table is always for the independent variable.

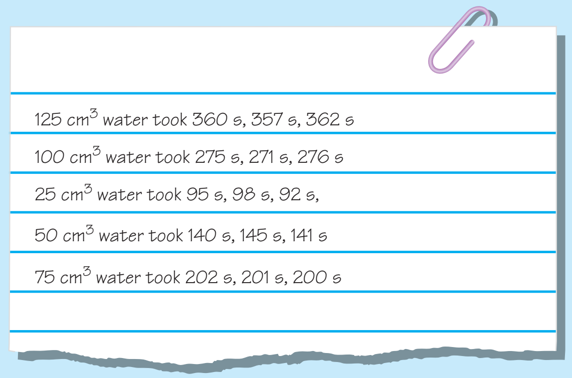
Each column in the results table must have a heading for the name of the variable. If the variable has units, put the correct units in brackets. Leave your table open-ended at the bottom because you may not know how many sets of results you will take. If you plan to take repeated measurements for each set of results, plan how many columns your table needs to show these repeats. More columns may be necessary if calculations are needed, for example calculation of a mean.

Worked example

This is the data collected by Gareth as he monitored the time taken for different volumes of water to reach 100 °C.

How should Gareth present his results in a table?

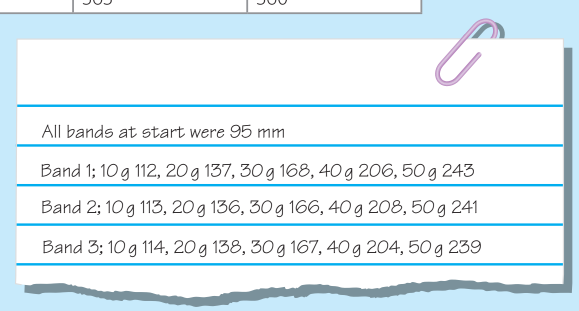
- **STEP 1** Identify the independent variable and its unit to put in the first column: Volume of water (cm³).
- **STEP 2** Identify the dependent variable and its unit. This is the heading for the other columns. You need more than one column for this variable to show all repeats: Time taken to reach 100 °C.
- **STEP 3** Draw the table: independent variable in the first column, dependent variable and its repeats in columns 2–4, and a final column for the mean of the three repeats.
- **STEP 4** Place data in the table. Put the values of the independent variable in order from lowest to highest.
- **STEP 5** Calculate the mean value and write this in the last column.



▲**Figure 19** Gareth's data.

Volume of water (cm³)	Time taken to reach 100 °C (s)			
	1	2	3	Mean
25	95	98	92	95
50	140	145	141	142
75	202	201	200	201
100	275	271	276	274
125	360	357	363	360

1 Eirin measured the total length of an elastic band when it stretched as more mass was added. She repeated the measurements using three different elastic bands from the same box.
Put this data in a results table. Include space for the mean results.



▲**Figure 20** Eirin's data.

Worked examples support students' development of literacy, numeracy and digital competency, taking them step-by-step through questions.

Plotting graphs

A graph makes it easier to see a trend or pattern in the data.

The type of graph you choose will depend on whether the independent variable is continuous or not.

- A **continuous variable** can have any numerical value, for example time, mass, volume or temperature. Continuous variables always have a unit.
- We use a line graph or scatter graph when both variables are continuous.
- A **non-continuous variable** has values that are words, or numbers that have no in-between values, for example, colour, month of the year, shoe size, number of leaves on a plant. Variables like this rarely have a unit.
- We use a bar graph when the independent variable is non-continuous.

