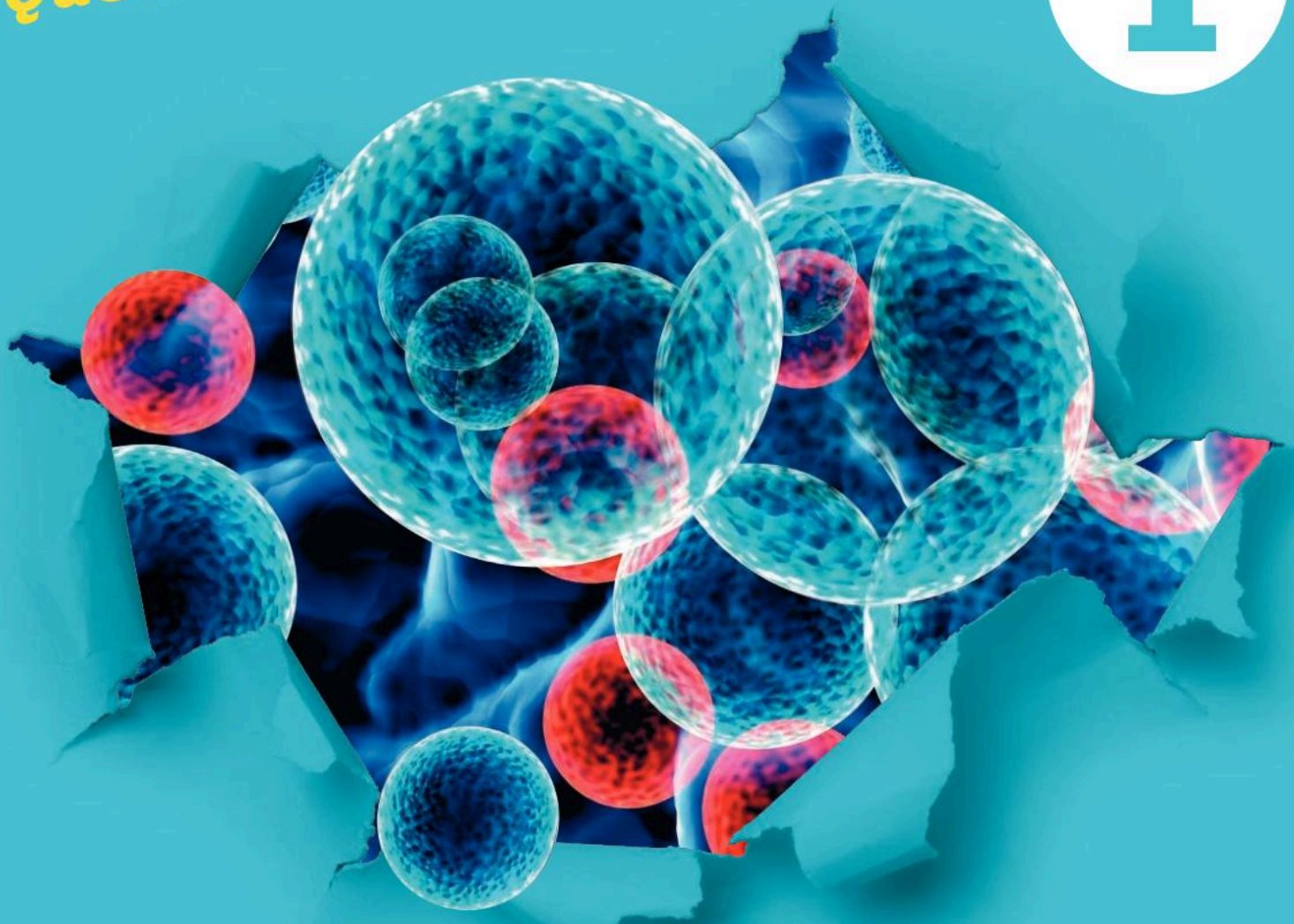
Oxford
KS3 Science

Activate 1

Question • Progress • Succeed



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OXFORD

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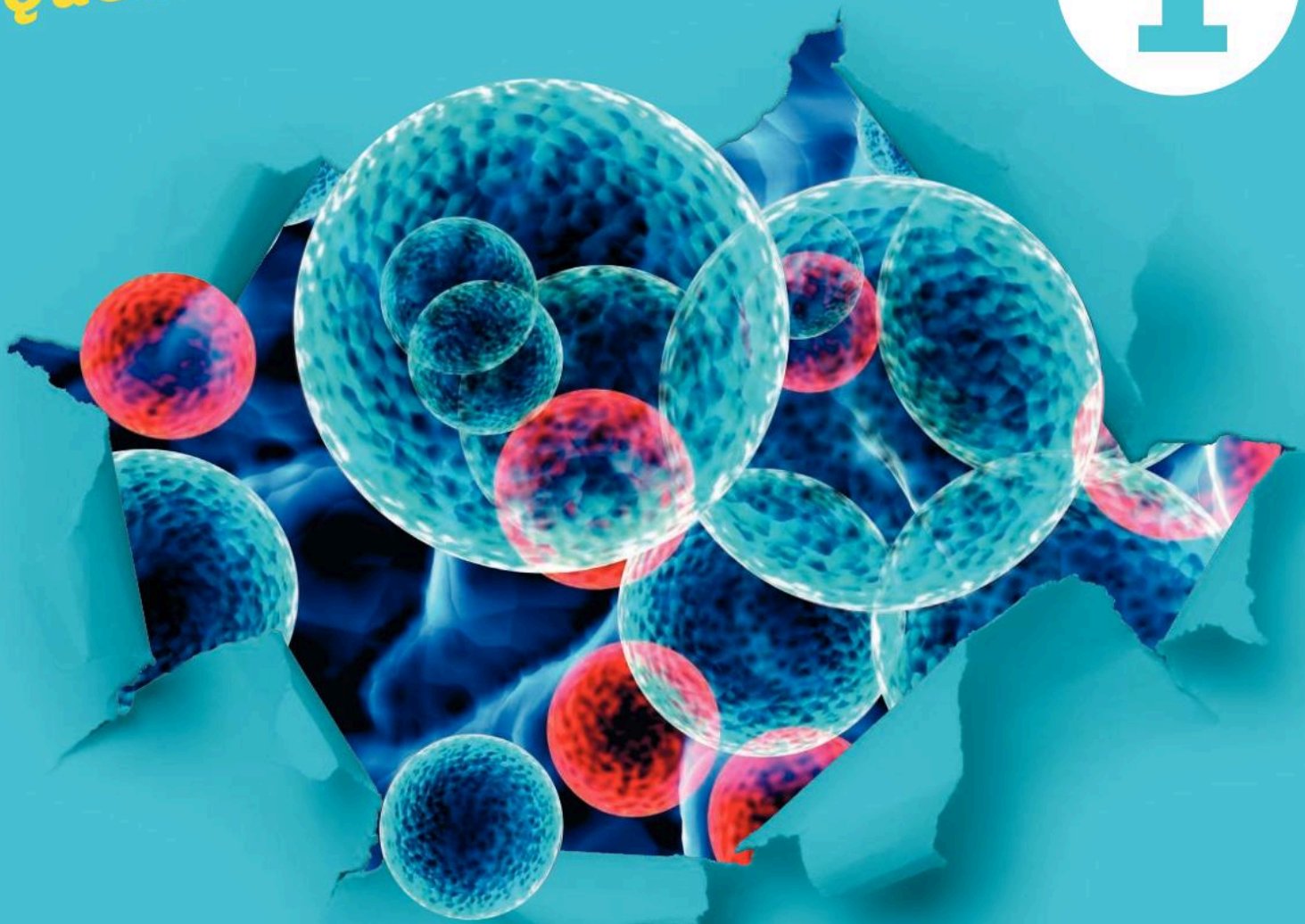

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Contents

Introduction

Learning objectives

Each spread has a set of learning objectives. These tell you what you will be able to do by the end of the lesson.

Key Words

The key words in each spread are highlighted in bold and summarised in the key-word box. They can also be found in the Glossary.

Link

Links show you where you can learn more about something mentioned in the topic.

Summary Questions

1 Questions with one conical-flask symbol are the easiest.

2 The questions get harder as you move down the list.

3 The question with three conical-flask symbols is the hardest. In these questions you need to think about how to present your answer.
In QWC questions you need to pay attention to the Quality of Written Communication.

Welcome to your *Activate* Student Book.
This introduction shows you all the different features *Activate* has to support you on your journey through Key Stage 3 Science.

Being a scientist is great fun. As you work through this Student Book, you'll learn how to work like a scientist, and get answers to questions that science can answer.

This book is packed full of fantastic (and foul!) facts, as well as plenty of activities to help build your confidence and skills in science.

Q These boxes contain short questions. They will help you check that you have understood the text.

Maths skills

Scientists use maths to help them solve problems and carry out their investigations. These boxes contain activities to help you practise the maths you need for science. They also contain useful hints and tips.

Literacy skills

Scientists need to be able to communicate their ideas clearly. These boxes contain activities and hints to help you build your reading, writing, listening, and speaking skills.

Working scientifically

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

Fantastic Fact!

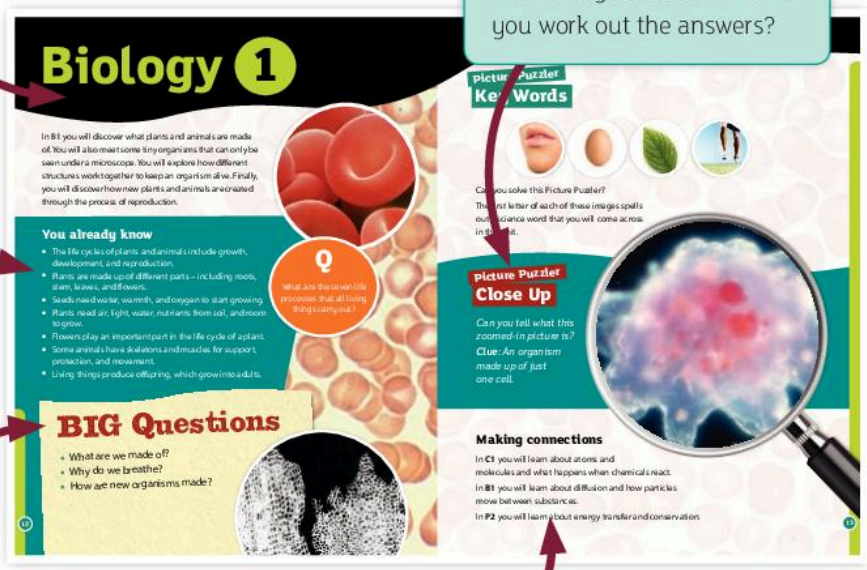
These interesting facts relate to something in the topic.

Opener
Each unit begins with an opener spread. This introduces you to some of the key topics that you will cover in the unit.

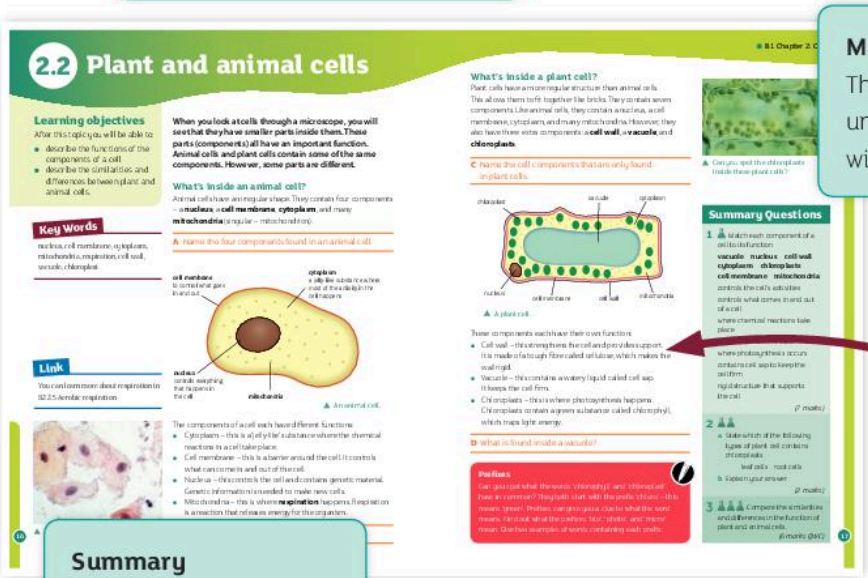
Picture Puzzlers
These puzzles relate to something in the unit – can you work out the answers?

You already know
This lists things you've already learnt that will come up again in the unit. Check through them to see if there is anything you need to recap on.

Big questions
These are some of the important questions in science that the unit will help you to answer.

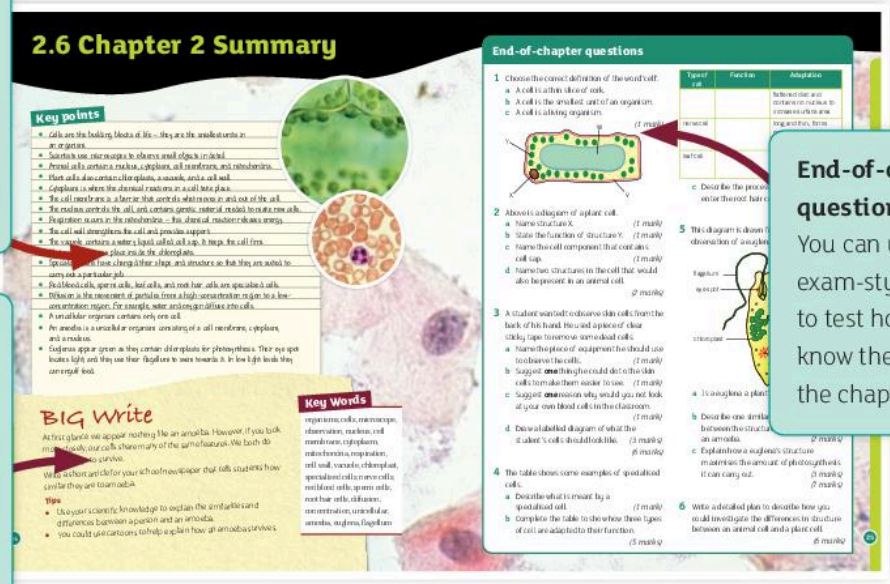


Making connections
This shows how what you will learn in the unit links up with the science that you will learn in other parts of the course..



Topic spreads
Each topic in the chapter has a double-page spread containing learning objectives, practice questions, key words, and task boxes to help you work through the chapter.

Summary
This is a summary of the chapter. You can use it to check that you have understood the main ideas in the chapter and as a starting point for revision.



End-of-chapter questions
You can use these exam-style questions to test how well you know the topics in the chapter.

Big write/Maths challenge/Case study
This is an activity that you can do at the end of the chapter. It will help you to practise using your scientific skills and knowledge.

1.1 Asking scientific questions

Learning objectives

After this topic you will be able to:

- describe how scientists develop an idea into a question that can be investigated
- identify independent, dependent, and control variables.

Why does the battery last longer in some mobile phones than others? What might mobile phones be like in the future? We can ask lots of different questions about the world. Some are questions that science can answer.

▲ What affects the battery life of your mobile phone?

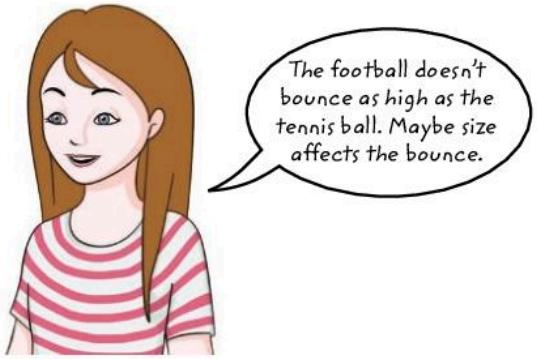
What's the question?

Scientists make **observations** of the world, and ask questions such as, 'How do fossil fuels form?' or 'Why are there are so many different animals on Earth?' These are scientific questions.

Scientists do **investigations**. They collect **data** to try to answer their questions.

Suggesting ideas

Tom and Katie are talking about balls used in sport.



Katie makes an observation about footballs and tennis balls. An observation can give you an idea that you can test in an investigation.

▲ The balls are changed every seven or nine games during a tennis match.

Developing ideas into questions

Tom watches a tennis match. New tennis balls are brought out from a refrigerator during the match.

Here are some questions that Katie and Tom might investigate:

- How does the size of a ball affect how high it bounces?
- How does the temperature of a ball affect how high it bounces?

What's a variable?

The size and temperature of the ball are not the only things that might affect the height of the bounce.

In science, anything that might affect the outcome of an investigation is called a **variable**. The thing that is affected as a result of the change is also a variable.

The temperature is the **independent variable**. It is independent because you change it. How high the ball bounces is the **dependent variable**. It is dependent because it changes when you change the temperature.

A State the two types of variable that you can change in an investigation.

Other variables

Katie and Tom think about all the other variables that might affect the bounce height. Here is their list:

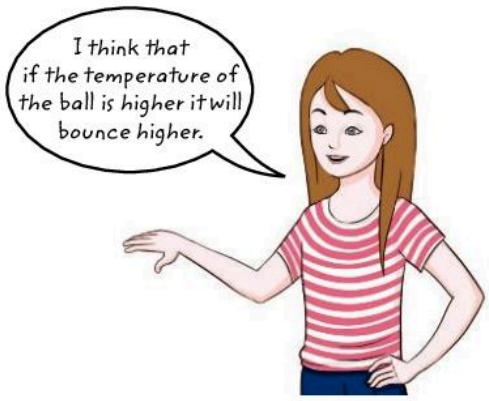
- the height you drop the ball from
- the type of ball
- the surface that you drop it onto
- the size of the ball

Katie and Tom need to keep these variables the same during their investigation so that they do not affect the bounce. These are called **control variables**.

B Name the type of variables that you keep the same in an investigation.

Making a prediction

Katie makes a **prediction** about what might happen. This is only part of the prediction. Katie should use her scientific knowledge to explain *why* she thinks that the ball will bounce higher.



Name those variables!

Imagine that you are going to investigate whether the size of a ball affects how high it bounces.

a State your dependent and indepedent variables.

b List all the variables that you would need to control.

Key Words

observation, investigation, data, variable, independent variable, dependent variable, control variable, prediction

Fantastic Fact!

Over 50 000 tennis balls are used during the Wimbledon tennis championship each year.

Summary Questions

1 Copy the sentences below, choosing the correct bold word.

You can turn an **idea/question** into an **idea/question** that you can investigate. You can answer some scientific **ideas/questions** by doing an investigation. You collect **data/observations** or make **data/observations**. Things that can change in an investigation are called **predictions/variables**. Science can answer **all/some** questions.

(7 marks)

2 A student is looking at an ice cube melting in a glass of water.

a Suggest a question that she could answer by doing an investigation. *(1 mark)*

b Explain why this is a question that science can answer. *(2 marks)*

3 Suggest three questions that scientists could investigate about food, and three that they could not. Explain your choices. *(6 marks QWC)*

1.2 Planning investigations

Learning objectives

After this topic you will be able to:

- describe how to write a plan for an investigation
- recognise what makes data accurate and precise
- describe a risk assessment.

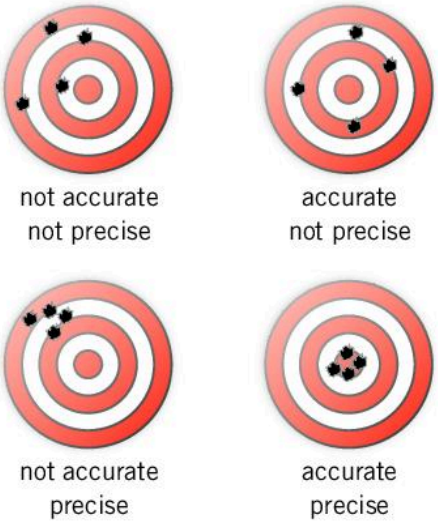
Have you ever cooked from a recipe? Did it turn out the way you wanted? The plan for an investigation or experiment is a bit like a recipe. It says what equipment and materials you are going to use, and what you are going to do with them.

Make a plan

Katie and Tom need to write a **plan** for their investigation. They need to think about how they will collect data to test their ideas. Their plan should include:

- what equipment they are going to use, and why
- what method they are going to use, and why.

A State two things that you need to include in an investigation plan.



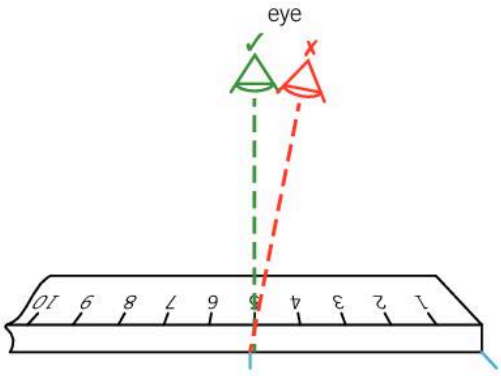
▲ Readings can be precise but not accurate.

Accurate and precise data

The measurements you make in an investigation are called data. It is important to collect data that is **accurate** and **precise**.

Accurate data is close to the true value of what you are trying to measure. For example, Tom needs to look directly at the ruler to get an accurate reading.

Precise data gives similar results if you repeat the measurement. Scientists talk about the **spread** of their sets of repeat data. Precise data has a very small spread when measurements are repeated. The repeat measurements in each set are grouped closely together.



▲ You should look straight at a scale to make an accurate measurement.

B State how to use a ruler accurately to measure length.

Uncertainty

If you look at a thermometer it might be hard to tell whether the temperature is 21.5 °C, 22.0 °C, or 22.5 °C. There is an **uncertainty** in your measurement because of the measuring instrument that you are using.

Repeatability and reproducibility

If Katie and Tom do the same investigation several times, or repeat a measurement in an investigation, the data should be similar. It is **repeatable**.

If other students do the same investigation they should get data similar to Katie and Tom. The data is **reproducible**.

Types of data

The data you collect might be words or numbers. Data can be:

- **continuous** – it can have any value, such as length or temperature
- **discrete** – it can have only whole-number values, such as number of paperclips or woodlice
- **categoric** – the value is a word, such as 'blue' or 'hot'.

How many measurements?

Katie and Tom need to plan what temperatures to test. They need to decide:

- the biggest and smallest temperatures – this is the **range**
- how many different temperatures they will test.

Is it safe?

A plan should also include a **risk assessment** . This explains how you will reduce the chance of damage to equipment, or injury to people.

What should a plan include?

Katie and Tom write a plan for their investigation. They include:

- the scientific question that they are trying to answer
- the independent and dependent variables
- a list of variables to control and how they will do it
- a prediction: what they think will happen and why
- a list of the equipment they will need
- a risk assessment
- how they will use the equipment to collect accurate and precise data.

Key Words

plan, accurate, precise, spread, uncertainty, repeatable, reproducible, continuous, discrete, categoric, range, risk assessment

Investigating dissolving

Does the temperature of water affect the mass of salt that dissolves in the water?

Write a plan to investigate this.

Summary Questions

1 Copy and complete the sentences below.

The plan for an investigation includes a list of the _____ that you will use and how you will use it. It shows how you will collect data that is _____, _____, _____, and _____. To make your investigation as safe as possible you need to do a _____ _____.

(6 marks)

2 A student investigates whether the type of surface affects the bounce of a ball.

a Explain why she should read the scale on the ruler by looking straight at it. *(2 marks)*

b Explain why the readings are not exactly the same when she repeats them. *(2 marks)*

c State and explain whether she needs to do a risk assessment. *(2 marks)*

3 Explain in detail why Katie and Tom's is a good plan.

(6 marks QWC)

1.3 Recording data

Learning objectives

After this topic you will be able to:

- describe how to make and record observations and measurements
- calculate a mean from repeat measurements
- present data appropriately in tables and graphs.

You usually collect data in a table. It is easier to see patterns in the data if you then draw a graph or chart.

Collecting data

Each time Katie and Tom change their independent variable they should take repeat measurements of their dependent variable.

Recording data

Katie and Tom make a table for their results. They need to record their measurements as they go, including all the repeat measurements.

A results table helps you to organise your data. This is Katie and Tom's results table:

Temperature	Height of bounce (cm)			
	1st Measurement	2nd Measurement	3rd Measurement	Mean
cold	45	40	35	40
warm	50	60	20	55
hot	65	75	70	70

A State the best way of recording data collected during an investigation.

Repeat readings

You should check your data for **outliers**. An outlier, or anomalous result, is a result that is very different to the others. You should repeat the measurement to replace an outlier.

In the table above, the third measurement for the warm temperature, 0.20 m, is an outlier. Katie and Tom do not include it when they work out the **mean**.

The mean is a type of average. You add up all the results and divide by the number of results. For example, the mean of the heights measured at the cold temperature in the table above is:

$$0.45\text{ m} + 0.40\text{ m} + 0.35\text{ m} = 1.2\text{ m}$$

then divide by 3 as there were 3 results:

$$\frac{1.2}{3} = 0.40\text{ m}$$

B State how to calculate the mean of a set of numbers.

Fantastic Fact!

The first ever tennis balls were hand stitched, so no two ever bounced in the same way.

Key Words

outlier, mean, line graph, bar chart, pie chart

Which graph?

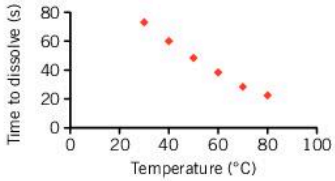
Tom and Katie have collected lots of data. They want to present their results in a graph or chart. To work out which graph or chart to plot you need to look at the variables in your investigation.

- If both your independent and your dependent variables are continuous, then you should plot a **line graph**.
- If your independent variable is categoric, you should plot a **bar chart**. In some cases you might want to display discrete or categoric data in a **pie chart**.
- For both line graphs and bar charts, you plot the independent variable on the *x* axis and the dependent variable on the *y* axis.

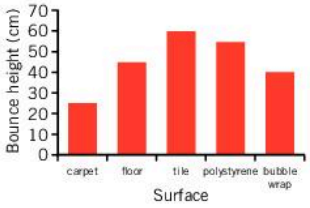
Temperature (°C)	Time to dissolve (s)
30	75
40	60

Surface	Height of bounce (cm)
Carpet	25
Floor	45

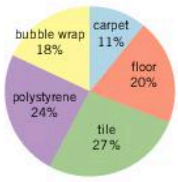
You plot a line graph:



You plot a bar chart:



... or a pie chart



C State what type of graph or chart you should plot if one of your variables is discrete.

When you draw a chart or plot a graph you should do the following:

- Choose scales for your axes so that your graph is as big as possible.
- Use a pencil and a ruler.
- Label the axes with the quantity and the unit, such as 'time (s)'.
- Write a title for your graph.

Dealing with results

A student investigated how fertiliser affects how high plants grow. Copy it and complete the final column of the table.

Mass of fertiliser (g)	Height of plant after 10 days (cm)			
	1st Measurement	2nd Measurement	3rd Measurement	Mean
2	3.2	3.7	3.6	
4	4.7	7.3	5.0	
6	5.1	5.5	5.3	

Summary Questions

1 Copy and complete the sentences below.

When you are collecting data you need to make sure that you are using _____ _____ correctly. You need to make _____ measurements to check that your data is repeatable. You need to look for _____, which are readings that are very different to the others. Then you calculate the _____.