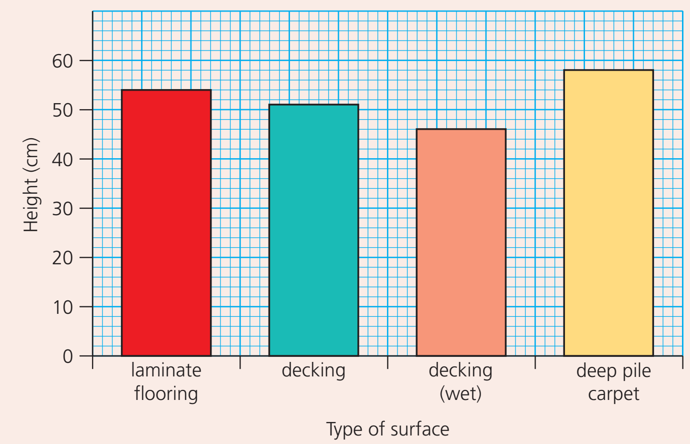
Key terms

Continuous variable – a variable that can have any numerical value, including decimals.

Non-continuous variable – a variable with values described in words or with numbers that have no in-between values.

Bar graphs

In a bar graph the height of the bar depends on the value you measured (the dependent variable), which is plotted along a scale on the *y*-axis. The bars are drawn with equal width. A clear gap must be left between the bars as the bar labels are not related in any way.



◀**Figure 21** A bar graph, chosen because the independent variable (type of surface) is a non-continuous variable.

Making links

You can use software to plot graphs from data. How to do this is covered in your **Computer science** course.

You should always label the *x* and *y*-axes with the names of the variables and put the units in brackets. The independent variable is placed on the *x*-axis and the dependent variable on the *y*-axis. On a bar chart, write the name of each category in the centre of the bar.

Choose a scale for each axis that makes it easy to plot the points. For example, label the divisions on the graph paper at intervals of 1, 2, 5, 10, 20, 50 or 100. Always keep the scale regular so the intervals between the graph lines have equal values.

Scatter graphs

A scatter graph will show if there is a relationship between two continuous variables. If there is a clear pattern, you can draw a **line of best fit**. This could be a straight line or a curved line. The steepness of the line shows how quickly the pattern is changing.

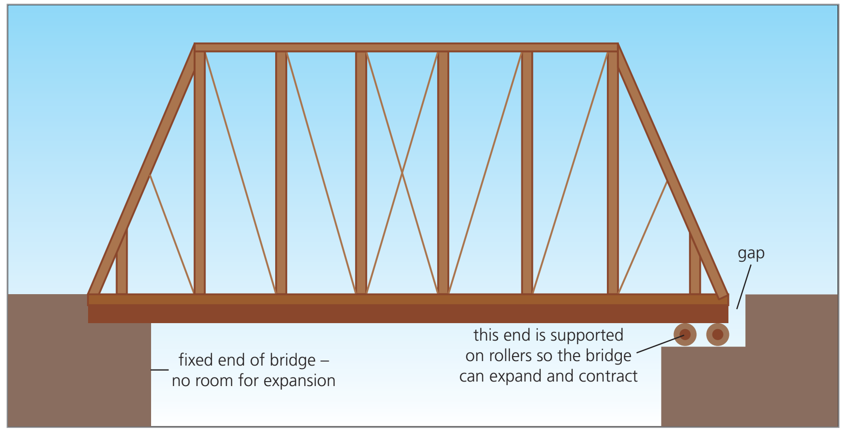
Key term

Line of best fit – a straight or curved line drawn to pass through or as close to as many plotted points as possible. It best represents the true relationship between the two variables.

'Science in context' sections highlight applications of Science outside the classroom, with historical and cultural examples from Wales.

Science in context

Expansion and contraction can be a problem – for example, railway lines and metal bridges can expand in hot weather. This can cause damage to the structure and so design features are added to prevent this. Robert Stephenson's (1803–1859) Britannia Bridge over the Menai Straits, constructed in 1846, was one of first to use roller bearings. The box girders were fixed at one tower but free to slide through the other towers, so the bridge can expand and contact as the temperature changes. The engineers calculated that the iron used to make the girders could make the bridge increase in length by up to 152 mm.



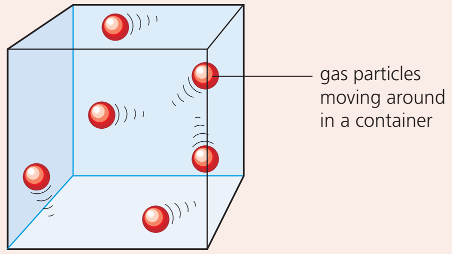
▲**Figure 7** The expansion rollers on this bridge allow the metal girders to increase or decrease in length, and so prevent cracks and twisting.

Gas pressure

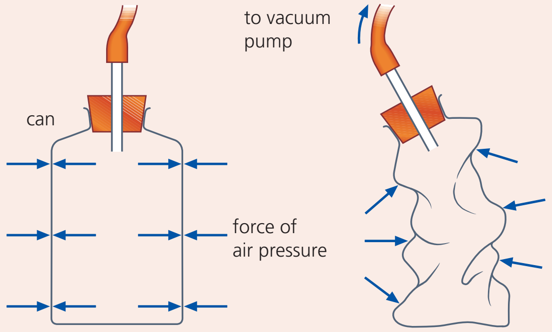
The particles in a gas are moving very fast. As gas particles move around they hit objects. This causes gas pressure. Faster gas particles produce a bigger force when they hit a surface, so the pressure is greater.

The hotter the gas the more energy its particles have, so they hit the walls of its container with more force and produce a greater pressure.

If gas pressure is greater on one side of a surface, the unbalanced forces can make the object move. If you remove the air from inside the can shown here, the can will collapse.



▲**Figure 8** As gas particles hit the sides of a container, they cause gas pressure.



▲**Figure 9** As the gas particles are pumped out of the can the force of the air on the outside collapses the can.

Science in context

Two thousand years ago, the Greek scientist, Hero of Alexandria, designed machines that used air pressure to move objects. He used air pressure to make doors appear to open on their own or toys that shot jets of water. These same principles are used in many modern systems, such as office chairs that use pressurised air to move the seat up or down.

Students are prompted to check their understanding throughout to review and consolidate their learning.

Check your understanding

Know

1 Describe the differences in how particles move in each of the three states of matter.
2 Which arrangement has the largest space between particles: gas, liquid or solid?

Apply

3 Explain why gases can be easily compressed, but solids and liquids are very difficult to compress.
4 Consider these everyday substances, which can be difficult to categorise as solid, liquid or gas:
- ice cream
- toothpaste
- sand.

For each one, describe whether it has a fixed shape and whether it can flow. Then choose which state of matter matches it best and explain your choice.

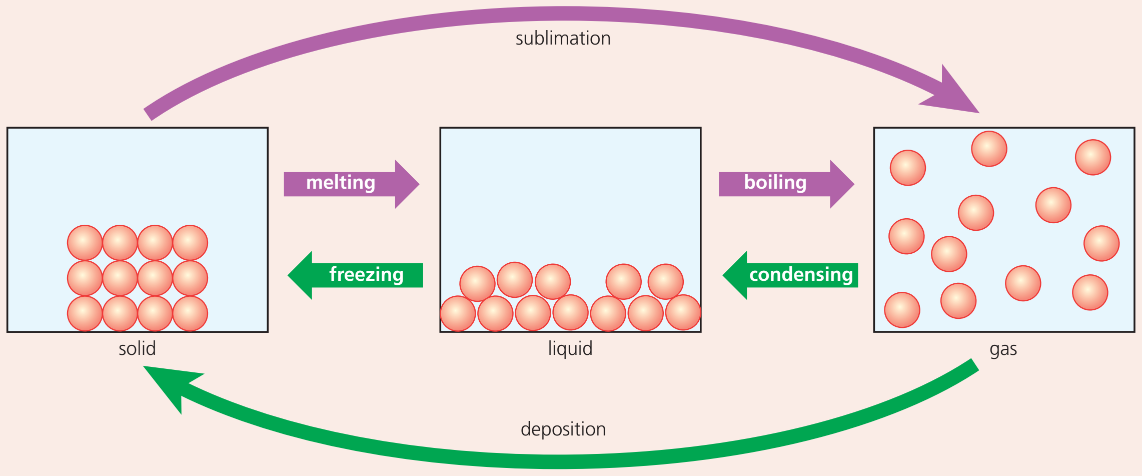
Extend

5 Use the particle model to compare contraction and compression.

▶ Changing states

A substance changes its state because energy is either transferred to or taken away from its particles. A change of state can be reversed – for example a solid ice cube, when heated, will go back to liquid water.