(5 marks)

2 A student is investigating how the temperature of water affects how long it takes sugar to dissolve.

a Describe two things that he should do when collecting data. *(2 marks)*

b Draw a table that he could use for his results. *(2 marks)*

c State and explain the type of graph that he should draw. *(2 marks)*

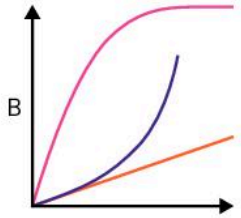
3 Design a hint sheet for students carrying out investigations. *(6 marks)*

1.4 Analysing data

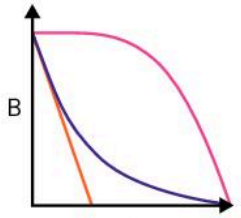
Learning objectives

After this topic you will be able to:

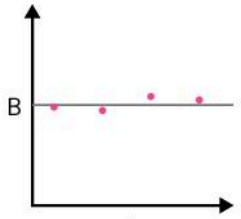
- find a pattern in data using a graph or chart
- interpret data to draw conclusions.



In these graphs, if A increases then B increases.



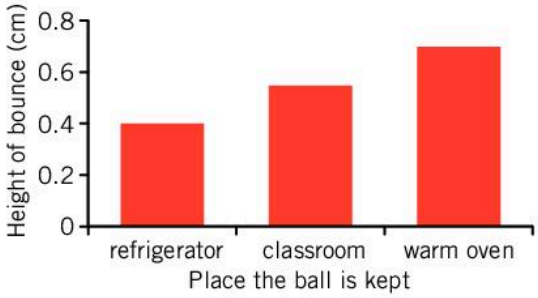
In these graphs, if A increases then B decreases.



In this graph, if A increases B does not change.

Katie and Tom have collected data and plotted a bar chart. Now they need to:

- work out what their graph tells them
- write a conclusion
- compare what they found out with their prediction.



▲ Katie and Tom's bar chart.

Using graphs or charts

When you **analyse** your data, plotting a line graph or chart helps you to spot a pattern. It shows how the dependent variable depends on the independent variable.

Your scientific knowledge will help you suggest why the independent variable affects the dependent variable in this way.

Find a pattern on a line graph

Once you have plotted a line graph you need to draw a **line of best fit**. This is a line that goes through as many points as possible, with equal numbers of points above and below the line. If there are any outliers, you should ignore these when you draw your line of best fit.

A State what is meant by a line of best fit.

Writing a conclusion

Once you have analysed your graph you can write a **conclusion**.

State what you have found out

Start by saying what the investigation shows. Then describe any relationship you can see between the two variables. Use your graph to support your conclusion.

B State two things to include in your conclusion.

Key Words

analyse, line of best fit, conclusion

Tom and Katie look at their bar chart and start to write a conclusion:

Explain what you found out

Saying what your results show is only part of analysing results. You also need to use scientific knowledge to explain the pattern.

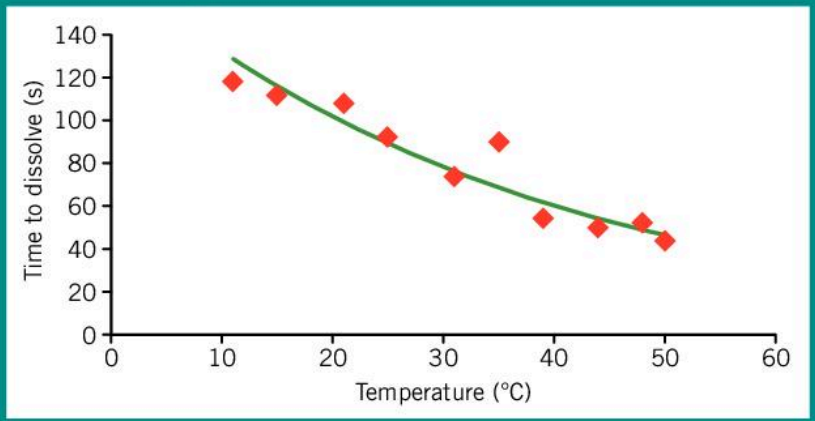
Tom begins to explain the relationship between temperature and the height of the bounce. However, to come up with a good explanation he needs to understand why balls bounce.

Comparing results with predictions

Finally, you can compare your results with your prediction.

What's the relationship?

A student plots a graph of water temperature and the time that it takes sugar to dissolve in the water.



Use information from the graph to describe what happens when you double the temperature of the water.

Link

You can learn more about why balls bounce in P1 1.1 Introduction to forces

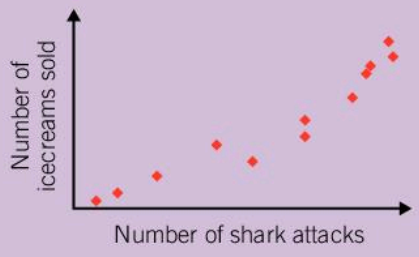
Summary Questions

1 Copy and complete the sentences below.

To analyse your data you plot a graph or chart and work out the _____ between the variables. Then you write a _____ that includes what you have found out, and explains why, using _____ _____. Finally you compare your results with your _____.

(5 marks)

2



A student has drawn a graph for an investigation into the relationship between the number of icecreams sold and the number of shark attacks in a certain period. Draw a flow chart to show how he should complete the analysis of his data and draw conclusions.

(4 marks)

3 Look at the graph in Question 2. Describe and explain in detail what the graph shows and suggest a conclusion that you can draw from the data.

(6 marks QWC)

1.5 Evaluating data

Learning objectives

After this topic you will be able to:

- describe the stages in evaluating data
- suggest ways to improve a practical investigation.

▲ Evaluating means working out what is good and what is not so good.

Katie and Tom have collected data and analysed it by plotting a bar chart. Now they need to evaluate their data and their methods.

There are two ways to **evaluate** your investigation. You should:

- discuss the quality of the data that you have collected
- suggest and explain improvements to your method so you can collect data of better quality if you did it again.

Your suggested improvements should increase the **confidence** that you have in your conclusion.

Evaluating the data

Katie and Tom look at their data. They had only one outlier in their experiment – the third measurement for 'warm'. If there were lots of outliers then they would have less confidence in their conclusion.

What's the spread?

The spread of data tells you how precise the data is. The spread is the difference between the highest and the lowest readings in a set of repeat measurements.

A State what is meant by the spread of a set of measurements.

In their experiment the measurements for one temperature do not overlap with the measurements for another. That makes the data very precise.

A small spread in the data will give you more confidence in your conclusion. You should discuss this in your evaluation.

Key Words

evaluate, confidence, random error, systematic error

Errors and uncertainty

There is uncertainty in any measurement that you make. This is one of the reasons why there is usually a spread in experimental data.

There are two types of error that can affect scientific measurements. These are:

- **random error** – this can affect the spread, or cause outliers. An example is the temperature of the room suddenly changing because someone opens a door.
- **systematic error** – this can make your measurements less accurate. An example is a newtonmeter reading 1 N even when there is nothing attached to it.

You should think about possible errors as well as the outliers and spread to help you to decide how confident you are in your conclusion.

Range and number of results

Tom and Katie only measured at three different temperatures. It would be better to have a wide range.

B State whether it is better to measure a wide range or a narrow range of values.

Suggesting improvements

You might get better data by:

- including a bigger range, or taking more readings
- using different apparatus – giving a smaller spread and fewer outliers.

Evaluating data

Ali and Emma do the same tennis-ball investigation as Katie and Tom. They produce this data:

Temperature (°C)	Height of bounce (cm)			
	1st Measurement	2nd Measurement	3rd Measurement	Mean
–4	25	27	45	
4	30	26	25	
20	42	59	49	
40	54	59	61	
60	65	42	71	

a Identify the outliers.

b Calculate the mean bounce height for each value of temperature.

c Comment on the spread of data for each value of temperature.

Improving data

Use your data to decide if your method was good, or could be improved. You should say how any improvements would make the data better.

Summary Questions

1 Copy and complete the sentences below.

When you evaluate your data you need to look at how many _____ you had. Then you need to look at the spread, which is the difference between the _____ and _____ reading within each set of repeat measurements. You need to look at the _____ and _____ of values. Finally, you can propose how to improve the _____ if you did it again.

(6 marks)

2

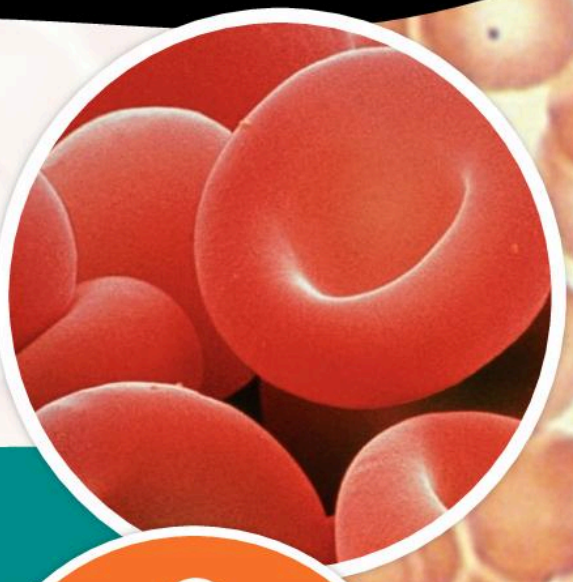
a State two ways that Katie and Tom could improve their data. *(2 marks)*

b Suggest one other way that they could improve the quality of their data. *(3 marks)*

3 Explain how using a video camera could improve the quality of Katie and Tom's data. *(6 marks QWC)*

Biology 1

In B1 you will discover what plants and animals are made of. You will also meet some tiny organisms that can only be seen under a microscope. You will explore how different structures work together to keep an organism alive. Finally, you will discover how new plants and animals are created through the process of reproduction.



You already know

- The life cycles of plants and animals include growth, development, and reproduction.
- Plants are made up of different parts – including roots, stem, leaves, and flowers.
- Seeds need water, warmth, and oxygen to start growing.
- Plants need air, light, water, nutrients from soil, and room to grow.
- Flowers play an important part in the life cycle of a plant.
- Some animals have skeletons and muscles for support, protection, and movement.
- Living things produce offspring, which grow into adults.

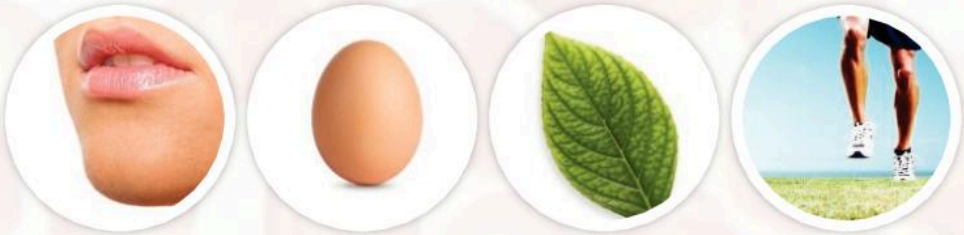
Q

What are the seven life processes that all living things carry out?

BIG Questions

- What are we made of?
- Why do we breathe?
- How are new organisms made?

Picture Puzzler
Key Words



Can you solve this Picture Puzzler?

The first letter of each of these images spells out a science word that you will come across in this unit.

Picture Puzzler
Close Up

Can you tell what this zoomed-in picture is?

***Clue**: An organism made up of just one cell.*

Making connections

In **C1** you will learn about atoms and molecules and what happens when chemicals react.

In **B1** you will learn about diffusion and how particles move between substances.

In **P2** you will learn about energy transfer and conservation.

1.1 Observing cells

Learning objectives

After this topic you will be able to:

- describe what a cell is
- explain how to use a microscope to observe a cell.

Look around you. Can you see any dust? Most household dust is actually dead cells. These come from anything living in your house. To see the cells, you need to look through a microscope.

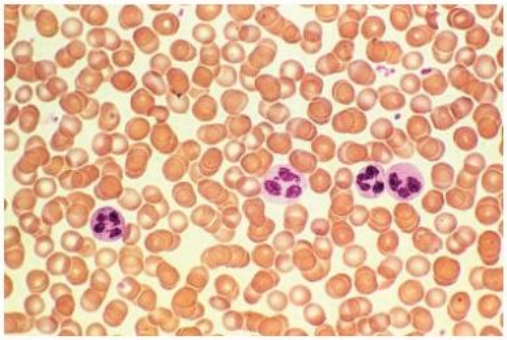
What are living organisms made of?

All living **organisms** (things) are made of **cells**. Cells are the building blocks of life. They are the smallest units found in an organism. Organisms such as bacteria can be formed from a single cell. Millions of cells can join together to form a person, like you.

A State what all living organisms are made up of.

Fantastic Fact!

Cells are so small that about 100 animal cells would fit across the width of this tiny full stop.



▲ There are different types of cells in your blood.

Seeing cells

Cells were first seen about 350 years ago when Robert Hooke, a scientist, looked down a **microscope** at a thin slice of cork. He saw tiny roomlike structures, which he called cells. These were plant cells; cork is a type of tree bark.

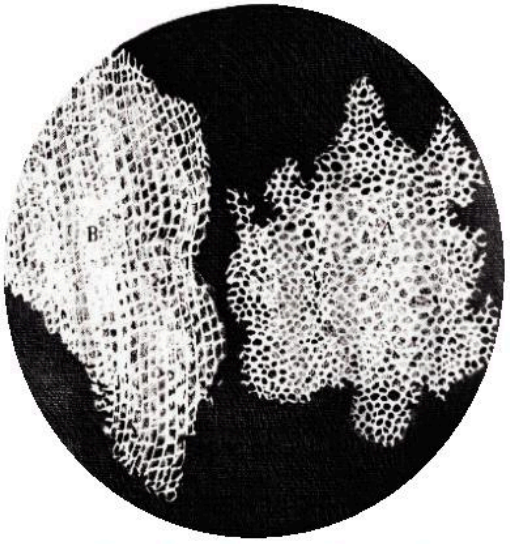
B Write down what Robert Hooke saw when he looked at cork using a microscope.

Making an observation

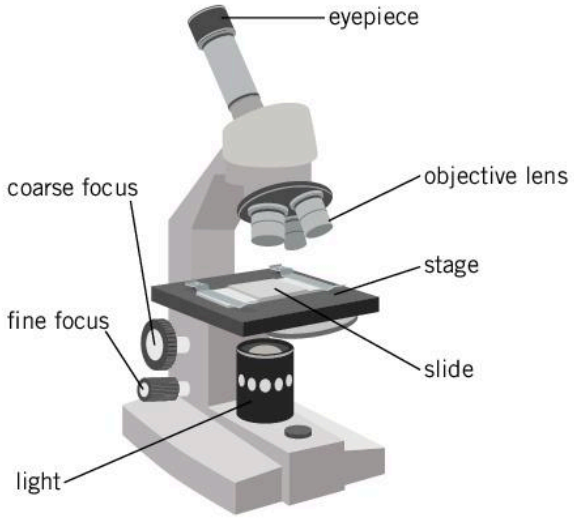
To see a very small object in detail, you need to use a microscope. This magnifies the image using lenses. Looking carefully and in detail at an object is called making an **observation**.

To make an observation, the object you wish to observe needs to be very thin so that light can travel through it. You might need to add coloured dye to make the object easier to see.

C State what is meant by a scientific observation.



▲ This is the drawing that Hooke made of cork cells.



Parts of a microscope

Follow the steps below to observe an object using a microscope.

1. Move the stage to its lowest position.
2. Place the object you want to observe on the stage.
3. Select the objective lens with the lowest magnification.
4. Look through the eyepiece and turn the coarse-focus knob slowly until you see your object.
5. Turn the fine-focus knob until your object comes into focus.
6. Repeat Steps 1 to 6 using an objective lens with a higher magnification to see the object in greater detail.

D Name the part of a microscope you look through.

Magnification

The eyepiece lens and objective lens in a microscope have different magnifications. Together they magnify the object.
For example, if you have an eyepiece lens of ×10 and an objective lens of ×20 the object would be magnified 200 times.

Total magnification = eyepiece lens magnification × objective lens magnification

= 10 × 20

= 200

Magnification

You are asked to observe an onion cell using a microscope. The eyepiece lens has a ×10 magnification and the objective lens has a ×50 magnification. What is the total magnification?

Microscope observations

When recording your observations from a microscope, you should always note down the magnification you used. Use a sharp pencil to draw diagrams, and use a ruler to draw label lines.

Key Words

organism, cell, microscope, observation

Summary Questions

1 Copy and complete the sentences below.

All living organisms are made up of _____ – these are the _____ blocks of life. To _____ cells in detail you need to use a _____. This _____ the object.

(5 marks)

2 Describe what the following parts of a microscope do:

a lenses *(1 mark)*

b stage *(1 mark)*

c focusing knobs *(1 mark)*

3 Describe in detail the method you would use to observe the cells within a white flower petal.

(6 marks QWC)

1.2 Plant and animal cells

Learning objectives

After this topic you will be able to:

- describe the functions of the components of a cell
- describe the similarities and differences between plant and animal cells.

When you look at cells through a microscope, you will see that they have smaller parts inside them. These parts (components) all have an important function. Animal cells and plant cells contain some of the same components. However, some parts are different.

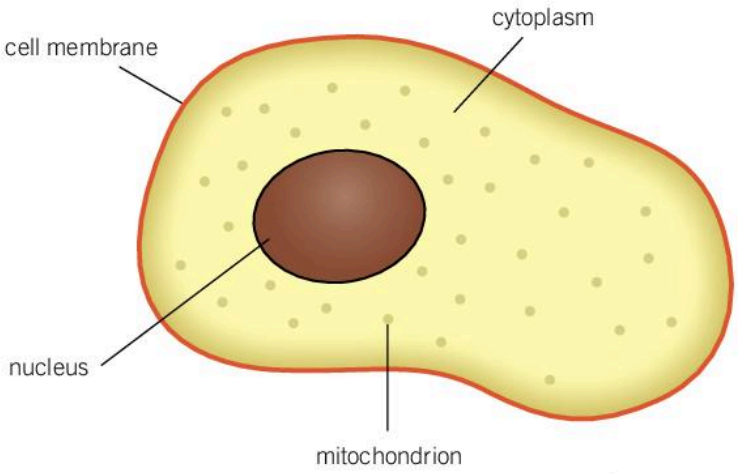
Key Words

nucleus, cell membrane, cytoplasm, mitochondria, respiration, cell wall, vacuole, chloroplast

What's inside an animal cell?

Animal cells have an irregular shape. They contain four components – a **nucleus**, a **cell membrane**, **cytoplasm**, and many **mitochondria** (singular – mitochondrion).

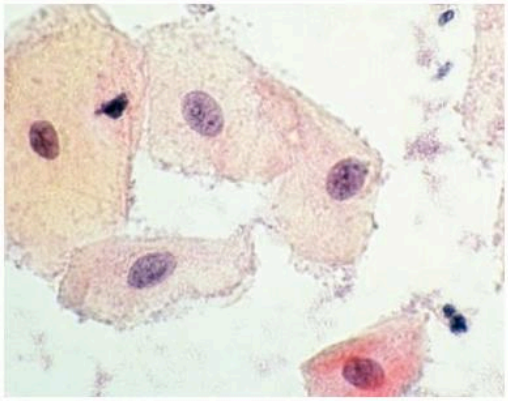
A Name the four components found in an animal cell.



▲ An animal cell.

Link

You can learn more about respiration in B2 2.5 Aerobic respiration



▲ Can you spot the nucleus inside these cheek cells?

The components of a cell each have different functions:

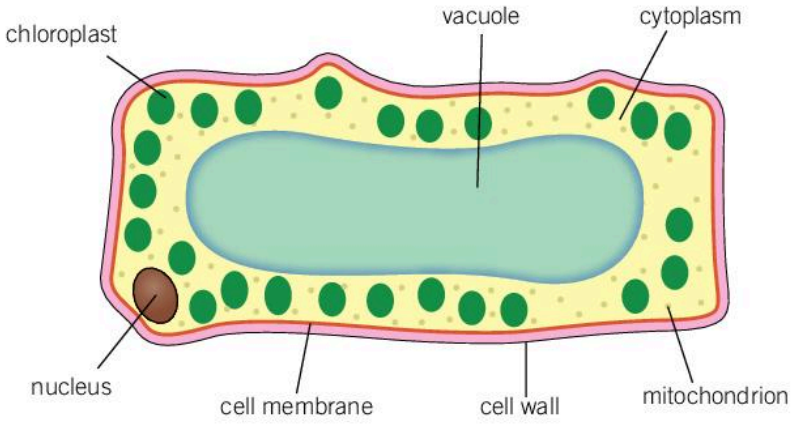
- Cytoplasm – this is a 'jelly-like' substance where the chemical reactions in a cell take place.
- Cell membrane – this is a barrier around the cell. It controls what can come in and out of the cell.
- Nucleus – this controls the cell and contains genetic material. Genetic information is needed to make new cells.
- Mitochondria – this is where **respiration** happens. Respiration is a reaction that transfers energy for the organism.

B State the function of a cell nucleus.

What's inside a plant cell?

Plant cells have a more regular structure than animal cells. This allows them to fit together like bricks. They contain seven components. Like animal cells, they contain a nucleus, a cell membrane, cytoplasm, and many mitochondria. However, they also have three extra components: a **cell wall**, a **vacuole**, and **chloroplasts**.

C Name the cell components that are only found in plant cells.



▲ A plant cell.

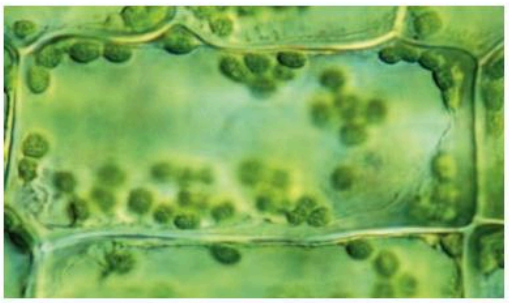
These components each have their own function:

- Cell wall – this strengthens the cell and provides support. It is made of a tough fibre called cellulose, which makes the wall rigid.
- Vacuole – this contains a watery liquid called cell sap. It keeps the cell firm.
- Chloroplasts – this is where photosynthesis happens. Chloroplasts contain a green substance called chlorophyll, which traps energy transferred from the Sun.

D What is found inside a vacuole?

Prefixes

Can you spot what the words 'chlorophyll' and 'chloroplast' have in common? They both start with the prefix 'chloro' – this means 'green'. Prefixes can give you a clue to what the word means. Find out what the prefixes 'bio', 'photo', and 'micro' mean. Give **two** examples of words containing each prefix.



▲ Can you spot the chloroplasts inside these plant cells?

Summary Questions

1 Match each component of a cell to its function.

vacuole **nucleus** **cell wall** **cytoplasm** **chloroplasts** **cell membrane** **mitochondria**

controls the cell's activities

controls what comes in and out of a cell

where chemical reactions take place

where respiration occurs

where photosynthesis occurs

contains cell sap to keep the cell firm

rigid structure that supports the cell

(7 marks)

2

a State which of the following types of plant cell contains chloroplasts: *(1 mark)*

leaf cells **root cells**

b Explain your answer. *(1 mark)*

3 Compare the similarities and differences in the function of plant and animal cells. *(6 marks QWC)*

1.3 Specialised cells

Learning objectives

After this topic you will be able to:

- describe examples of specialised animal cells
- describe examples of specialised plant cells.

Fantastic Fact!

The sciatic nerve is the largest and longest nerve in the body. It is as wide as a thumb at its largest point. It starts in the bottom of your spine and extends all the way down the back of your leg to your toes.

Key Words

specialised cell, nerve cell, red blood cell, sperm cell, leaf cell, root hair cell

Detailed descriptions

Use the description below to draw a diagram of a type of cell called a ciliated cell.

Ciliated cells are found in your airways. They are rectangular-shaped cells and each contains a nucleus. They are arranged in a single layer, like bricks standing upright. On their top surface they have lots of little hairs called cilia. These cilia sweep a sticky substance called mucus away from your lungs.

As you are reading this, your body is doing many different things. Each function carried out in the body is performed by different cells. Each type of cell has slightly different features.

How do animal cells differ?

Most cells in your body contain a nucleus, cell membrane, cytoplasm, and mitochondria. However, many cells have changed their shape and structure so that they are suited to carry out a particular job. These cells are called **specialised cells**.

If you look carefully at a specialised cell, its shape and special features can provide clues about what it does.

A Write down what specialised cell means.

Nerve cell

Nerve cells carry electrical impulses around your body.

▲ A nerve cell. Its scientific name is a neurone.

They are long and thin and have connections at each end where they can join to other nerve cells. This allows them to transmit messages around the body.

B State the function of a nerve cell.

Red blood cell

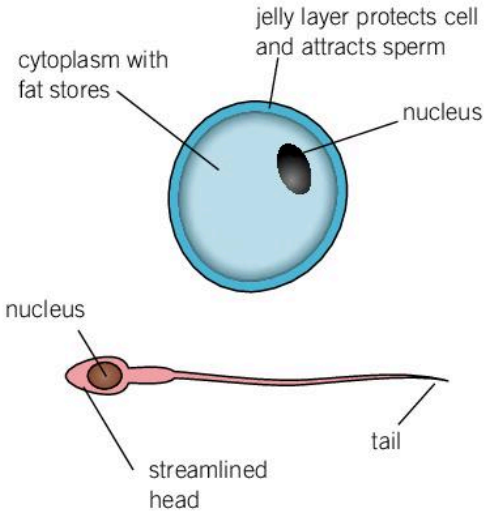
Red blood cells transport oxygen around the body. They contain haemoglobin, a red pigment that joins to oxygen. Unlike most animal cells they have no nucleus. They also have a disc-like shape. This increases their surface area for carrying oxygen.

C Name the component, normally found in animal cells, that is missing in a red blood cell.

Sperm cell

Sperm cells carry male genetic material. They have a streamlined head and a long tail. This allows the cell to move through a liquid. They contain lots of mitochondria to transfer energy. This allows the tail to 'swim'. When the sperm cell meets an egg cell, the head of the sperm burrows into the egg.

D Name two features that help a sperm cell to do its job.

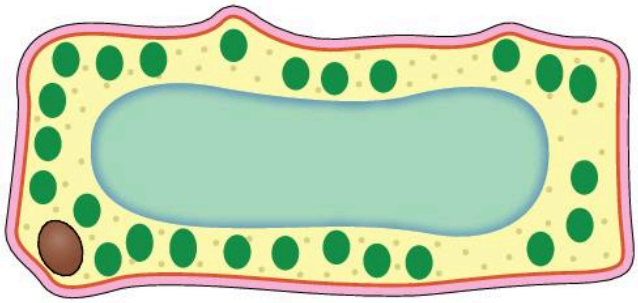


▲ An egg cell and a sperm cell.

How do plant cells differ?

Not all plant cells are the same. Cells in different parts of a plant are specialised to perform their job.

Leaf cell

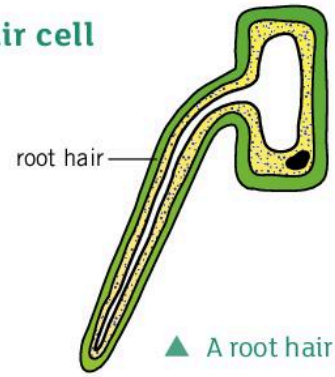


◀ A cell from the top of a leaf. Its scientific name is a palisade cell.

The **leaf cells** found near the top of a leaf carry out photosynthesis. The cells are long and thin and packed with chloroplasts. This means they have a large surface area for absorbing energy transferred from the Sun.

E Name two special features that help a leaf cell to carry out photosynthesis.

Root hair cell



▲ A root hair cell.

Root hair cells absorb water and nutrients from soil. The root hair creates a large surface area for absorbing water and nutrients. They have no chloroplasts as there is no light underground, so these cells do not carry out photosynthesis.

Summary Questions

1 Copy and complete the sentences below.

_____ cells have special features to allow them to carry out their _____. Red blood cells carry _____ around the body. Leaf cells are packed full of _____ to carry out _____.

(5 marks)

2 Choose an animal or plant cell from this page and describe the features that make it specialised.

(2 marks)

3 Draw a labelled diagram of a sperm cell. Explain how each feature enables the sperm cell to perform its function.

(6 marks)

1.4 Movement of substances

Learning objectives

After this topic you will be able to:

- name some substances that move into and out of cells
- describe the process of diffusion.

Link

You can learn more about diffusion in C1 1.6 Diffusion

Key Words

diffusion, concentration

Stink-bomb alert!

Imagine you work for a company that makes stink bombs. A toy shop is interested in selling your stink bombs but wants to know how they work. Using ideas about diffusion, write a reply to the toy shop that explains simply how stink bombs work.

How do you know when someone is cooking? The chances are that you will smell the food before you see it. A scientific process is taking place. It is the same process that moves substances into and out of your cells.

Can substances move into cells?

All the cells inside your body need glucose (a substance gained from food) and oxygen for respiration. During respiration energy is transferred. Glucose and oxygen are carried around your body in the blood. They then pass into the cells that need them.

A Name two substances that move into a body cell.

Can substances move out of cells?

Some chemical reactions inside cells make waste products. For example, carbon dioxide is produced during respiration. It passes out of the cell into the blood. The blood then transports the carbon dioxide to the lungs, where you breathe it out.

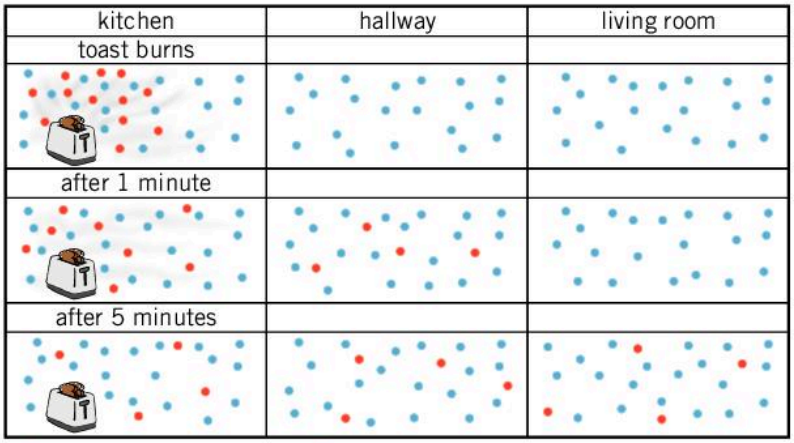
B Name one substance that moves out of a body cell.

How do substances move in and out of cells?

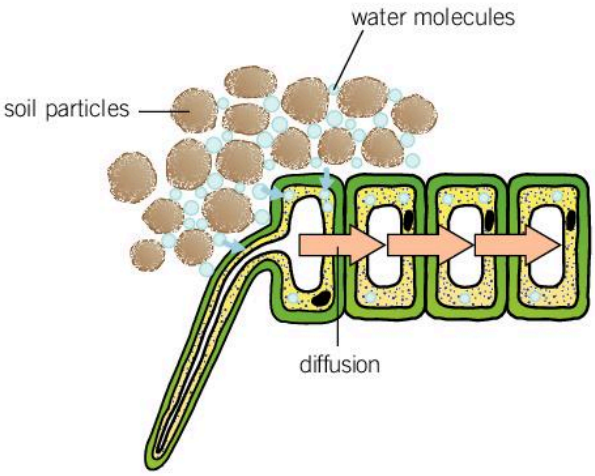
Substances move in and out of cells by **diffusion**. Diffusion is the movement of particles from a place where they are in a high **concentration** to a place where they are in a low concentration. The concentration of a substance means the number of particles of a substance present in an area.

Think about what happens when someone burns toast.

The particles that make up the smell of burnt toast move from a place of high concentration (the kitchen) to one of low concentration (the rest of the house). At first, you may only be able to smell the burnt toast in the kitchen. A short time later, you may be able to smell the burnt toast in the living room. Diffusion continues until there is the same concentration of the particles everywhere.



▲ This diagram shows how you smell burnt toast in another room.



▲ The diffusion of water is known as osmosis.

Diffusion in plant cells

Plants need a constant supply of water for photosynthesis. Water diffuses into the plant through the root hair cells. The water molecules move from the soil (high water concentration) into the root hair cell (low water concentration). Water then travels from the root hair cells to other cells in the plant by diffusion.

Why do plants wilt?

If plants are not watered regularly they will wilt and eventually die. Inside the cells, water fills up the vacuole. This pushes outwards on the cell wall and makes the cell rigid. This helps the plant to stand upright.

If the plant does not have enough water, the vacuole shrinks. The cells then become floppy and the plant wilts.

▲ If a plant does not have enough water it will wilt.

Link

You can learn more about molecules in C1 2.3 Compounds

Summary Questions

1 Copy and complete the sentences below.

Substances move from an area where they are in a _____ concentration to an area where they are in a _____ concentration. This process is called _____ .

(3 marks)

2 Explain how the smell of perfume can move throughout a room.

(3 marks)

3 Draw a visual summary of the key ideas on this page about cells and diffusion, including diagrams.

(6 marks)

1.5 Unicellular organisms

Learning objectives

After this topic you will be able to:

- describe what a unicellular organism is
- describe the structure of an amoeba
- describe the structure of a euglena.

Not all living organisms are as complicated as you are. The first organisms that existed on Earth were made up of just a single cell. There are still many organisms alive today that consist of only one cell.

What is a unicellular organism?

A **unicellular** organism is an organism that is made up of just one cell. It is not a plant or an animal, as these are made up of lots of cells.

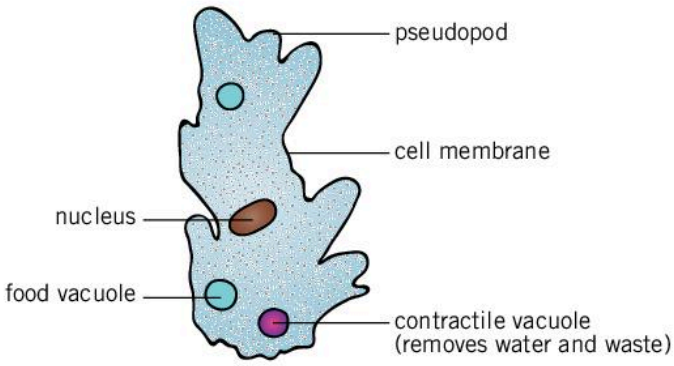
A State what unicellular means.

Unicellular organisms

Working in small groups, produce a presentation to introduce an amoeba and a euglena to another group. What are they? What do they look like? How are they similar, and how do they differ?

Amoeba

An **amoeba** is a unicellular organism that has no fixed shape. Amoebas look a bit like a blob of jelly. They can be found in fresh water, salt water, wet soil, and even inside animals.



▲ Parts of an amoeba.

Key Words

unicellular, amoeba, euglena, flagellum

Just like an animal cell, an amoeba consists of a cell membrane filled with cytoplasm. Inside the cell there is also a nucleus, which controls growth and reproduction.

Amoebas move by changing the shape of their body. They can make part of their body move in the direction they want to travel. The rest of the cell then slowly follows.

Foul Fact!

The amoeba naegleria is known as the brain-eating amoeba. It is found in warm fresh water. Very occasionally it infects people. It attacks the nervous system and slowly destroys the brain tissue, almost always resulting in death.

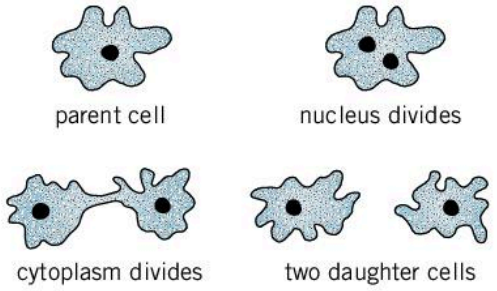
B Name two structures found in both an animal cell and an amoeba.

What do they eat?

Amoebas eat algae, bacteria, and plant cells. They eat by surrounding tiny particles of food and forming a food vacuole. This is known as engulfing. The food vacuole then digests the food.

How do they reproduce?

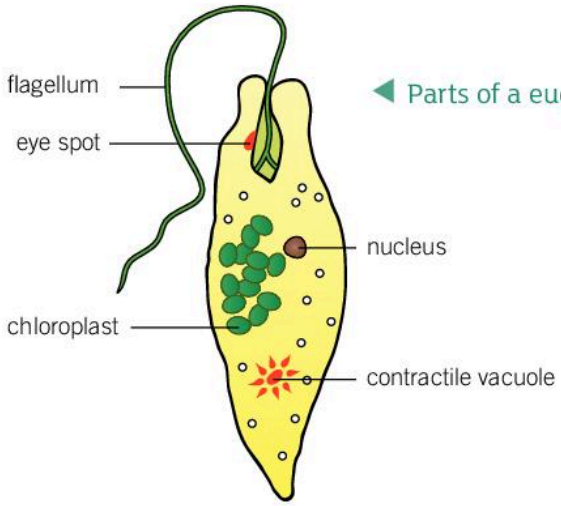
To reproduce, an amoeba splits itself into two cells. This is known as binary fission. First, the nucleus in the cell divides. Then the cytoplasm divides, producing two identical cells.



▲ Amoebas divide by binary fission.

Euglena

A **euglena** is a microscopic unicellular organism, found in fresh water.



◀ Parts of a euglena.

Like amoebas, euglenas contain cytoplasm and a nucleus. However, they also have chloroplasts, which make them look green. The chloroplasts trap energy transferred from the Sun so that the euglena can make food by photosynthesis.

Euglenas also have an eye spot, which detects light, and a **flagellum**. This tail-like structure spins like a propeller, causing the euglena to 'swim' towards the light. This allows the euglena to maximise the amount of food it makes.

C Name one way in which a euglena is different to an amoeba.

What do they eat?

When a euglena doesn't have enough light to make its own food, it looks for other things to eat. They eat other microorganisms, such as bacteria and algae, by surrounding and engulfing them.

How do they reproduce?

Like amoebas, euglenas reproduce by binary fission.

Link

You can find out more about photosynthesis in B2 2.1 Photosynthesis

Summary Questions

1 Copy and complete the sentences below.

Amoebas and euglenas are examples of _____ organisms. This means that they are only made up of _____ cell. Both organisms reproduce by _____ _____ . Amoebas have to _____ food to survive but euglenas can carry out _____ to produce their own food.

(6 marks)

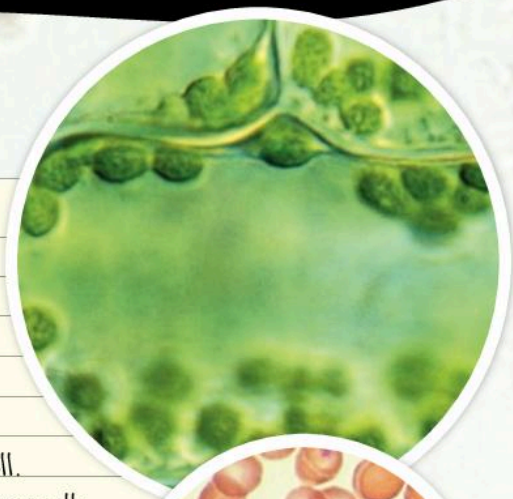
2 Describe how amoebas and euglenas reproduce.

(3 marks)

3 Compare the structures of euglenas and amoebas. In what ways are the organisms similar and in what ways are they different?

(6 marks QWC)

B1 Chapter 1 Summary



Key Points

- Cells are the building blocks of life – they are the smallest units in an organism.
- Scientists use microscopes to observe small objects in detail.
- Animal cells contain a nucleus, cytoplasm, cell membrane, and mitochondria.
- Plant cells also contain chloroplasts, a vacuole, and a cell wall.
- Cytoplasm is where the chemical reactions in a cell take place.
- The cell membrane is a barrier that controls what moves in and out of the cell.
- The nucleus controls the cell, and contains genetic material needed to make new cells.
- Respiration occurs in the mitochondria – this chemical reaction transfers energy.
- The cell wall strengthens the cell and provides support.
- The vacuole contains a watery liquid called cell sap. It keeps the cell firm.
- Photosynthesis takes place inside the chloroplasts.
- Specialised cells have changed their shape and structure so that they are suited to carry out a particular job.
- Nerve cells, red blood cells, sperm cells, leaf cells, and root hair cells are specialised cells.
- Diffusion is the movement of particles from a high-concentration area to a low-concentration area. For example, water and oxygen diffuse into cells.
- A unicellular organism contains only one cell.
- An amoeba is a unicellular organism consisting of a cell membrane, cytoplasm, and a nucleus.
- Euglenas appear green as they contain chloroplasts for photosynthesis. Their eye spot locates light, and they use their flagellum to swim towards it. In low light levels they can engulf food.

BIG Write

Amoeba and me

At first glance we appear nothing like an amoeba. However, if you look more closely, our cells share many of the same features. We both do similar things to survive.

Task

Write a short article for your school newspaper that tells students how similar they are to amoeba.

Tips

- Use your scientific knowledge to explain the similarities and differences between a person and an amoeba.
- You could use cartoons to help explain how an amoeba survives.

Key Words

organism, cell, microscope, observation, nucleus, cell membrane, cytoplasm, mitochondria, respiration, cell wall, vacuole, chloroplast, specialised cell, nerve cell, red blood cell, sperm cell, root hair cell, diffusion, concentration, unicellular, amoeba, euglena, flagellum

End-of-chapter questions

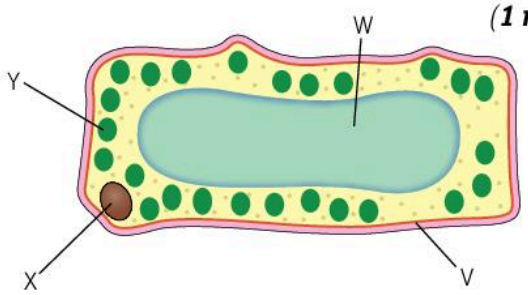
1 Choose the correct definition of the word 'cell'.

A A cell is a thin slice of cork.

B A cell is the smallest unit of an organism.

C A cell is a living organism.

(1 mark)



2 Above is a diagram of a plant cell.

a Name structure X. *(1 mark)*

b State the function of structure Y. *(1 mark)*

c Name the cell component that contains cell sap. *(1 mark)*

d Name **two** structures in the cell that would also be present in an animal cell. *(2 marks)*

(5 marks)

3 A student wanted to observe skin cells from the back of his hand. He used a piece of clear sticky tape to remove some dead cells.

a Name the piece of equipment he should use to observe the cells. *(1 mark)*

b Suggest **one** thing he could do to the skin cells to make them easier to see. *(1 mark)*

c Suggest **one** reason why you would not look at your own blood cells in the classroom. *(1 mark)*

d Draw a labelled diagram of what the student's cells should look like. *(3 marks)*

(6 marks)

4 The table shows some examples of specialised cells.

a Describe what is meant by a specialised cell. *(1 mark)*

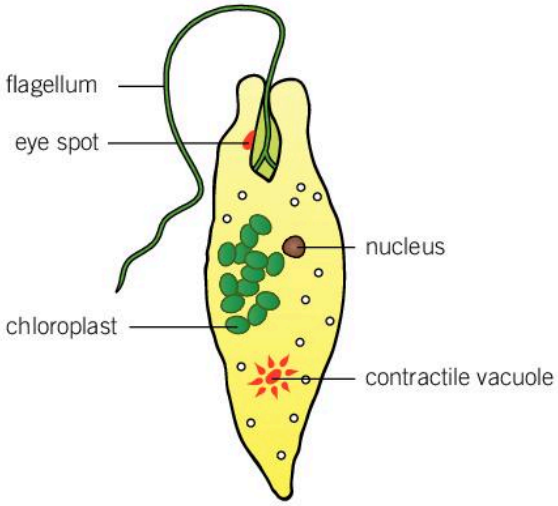
b Complete the table to show how **three** types of cell are adapted to their function. *(5 marks)*

Type of cell	Function	Adaptation
		flattened disc and contains no nucleus to increase surface area
nerve cell		long and thin, forms connections with many nerves
leaf cell		

c Describe the process that causes water to enter the root hair cell. *(3 marks)*

(9 marks)

5 This diagram is drawn from a microscope observation of a euglena.



a Is a euglena a plant? Explain your answer. *(2 marks)*

b Describe **one** similarity and **one** difference between the structure of a euglena and an amoeba. *(2 marks)*

c Explain how a euglena's structure maximises the amount of photosynthesis it can carry out. *(3 marks)*

(7 marks)

6 Write a detailed plan to describe how you could investigate the differences in structure between an animal cell and a plant cell. ***(6 marks QWC)***

2.1 Levels of organisation

Learning objectives

After this topic you will be able to:

- define and state examples of tissues, organs, and organ systems
- explain the hierarchy of organisation in a multicellular organism.

Do the trees outside look like a euglena? No, not really! As well as being much larger, they are much more complicated. They consist of many cells working together to form a multicellular organism.

What are multicellular organisms?

Multicellular organisms are made up of many cells. They contain organ systems to perform their life processes.

Multicellular organisms have five layers of organisation. This is called a hierarchy. Cells are the building blocks of life. They are the first level of organisation. Nerve, muscle, and red blood cells are examples of animal cells. Root hair and leaf cells are examples of plant cells.

A State the first level of organisation in a multicellular organism.

What is a tissue?

The second level of organisation is a **tissue**. A tissue is a group of similar cells that work together to perform a certain function.

An example of an animal tissue is muscle tissue. Muscle cells contract together to make the body move. Another example is nervous tissue – nerve cells work together to transmit messages around the body.

An example of a plant tissue is the xylem – these are tubes that carry water around the plant.

B State one example of an animal tissue.

What is an organ?

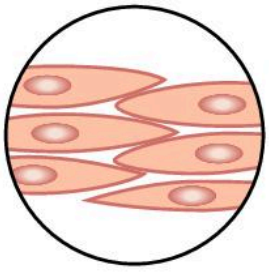
The third level of organisation is an **organ**. An organ is made up of a group of different tissues that work together to perform a certain function. The main organs in a plant and animal are shown below.

Link

You can find out more about plant and animal cells in B1 1.2 Plant and animal cells

Fantastic Fact!

Your skin is your largest organ. It covers your entire body and has a surface area of about 2 m^2. The skin on the bottom of your feet is the thickest. The thinnest skin is found on your eyelids.

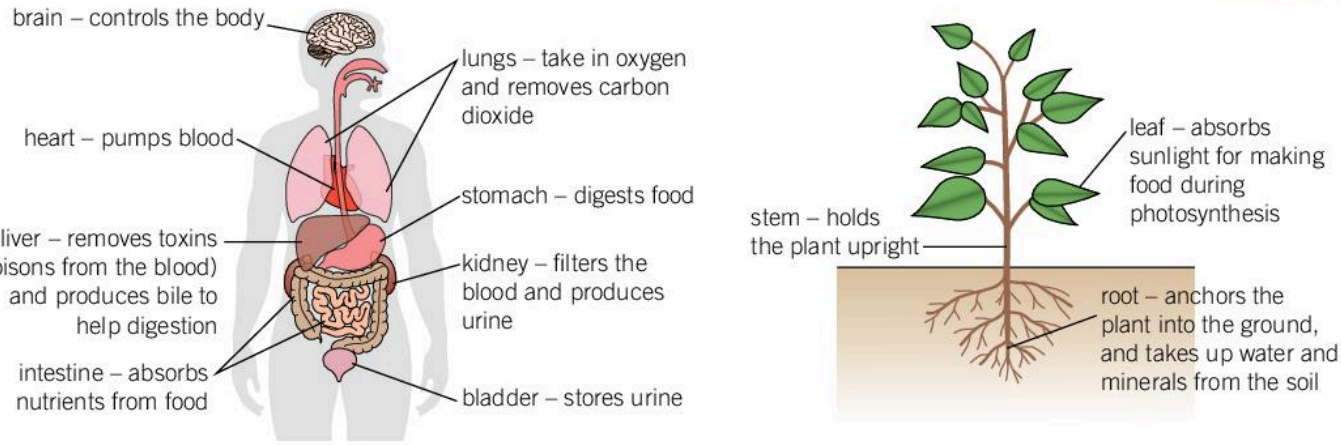


◀ Muscle tissue is a type of animal tissue.

Organise this

Organise these terms into a hierarchy. Start at the bottom level.

nervous tissue, chimpanzee, brain, nervous system, nerve cell



▲ These are the main organs in plants and animals.

C State one example of an organ.

What is an organ system?

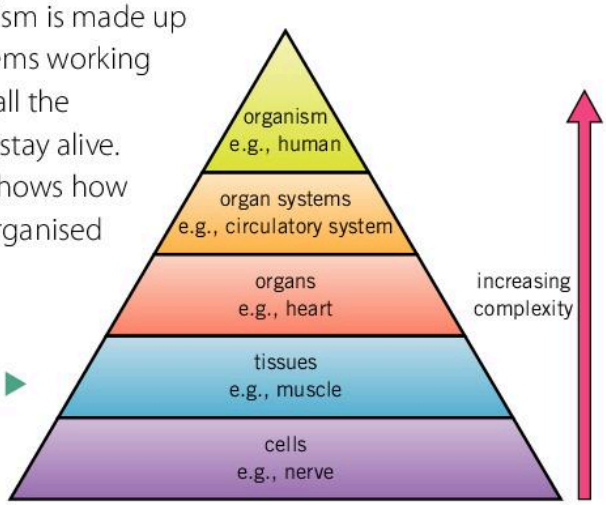
The fourth level of organisation is an **organ system**. An organ system is a group of different organs that work together to perform a certain function. Some examples of organ systems are:

- circulatory system – transports materials around the body in the blood
- respiratory system – takes in oxygen and removes carbon dioxide
- reproductive system – produces new organisms

Plant structure is mainly organised into organs or tissues. However, flowers are an organ system. They usually contain both male and female sex organs, which form the reproductive system.

D State one example of an organ system.

The fifth level of organisation is a multicellular organism. A multicellular organism is made up of several organ systems working together to perform all the processes needed to stay alive. The diagram below shows how the human body is organised into different levels.



This is the hierarchy of organisation in the human body. ▶

Key Words

multicellular organism, tissue, organ, organ system

Summary Questions

1 Match the level of organisation to its function.

cell group of organs working together

tissue group of tissues working together

organ group of similar cells working together

organ system group of organ systems working together

organism building blocks of life

(5 marks)

2 Describe an example of an organ system and describe the organs it is made up of.

(2 marks)

3 Draw a diagram that shows the levels of organisation within an organism – choose either a plant or an animal and give an example for each level of organisation.

(6 marks)

2.2 Gas exchange

Learning objectives

After this topic you will be able to:

- describe the structure of the gas exchange system
- describe how parts of the gas exchange system are adapted to their function.

▲ You can see the lungs on a chest X-ray.

Link

You can learn more about why you breathe in B2 2.5 Aerobic respiration

Key Words

gas exchange, lungs, ribcage, respiratory system, trachea, alveolus, inhale, respiration, exhale condense

Fantastic Fact!

Your lungs are not the same size. The left lung is normally smaller than the right lung, which leaves space for your heart to fit in.

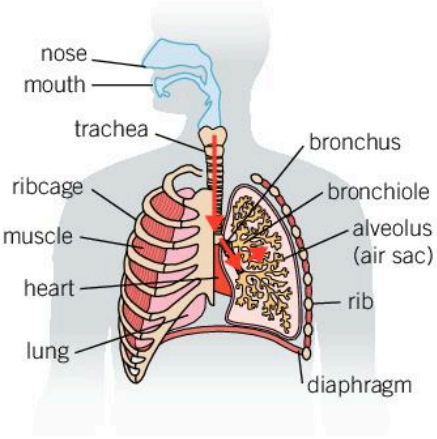
If you are travelling on a bus, the windows may sometimes steam up. This is because it contains lots of water vapour.

What happens when we breathe?

When you breathe, you take in oxygen and give out carbon dioxide. This is called **gas exchange**. It takes place inside your **lungs**. They are made of elastic tissue that can expand when you breathe in – this allows you to take in lots of oxygen. However, your lungs are delicate, so they are protected by the hard and strong bones that make up your **ribcage**.

A Name the structure that protects your lungs.

The diagram below shows the main components of your **respiratory system** (gas exchange system). Follow the arrows with your finger to see how air travels through your mouth and nose and ends up in the blood around your lungs. The blood then takes the oxygen to all cells in your body.



Air enters your body through your mouth and nose.

↓

Air moves down the **trachea** (windpipe) – a large tube.

↓

Air moves down a bronchus – a smaller tube.

↓

Air moves through a bronchiole – a tiny tube.

↓

Air moves into an **alveolus** – an air sac.

↓

Oxygen then diffuses into the blood.

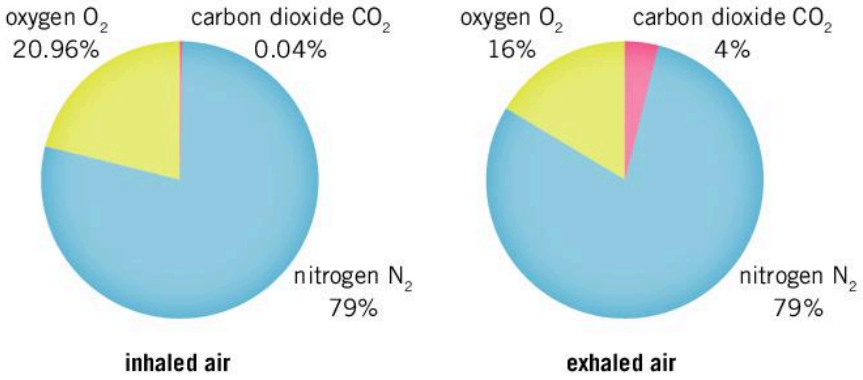
There are millions of alveoli (plural of alveolus) in your lungs. They create a large surface area. They also have thin walls that are only one cell thick. This means that gas exchange can occur quickly and easily.

B State the scientific name for an air sac.

Why do we breathe in and out?

When we breathe in we **inhale** to take in oxygen. The oxygen is used in **respiration** to transfer energy. Respiration produces carbon dioxide, which needs to be removed from the body. When we breathe out we **exhale** to remove carbon dioxide.

The pie charts below show how much of the different gases are present in inhaled and exhaled air. This is called the composition of the air.



▲ These pie charts show the amount of each gas in inhaled and exhaled air.

Why can you see your breath on a cold mirror?

If you breathe onto a cold mirror, it steams up. This is because the air you breathe out contains water vapour. Water is a waste product of respiration. When the warm exhaled water vapour hits the mirror it **condenses**, turning it back into a liquid. This is what you see on the mirror.

C State which gas, present in air, is not used by the body.

▲ Water vapour in the air you breathe out condenses on cold surfaces.

Which chart?

The composition of inhaled and exhaled gases is shown in a pie chart. Why is this the best chart to use? Would another type of graph be better?