When substances change state, the particles do not change size or mass – they are just arranged differently. If you melt 1 kg of solid iron, you will get 1 kg of liquid iron!



Solid ice beginning to melt – note the liquid water on the surface.

When water vapour is cooled by a cold surface it condenses to form liquid water.

The bubbles in this boiling water are water in a gaseous state – water vapour.

▲**Figure 10** Using the particle model to explain changes of state.

Make links within the Science and Technology AoLE with connections highlighted throughout.

A short history of microscopy

1590s

Zaccharias Janssen (c.1580–1632) and his father Hans, two Dutch spectacle makers, are credited with making the first compound microscope. They found that using two lenses gave a more magnified image than just one lens. Unfortunately, the image was not very clear.

1665

Robert Hooke (1635–1703) improved the compound microscope and his work was important in the development of cell theory. When he looked at cork, which comes from the bark of a tree, he saw lots of tiny boxes. He called these cells because they reminded him of the small rooms where monks lived called cells.

1674

Antonie van Leeuwenhoek (1632–1723), a Dutchman, improved the technology to grind high quality lenses. His lenses had a much higher magnification and produced much clearer images. Leeuwenhoek was probably the first person to see living cells. He saw small organisms in pond water. In 1676 he named these animalcules.

Making links

In the late 13th century spectacle makers used curved glass to magnify images. You will find out how these lenses work when you study light waves later in your course in the topic on **Waves**. Lenses are also used in cameras and telescopes.

▲**Figure 8** Robert Hooke's drawing of cork cells.

Electron microscopes

The most powerful microscopes today are **electron microscopes**. They were developed in the 1930s.

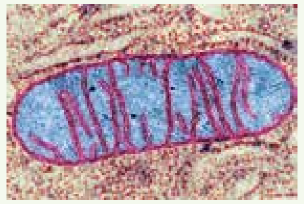
A good light microscope can magnify up to ×2000, but an electron microscope can magnify between ×1 000 000 and ×5 000 000 depending on the type. An electron microscope can be used to study objects much smaller than cells, such as the internal structure of mitochondria and viruses. It can even produce images of molecules and atoms. An electron microscope also produces a much clearer and more detailed image than a light microscope.

Key term

Electron microscope – a microscope that uses electrons, rather than light, to form an image. An electron microscope can produce a much greater magnification than a light microscope.

Science in context

A new electron microscopy facility is due to open at Cardiff University in 2022. It will allow researchers from all areas of science and technology to study materials at extremely high magnification. Their research may lead to the identification of new disease-causing microorganisms and the production of new drugs. Understanding the structure of materials is also helping in the development of new electronic components that can transfer or store data very efficiently.



▲**Figure 9** A mitochondrion magnified using an electron microscope.

Check your understanding

Know

1. How do you calculate the total magnification when using a microscope?
2. Why is it important that the sample on a microscope slide is very thin?
3. Why do scientists often use stains when preparing microscope slides?

Apply

4. Why is it easier to focus on cells using the lowest power objective lens, rather than a higher-powered lens?
5. How many times greater is the magnification of an electron microscope compared to the best light microscopes?
6. You are given a prepared slide of cheek cells. Describe how you would use a microscope to see the cells clearly at high magnification.

Extend

7. Siân used a microscope to view some blood cells.
   The eyepiece lens had a magnification of ×5.
   The objective lens had a magnification of ×40.
   The image of one red blood cell was 1.4 mm wide.
   - a Calculate the real width of the red blood cell in mm.
   - b Convert the real width of the cell from mm to micrometres (μm).