Link

You can find out more about condensing in C1 1.5 More changes of state

Summary Questions

1 Copy and complete the following table to show the differences between inhaled and exhaled air. Use the words **less**, **more**, **same**, **hotter**, **colder**. Words can be used once, more than once, or not at all.

	inhaled	exhaled
oxygen		
carbon dioxide		
temperature		
water vapour		

(4 marks)

2 Draw a diagram of the gas exchange system and label how each structure is adapted to its function.

(3 marks)

3 Describe, step by step, the journey that carbon dioxide takes from the alveolus out of the body.

(6 marks QWC)

2.3 Breathing

Learning objectives

After this topic you will be able to:

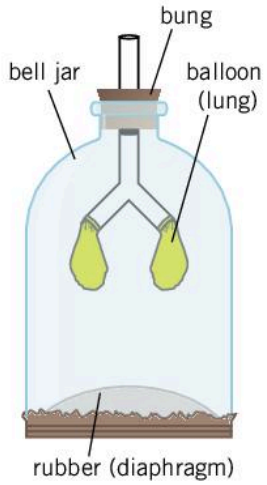
- describe the processes of inhaling and exhaling
- describe how a bell jar can be used to model what happens during breathing
- explain how to measure lung volume.

Even when you are sitting still, your ribcage is moving. This allows your lungs to fill with oxygen. This is essential for you to stay alive.

How do you breathe?

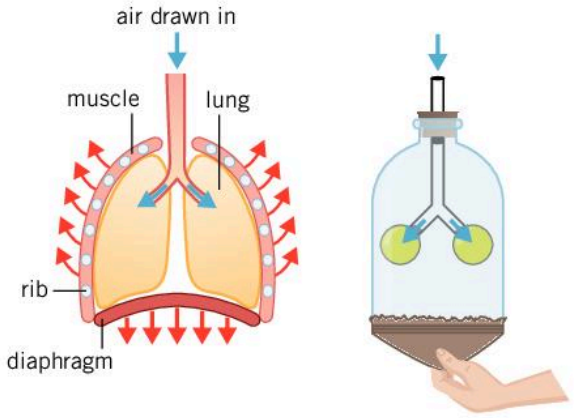
When you breathe, muscles in your chest tighten or **contract**.

A bell-jar model can show you what is happening inside your lungs when you breathe in and out. The jar represents your chest, the balloons represent your lungs, and the rubber sheet represents a muscle called the **diaphragm**.



▲ A bell-jar model shows what happens inside the lungs when we breathe in and out.

Inhaling (breathing in)



▲ Inhaling in the lungs and in the bell-jar model.

This is what happens in the body when we inhale:

- The muscles between your ribs contract – this pulls your ribcage up and out.
- The diaphragm contracts – it moves down.
- The volume inside your chest increases.
- The pressure inside your chest decreases – this draws air into your lungs.

A State what happens to your ribcage when you breathe in.

To show inhaling, this is what happens in the bell-jar model:

- The rubber sheet is pulled down.
- The volume inside the jar increases.
- The pressure inside the jar decreases – air rushes into the jar.
- The balloons inflate.

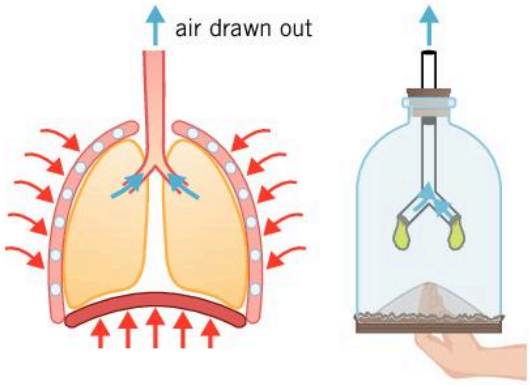
Link

You can find out more about gas pressure in C1 1.7 Gas pressure

Key Words

contract, diaphragm, lung volume, asthma

Exhaling (breathing out)



◀ Exhaling in the lungs and in the bell-jar model.

This is what happens in the body when we exhale:

- The muscles between your ribs relax – this pulls your ribcage down and in.
- The diaphragm relaxes – it moves up.
- The volume inside your chest decreases.
- The pressure inside your chest increases – this pushes air out of your lungs.

To show exhaling, this is what happens in the bell-jar model:

- The rubber sheet is pushed up.
- The volume inside the jar decreases.
- The pressure inside the jar increases – this makes air rush out of the jar and the balloons.
- The balloons deflate.

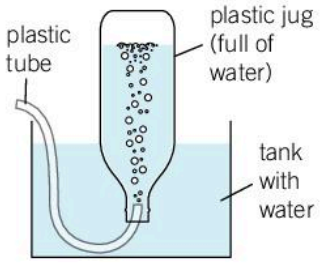
B State what happens to your diaphragm when you breathe out.

How can we measure lung volume?

You can measure your **lung volume** using a plastic bottle.

As you breathe out into the plastic tube, air from your lungs takes the place of the water in the bottle. If you breathe out fully, the volume of water pushed out of the bottle is equal to how much air your lungs can hold.

Lung volume can be increased with regular exercise. A large lung volume means that more oxygen can enter your body. Smoking, diseases such as **asthma**, and old age can reduce lung volume.



▲ You can measure your lung volume by breathing into a bottle.

Lung volume

How big are your lungs? Calculate your own lung volume by breathing as hard as you can into a 3-litre bottle of water. Suggest why your doctor would not use this as an accurate measurement of your lung volume.

Summary Questions

1 Copy and complete the table using the following words:

up and out down and in down up decreases increases

	Inhaling	Exhaling
ribs move		
diaphragm moves		
chest volume		

(3 marks)

2 Name two factors that can reduce lung volume.

(2 marks)

3 Imagine that you are an athletics coach at the Olympics. Describe how you would measure the lung volume of Usain Bolt.

(3 marks)

4 Describe how a bell-jar model can be used to represent inhalation. Include a diagram and suggest at least one problem with the model.

(6 marks)

2.4 Skeleton

Learning objectives

After this topic you will be able to:

- describe the structure of the skeleton
- describe the functions of the skeletal system.

Why are you not a blob of jelly? Most parts of your body have hard structures inside them. These are your bones. They stop you being shapeless, and allow you to stand up and move. They also have a number of other important roles.

What are bones?

Although **bones** in a museum are old and dry, the bones in your body are different. Bone is a living tissue with a blood supply. It is growing and changing all the time. Just like other parts of your body, it can repair itself when damaged. Calcium and other minerals make the bone strong but slightly flexible. Exercise and a balanced diet are important to keep your bones healthy.

A State what a bone is.

▲ Doctors use X-rays to check if a bone is broken.

Naming bones

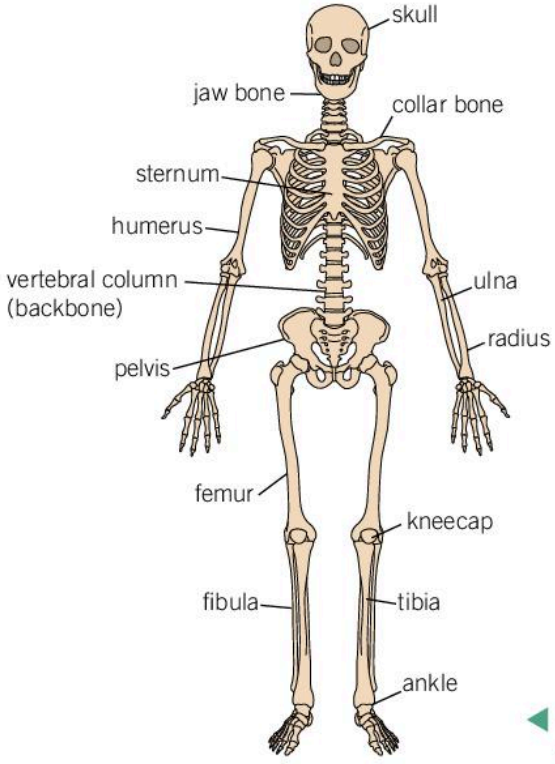
Find out the scientific names for these parts of the body:
kneecap, shoulder blade, jaw

Link

You can learn more about how your body moves in B1 2.5 Movement: joints

What is a skeleton?

Together all the bones in your body make up your **skeleton**. They are joined together to form a framework. The average adult human skeleton consists of 206 bones.



◀ The main bones of the human body.

Why do we have a skeleton?

The skeleton has four main functions:

- support the body
- protect vital organs
- help the body move
- make blood cells

B State four functions of the skeleton.

Support

The skeleton provides **support** for your body and holds your internal organs in place. Without bones the body would be floppy, like a jellyfish. The bones create a framework for your muscles and organs to connect to. Your vertebral column (backbone) holds the body upright.

Protect

Bones are hard and strong so they can **protect** vital organs from being damaged. For example:

- Your skull protects your brain.
- Your ribcage protects your heart and lungs.
- Your backbone protects your spinal cord.

Move

Muscles are attached to bones. If a muscle pulls on a bone, it will cause the bone to move. The skeleton moves at joints, such as your knee. The movement of bones about joints allows the body to move.

C Name the tissue that causes your skeleton to move.

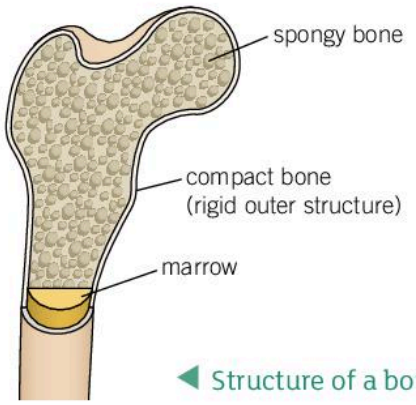
Making blood cells

Some bones inside your body, such as the long ones in your arms and legs, are not solid. In the middle of these bones is a soft tissue called **bone marrow**. The bone marrow produces red and white blood cells. Red blood cells are needed to carry oxygen around the body, and white blood cells are used to protect against infection.

D Name the tissue that produces red and white blood cells.

Fantastic Fact!

Around 2.5 million red blood cells are produced each second by bone marrow.



◀ Structure of a bone.

Key Words

bone, skeleton, support, protect, bone marrow

Summary Questions

1 Copy and complete the sentences below.

Your skeleton is made up of _____. The skeleton has four important functions – to _____ the body, to _____ organs, to help the body move, and to make _____. Red and white blood cells are produced in bone _____, which is found in the centre of some bones.

(5 marks)

2 Describe the structure and function of one of the long bones in your leg.

(3 marks)

3 Write a summary of the skeletal system, including the structure and function of the bones on this page.

(6 marks QWC)

2.5 Movement: joints

Learning objectives

After this topic you will be able to:

- describe the role of joints in movement
- explain how to measure the force exerted by different muscles.

Without muscles and joints, we would all look like statues. Muscles move bones, and joints allow the skeleton to bend. This combination is called biomechanics.

What are joints?

Joints occur where two or more bones join together. Most joints are flexible. However, some bones in your skeleton are joined rigidly together and cannot move.

A State where joints are found.

▲ Pivot joints allow movement around a point. Your neck is a pivot joint. It allows you to rotate your head from side to side.

How do joints allow you to move?

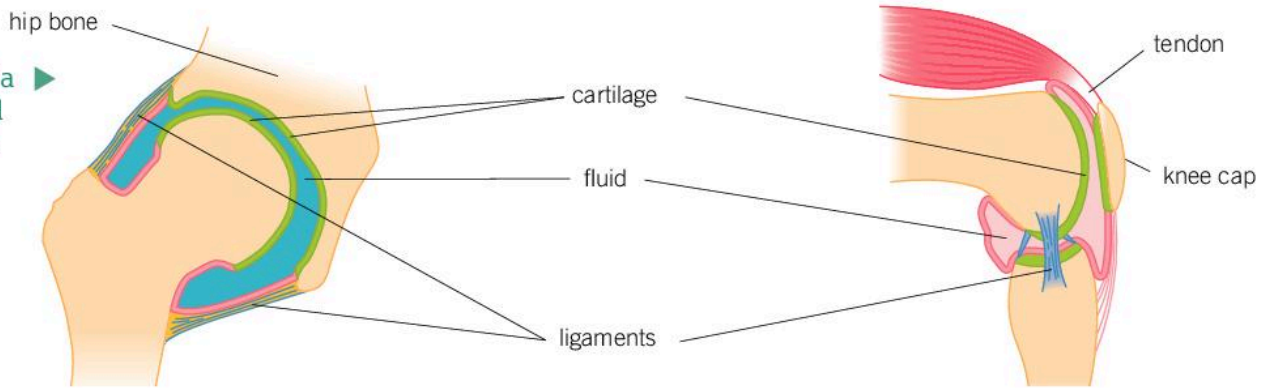
Your joints need to be strong enough to hold your bones together but flexible enough to let them move. Different types of joint allow movement in different directions. Three types of joint are:

- hinge joints – for movement backwards and forwards, for example, the knee and elbow
- ball-and-socket joints – for movement in all directions, for example, the hip and shoulder
- fixed joints – do not allow any movement, for example, the skull.

B Name two types of hinge joint.

What does a joint look like?

If your bones moved against each other, they would rub, causing lots of pain. Eventually, the bone would wear away. To stop this happening, the ends of bones in a joint are covered with **cartilage**, a strong, smooth tissue. It is kept slippery by fluid in the joint. This allows the bones to move without rubbing together. The two bones are held together by **ligaments**.



Structure of a hip joint and a knee joint. ▶

How can you measure muscle strength?

Different muscles in your body have different strengths. For example, arm muscles are much stronger than the muscles in skin that make body hair stand up when it is cold.

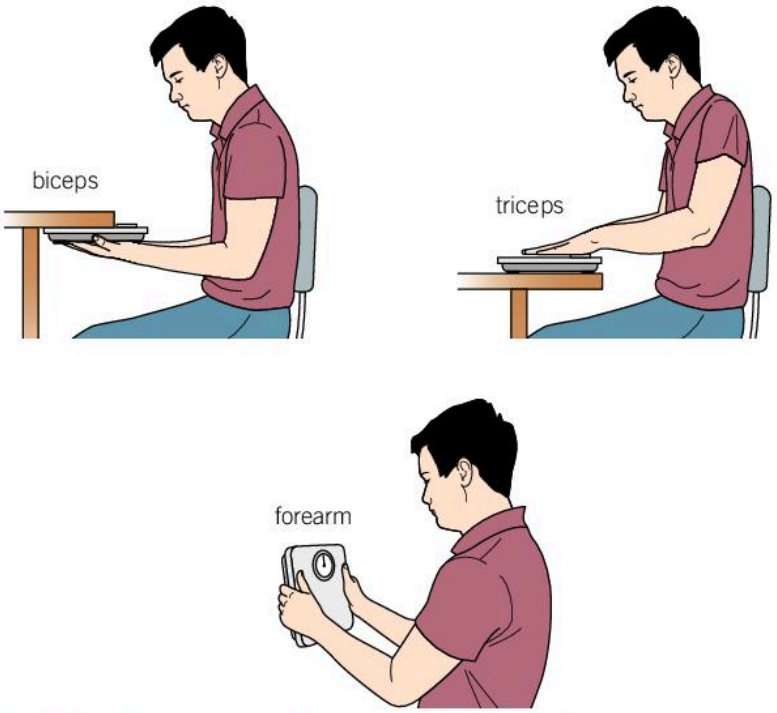
The strength of a muscle can be measured by how much force it exerts. You can measure the strength of your muscles using a Newton scale. The harder you can push on the scale, the greater the force exerted. Force is measured in **newtons** (N).

C State the unit of force.

You can use a newton scale to measure the strength of many different muscles. For example:

- to measure the strength of your triceps (muscles in the back of your upper arms) – push down as hard as you can on the scales
- to measure the strength of your biceps (muscles in the front of your upper arms) – put the scales under the table and push up as hard as you can (ask another student to sit on the table to ensure it doesn't move)
- to measure the strength of your forearms – hold the scales in the air and squeeze together as hard as you can, without using your thumbs.

In each technique you or your partner should read the force you exerted, in newtons, from the scale.



▲ Measuring your muscle strength using scales.

Health and safety

Many people go to the gym and lift dumbbells to improve the strength of their muscles. What are the risks of trying to lift the heaviest dumbbell?

Key Words

biomechanics, joint, cartilage, ligament, newtons

Summary Questions

1 Copy and complete the sentences below.

Joints occur where two or more _____ join together.

Different types of joint allow _____ in different directions. For example, ball-and-socket joints in the _____ allow movement in all directions. _____ covers the end of the bones in joints to stop them _____ together.

(5 marks)

2 Draw a diagram of a joint in the body, labelling the key structures.

(3 marks)

3 Imagine you are a fitness trainer at a gym. Write a set of instructions for gym users on how they can measure their muscle strength using a set of newton scales.

(6 marks)

2.6 Movement: muscles

Learning objectives

After this topic you will be able to:

- describe the function of major muscle groups
- explain how antagonistic muscles cause movement.

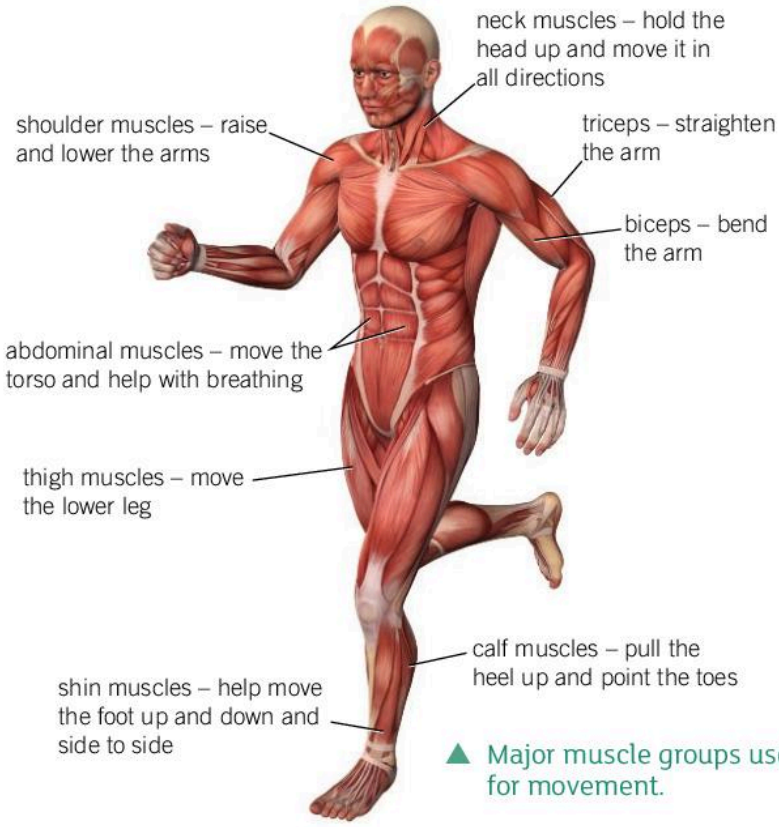
Can you feel the muscle in the front of your arm working as you bend it? The muscle is pulling on one of the bones in your forearm, causing it to move upwards.

Muscles in the body

Muscles are found all over your body. They are a type of tissue – lots of muscle cells work together to cause movement.

A State why muscle is a tissue.

There are many types of muscle in your body. For example, your heart is a muscle made of cardiac muscle tissue. This muscle pumps blood around the body. Other muscles are found in your gut to help squeeze the food along. The diagram below shows the major muscle groups in your body that are used for movement.



▲ Major muscle groups used for movement.

B Name three groups of muscles in the body used for movement.

Model limb

Design a model to show how antagonistic muscles allow your leg to move. Present your model to a partner, explaining how it represents antagonistic muscles.

How do muscles work?

To make you move, muscles work by getting shorter – they contract.

Muscles are attached to bones by **tendons**. When a muscle contracts, it pulls on a bone. If the bone is part of a joint, the bone will move.

C State what happens to the length of a muscle when it contracts.

How do pairs of muscles work together?

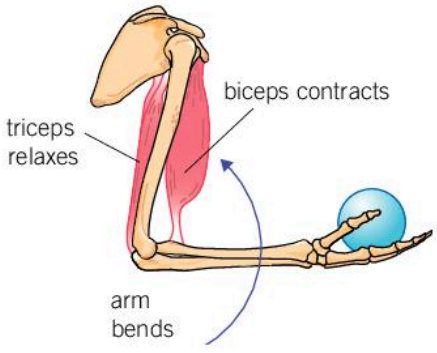
Muscles can only pull. They cannot push. This means that two muscles have to work together at a joint. If you only had one muscle in your arm, you may be able to bend your arm but you would not be able to straighten it again.

At each joint a pair of muscles work together to cause movement. These are known as antagonistic muscles. When one muscle contracts, the other muscle relaxes.

The biceps and triceps are an example of a pair of **antagonistic muscles**. These are used to bend and straighten the arm at the elbow joint.

To bend the arm:

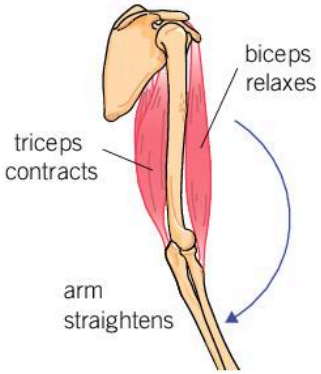
- the biceps muscle (on the front of the upper arm) contracts
- the triceps muscle (on the back of the upper arm) relaxes.



The biceps muscle contracts to bend the arm.

To straighten the arm:

- the biceps muscle relaxes
- the triceps muscle contracts.



The triceps muscle contracts to straighten the arm.

Key Words

tendon, antagonistic muscles

Summary Questions

1 Copy and complete the sentences below.

Muscles are attached to bones by _____. When a muscle _____ it shortens and _____ on a bone. If the bone is part of a _____ this will cause the bone to move. Pairs of muscles work together to control movement at a joint. They are called _____ muscles.

(5 marks)

2 Describe the difference between a tendon and a ligament.

(2 marks)

3 Explain in detail why two muscles are needed to bend and straighten a joint. Draw diagrams to help explain your answer.

(6 marks)

B1 Chapter 2 Summary

Key Points

- Multicellular organisms are made of many cells. They are organised into layers: cells → tissues → organs → organ systems → organisms
- Gas exchange takes place inside the lungs – oxygen is taken in and carbon dioxide is given out.
- Oxygen enters the body through the mouth and nose. It then travels down the windpipe, through a bronchus, then a bronchiole, into an alveolus, and diffuses into the blood.
- Exhaled air is warmer and contains more carbon dioxide and water vapour than inhaled air, but less oxygen.
- When you inhale, muscles between your ribs and the diaphragm contract. This increases the volume inside your chest. The pressure decreases and air is drawn into the lungs.
- When you exhale, muscles between your ribs and the diaphragm relax. This decreases the volume inside your chest. The pressure increases and air is forced out of your lungs.
- The skeleton is made up of bones. It has four important functions – support the body, protect the organs, allow movement, and make blood.
- Red and white blood cells are produced in bone marrow found in the centre of some bones.
- Joints occur where two or more bones join together.
- Cartilage in joints stop bones rubbing together.
- Bones are held together by ligaments. Muscles are attached to bones by tendons.
- Antagonistic muscles are pairs of muscles that work together at a joint. When one muscle contracts, the other muscle relaxes.

BIG Write

How do you toss a pancake?

Everyone enjoys tossing pancakes but which parts of your body are needed to do this?

Task

Produce an A4 cartoon strip showing how your muscles and skeleton work to make your body move when you are tossing a pancake.

Tips

- Include labelled diagrams to show the structures inside your body.
- Use speech bubbles to explain what is happening during each part of the cartoon strip.

Key Words

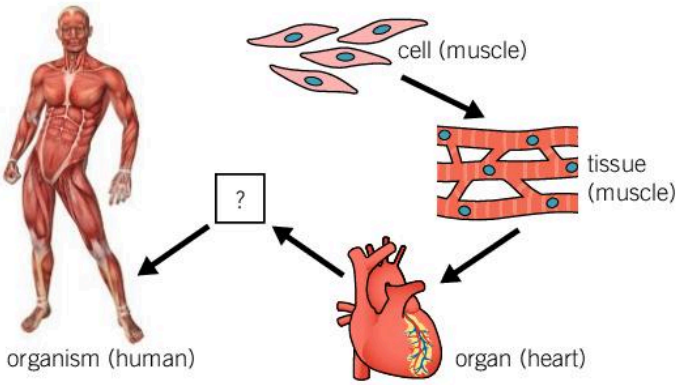
multicellular organism, tissue, organ, organ system, gas exchange, lungs, ribcage, respiratory system, trachea, alveolus, inhale, respiration, exhale, condense, contract, diaphragm, lung volume, bone, skeleton, support, protect, bone marrow, biomechanics, joint, cartilage, ligament, newtons, tendon, antagonistic muscles

End-of-chapter questions

1 Draw a line to match each organ system to its function in the cell.

reproductive system	takes in oxygen and removes carbon dioxide
digestive system	transports materials around the body
respiratory system	produces new organisms
circulatory system	breaks down food so it can be absorbed into the body

(4 marks)



2 The diagram shows how the body is organised into levels.

a Name the type of cell shown in the diagram above. *(1 mark)*

b State the function of this cell. *(1 mark)*

c State what is meant by a tissue. *(1 mark)*

d Name the level of organisation that is missing from the diagram above. *(1 mark)*

e State and describe the function of **two** organs. *(4 marks)*

(8 marks)

3 A student wanted to measure the strength of his biceps muscle.

a Name a piece of equipment he could use. *(1 mark)*

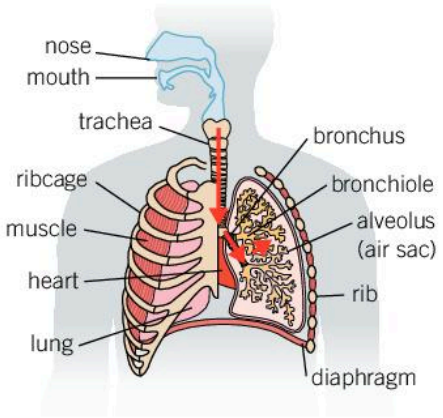
b State the unit of force that he should use. *(1 mark)*

c Explain why the student should repeat each measurement that he takes. *(1 mark)*

d Describe the experimental procedure the student should follow to measure the strength of his biceps muscle. *(3 marks)*

(6 marks)

4 This diagram shows the main structures in the respiratory system.



a Name the bones that protect the lungs. *(1 mark)*

b Name the process that occurs in the alveolus. *(1 mark)*

c State what the diaphragm is made of. *(1 mark)*

d Describe what happens in the lungs when you exhale. *(3 marks)*

(6 marks)

5 Compare the main differences in the composition of inhaled and exhaled air.

(6 marks QWC)

3.1 Adolescence

Learning objectives

After this topic you will be able to:

- state the difference between adolescence and puberty
- describe the main changes that take place during puberty.

▲ Most teenagers get spots or acne. This is caused by hormones.

Problem pages

Imagine you are the editor of a magazine for teenagers, called Teen Mag. You receive the letter below from a 12-year-old boy.

Dear Teen Mag,
In the past few months my voice has started making funny squeaky sounds and my body is changing shape. What is happening to me, and can I do anything to make it stop?
Thanks,
Kyle

Write a reply to Kyle that will be published in the next issue of the magazine.

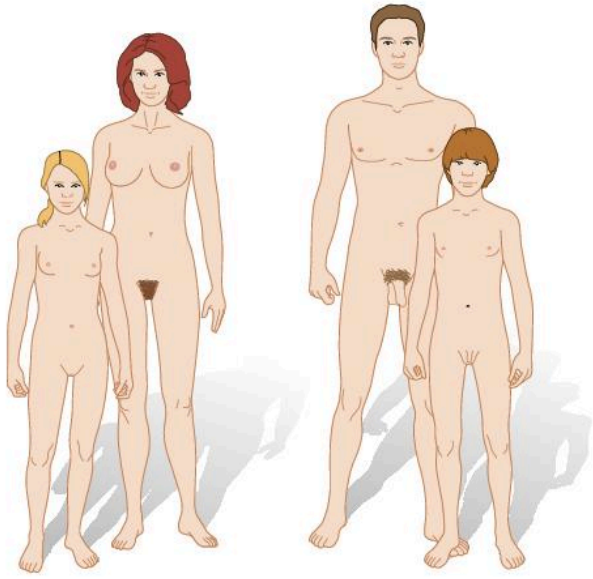
Think about yourself and your friends. Do you think of yourselves as children or adults? Everyone in your year group is at a different stage of their emotional and physical development. The time during which you change from a child to an adult is known as adolescence.