Learning summary

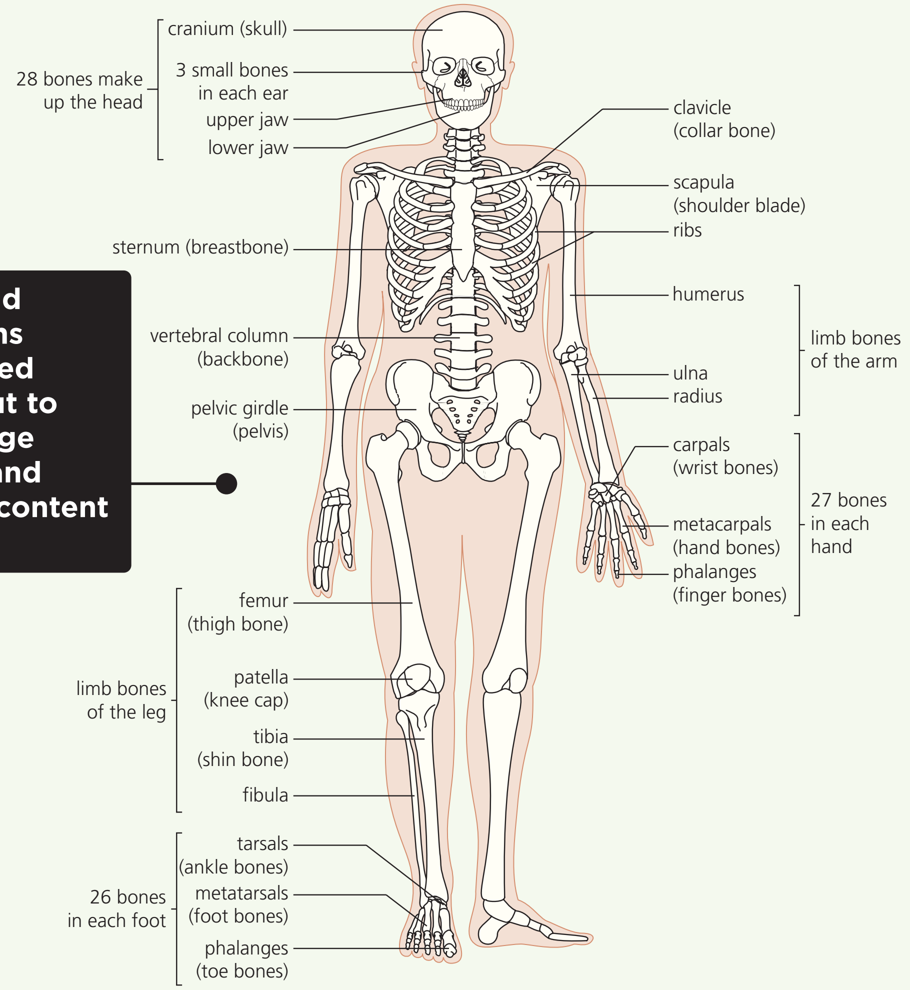
Now you have completed **Cells**, **Cell structure** and **Microscopes**, you should be able to:

- label an animal cell and a plant cell
- describe the different parts of a cell and explain their functions
- convert measurements between millimetres and micrometres
- label a diagram of a microscope
- use a microscope to view cells
- calculate the total magnification of a microscope
- calculate the real size of an object viewed using a microscope
- prepare a microscope slide
- make drawings to record what you see when using a microscope.

Learning summaries provide a short bullet-point recap of each topic.

The skeletal system

The main parts of the **skeletal system** are the bones and muscles.



▲**Figure 25** The human skeleton. You do not need to learn the names of the bones, unless you really want to!

Key term

Skeletal system – made up of bones and muscles. It has several functions: support, movement, to protect body organs and to make blood cells.

Images and illustrations are included throughout to help engage students and bring the content to life.

An adult human skeleton is made up of 206 bones. The longest bone in your body is the femur (thigh bone), which is about a quarter of your height. The smallest bones are in your ears.