What happens during adolescence?

Adolescence involves both emotional and physical changes. These can cause you to become moody, self-conscious, and angry. Some adolescents' behaviour may also change – they want to experiment with new and risky activities, such as smoking, alcohol, and sex.

During adolescence your body goes through physical changes; this is called **puberty**.

A State what is meant by adolescence.



▲ Physical changes take place during puberty.

Puberty takes place between the ages of about 9 and 14 in most people. Generally girls start puberty before boys but it differs for everyone. Most of the changes take place in your reproductive system. The system needs to develop so that you can have children if you choose to when you are older.

B State what is meant by puberty.

What happens during puberty?

There are a number of changes that happen to both girls and boys during puberty. These include:

- your pubic hair and underarm hair grows
- your body smell becomes stronger – this is often called body odour
- you experience emotional changes
- you have a growth spurt (get taller).

What happens to a girl during puberty?

Some changes only happen to girls. These include:

- breasts develop
- ovaries start to release egg cells
- periods start
- hips widen.

C State two changes during puberty that only happen to girls.

What happens to a boy during puberty?

Some changes only happen to boys. These include:

- voice breaks – it gets deeper
- testes and penis get bigger
- testes start to produce sperm
- shoulders widen
- hair grows on the face and chest.

D State two changes during puberty that only happen to boys.

What causes puberty?

All of the changes that take place in your body during puberty are caused by **sex hormones**. These are chemical messengers that travel around your body in the blood. Female sex hormones are made in the ovaries. Male sex hormones are made in the testes.

These chemicals trigger different processes, such as egg release in females and pubic-hair growth in both males and females.

Link

You can learn more about periods in B1 3.5 The menstrual cycle

Key Words

adolescence, puberty, sex hormones

▲ To reduce unwanted body odour, you should wash regularly and use deodorant.

Summary Questions

1 Copy and complete the sentences below.

The period of time when a person develops from a child into an adult is known as _____.

The _____ changes that take place are known as _____.

These changes are caused by _____.

(4 marks)

2 State **three** physical changes that occur to both boys and girls during adolescence.

(3 marks)

3 A boy in Year 6 has noticed that his body is changing. Write the text for an information leaflet that details all the changes that will happen to him and explain why they occur.

(6 marks)

3.2 Reproductive systems

Learning objectives

After this topic you will be able to:

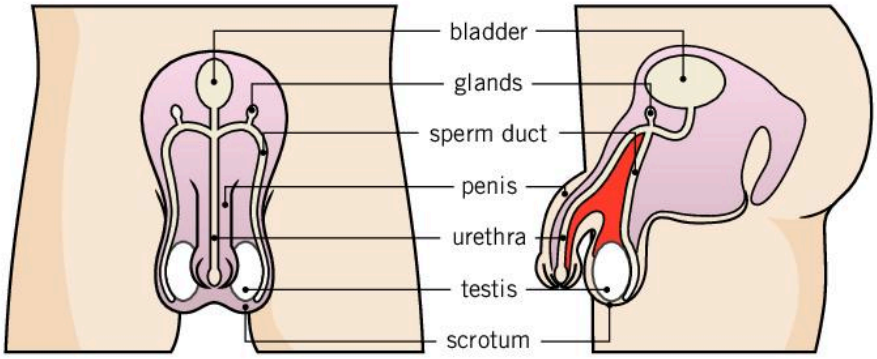
- describe the main structures in the male and female reproductive systems
- describe the function of the main structures in the male and female reproductive systems.

You have known since you were very small that males and females look different. They look different because their bodies have to perform different jobs, or functions. Their reproductive systems need to work together to produce a baby.

The male reproductive system

The function of the male reproductive system is to produce **sperm cells** (the male sex cells) and release them inside a female.

A State the function of the male reproductive system.



▲ The male reproductive system.

The main parts of the male reproductive system are:

- **testes** – the two testes are contained in a bag of skin called the **scrotum**. The testes produce sperm cells and the male sex hormones.
- glands – they produce nutrients that help to keep sperm alive. The mixture of sperm and fluid is called **semen**.
- **sperm ducts** – these are tubes that carry sperm from the testes to the penis.
- **urethra** – a tube that carries urine from the bladder out of the body or sperm from the sperm duct.
- **penis** – this carries urine or semen out of the body. The penis swells with blood and stiffens. This is known as an erection, and allows the male to release sperm into a female during **sexual intercourse**. The bladder cannot empty when the penis is erect, so semen and urine are never released at the same time.

Glossary

A glossary provides a definition of key words used in a book. There are many new words on these pages. Produce a glossary of the terms you have learnt so far.

Link

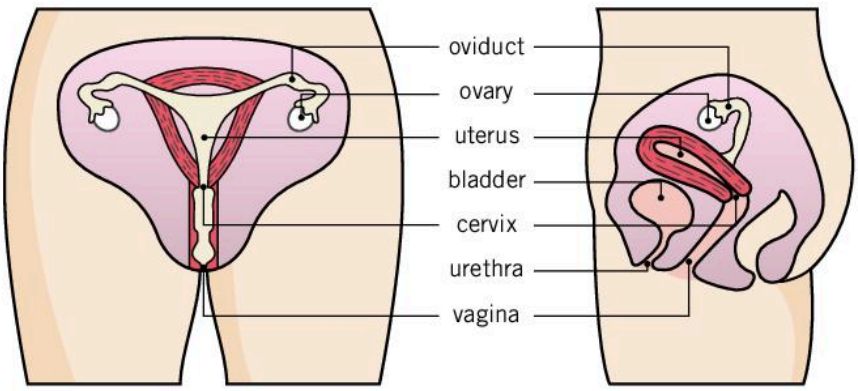
You can learn more about sexual intercourse in B1 3.3 Fertilisation and implantation

B State where sperm are produced.

The female reproductive system

The job of the female reproductive system is to produce **egg cells** (the female sex cells), and then grow a baby for long enough that it can be born and survive.

C State the function of the female reproductive system.



▲ The female reproductive system.

The main parts of the female reproductive system are:

- **ovaries** – they contain egg cells. One egg is released each month.
- **oviducts** (egg tubes) – they carry an egg to the uterus.
- **uterus** (womb) – this is where a baby develops until it is born.
- **cervix** – a ring of muscle at the entrance to the uterus. It keeps the baby in place while the woman is pregnant.
- **vagina** – receives the sperm during sexual intercourse. This is where the man's penis enters the female's body.
- **urethra** – a tube that carries urine from the bladder out of the body.

D State where an unborn baby develops inside its mother.

Key Words

sperm cell, testes, scrotum, semen, sperm duct, urethra, penis, sexual intercourse, egg cell, ovary, oviduct, uterus, cervix, vagina

Summary Questions

1 Match each structure to its function.

penis	contains eggs
vagina	produces sperm
sperm duct	carries an egg to the uterus
oviduct	carries sperm out of the body
testes	carries sperm to the penis
ovaries	receives sperm during sexual intercourse

(6 marks)

2 Describe the difference between sperm and semen.

(2 marks)

3 Draw a flow chart to show the structures a sperm cell would pass through on its way out of the male and into the female's body.

(6 marks)

3.3 Fertilisation and implantation

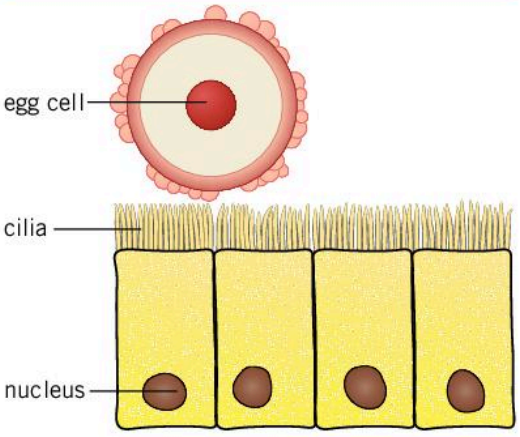
Learning objectives

After this topic you will be able to:

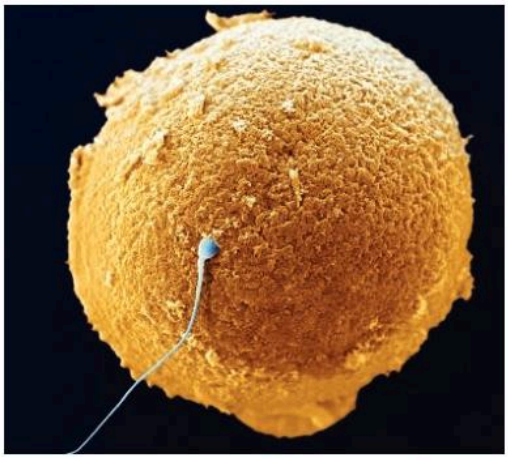
- describe the structure and function of gametes
- describe the processes of fertilisation.

Link

You can learn more about the structure of a sperm cell in B1 1.3 Specialised cells



▲ Cilia in the oviduct waft the egg towards the uterus.



▲ During fertilisation, the head of the sperm burrows into the egg.

How are you made? Babies are made by a mother and a father but how does this actually happen? During adolescence, your body becomes able to create a baby with someone of the opposite sex.

What are gametes?

Gametes are reproductive cells. They join together to create a new organism. The male gamete is a sperm cell. The female gamete is an egg cell. To create a new organism, the nucleus of the sperm and the nucleus of the egg have to join together – this is known as **fertilisation**. This process takes place in most animals.

A State what a gamete is.

Where do sperm cells meet an egg cell?

Each ovary is connected to the uterus by an oviduct. An egg cell cannot move by itself. However, the oviduct is lined with **cilia** – these are tiny hairs on the surface of cells. Every month, an egg is released from an ovary. The cilia then waft the egg along the inside of the oviduct towards the uterus.

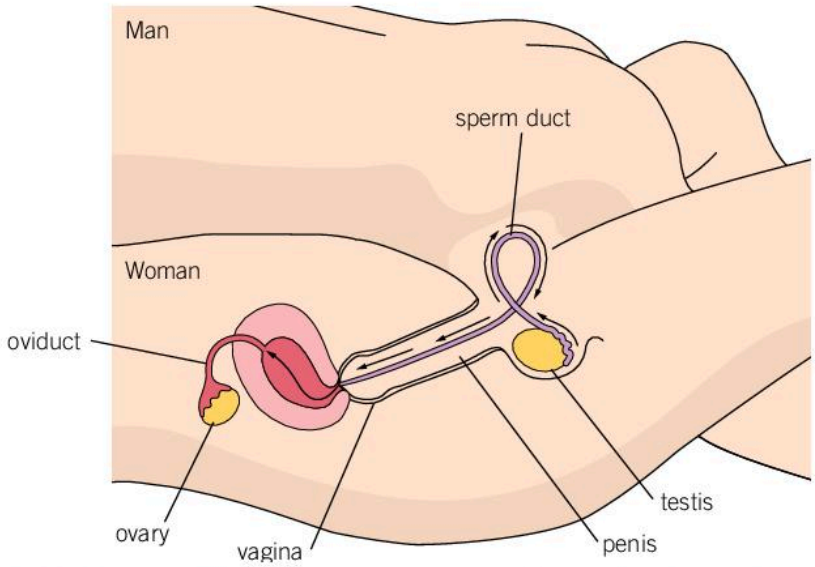
The sperm are released into the vagina in semen during sexual intercourse. They then swim towards the egg in the oviduct.

B Describe how an egg cell travels along the oviduct.

What happens during sexual intercourse?

When people 'have sex' or 'make love', semen is released into the vagina. People do this to make a baby or to show how much they care for each other. It is a very intimate act that gives many people a lot of pleasure.

When a male becomes sexually aroused, his penis fills with blood and becomes erect. When a woman becomes sexually aroused her vagina becomes moist. This allows the penis to enter her vagina.

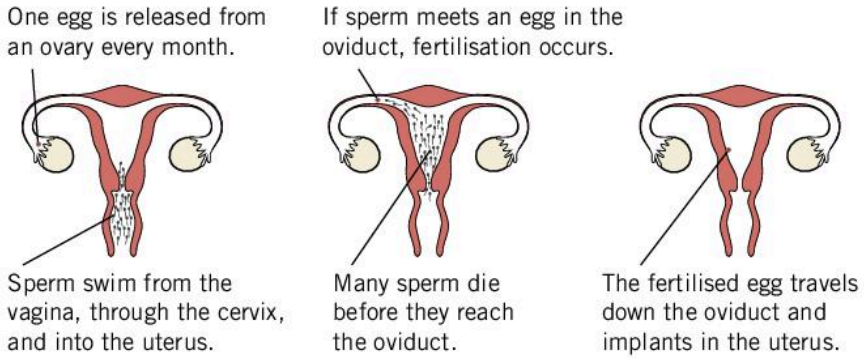


▲ During sexual intercourse, sperm are released into the vagina.

During intercourse, the male moves his penis backwards and forwards. This increases the pleasure and stimulates the release of semen into the vagina. This is known as **ejaculation**.

C State what happens during sexual intercourse.

How do sperm cells reach the egg cell?



▲ Sperm cells swim from the vagina to meet the egg cell.

Sperm cells swim from the vagina to the uterus. They enter the uterus through the cervix and travel to the oviduct. If a sperm cell meets an egg cell there, fertilisation can happen.

The fertilised egg divides several times to form a ball of cells called an embryo. The **embryo** attaches to the lining of the uterus and begins to develop into a baby. This is called **implantation**.

D State what happens during implantation.

Fantastic Fact!

In each ejaculation, up to 500 million sperm are released.

Key Words

gamete, fertilisation, cilia, ejaculation, embryo, implantation

Summary Questions

1 Match each word to its meaning.

fertilisation	the fertilised egg attaches to the lining of the uterus
ejaculation	the nuclei of the sperm and egg cell join together
implantation	the little hairs that move the egg cell along the oviduct
cilia	semen is released into the vagina
gametes	reproductive cells

(5 marks)

2 Describe what happens during sexual intercourse.

(3 marks)

3 Draw and complete a table to compare the structure of sperm and eggs and how they are produced.

(6 marks)

3.4 Development of a fetus

Learning objectives

After this topic you will be able to:

- describe what happens during gestation
- describe what happens during birth.

Small children often say that they 'grow inside their mum's tummy'. A baby actually develops in the uterus, not the stomach.

How long to grow a baby?

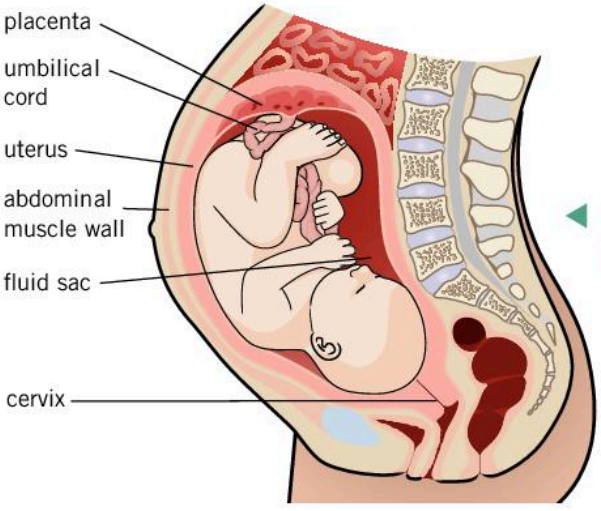
In all mammals the time in the uterus from fertilisation until birth is known as **gestation**. In humans we also call it pregnancy. It takes around 9 months (40 weeks) for a fertilised egg to develop into a baby.

During pregnancy a woman has regular check-ups with a midwife to check her health and her developing baby's health. The midwife will advise the woman to eat a healthy diet, not to smoke, and to avoid alcohol. Smoking can cause babies to be born early, when they are not fully developed. Alcohol can cause problems in the development of the baby's brain.

A State how long gestation lasts in humans.

Where does a baby grow?

During the early stages of pregnancy, cells in the embryo divide and specialise. After eight weeks of growth the embryo is called a **fetus**.



A baby develops inside the uterus.

To grow, a fetus needs nutrients and oxygen. It receives these from its mother, through her blood.

B State what a fetus needs in order to grow.

Link

You can learn more about the harmful effects of smoking in B2 1.8 Smoking

In elephants, gestation lasts for around 22 months. Calculate how may weeks this is, and compare it to gestation in humans.

Key Words

gestation, fetus, placenta, umbilical cord, fluid sac

There are three important structures inside the uterus:

- **placenta** – an organ where substances pass between the mother's blood and the fetus's blood. It acts as a barrier, which stops infections and harmful substances from reaching the fetus.
- **umbilical cord** – this connects the fetus to the placenta.
- **fluid sac** – this acts as a shock absorber, protecting the fetus from any bumps.

Inside the placenta the blood of the mother and the blood of the fetus flow very close to each other. They do not mix. Oxygen and nutrients diffuse across the placenta from the mother to the fetus. Waste substances, such as carbon dioxide, diffuse from the fetus to the mother.

How does a baby develop?

The diagram below shows the main steps in a baby's development.

Just a dot		1 week – cells beginning to specialise
3 mm long		4 weeks – spine and brain forming, heart beating
3 cm long		9 weeks – tiny movements, lips and cheeks sense touch, eyes and ears forming
7 cm long		12 weeks – fetus uses its muscles to kick, suck, swallow and practise breathing

▲ Steps in development.

C State when the baby's heart starts to beat.

What happens during birth?

After around 40 weeks the baby is ready to be born. The mother's cervix relaxes, and muscles in the wall of the uterus contract. This gradually pushes the baby out through the vagina.

When the baby is born it is still joined to its mother by the umbilical cord. This needs to be cut. The placenta is then pushed out.

D Describe how a baby is born.

▲ This baby has just been born – the umbilical cord still needs to be cut.

Link

You can learn more about diffusion in C1 1.6 Diffusion

Summary Questions

1 Copy and complete the sentences below.

A _____ develops in the _____. This is known as _____. The _____ protects the fetus from bumps. The fetus is attached to the placenta by the _____. Substances transfer between the mother and baby through their _____ in the placenta. After _____ weeks the baby is ready to be born.

(7 marks)

2 Describe how substances are transferred between a mother and her fetus.

(3 marks)

3 Explain how the uterus supports the development of a baby during gestation.

(6 marks QWC)

3.5 The menstrual cycle

Learning objectives

After this topic you will be able to:

- state what the menstrual cycle is
- describe the main stages in the menstrual cycle.

Key Words

period, menstrual cycle, ovulation, contraception, condom , contraceptive pill

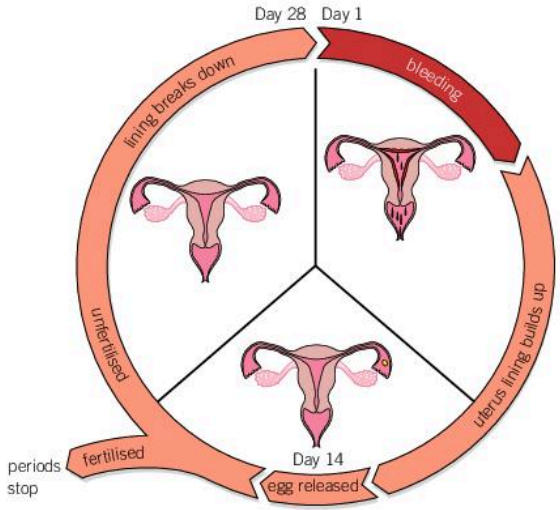
You may have heard your classmates talking about periods. You may know that only girls have them, but what are they and why do they happen?

What are periods?

During puberty a girl will start her **periods**. Around once a month, blood from the lining of the uterus leaves the body through the vagina. Each period normally lasts between three and seven days.

A State how often a period occurs.

The female reproductive system works in a sequence called the **menstrual cycle**. This lasts about 28 days, though the length and timing of each stage in the cycle is different for each female. The cycle is controlled by hormones.



◀ The menstrual cycle.

The stages in the cycle are:

- Day 1 – blood from the uterus lining leaves the body through the vagina.
- Day 5 – bleeding stops. The lining of the uterus begins to re-grow. The lining is spongy and filled with blood. This will provide a deep layer for implantation if an egg cell is fertilised.
- Day 14 – an egg cell is released from one of the ovaries. This is called **ovulation**. The egg cell travels through the oviduct towards the uterus.

B State what is meant by ovulation.

▲ Girls can choose to use sanitary towels or tampons to absorb the blood during her period.

If the egg cell does not meet with a sperm cell, the lining of the uterus break downs and the cycle starts again from Day 1.

However, if the egg is fertilised, it attaches to the lining of the uterus and the woman is pregnant. During pregnancy a woman does not have any periods.

What is contraception?

Pregnancy is a result of sexual intercourse. Until you decide to have a baby, you should take steps to avoid pregnancy. This is called **contraception**. Two of the most common forms of contraception are **condoms** and the **contraceptive pill**.

C Name two different methods of contraception.

How do condoms work?

A condom is a thin layer of latex rubber that fits over an erect penis. It is called a 'barrier' method of contraception. It prevents semen from being released into a woman's vagina.

When used correctly, condoms are a very effective method of contraception. Condoms also prevent the transfer of sexually transmitted infections (STIs), such as HIV and syphilis.

D State what method of contraception a condom is.

How does the pill work?

The contraceptive pill ('the pill') is a tablet that a female must take daily in order for it to work. The tablet contains hormones, which can prevent pregnancy by stopping ovulation.

◀ The contraceptive pill is very effective at preventing pregnancy.

When used correctly, the contraceptive pill is a very effective method of contraception. However, it provides no protection against the transfer of STIs.

▲ Condoms are a barrier method of contraception.

Summary Questions

1 Copy and complete the sentences below.

The female reproductive system works in a cycle called the _____. An egg is released each month.

If the egg is not fertilised then the _____ of the uterus breaks down and leaves the body through the _____. This is called a _____. The contraceptive pill and _____ can be used to prevent _____.

(6 marks)

2 Describe the key stages that take place during the menstrual cycle.

(4 marks)

3 To avoid pregnancy, people use contraception. Compare the use of condoms and the contraceptive pill as methods of contraception.

(6 marks QWC)

3.6 Flowers and pollination

Learning objectives

After this topic you will be able to:

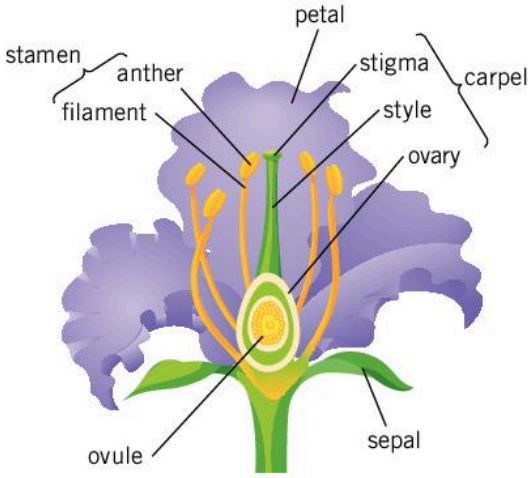
- identify the main structures of a flower
- describe the process of pollination
- describe the differences between wind-pollinated and insect-pollinated plants.

When looking at a flower, you often just notice its colour or its smell. But what is inside a flower and why are flowers important?

What's inside a flower?

If you look carefully inside a flower you will see different structures. The **petals** of a flower are normally brightly coloured to attract insects. Underneath the flower are the **sepals** – these are special leaves that protect unopened buds.

A State why flowers have petals.



▲ Parts of a flower.

Inside the flower there are both male and female parts.

The **stamen** is the male reproductive part – it contains:

- **anther** – produces **pollen**, the male gamete
- **filament** – holds up the anther.

The **carpel** is the female reproductive part – it contains:

- **stigma** – this is sticky to 'catch' grains of pollen
- **style** – holds up the stigma
- **ovary** – contains **ovules**, the female gamete.

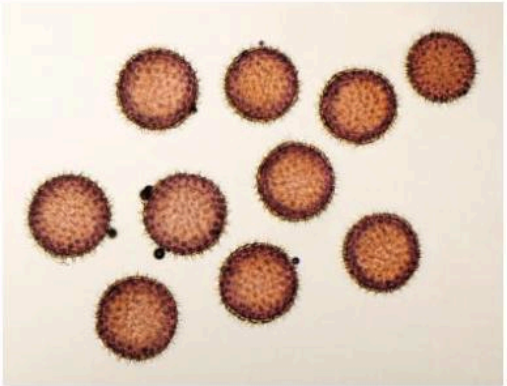
B State where pollen is made.

How are new plants made?

Just like people, the formation of a new plant begins with fertilisation. The pollen grain needs to fertilise the ovule. For this to happen, pollen from the anther needs to transfer to the stigma. This is called **pollination** and is caused by insects or the wind.

Pollination can occur between two different plants (cross-pollination) or between the male and female parts of the same plant (self-pollination).

C State what happens during pollination.



▲ These are pollen grains. If you suffer from hayfever you may be allergic to some types of pollen grain.

How does pollination happen?

There are two ways that pollen can be transferred to the stigma – by the wind or by insects.

Insect-pollinated plants

Features of insect-pollinated plants include:

- brightly coloured and sweet-smelling petals to attract insects
- often contain nectar, a sweet, sugary fluid; bees use nectar to make honey
- smaller quantities of pollen produced
- pollen is often sticky or spiky, to stick to insects
- anthers and stigma are held firmly inside the flower, so insects can brush against them
- stigma has a sticky coating, so pollen sticks to it.

When insects visit the flower, pollen gets stuck to them. When they move to the flowers of another plant, the pollen from the first flower rubs off on to the stigma of the next flower.

Insect pollination is very important in food production. Foods such as fruit, vegetables, and nuts are pollinated by insects.

D State what nectar is.

▲ An insect-pollinated plant.

▲ A wind-pollinated plant.

Wind-pollinated plants

The features of wind-pollinated plants include:

- small petals, often brown or dull green
- no nectar
- pollen produced in large quantities to increase the chances of it reaching another plant
- pollen has a very low mass so it is very light; it can be blown easily by the wind
- anthers are loosely attached and dangle out of the flower, to make it easier to release pollen into the wind
- stigma hangs outside the flower, to make it easier to catch pollen blown by the wind.

The pollen from the flower of one plant is blown by the wind and might land on the stigma of another plant's flower.

Cartoon strip

Produce a cartoon strip showing how a plant is insect pollinated. Each frame should contain a caption explaining what is happening.

Key Words

petal, sepal, stamen, anther, pollen, filament, carpel, stigma, style, ovary, ovule, pollination

Summary Questions

1 Match each part of a flower to its function.

anther	holds up the anther
filament	brightly coloured to attract insects
stigma	produces pollen
style	contains ovules
ovary	this is sticky to 'catch' pollen grains
petal	holds up the stigma

(6 marks)

2 Pollination can occur in a number of ways.

a Describe what pollination is. *(2 marks)*

b Describe the differences between cross-pollination and self-pollination. *(2 marks)*

3 Explain in detail the difference in structure between an insect-pollinated plant and a wind-pollinated plant. *(6 marks QWC)*

3.7 Fertilisation and germination

Learning objectives

After this topic you will be able to:

- describe the process of fertilisation in plants
- describe how seeds and fruits are formed.

Have you ever grown a plant from a seed? Seeds need water, oxygen, and a warm enough temperature to start to grow. A plant only needs light once it has grown its first leaf. All the nutrients a seed needs are stored inside the seed.

Key Words

fertilisation, fruit, seed, germination

How do plants make seeds?

Carried by either the wind or an insect, a pollen grain lands on a stigma. If the stigma is the correct species, it grows a pollen tube down the style until it reaches an ovule inside the ovary. The nucleus of the pollen grain then travels down the pollen tube. The nucleus of the pollen grain joins with the nucleus of the ovule. This process is called **fertilisation**.

The tube grows out of the pollen grain and down through the style.

The pollen nucleus moves down the tube.

The pollen nucleus joins with the ovule nucleus. Fertilisation takes place and a seed will form.

▲ Fertilisation of a plant.

A State what happens during fertilisation in plants.

After fertilisation the ovary develops into the **fruit**, and the ovules become **seeds**. A fruit is normally the sweet and fleshy product of a plant that can be eaten as food. All fruits contain seeds.

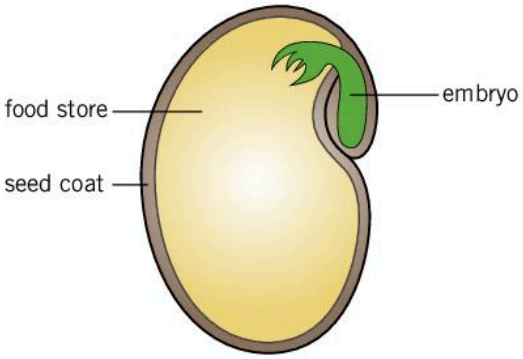
▲ Fruits contain seeds.

B Name the part of the flower that becomes the fruit.

What's inside a seed?

Most seeds have a similar structure but they vary in shape, size, and colour. Seeds have three important structures:

- a seed coat – a tough, protective outer covering
- an embryo – the young root and shoot that will develop into the adult plant
- a food store – a store of food (starch) that the young plant uses until it can make its own food by photosynthesis.



▲ The structure of a seed.

What do seeds need for growth?

When a seed starts to grow, it is called **germination**. A seed needs three things to germinate:

- water – this allows the seed to swell up and the embryo to start growing
- oxygen – this is used for respiration, transferring energy for germination
- warmth – this speeds up reactions in the plant, speeding up germination.

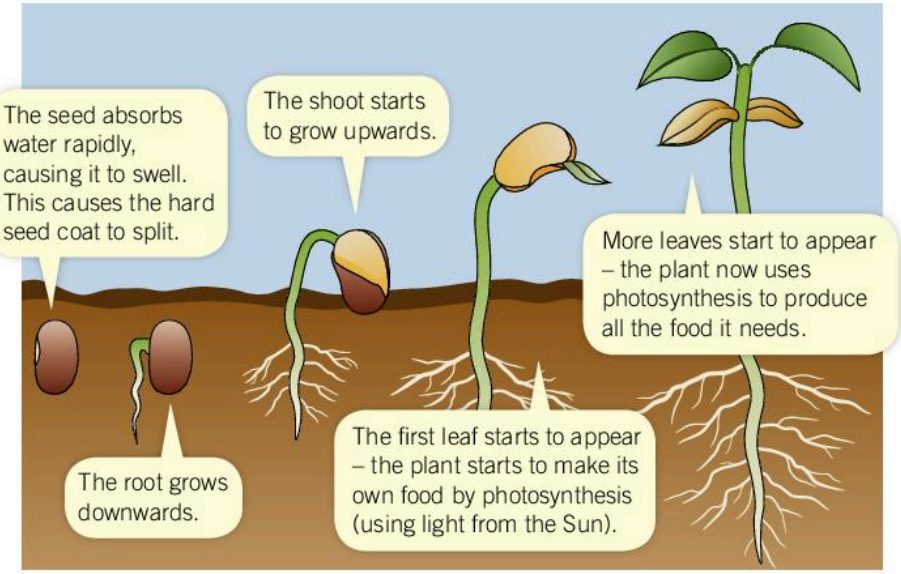
C State the three things needed for germination.

Link

You can learn more about respiration in B2 2.5 Aerobic respiration

How does a plant grow?

The diagram below shows the main steps in germination.



Investigating germination

Design an investigation to test the hypothesis that warmth, oxygen, and water are required for germination. What equipment will you need? What method will you use? What variables will you keep the same, change, and control? How will you know if the hypothesis is correct?

Summary Questions

1 Copy and complete the sentences below.

During _____ the nucleus of the _____ grain and the nucleus of the _____ join together.

The ovary then develops into the _____, and the ovules become _____.

To _____, the seed needs _____ water and oxygen.

(7 marks)

2 Describe what happens after the ovule is fertilised.

(2 marks)

3 To produce new plants, the seeds have to germinate. Describe in detail what happens during germination.

(6 marks QWC)

3.8 Seed dispersal

Learning objectives

After this topic you will be able to:

- state the ways seeds can be dispersed
- describe how a seed is adapted to its method of dispersal.

▲ Dandelion seeds being dispersed by the wind.

Sometimes on a summer's day you can see lots of things blowing in the air. Many people think this is pollen but pollen grains are tiny and hard to see. You are probably looking at seeds being moved away from the parent plant. This is known as seed dispersal.

How are seeds dispersed?

Seeds are dispersed away from each other and from the parent plant. This is so they have space to grow and do not compete for resources such as nutrients. Nearly all seeds are found inside fruits. This increases the number of ways they can be dispersed. The main methods of **seed dispersal** are:

- wind
- animal
- water
- explosive.

A Name four methods of seed dispersal.

Wind dispersal

The wind is very useful for dispersing seeds and fruits. To help them catch the wind, some fruits and seeds have a small mass and extensions that act as parachutes or wings. Examples include dandelion and sycamore seeds.

Animal dispersal

Animals can disperse fruits and seeds in two ways:

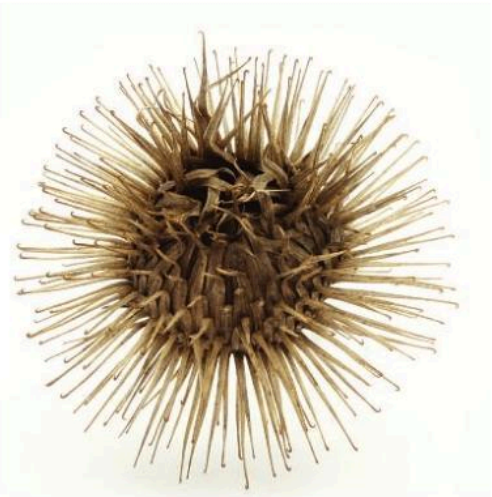
- internally – animals eat lots of fruit, including tomatoes, blackberries, and strawberries. Fruits are normally brightly coloured and taste sweet, which attracts animals to them. These fruits contain seeds with hard coats. This means the seeds pass through the animal without being damaged. When they reach the ground in animal droppings, the seeds might be able to germinate. They are surrounded by waste material, which provides nutrients and helps the plant to grow.

Key Words

seed dispersal

- externally – some fruits have hooks on them, which help them stick to animals. As an animal brushes past a plant such as goose grass or burdock, the seeds get caught in their fur. They get carried away from the parent plant. The seeds drop off the animal's fur and reach the ground, where they might be able to germinate.

B Name two types of seed that are dispersed by animals.



▲ Burdock seeds have little hooks on them to help them stick to animals' fur.

Water dispersal

Many plants that live near water, such as willow trees, produce seeds with a small mass that float on water. The seeds are transported away from the parent plant in streams and rivers. They might germinate if they get washed up onto land. Other trees, such as the coconut, produce woody fruits that are waterproof. They are carried away by the sea and might germinate if they reach another shore.

C Describe the structure of a seed that can be transported by water.

Explosive dispersal

Some fruits burst open when they are ripe, throwing the seeds in all directions. Peapods and gorse disperse seeds in this way.

▲ Peapods burst open when ripe, dispersing the seeds away from the parent plant.

D Name a plant that disperses its seeds by explosion.

Summary Questions

1 Copy and complete the sentences below.

Seeds are _____ away from the parent plant and other seeds to reduce _____. This increases their chances of having enough space and _____ to grow.

Seeds can be dispersed by the _____, water, _____, and explosion.

(5 marks)

2 Describe the two ways that animals can disperse seeds.

(4 marks)

3 Explain in detail how different seed types are adapted to their method of seed dispersal.

(6 marks QWC)

B1 Chapter 3 Summary

Key Points

- Adolescence is the time when you change from a child to an adult.
- The physical changes that your body goes through during adolescence is called puberty. Puberty is caused by hormones.
- Boys and girls both have a growth spurt, and grow pubic and underarm hair.
- Girls develop breasts, the ovaries release egg cells, and the hips widen.
- Girls begin the menstrual cycle. Periods occur when the lining of the uterus breaks down. This happens once a month.
- Boys' voices break, the testes and penis get bigger, the testes start to produce sperm, shoulders widen, and hair grows on the face and chest.
- Fertilisation in animals occurs when the nucleus of a sperm joins with the nucleus of an egg.
- The fertilised egg divides several times to form a ball of cells called an embryo. This implants in the lining of the uterus and begins to develop into a baby.
- The fetus receives nutrients and oxygen from the mother through the placenta.
- Pollination occurs when pollen from the anther is transferred to the stigma.
- Fertilisation in plants occurs when the nucleus of a pollen grain joins with the nucleus of an ovule.
- The ovary becomes a fruit and the ovules turn into seeds. The seeds are dispersed by either the wind, water, animals, or explosion.
- A seed requires warmth, oxygen, and water to germinate.

Case Study

Seed-dispersal investigation

The shape and mass of a seed plays an important role in its method of dispersal.

Task

Plan an investigation to see how far different types of seed can be dispersed.

Tips

- Think about the variables. What will you change, measure, and control?
- How will you measure how far the seeds travel?
- How will you make the investigation repeatable and reproducible?

Key Words

adolescence, puberty, sex hormones, sperm cell, testes, scrotum, semen, sperm duct, urethra, penis, sexual intercourse, egg cell, ovary, oviduct, uterus, cervix, vagina, gamete, fertilisation, cilia, ejaculation, embryo, implantation, gestation, fetus, placenta, umbilical cord, fluid sac, period, menstrual cycle, ovulation, contraception, condom, contraceptive pill, petal, sepal, stamen, anther, pollen, filament, carpel, stigma, style, ovary, ovule, pollination, fertilisation, fruit, seed, germination, seed dispersal

End-of-chapter questions

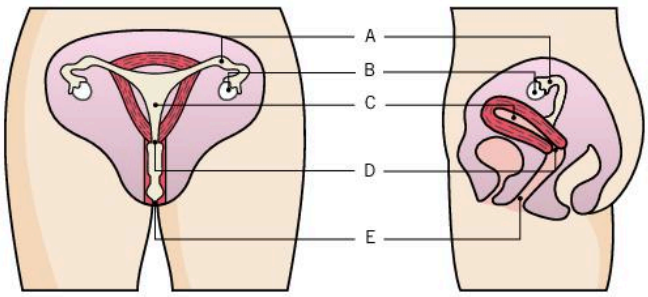
1 a Sort the physical changes that take place during adolescence into those that happen to boys, those that happen to girls, and those that happen to both.

breasts develop **voice deepens**
testes produce sperm **growth spurt**
pubic hair grows **periods start**

Boys	Girls	Both

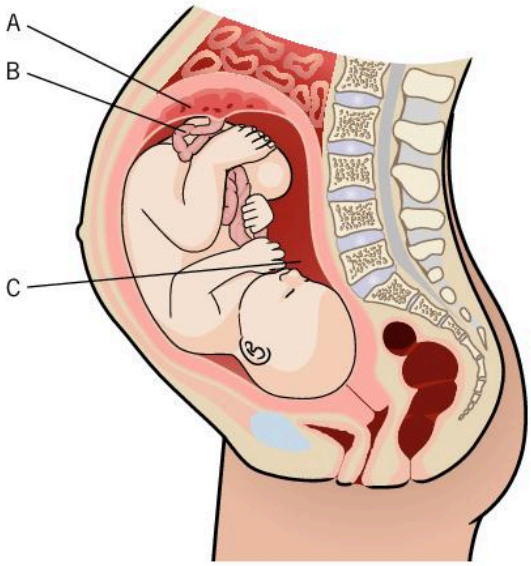
*(**6 marks**)*

b State the name given to the physical changes that take place during adolescence.
*(**1 mark**)*



2 The diagram shows the main structures in the female reproductive system.

a Name structures A and D. *(2 marks)*
b State where sperm are released during sexual intercourse. *(1 mark)*
c State where the baby develops during pregnancy. *(1 mark)*
d Describe what happens during ovulation. *(2 marks)*
*(**6 marks**)*



3 A fetus develops inside the uterus. During this time it depends on the mother for its growth and development.

a Name structure B. *(1 mark)*
b State how the fetus is protected from bumps. *(1 mark)*
c Describe what happens during birth. *(3 marks)*
d Explain the role of the placenta. *(3 marks)*
*(**8 marks**)*

4 Plants can be pollinated by insects or the wind.

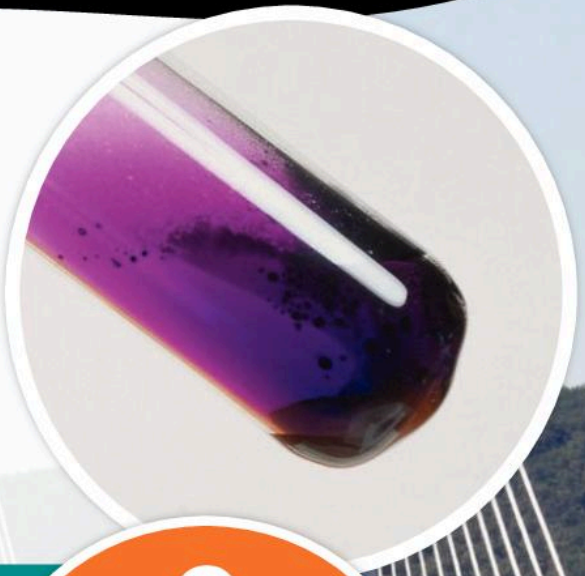
a State **two** features of a wind-pollinated plant. *(2 marks)*
b State **two** ways that an insect-pollinated plant is different. *(2 marks)*
c Describe what happens during pollination. *(2 marks)*
d Describe how a seed is formed after pollination has taken place. *(4 marks)*
*(**10 marks**)*

5 Describe in detail the structure and function of the main parts of a flower.
*(**6 marks QWC**)*

Chemistry 1

What is stuff made of? Everything is made up of chemicals – the food you eat, the plastic in your phone…and you! But what are these chemicals like inside, and why do they behave the way they do?

In C1 you will learn about the atoms that make up everything on Earth… and beyond. You will explore how chemical reactions make vital materials, and transfer energy for almost everything we do.



You already know

- Different materials have different properties.
- The different properties of different materials make them suitable for different uses.
- Many materials can exist in the solid, liquid, and gas states.
- The state of a material depends on the temperature.
- Changes of state are reversible.
- Melting, freezing, evaporating, boiling, and condensing are changes of state.
- Changes that form new materials are not reversible.
- Changes that are not reversible include burning, oxidation, and reactions of acid.

Q

What is the name of the change of state in which liquid water becomes ice?

BIG Questions

- What are materials like inside and why do they behave as they do?
- What are atoms and elements?
- How do scientists make new materials?

Picture Puzzler
Key Words


Can you solve this Picture Puzzler?

The first letter of each of these images spells out a science word that you will come across in this book.

Picture Puzzler
Close Up

Can you tell what this zoomed-in picture is?

***Clue**: It's a cold and frosty morning.*

Making connections

In **C1** you will learn about atoms and molecules and what happens when chemicals react.

In **B1** you will learn about diffusion and how particles move between substances.

In **P2** you will learn about energy transfer and energy conservation.

1.1 The particle model

Learning objectives

After this topic you will be able to:

- describe how materials are made up of particles
- use the particle model to explain why different materials have different properties.

Look around you. Can you see things made of wood, plastic, or steel? The different types of stuff that things are made from are called materials. There are millions of materials.

What's in a material?

Materials are made up of tiny **particles**. You cannot see the particles. They are too small. There are about 8 400 000 000 000 000 000 000 000 particles in a glass of water.

A State what materials are made up of.

Are all particles the same?

Many materials are **mixtures**. Wood is a mixture. So is milk, and the air. But some materials are not mixtures. They consist of just one substance. A **substance** is made of just one type of material. Substances include gold, water, and oxygen.

▲ Gold is a single substance. All of its particles are the same.

▲ The bridge cables are made from steel. Steel is a mixture.

Fantastic Fact!

If people were the same size as gold particles, the world's population would fit into a ball less than a thousandth of a millimetre across.

In a substance, every particle is the same. One gold particle is the same as all other gold particles. One water particle is the same as all other water particles. In the air, all oxygen particles are identical.

But gold particles are not the same as oxygen particles. Oxygen particles are not the same as water particles. Every substance has its own type of particle.

B State what is meant by a substance.

What gives a substance its properties?

The **properties** of a substance describe what it looks like and how it behaves. Every substance has its own properties. The properties of a substance depend on its particles.

The table shows data for gold and water.

Substance	Relative mass of particle	Mass of 1 cm^3 of the substance (g)
gold	197	19
water	18	1

A gold particle has a greater mass than a water particle. This helps to explain why 1 cm^3 of gold weighs more than 1 cm^3 of water.

In liquid water, particles slide over each other. In an ice cube, the particles do not move around. This explains why you can pour water from a glass but you cannot pour water from an ice cube.

The properties of a substance depend on three things, or factors:

- what its particles are like
- how its particles are arranged
- how its particles move around.

C List three factors that give a substance its properties.

Vital vocab

Plan how to explain the meanings of the key words on this page. Present your explanations to a partner.

Key Words

material, particle, mixture, substance, property

Link

You can learn more about the arrangement and movement of particles in C1 1.2 States of matter

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

There are **hundreds/millions** of materials. Materials are made up of **practicals/particles**. A substance has **the same/different** properties all the way through. In a substance, all the particles are **the same/different**. The particles of different substances are **the same/different**. The properties of a substance describe its **behaviour/particles**.

(6 marks)

2 Use the data to estimate which is heavier, 10 cm^3 of water or 10 cm^3 of mercury. Show how you decided.

Data: relative mass of water particle = 18; relative mass of mercury particle = 201.

(2 marks)

3 Using all the key words, draw a visual summary to summarise and organise the information on this page.

(6 marks)

1.2 States of matter

Learning objectives

After this topic you will be able to:

- describe the properties of a substance in its three states
- use ideas about particles to explain the properties of a substance in its three states.

Do you like ice in cold drinks? An ice cube is made up of water particles. Ice is water in the solid state. Now imagine a steaming kettle. Steam is also made up of water particles. It is water in the gas state.

Water can exist in three states, as a **solid**, a **liquid**, or a **gas**. These are the **states of matter**. The particles of water in its three states are identical. But the properties of ice, liquid water, and steam are different. These pages explain why.

A Name the three states of matter.

How does state affect properties?

Most substances can exist in three states. The state of a substance depends on temperature. At room temperature, gold is solid. But if you make it hot enough, gold exists as a liquid or gas.

The table compares the properties of a substance in its three states.

State	Can you compress (squash) the substance in this state?	Does the substance flow?	Shape
solid	no	no	fixed, unless you apply a force
liquid	no	yes	takes the shape of the bottom of its container
gas	yes	yes	takes the shape of the whole container

B Identify three differences between a substance in the solid and liquid states.

▲ Ice is water in the solid state.

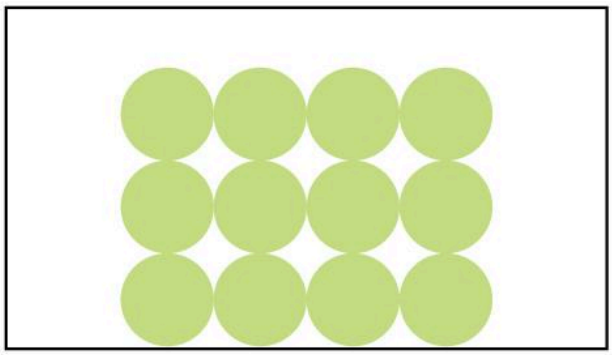
How do particles explain properties?

The particles of a substance do not change. All water particles are the same, in all three states. But the arrangement and movement of particles are different in each state.

The solid state

When a substance is in the solid state, its particles touch their neighbours. This explains why you cannot compress a solid. In the solid state, a substance's particles are arranged in a pattern.

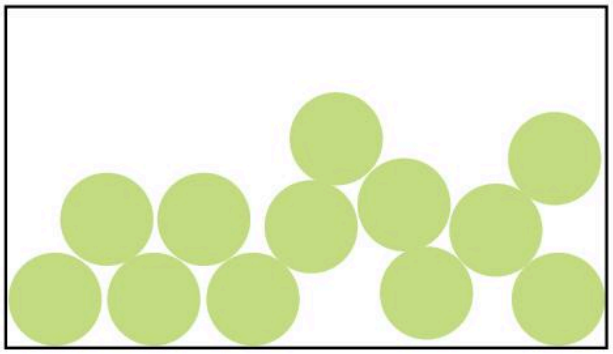
In the solid state, particles do not move around. They vibrate on the spot. This explains why solids cannot flow.



The particles of a substance in the solid state.

The liquid state

When a substance is in the liquid state, its particles touch their neighbours. This is why you cannot compress a liquid. The particles move from place to place, sliding over each other. This explains why liquids flow and why they have no fixed shape.

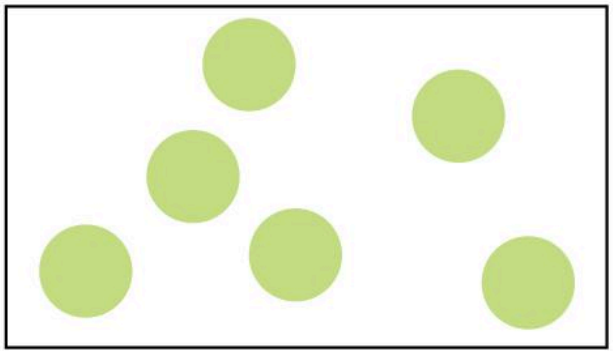


The particles of a substance in the liquid state.

C State why you cannot compress a liquid.

The gas state

In the gas state, particles spread out. So it is easy to compress a gas. The particles move throughout the whole container. This explains why gases flow.



The particles of a substance in the gas state.

Express particle?

In 2010 a Chinese train became the world's fastest passenger train. It reached a speed of 486 km/h (0.135 km/s). In the air, oxygen particles travel at about 500 m/s. Calculate which is faster – the train or the particles.

Key Words

solid, liquid, gas, states of matter

Summary Questions

1 Each sentence in the paragraph below has one or more mistakes. Write corrected versions of the sentences.

There are two states of matter. You can compress a substance in the solid state because the particles touch each other. In the liquid and gas states, a substance flows because the particles cannot move from place to place. You cannot compress a gas because the particles are spread out.

(4 marks)

2 Compare the properties of a substance in the liquid and gas states.

(3 marks)

3 Use the particle model to explain in detail why the properties of water are different in its three states.

(6 marks QWC)

1.3 Melting and freezing

Learning objectives

After this topic you will be able to:

- use the particle model to explain changes of state involving solids and liquids
- interpret data about melting points.

▲ Gallium metal is solid at room temperature. On a warm hand, it melts.

▲ Lava cools and freezes. This forms rock.

Key Words

melting, change of state, freezing, melting point

Imagine an ice cube in your hand. What happens?

When a substance changes from the solid to liquid state, it melts. **Melting** is a **change of state**. **Freezing** is the change of state from liquid to solid. Liquid gold freezes if cooled to 1063 °C.

A Name the two states involved in freezing.

Explaining melting and freezing

What happens when an ice cube melts? The surroundings transfer energy to the ice, so its particles vibrate faster. Particles move away from their places in the pattern. They continue to move around. As more particles leave the pattern, more ice melts.

When a liquid starts to freeze, its particles move more slowly as they transfer energy to the surroundings. The particles get into a pattern, and vibrate on the spot. Eventually, all the liquid freezes. The mass does not change when a substance melts or freezes. This is because no particles have been added or removed.

B Describe how particle movement changes when a substance melts.

What is a melting point?

The temperature at which a substance melts is its **melting point**.

Substance	Melting point (°C)
gallium	30
gold	1063
oxygen	–218
water	0

Melting points give information about the states of substances at different temperatures. The melting points of gallium and gold are above 20 °C. So at 20 °C, gallium and gold are solid. You cannot work out the state of oxygen from the data in the table.

C List the substances in the table in order of increasing melting point.

Using melting points

Identifying substances

Jackson and Marcus are at university. They have three painkillers – paracetamol, aspirin, and ibuprofen. They do not know which is which. They use the Internet to find out their melting points. They record the data in the table shown on the right.

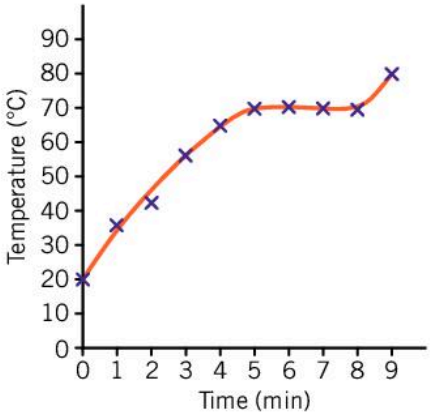
The students measure the melting point of one painkiller. It is 136 °C. They conclude that it is aspirin.

Substance	Melting point (°C)
paracetamol	169
aspirin	136
ibuprofen	76

▲ Apparatus used to measure melting points.

Checking purity

A single substance has a sharp melting point. Stearic acid is solid at 20 °C. If you heat the acid, it stays solid up to 70 °C. Then it starts to melt. It stays at 70 °C until it has all melted. Then the liquid warms up.

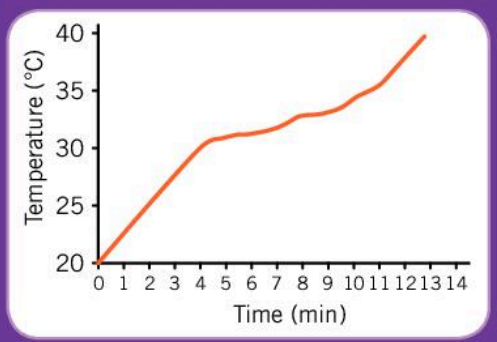


▲ The graph shows the temperature of stearic acid as it is heated.

A material that is a mixture of substances does not have a sharp melting point. Chocolate melts between 30 °C and 32 °C. This shows that it is a mixture.

Butter wouldn't melt...

Look at the graph. Is butter a single substance or a mixture? Explain your decision.



Summary Questions

1 Copy the sentences below, choosing the correct bold words.

The change of state from solid to liquid is **freezing/melting**. As a substance melts, its particles vibrate **slower/faster**. The particles start moving **around/upwards**. The substance is now in the **liquid/solid** state. The melting point of a substance is the **speed/temperature** it melts at.

(5 marks)

2 A substance has a melting point of -7 °C. Tom says the substance is liquid at 20 °C. Ben says it could be liquid or gas. Explain who is correct. Use evidence to support your answer.

(3 marks)

3 Use the particle theory to explain in detail the difference between melting and freezing.

(6 marks QWC)

1.4 Boiling

Learning objectives

After this topic you will be able to:

- use the particle model to explain boiling
- interpret data about changes of state.