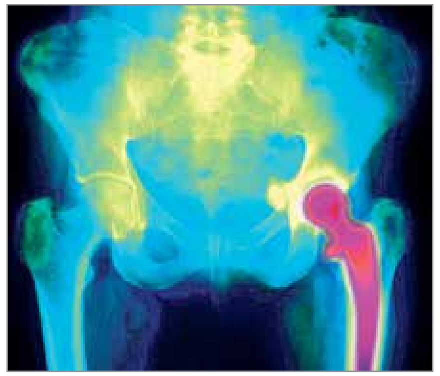
Functions of the skeleton

- To support the body
- For movement, using muscles and joints
- To make blood cells
- To protect body organs:
  - the cranium (skull) protects the brain
  - the ribcage protects the lungs, heart and main blood vessels
  - the vertebral column (backbone) protects the spinal cord
  - the pelvic girdle protects the reproductive organs in females.

Science in context

Osteoarthritis is a condition that causes joints to become painful and stiff, due to the bones rubbing against each other. Hip and knee joints are most commonly affected. The joint can be surgically replaced.

Scientists at Cardiff University are developing a smart patch to detect the early stages of osteoarthritis in patients' knees. A smart patch is an electronic sensor in a patch that can be stuck onto the body. The patch detects cracking sounds in the joint, which indicates that bones are rubbing together.

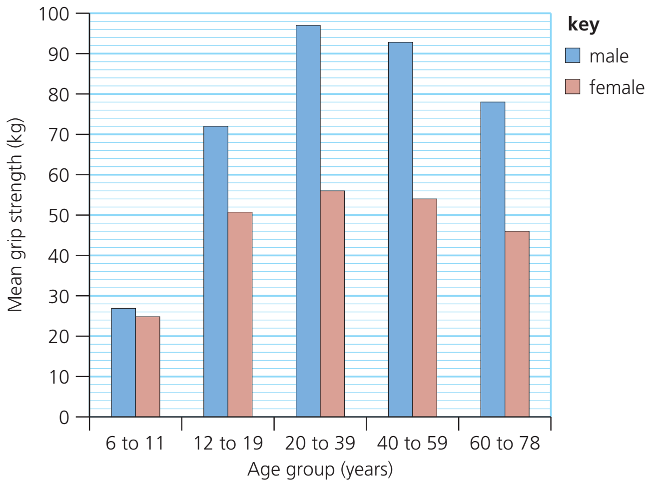


▶**Figure 26** A coloured X-ray of an artificial hip joint. The pink section is made of metal and replaces the bone in the top of the leg.

Practical skills — Analysing data in bar charts

Olaf compared the grip strength of males and females of different ages. He recorded whether they were male or female, their age and their grip strength in kilograms. He organised the data into age groups and calculated the mean grip strength for each group.

▲**Figure 27** A grip strength meter. You squeeze the meter as hard as you can for 5 seconds and record the reading.



▲**Figure 28** A bar chart showing Olaf's results for the mean grip strength in males and females of different ages.

1 What was the mean grip strength for 40 to 59-year-old females?
2 How much greater is the grip strength for males than females in the 12 to 19-year-old age group?
3 Which age group showed the biggest difference in grip strength between males and females?
4 What is unusual about the data collected for the age group 6 to 11 years?
5 Describe how grip strength varies with age.

'Practical skills' boxes focus on the skills students need to develop for practical work.

Contents

Curriculum for Wales: Science for 11–14 years Book 2

These are draft contents lists from Books 2 and 3 and therefore are subject to change.

Contents

Curriculum for Wales: Science for 11–14 years Book 3

Inspire a new generation of capable and curious scientists.

Build pupils' understanding through clear explanations, practicals and skills-based activities, ensuring that they're ready for the next step in their learning and promoting a sense of cynefin through examples and context from all around Wales and the wider world.

- Improve working scientifically skills and prepare students for future lab work with practical skills and activities highlighted throughout
- Guide pupils through the trickier literacy and maths skills with key term definitions and worked examples with and step-by-step solutions
- Support a holistic approach with links between the 'what matters' statements in the Science and Technology Area of Learning and Experience (AoLE)
- Boost progress using summaries to recap prior knowledge, alongside 'check your understanding' questions to embed understanding
- Develop pupils' curiosity and interest in science with historical context and examples from across Wales and the world

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