Close your eyes. Imagine water boiling. What can you hear? What can you see? When a substance is boiling it is changing from the liquid state to the gas state.

Explaining boiling

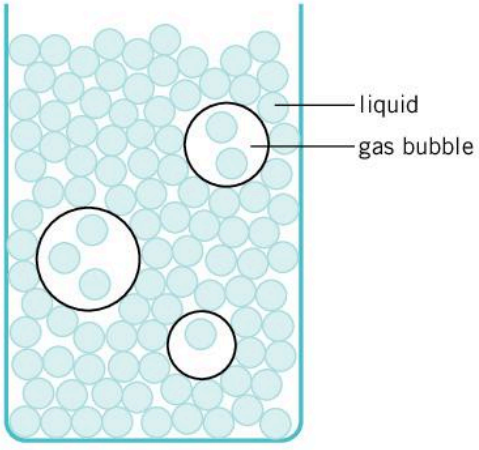
When water boils, bubbles of steam form all through the liquid. In the liquid, water particles touch their neighbours. Inside the bubbles, the water particles are spread out.

As water boils, the steam bubbles rise to the surface of the liquid. They escape into the air. The total mass of steam and water is the same as the mass of water at the start. Scientists say that mass is **conserved** in **boiling**.

A Name the substance in the bubbles in boiling water.

Link

You can learn more about evaporation in C2 2.5 Evaporation and distillation



▲ Boiling water.

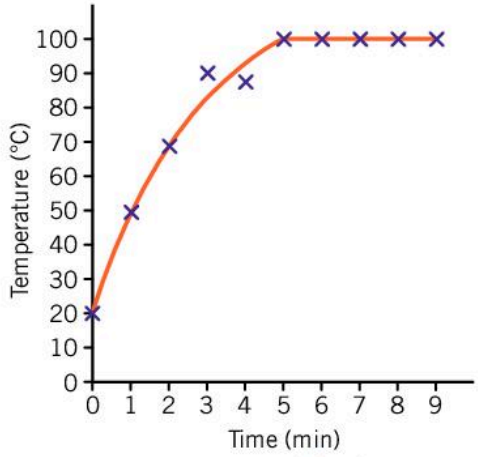
What is a boiling point?

Boiling happens if enough energy is transferred to the particles. Different substances need different amounts of energy to boil. This means that different substances boil at different temperatures. The temperature a substance boils at is its **boiling point**.

Measuring boiling point

You can measure the boiling point of a substance like this:

- Pour the liquid into a beaker.
- Heat the liquid, and measure the temperature every minute.
- Plot the results on a graph.



▲ A temperature–time graph for heating water.

Fantastic Fact!

The boiling point of a substance depends how high above the Earth's surface you are. At Mount Everest Base Camp (5364 m above sea level), water boils at 82 °C.

A student heated liquid water and plotted the graph shown on the opposite page. At first, the temperature increased. At 100 °C, the water bubbled vigorously. It was boiling. The temperature remained at 100 °C. This is the boiling point of water.

B State what is meant by the term boiling point.

Using boiling points

Identifying substances

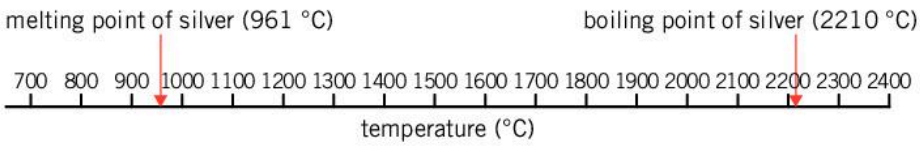
You can use data about boiling points to help identify substances. Lucy has a colourless liquid. Her teacher tells her it could be water, ethanol, or propanol. Lucy notes the boiling points of these substances in the table below.

Substance	Boiling point (°C)
water	100
ethanol	78
propanol	97

Lucy heats her liquid on an electric heater. She measures its temperature every minute. At 78 °C the liquid bubbles vigorously. It remains at 78 °C for several minutes. Lucy concludes that the liquid is ethanol.

Predicting states

If you know the melting point and the boiling point of a substance, you can predict its state at different temperatures. The melting and boiling points of silver are shown below.



At room temperature (20 °C), silver is in the solid state. At 961 °C, the melting point, silver exists as both a solid and a liquid. Between 961 °C and 2210 °C silver is a liquid. At 2210 °C, the boiling point, silver exists as both a liquid and a gas. Above 2210 °C silver exists in the gas state.

C Predict the state of silver at 1000 °C.

Mystery liquid

Sarah has a liquid. It could be water, ethanol, or propanol. Sarah heats the liquid. It bubbles vigorously at 97 °C. Use data from this page to suggest what the liquid might be.

Key Words

conserve, boiling, boiling point,

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

When a substance boils, it changes state from **liquid/gas** to **liquid/gas**. Bubbles form **at the top of/all the way through** the liquid. A certain substance boils at **any/a certain** temperature.

(4 marks)

2 Use the data to predict the state of copper at 2000 °C.

Data for copper:

melting point = 1083 °C

boiling point = 2595 °C

(1 mark)

3 Design a particle model that can explain why different substances boil at different temperatures. Use the data on this page to compare two substances using your particle model. Identify the strengths and weaknesses of your model.

(6 marks)

1.5 More changes of state

Learning objectives

After this topic you will be able to:

- describe changes of state involving gases
- use the particle model to explain evaporation, condensation, and sublimation.

What happens to the water when you use a hairdryer to dry your hair? It changes state from liquid to gas without boiling. This is called evaporation.

Explaining evaporation

In a liquid, some particles have more energy than others. The particles with most energy leave the liquid surface. Then they move away from the liquid. The particles spread out, forming a gas. They mix with air particles. This is **evaporation**.

A substance can change from the liquid to the gas state by evaporating or boiling. The table below shows some differences between these two processes.

Process	How particles leave the liquid	Temperature	Does the mass change?
evaporation	Particles escape from the liquid surface.	happens at any temperature	no
boiling	Bubbles of the substance in the gas state form throughout the liquid. They rise to the surface and escape.	happens only at the boiling point	no

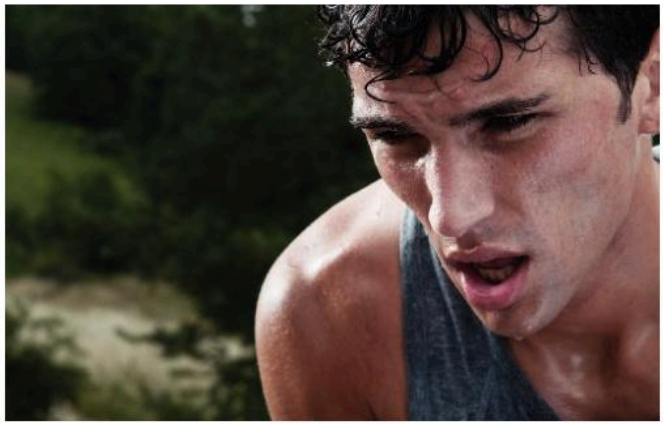
A State two differences between evaporation and boiling.

Key Words

evaporation, condensation, sublimation

How is evaporation useful?

Why do you sweat? Sweating cools you down by evaporation. Sweat comes out of pores in your skin. Water from the sweat evaporates. The water particles need energy to move away as a gas. They take this energy from your skin. This cools you down.



Sweat helps to cool you down by evaporation.

Evaluating evaporation

Eva is investigating evaporation. She puts a small, damp tissue in a cold place. She puts a big, wet towel above a heater. The tissue dries first. Eva concludes that cold conditions speed up evaporation. Evaluate Eva's investigation: How could she improve it? Does the evidence support the conclusion?

Why is it quicker to dry your hair with a hairdryer? The hairdryer speeds up evaporation in two ways. It transfers energy to help particles leave the liquid surface. It also moves just-evaporated water particles away from your hair.

B Identify two ways that a hairdryer speeds up evaporation.

What is condensation?

Is the inside of your bedroom window ever wet after a cold night? At bedtime, water particles were mixed with air particles. They were spread out, as a gas. During the night, water particles hit the cold glass of the window. They moved closer to other water particles, until they were touching. This formed liquid water. The change of state from gas to liquid is called **condensation**. It can happen at any temperature below the boiling point.

C Identify the state formed when a substance condenses.

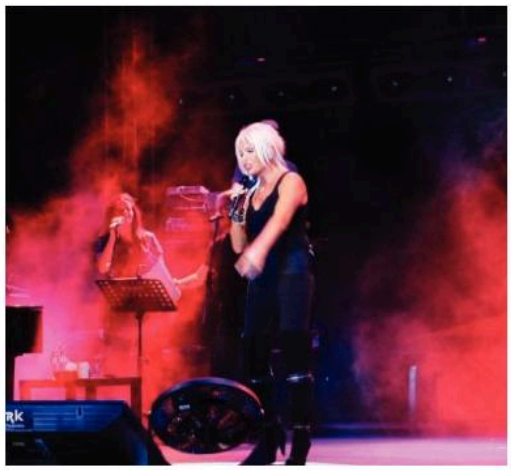
What is sublimation?

Where does stage smoke come from? It comes from solid carbon dioxide. Carbon dioxide is solid at temperatures below –78.5 °C. At this temperature and above, solid carbon dioxide changes state to become a gas. It does not normally exist as a liquid. The change of state from solid to gas is called **sublimation**.

At first, the carbon dioxide gas is very cold. Water particles condense around carbon dioxide particles. Tiny drops of liquid water form. It is this liquid water that makes stage smoke.

Solid grey iodine sublimes to form purple iodine gas. ▶

D Name the change of state that occurs when a substance in the solid state changes into a gas.



▲ Stage smoke comes from solid carbon dioxide. The solid is also known as dry ice.

Summary Questions

1 Write **five** correct sentences from the sentence starters and enders below.

Sentence starters

In boiling...
In condensing...
In evaporating...

Sentence enders

...particles leave from the surface of the liquid.
...substances change from the liquid to the gas state.
...particles leave from all parts of the liquid.
...substances change from the gas to the liquid state.

(5 marks)

2 Describe the changes in behaviour of the particles when a substance condenses.

(2 marks)

3 Compare the processes of evaporation, boiling, and condensation.

(6 marks QWC)

1.6 Diffusion

Learning objectives

After this topic you will be able to:

- use the particle model to explain diffusion
- describe evidence for diffusion.

▲ Coloured ink particles diffuse through water. There is no need to stir.

Fantastic Fact!

At room temperature, particles in liquid water move at an average speed of 1600 km/h (444 m/s).

Key Words

diffusion

Link

You can learn more about diffusion in B1 1.4 Movement of substances

Do you wear perfume or deodorant? How does the smell reach your nose?

Perfume particles evaporate from your skin. The particles move around randomly. They mix with the air. As the perfume particles spread out, some enter your nose. Your nose detects the smell. The random moving and mixing of particles is called **diffusion**.

Why do substances diffuse?

Particles diffuse because they are moving. Perfume particles move randomly in the air, even if the air seems completely still. Ink particles spread through water by themselves. You do not need to shake or stir.

A State what is meant by diffusion.

What factors affect diffusion speed?

Diffusion does not always happen at the same speed. Three factors affect the speed of diffusion:

- temperature
- particle size
- the state of the diffusing substance.

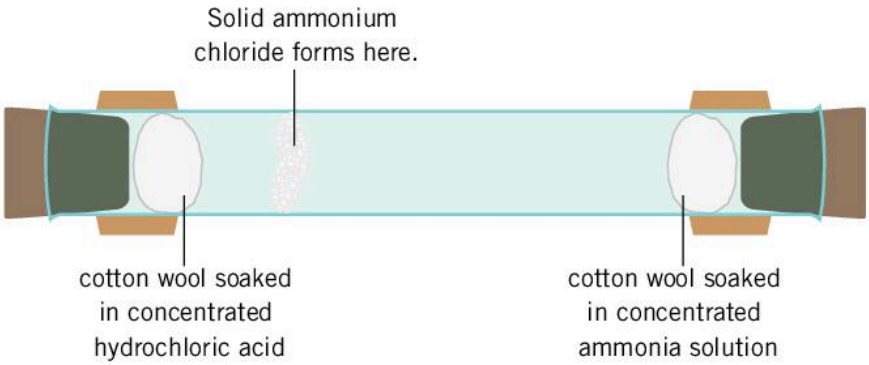
Temperature

At higher temperatures, particles are moving more quickly. Perfume particles leaving warm skin travel faster than perfume particles leaving a cold bottle.

B Explain why particles diffuse more quickly at higher temperatures.

Particle size

A teacher sets up the apparatus below to demonstrate diffusion.



▲ Particles of potassium manganate(VII) diffuse through the water.

Hydrogen chloride particles evaporate from the piece of cotton wool at the left side of the test tube. Ammonia particles evaporate from the piece of cotton wool at the right. The particles diffuse along the tube. The two types of particle meet, and form a ring of white solid. The solid is closer to the hydrogen chloride end. This shows that the hydrogen chloride particles diffuse more slowly. Hydrogen chloride particles are bigger and heavier than ammonia particles. Big, heavy particles diffuse more slowly than small, light ones.

State

Diffusion happens quickly in gases. This is because the particles are far apart. A particle in a gas travels a long way before hitting another particle.

In the liquid state, particles are closer than in the gas state. This is why diffusion is slower in liquids.

Diffusion does not happen in solids. The particles cannot move from place to place.

Fair's fair

Raj investigates how temperature affects diffusion speed. He puts purple crystals into five test tubes. He adds water of a different temperature to each test tube. He watches the purple colour spread through the water. Identify the variables Raj should change, measure, and control to make it a fair test.

Summary Questions

1 Copy and complete the sentences below.

When food cooks, you can smell it because some _____ leave the food. The particles move _____ and mix with the _____. This is called _____. Particles diffuse because _____ is transferred. The higher the temperature, the _____ the diffusion.

(6 marks)

2 Describe **three** pieces of evidence for diffusion.

(3 marks)

3 The air contains particles of argon, nitrogen, and other substances. Use the data below to predict which type of particle diffuses faster. Give a reason for your choice.

Relative masses of particles: nitrogen = 28 and argon = 40

(2 marks)

4 Explain in detail the different diffusion speeds through substances in the solid, liquid, and gas states.

(6 marks QWC)

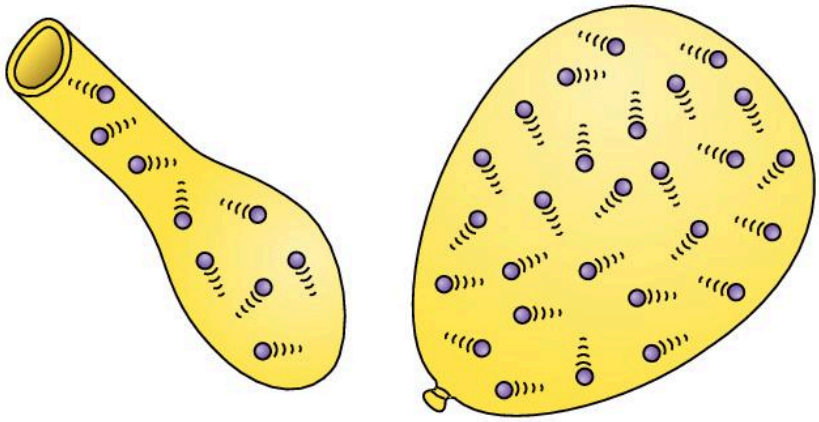
1.7 Gas pressure

Learning objectives

After this topic you will be able to:

- use the particle model to explain gas pressure
- describe the factors that affect gas pressure.

Why do balloons get bigger as you blow them up? When you blow up a balloon, you are filling it with air particles. The more air particles you add, the bigger the balloon.



▲ The more particles you blow into a balloon, the bigger the balloon.

Inside the balloon, the air particles move quickly from place to place. They bump into, or collide with, each other. They also **collide** with the rubber the balloon is made from. The collisions exert a force on the rubber. The force per unit area (every square metre) is the **gas pressure**.

Gas particles always exert pressure on the walls of their container, whatever the container is made from.

A State what is meant by gas pressure.

Fantastic Fact!

Racing-car tyres reach 100 °C. Before a race, technicians pump tyres to a lower pressure than they need in the race. The air pressure in the tyre increases as it heats up.

▲ The air pressure in racing-car tyres increases during a race.

How does the number of particles affect pressure?

Rubber is stretchy. So when you blow more particles into a balloon, the balloon expands.

But some containers cannot expand. Adding more particles causes more frequent collisions with the walls. The pressure inside the container increases.

B Explain why adding more air increases the pressure inside a container.

Particle performance

Read the Fantastic Fact before you do this task.

Racing-car tyres are pumped full of air. Write a script for particles in a racing-car tyre. What do they say as the car goes faster and the air gets hotter? Then perform your script.

How does temperature affect pressure?

Hotter and hotter

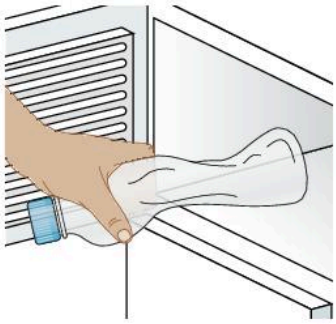
Balloons sometimes burst on hot days. Why does this happen?

As the air in a balloon gets warmer, more energy is transferred to the particles. The particles move faster. They collide with the rubber more often. The pressure inside the balloon increases.

The higher the temperature, the higher the air pressure. At first the rubber stretches. As the temperature gets even higher, the rubber cannot withstand the greater pressure. Eventually, it cannot stretch any further and the balloon bursts.

Cooling down

Imagine a plastic bottle of air in a freezer. The particles transfer energy to the freezer, and the air cools down. The particles move more slowly. They collide with the plastic less often. The pressure in the bottle decreases. The particles outside exert a higher pressure than the particles inside. The bottle collapses.



◀ In the freezer, the air pressure inside the bottle decreases.

Now imagine taking the bottle out of the freezer. The air inside the bottle warms up. Soon, the air particles inside and outside the bottle exert the same pressure. The bottle returns to its normal shape.

C Explain why a bottle collapses in the freezer.

Key Words

collide, gas pressure

Summary Questions

1 Copy the true sentences below. Write corrected versions of the false sentences.

Gas particles collide with the walls of their container.

Colliding gas particles exert pressure on the inside of the container.

The more particles in a container, the lower the pressure.

The higher the temperature, the lower the pressure.

(4 marks)

2 Jack was camping. He put a can of baked beans on his camp fire, without opening the lid. The can exploded. Use ideas about particles to explain why.

(3 marks)

3 Plan a talk that you could give to another class to explain what happens to an inflated balloon when you put it in a warm room and when you put it in a fridge.

(6 marks)

C1 Chapter 1 Summary

Key Points

- Materials are made up of tiny particles.
- A substance is made up of just one type of material.
- The properties of a substance describe what it looks like and how it behaves.
- The properties of a substance depend on what its particles are like, and how they are arranged.
- There are three states of matter – solid, liquid, and gas. For a certain substance, the particles never change. But in different states, the particles move differently, and have different arrangements.
- In the solid state, you cannot compress a substance, or make it flow.
- In the liquid state, you cannot compress a substance, but you can make it flow.
- In the gas state, you can compress a substance, and make it flow.
- The change of state from solid to liquid is melting. A substance melts at its melting point. Pure substances have sharp melting points.
- A substance changes from the liquid to the gas state by evaporating or boiling. A substance boils at its boiling point.
- The change of state from gas to liquid is condensing.
- The change of state from liquid to solid is freezing.
- Some substances change directly from the solid state to the gas state. This is subliming.
- Diffusion is the random moving and mixing of particles.
- Gas particles collide with the walls of their container. The collisions cause gas pressure.

Maths Challenge

Up in the air

The air is a mixture of substances. The table shows the percentages of the substances in the air.

Substance	Percentage of substance in dry air
nitrogen	78.08
oxygen	20.95
argon	0.93
others, including carbon dioxide	0.04

Task

Draw a graph or chart to represent the data in the table.
Decide which type of chart is best, and explain why.

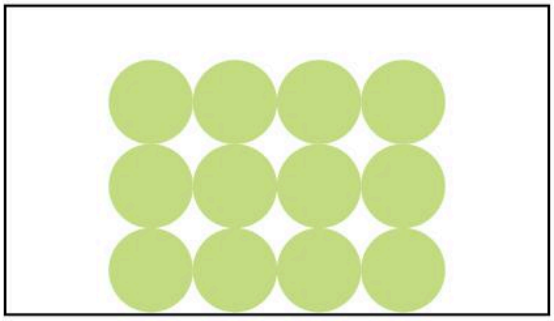
Key Words

material, particle, mixture, substance, property, solid, liquid, gas, states of matter, melting, change of state, freezing, melting point, boiling, boiling point, conserve, evaporation, condensation, sublimation, diffusion, collide, gas pressure

End-of-chapter questions

1 The diagram shows some particles in solid gold. Draw another diagram to show particles of gold in the gas state.

*(**2 marks**)*



2 Describe the arrangement and movement of particles in the liquid state.

*(**2 marks**)*

3 The table shows the melting points and boiling points of six substances.

Substance	Melting point (°C)	Boiling point (°C)
bromine	–7	59
krypton	–157	–152
mercury	–39	357
neon	–249	–246
platinum	1769	4530
silver	961	2210

a Write down the name of the substance with the highest boiling point.

(1 mark)

b Write down the names of the substances in order of increasing melting point, starting with the lowest.

(5 marks)

c Name **one** substance in the table that is in the gas state at 20 °C.

(1 mark)

d Name **two** substances in the table that are in the liquid state at 20 °C

(2 marks)

e Name **one** substance in the table that is in the liquid state at 100 °C.

(1 mark)

*(**10 marks**)*

4 Read the statements about particles in a substance in the solid state.

A The particles touch other particles.

B The particles are in a pattern.

C The particles do not move around from place to place.

D The particles vibrate.

a Write down the letter of the statement that best explains why you cannot pour a solid.

(1 mark)

b Choose one of the other statements and explain why it does not explain why you cannot pour a solid.

(1 mark)

*(**2 marks**)*

5 Olivia says that gas pressure is the result of particles colliding with each other. Is Olivia correct? Explain your answer.

*(**2 marks**)*

6 Compare the processes of boiling and evaporating.

*(**6 marks QWC**)*

2.1 Elements

Learning objectives

After this topic you will be able to:

- state what an element is
- recall the chemical symbols of six elements.

Fantastic Fact!

You are made up of elements. A 50 kg person is 32.5 kg oxygen, 9 kg carbon, 5 kg hydrogen, 1.5 kg nitrogen, 0.5 kg phosphorus, and 1.5 kg other elements.

Look at the pictures. What do the objects have in common?

▲ Jewellery.

▲ A catalytic converter. This changes harmful car exhaust gases into less harmful ones.

▲ A hard disk. This stores data on a computer.

▲ A heart pacemaker. This helps the heart to beat regularly.

All of these objects contain platinum. Platinum is a shiny substance. It is not damaged by air or water. It is easy to make platinum into different shapes.

Platinum is an example of an **element**. An element is a substance that cannot be broken down into other substances. You've probably heard of some elements: gold, silver, oxygen, chlorine, and helium are all examples of elements.

A State what an element is.

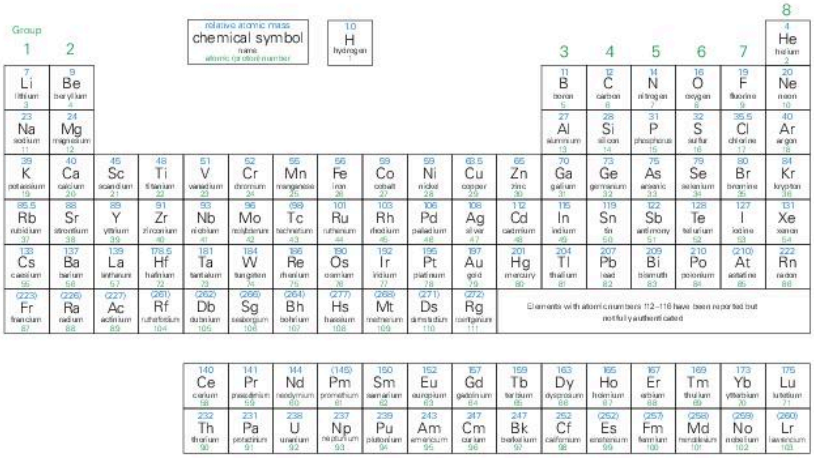
How many elements?

There are millions of materials. They are all made up of one or more elements. There are 92 elements that exist naturally. Scientists have made a few more.

Platinum propaganda

Platinum is useful. But it is very rare. It is also expensive. In March 2013, 1 g of platinum cost £33. Write the text for a leaflet to persuade car scrapyard owners to recycle platinum used in car exhausts.

The **Periodic Table** lists the elements. In the Periodic Table, elements with similar properties are grouped together.



▲ The Periodic Table lists the elements.

B State what the Periodic Table is.

What are chemical symbols?

Every element has its own **chemical symbol**. This is a one- or two-letter code for the element. Scientists all over the world use the same chemical symbols.

The table shows some chemical symbols.

Name of element	Chemical symbol
carbon	C
nitrogen	N
nickel	Ni
chlorine	Cl
gold	Au
iron	Fe
tungsten	W

For some elements, the chemical symbol is the first letter of its English name. For others, the chemical symbol is the first and second, or first and third, letters of its name. The chemical symbols of some elements come from their Latin names, for example, *aurum* for gold and *ferrum* for iron. The chemical symbol of tungsten comes from its German name, *Wolfram*.

C Write down the chemical symbols of the elements carbon, chlorine, gold, and iron.

Key Words

element, Periodic Table, chemical symbol

Link

You can learn more about the Periodic Table in C2 1.2 Groups and periods

When you write a chemical symbol, make sure the first letter is a capital letter. The second letter is lowercase.

Summary Questions

1 Write down the names of **10** elements.

(10 marks)

2 Use the Periodic Table to write the names and chemical symbols of six elements whose names begin with the letter C.

(6 marks)

3 Write a paragraph describing some uses of platinum. Choose two of these uses, and explain why the properties of platinum make it suitable for these two uses.

(6 marks QWC)

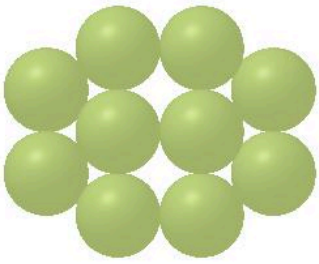
2.2 Atoms

Learning objectives

After this topic you will be able to:

- state what atoms are
- compare the properties of one atom of an element to the properties of many atoms.

▲ A silicon chip. This photograph was taken with a normal camera.

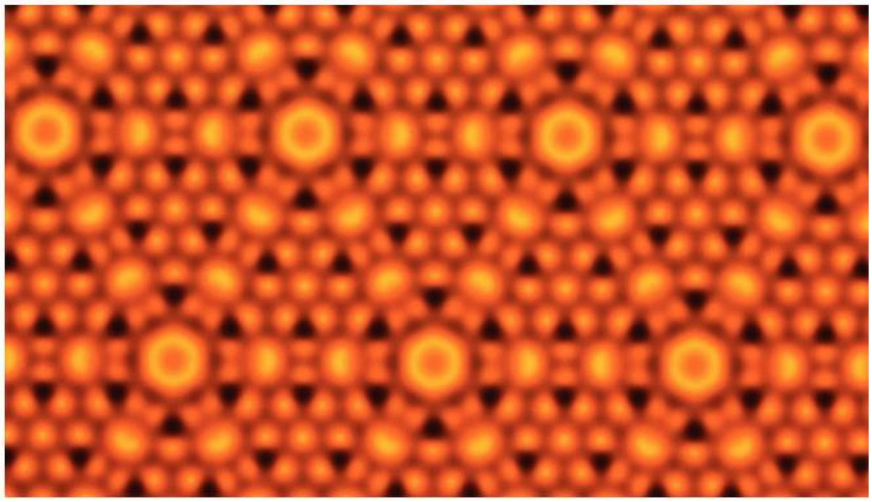


▲ This diagram shows silicon atoms in solid silicon.

Key Words

atom

Look at the picture below. What do you think it shows?



The picture shows the surface of a silicon crystal. Silicon is an element. Every computer, calculator, and mobile phone has silicon crystals inside. The crystals are called silicon chips. They contain millions of tiny electronic parts. These make the computers, calculators, and phones work.

Atoms

The picture shows atoms of silicon. An **atom** is the smallest part of an element that can exist.

The picture above was not taken with a normal camera. It was taken with a special type of microscope that can detect things as small as an atom.

A State what an atom is.

How many types of atom are there?

Every element is made up of one type of atom. All the atoms of an element are the same as each other. The atoms of one element are different to the atoms of all other elements. There are 92 elements that exist naturally, so there are 92 types of atom.

All silicon atoms are the same. But silicon atoms are different to gold atoms. For example, gold atoms are bigger.

Gold atoms are heavier than silicon atoms. This explains the data in the table on the next page.

Element	Mass of 1 cm^3 of the element (g)
gold	19.3
silicon	2.33

B Describe two differences between gold and silicon atoms.

Just one atom?

One atom on its own does not have the properties of the element. A gold atom is not yellow. It is not shiny. It is not in the solid, liquid, or gas state.

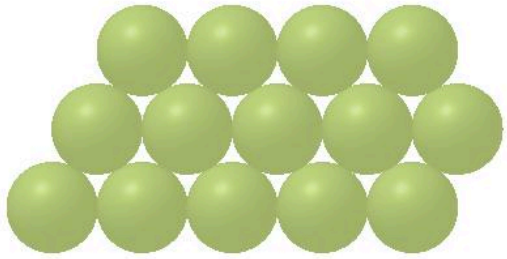
◀ The atoms in this piece of gold are all the same.

The properties of an element are the properties of very many atoms joined together. The piece of gold in the picture has a mass of 1000 g. It is made up of about 3 000 000 000 000 000 000 000 000 atoms. Together, these atoms make the gold yellow and shiny.

The atoms are touching each other in rows. They vibrate on the spot. The gold in the picture is in the solid state. If you heat gold to 1063 °C its atoms start moving around. The gold is melting. One atom of gold cannot melt. Only a group of many atoms can melt.

Going for gold?

A gold ring has a mass of 10 g. Choose data from the paragraphs above to estimate the number of atoms in the ring.



▲ This diagram shows gold atoms in solid gold.

Fantastic Fact!

The 2012 Olympic gold medals are only 1% gold by mass. There are 170 times more silver atoms than gold atoms in a gold medal.

Summary Questions

1 Copy and complete the sentences below.

The smallest part of an element that can exist is called an _____. All the atoms of an element are the _____. The atoms of one element are _____ to the atoms of all other elements.

(3 marks)

2 An Olympic bronze medal is made up of three elements – copper, zinc, and tin. State the number of types of atom in the medal. Explain your answer.

(2 marks)

3 Create and illustrate a visual summary to summarise and organise the information on this spread.

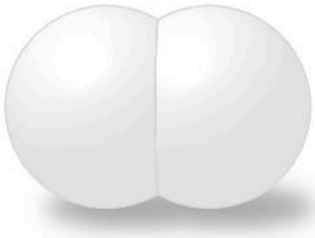
(6 marks)

2.3 Compounds

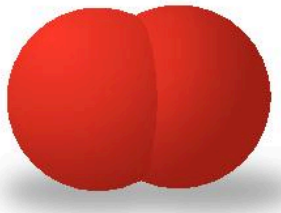
Learning objectives

After this topic you will be able to:

- state what a compound is
- explain why a compound has different properties to the elements in it.



▲ A hydrogen molecule consists of two hydrogen atoms.



▲ An oxygen molecule consists of two oxygen atoms.

▲ A water molecule has one oxygen atom joined to two hydrogen atoms.

Key Words

compound, molecule

How much water have you used today?

Water is vital for survival. But what is water? Water is made up of atoms of two elements, hydrogen and oxygen. This means that water is a **compound**. A compound is a substance made up of atoms of two or more elements. The atoms are strongly joined together.

The properties of a compound are different to the properties of the elements it is made up of.

A State what a compound is.

Why is water different to its elements?

Hydrogen is a gas at room temperature. Mixed with air, and ignited with a spark, it explodes. Hydrogen atoms go round in pairs. These are **molecules** of hydrogen. A molecule is a group of two or more atoms strongly joined together.

Oxygen is a gas at room temperature. You cannot see or smell it. Oxygen exists as molecules. Each molecule is made up of two oxygen atoms. In the air, oxygen molecules mix with atoms and molecules of other substances.

Water exists as molecules. The molecules are made up of atoms of two elements. This means that water is a compound.

Water molecules are different to hydrogen molecules and oxygen molecules. This is why water has different properties to hydrogen and oxygen. For example, water has a higher boiling point than hydrogen.

Weak forces hold molecules close to each other in liquid hydrogen. Stronger forces hold molecules close together in liquid water. It takes more energy to separate water molecules from each other than to separate hydrogen molecules from each other. Water has a higher boiling point than hydrogen.

B State which has a higher boiling point, water or hydrogen.

What is salt?

Do you add salt to your food? Salt is a compound. Its scientific name is sodium chloride. It contains atoms of two elements, sodium and chlorine.

- Sodium is a shiny metal. It fizzes in water.
- Chlorine is a smelly green poisonous gas.

So why doesn't salt smell? Or poison you? Or fizz in your mouth?

In salt, the atoms of sodium and chlorine are not just mixed up. They are joined together to make one substance – sodium chloride. This compound has different properties to the elements in it.

C Describe one difference in properties between sodium chloride and sodium.

Fantastic Fact!

Tooth enamel is a compound of calcium (a shiny metal that fizzes in water), phosphorus (a poisonous solid that catches fire easily), and oxygen (a gas that helps things burn).

Link

You can learn more about boiling points in C1 1.4 Boiling

Organising ideas

Make a table showing properties of sodium, chlorine, and sodium chloride. Use the table to help you plan and then write some paragraphs comparing the properties of the three substances.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

A compound is a substance made up of atoms of **one/two** or more elements. The properties of a compound are **the same as/different to** the properties of its elements. A molecule is a group of **two/three** or more atoms **weakly/strongly** joined together.

(4 marks)

2 Suggest an explanation for this boiling-point data:
oxygen = −183 °C; water = 100 °C

(3 marks)

3 Write a paragraph to compare the properties of hydrogen, oxygen, and water.

(6 marks QWC)

2.4 Chemical formulae

Learning objectives

After this topic you will be able to:

- write the chemical names for some simple compounds
- write and interpret chemical formulae.

Are the windows closed? If so, there is probably more carbon dioxide in the room now than there was 10 minutes ago. Every cell in your body makes carbon dioxide. You breathe it out. Carbon dioxide is a compound. It is made up of two elements – carbon and oxygen.

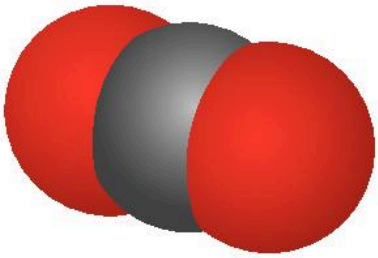
Carbon monoxide is another compound. It also consists of atoms of carbon and oxygen. But carbon monoxide is poisonous. It can be deadly if you breathe it in.

Link

You can learn more about the property differences between compounds and elements in C1 2.3 Compounds

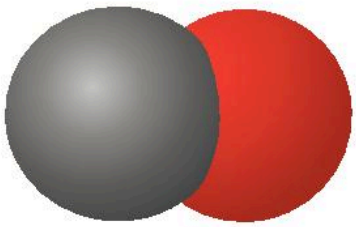
Why are carbon compounds different?

You already know that the properties of a compound depend on the elements in it. The numbers of atoms of each element also make a difference.



◀ A carbon dioxide molecule has one carbon atom and two oxygen atoms.

A carbon monoxide molecule ▶ has one carbon atom and one oxygen atom.



What's water?

Water contains 2 g of hydrogen for every 16 g of oxygen. Nitrogen dioxide contains 14 g of nitrogen for every 32 g of oxygen. Which compound has the higher proportion of oxygen? Show your working.

Carbon dioxide always has 12 g of carbon for every 32 g of oxygen. The amounts of carbon and oxygen in carbon monoxide are different. Carbon monoxide has 12 g of carbon for every 16 g of oxygen.

A State the number and types of atoms that make up one carbon dioxide molecule.

How do we name compounds?

Compounds made up of oxygen and another element have two-word names. The second word is *oxide*.

Elements in compound	Name of compound
aluminium and oxygen	aluminium oxide
zinc and oxygen	zinc oxide

Some elements form more than one type of oxide.

Molecule of compound made up of...	Name of compound
1 carbon atom and 1 oxygen atom	carbon **mon**oxide
1 carbon atom and 2 oxygen atoms	carbon **di**oxide

The compound of sodium and chlorine is called sodium chloride. Chlori***n***e becomes chlori***d***e.

B Name the compound of sodium and chlorine.

What is a chemical formula?

A **chemical formula** shows the relative number of atoms of each element in a compound – 'relative number' means how many of one type of atom there are compared to another. For example:

- The chemical formula of carbon dioxide is CO_2. This shows that there is one carbon atom for every two oxygen atoms.
- The chemical formula of carbon monoxide is CO. This shows that there is one carbon atom for every oxygen atom.

When you are writing chemical formulae, the numbers should be:

- to the right of their chemical symbol, just below the line
- smaller than the chemical symbols.

Key Words

chemical formula

Summary Questions

1 Copy and complete the sentences below.

The formula of carbon dioxide is _____. This shows that a molecule of carbon dioxide is made up of _____ carbon atom and _____ atoms of _____. The relative masses of carbon and oxygen in carbon dioxide are _____.

(5 marks)

2 The chemical formula of water is H_2O. State the number of atoms of each element in a water molecule.

(2 marks)

3 Draw and label diagrams to show how you could make models of the molecules on this spread. If possible, make the models.

(6 marks)

C1 Chapter 2 Summary

Key Points

- All materials are made up of one or more elements.
- Elements are substances that cannot be broken down.
- There are 92 elements that exist naturally.
- The Periodic Table lists all the elements.
- Every element has its own chemical symbol.
- An atom is the smallest part of an element that can exist.
- Every element is made up of one type of atom. All the atoms of an element are the same.
- The atoms of one element are different to the atoms of all other elements.
- The properties of a substance are the properties of many atoms, not just a single atom.
- A compound is a substance made up of atoms of two or more elements, strongly joined together.
- The properties of a compound are different to the properties of the elements that it is made from.
- A molecule is a group of two or more atoms that are strongly joined together.
- A chemical formula shows the relative number of atoms of each element in a compound.

Key Words

element, Periodic Table, chemical symbol, atom, compound, molecule, chemical formula

BIG Write

Science web

You work for a company that makes on-line revision resources for school students. Your boss wants you to write some new webpages for Key Stage 3 science.

Task

Write the text for the revision pages about elements, atoms, compounds, and chemical formulae.

Tips

- Before you start writing, decide what to include on each web page. Work out how many pages you will need. Do not try to include too much information on a page.
- Include diagrams and examples to help students understand the text.
- Highlight key words and explain their meanings.

End-of-chapter questions

1 Carbon dioxide is a compound made up of two elements.

a State what is meant by the word element. *(1 mark)*

b State the number of types of atom in the element carbon. *(1 mark)*

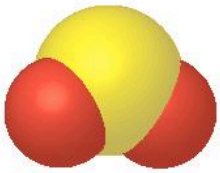
c One of the elements in carbon dioxide is carbon. Name the other element. *(1 mark)*

d State the number of types of atom in carbon dioxide. *(1 mark)*

e Copy and complete the sentences below. The formula of carbon dioxide is CO_2. There is _____ atom of carbon for every two atoms of _____. *(2 marks)*

(6 marks)

2 The diagram below shows a molecule of sulfur dioxide. Each sphere represents one atom. Different-coloured spheres represent atoms of different elements.



a State the total number of atoms in the molecule. *(1 mark)*

b State the number of different types of atom in the molecule. *(1 mark)*

c State whether sulfur dioxide is an element or a compound. Explain your decision. *(2 marks)*

d Copy and complete the table below. *(2 marks)*

Name of element	Number of atoms of this element in one sulfur dioxide molecule
sulfur	
	2

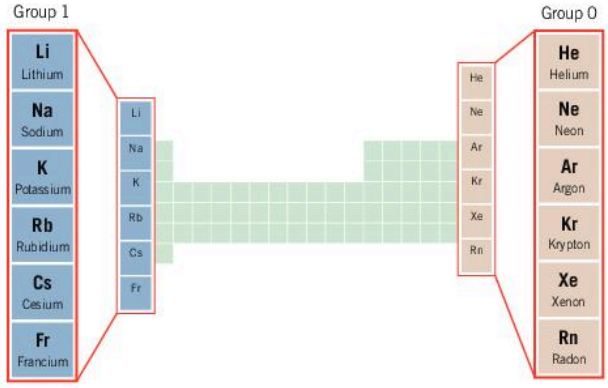
e Write the formula of sulfur dioxide. *(2 marks)*

(8 marks)

3 Describe **two** differences between elements and compounds.

(2 marks)

4 The table below shows data for six elements. The diagram shows their positions in the Periodic Table.



Name of element	Chemical symbol	Melting point (°C)
lithium	Li	180
sodium	Na	98
potassium	K	64
neon	Ne	–249
argon	Ar	–189
krypton	Kr	–157

Compare the melting point patterns for the Group 1 and Group 0 elements.

(6 marks QWC)

3.1 Chemical reactions

Learning objectives

After this topic you will be able to:

- describe what happens to atoms in chemical reactions
- explain why chemical reactions are useful
- compare chemical reactions to physical changes.

▲ Chemical reactions mean you can fry an egg.

Reaction, reaction, reaction

'Chemical reactions?' says Rick. 'They're all bangs and bad smells.' Is he right? Read over the examples from this page to help you decide. Make a visual summary to help you organise your ideas, and then write down what you plan to say to Rick.

Key Words

chemical reaction, reversible, catalyst, physical change

What did you have for breakfast today?

Chemical reactions make food and drink. Chemical reactions in cows produce milk from grass. Chemical reactions in plants produce maize, for cornflakes. Chemical reactions convert raw egg to fried egg. Burning gas for cooking is another chemical reaction.

What are chemical reactions?

A **chemical reaction** is a change in which atoms are rearranged to create new substances. The atoms are joined together in one way before the reaction and in a different way after the reaction.

All chemical reactions:

- make new substances.
- transfer energy to or from the surroundings.

Most chemical reactions are not easily **reversible**. At the end of the reaction it is very difficult to get back the substances you started with.

A State what happens to the atoms in a chemical reaction.

How do you know if it's a chemical reaction?

You do an experiment in the lab. How do you know if it involved chemical reactions? There are many clues to look out for. You might:

- see huge flames … or tiny sparks

- notice a sweet smell … or a foul stink

- feel the chemicals getting hotter … or colder
- hear a loud bang … or gentle fizzing.

B State three pieces of evidence that may suggest that a chemical reaction is happening.

Why are chemical reactions useful?

Chemical reactions are very useful. They make many useful substances. These include:

- medicines, such as paracetamol
- fabrics, such as polyester
- building materials, such as cement.

Chemical reactions also transfer energy. This transfer can be useful. Burning petrol makes vehicles go. Burning coal heats water to produce steam to generate electricity.

Some chemical reactions are not useful. Rusting is a chemical reaction. It may damage cars, boats, and bridges. Chemical reactions make food rot.

C State three examples of useful products made in chemical reactions.

Are all chemical reactions fast?

Some reactions happen quickly. Others are much slower. Chemists use **catalysts** to speed up slow reactions if they want to make a product more quickly. Different reactions need different catalysts. A catalyst is not used up in a reaction.

Are all changes chemical reactions?

Not all changes involve chemical reactions. If you warm chocolate, it melts. But you still have chocolate. Changes of state, and dissolving, are reversible. This means you can get back what you started with. This is called a **physical change**.

D Give examples of two types of physical change.

▲ This car burns methane gas instead of petrol. Chemical reactions make methane from human waste at a sewage works.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

Chemical reactions involve re-arranging **atoms/states**. Chemical reactions **always/sometimes** make new substances. They **are/are not** easily reversible. They **always/never** involve energy transfers. Physical changes include changes of **substance/state**. They **are/are not** reversible. *(6 marks)*

2 State which of the changes listed below are chemical changes, and which are physical changes.

a burning diesel to make carbon dioxide and water *(1 mark)*

b dissolving sugar in tea to make it taste sweet *(1 mark)*

c boiling water to make steam *(1 mark)*

d baking raw cake to make cooked cake *(1 mark)*

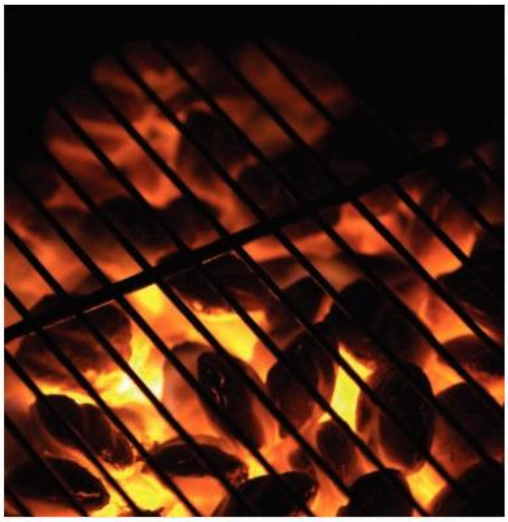
3 Compare chemical changes with physical changes. Include examples to illustrate your answer. *(6 marks QWC)*

3.2 Word equations

Learning objectives

After this topic you will be able to:

- identify reactants and products in word equations
- write word equations to represent chemical reactions.



▲ Charcoal is a form of carbon. It reacts with oxygen from the air to make carbon dioxide.

Risky reaction

Many reactions have **hazards**. A hazard is a possible source of danger. You must control the **risks** from hazards. Risk is the chance of damage or injury from a hazard. Burning magnesium has two hazards:

- The bright flame could be harmful to eyesight.
- The flame is difficult to put out.

Suggest how to control the risks from these hazards.

Do you like barbeques? What happens when charcoal burns?

Charcoal is a form of carbon. In the burning reaction, carbon reacts with oxygen from the air. The reaction makes a new substance, carbon dioxide. It forms as an invisible gas. In this reaction, two elements join together to make a compound.

A Name the two elements that react to make carbon dioxide.

Representing reactions

Many other pairs of elements join together in chemical reactions. You can mix iron filings and sulfur powder. They do not react. But if you heat them, the mixture glows red. A chemical reaction happens, and a new substance forms. The new substance looks different to the substances you started with. It has different properties. The new substance is iron sulfide.

▲ A mixture of iron and sulfur has different properties to iron sulfide.

In chemical reactions, the starting substances are called **reactants**. The substances made in the reaction are called **products**. In the reaction of iron with sulfur, the reactants are iron and sulfur. There is one product – iron sulfide.

B Name the reactants and products in the reaction of carbon with oxygen to make carbon dioxide.

Key Words

reactant, product, word equation, hazard, risk

Word equations represent reactions in a simple way.
A word equation shows:

- reactants on the left
- products on the right.

The arrow means *reacts to make*. It is different to an equals sign (=) in a maths equation.

The word equation for the reaction of iron and sulfur is:

iron + sulfur → iron sulphide

C Write a word equation for the reaction of iron and sulfur to make iron sulfide.

Re-arranging atoms

Magnesium burns in air. It reacts with oxygen. The product is magnesium oxide.

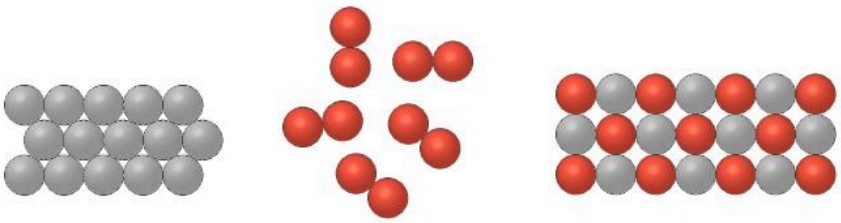
magnesium + oxygen → magnesium oxide

In this reaction there are many signs that a chemical reaction is taking place. There is a bright white flame, transferring energy to the surroundings.

The reactants and products look different.

- reactants – shiny magnesium and invisible oxygen gas
- product – white magnesium oxide powder

In every chemical reaction, the atoms get re-arranged. The diagrams show how the atoms are arranged in magnesium, oxygen, and magnesium oxide.



Summary Questions

1 Match the sentence starters and endings.

Sentence starters

Reactants are...
Products are...
Hazards are...
Risks are...

Sentence endings

...possible sources of danger.
...the chances of damage or injury from hazards.
...the starting substances in chemical reactions.
...the substances made in chemical reactions.

(4 marks)

2 Name the reactants and products in each reaction below.

a aluminium + iodine → aluminium iodide *(2 marks)*

b sodium + chlorine → sodium chloride *(2 marks)*

c lithium + bromine → lithium bromide *(2 marks)*

3 Write word equations for the reactions below.

a sulfur and oxygen producing sulfur dioxide *(2 marks)*

b potassium and chlorine *(2 marks)*

4 Use information from this page to compare the burning reactions of carbon and magnesium. Include word equations in your answer. *(6 marks QWC)*

3.3 Burning fuels

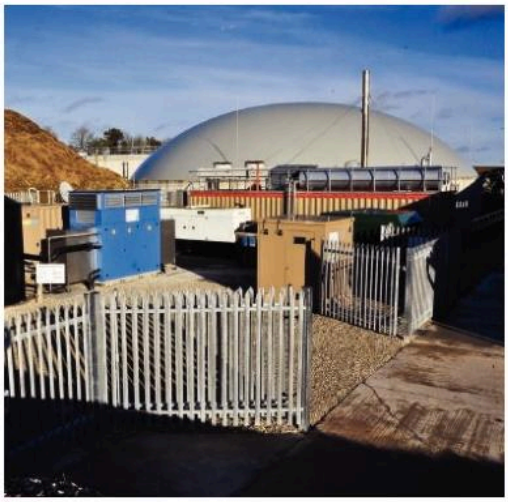
Learning objectives

After this topic you will be able to:

- predict products of combustion reactions
- categorise oxidation reactions as useful or not.

How do you heat your home? Many central-heating systems burn methane gas. Methane comes from under the ground, or under the sea. It was formed from tiny plants and animals that lived millions of years ago.

If you live in Poundbury, Dorset, your methane might come from another source. Waste from chocolate and cereal factories produces methane in just a few weeks.



▲ This apparatus makes methane from waste.

What are fuels?

Methane is a **fuel**. A fuel is a material that burns to transfer energy by heating. Fuels include petrol, diesel, coal, hydrogen, and waste cooking oil.

▲ This vehicle burns waste cooking oil.

A State the meaning of the word fuel.

Key Words

fuel, combustion, fossil fuel, non-renewable, oxidation

What happens when fuels burn?

Fuels burn in chemical reactions. Burning is also called **combustion**. Methane is a compound of carbon and hydrogen. Its chemical formula is CH_4. When it burns, it reacts with oxygen from the air. The reaction makes two products, carbon dioxide and water:

methane + oxygen → carbon dioxide + water

Petrol is a mixture of compounds. Most of its compounds consist of atoms of hydrogen and carbon. Petrol makes mainly carbon dioxide and water when it burns in car engines.

Foul Fact!

In Cirencester, Gloucestershire, methane made from chicken poo burns in a power station to generate electricity.

B Name the two elements that methane is made up of.

Petrol, diesel, coal, and methane from under the ground or sea, are **fossil fuels**. They are **non-renewable**. This means that they cannot be replaced once they have been used. They will run out one day.

Hydrogen – future fuel?

A few types of car burn hydrogen in their engines. In this reaction, hydrogen joins with oxygen. There is one product.

hydrogen + oxygen → water

Some people think that hydrogen should be used to fuel more cars. This is because the only product of its combustion is harmless water. Burning methane, petrol, and diesel produce carbon dioxide and water. Extra carbon dioxide in the air is harmful to the environment. It is a cause of climate change.

But where does the hydrogen to fuel cars come from? Companies make hydrogen from methane, or water. The processes they use to make the hydrogen also produce harmful gases.

C Name the two reactants when hydrogen burns in air.

What are oxidation reactions?

Burning reactions are **oxidation** reactions. In oxidation reactions, substances react with oxygen. Rusting is another oxidation reaction. In rusting, iron reacts with oxygen and water.

D State one example of an oxidation reaction.

Fuels for the future

Should we fuel cars with petrol and diesel or find other fuels, such as hydrogen or waste cooking oil? Organise your ideas in a table, then write a few paragraphs to explain your decision.

Link

You can learn more about climate change in C2 4.6 Climate change

▲ North Sea oil and methane gas are fossil fuels.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

a Fuels burn to transfer **useless**/**useful** energy. *(1 mark)*

b Combustion is another word for **burning**/**melting**. *(1 mark)*

c When a substance burns it reacts with **nitrogen**/**oxygen** from the air. *(1 mark)*

d Methane is a **compound**/**element** of carbon and hydrogen. It burns to make carbon dioxide and **water**/**hydrogen**. *(2 marks)*

2 Cooking oil contains compounds of carbon, hydrogen, and oxygen. Predict two products of its combustion. *(2 marks)*

3 Nathan says that burning any fuel contributes to climate change. Riana thinks Nathan is wrong. Use cartoon pictures and speech bubbles to show them having a conversation about burning fuels. *(6 marks)*

3.4 Thermal decomposition

Learning objectives

After this topic you will be able to:

- identify decomposition reactions from word equations
- use a pattern to predict products of decomposition reactions.

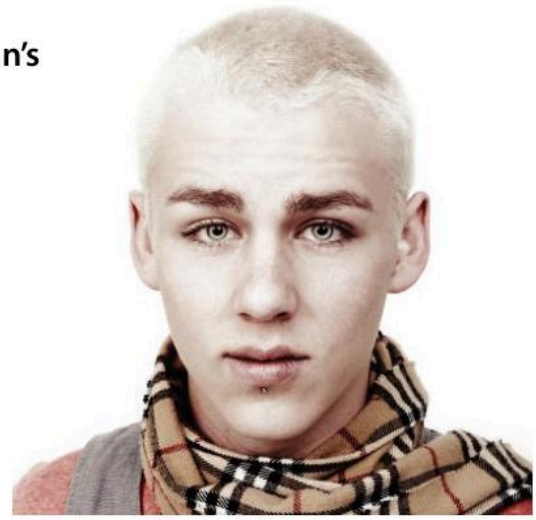
▲ Copper carbonate.

Key Words

decomposition, thermal decomposition, discrete

▲ Copper oxide and carbon dioxide form when copper carbonate decomposes.

What made this man's hair so blond?



He put hydrogen peroxide in his hair. Hydrogen peroxide is a compound. It has atoms of two elements, hydrogen and oxygen. Its formula is H_2O_2.

You cannot bleach hair with old hydrogen peroxide. This is because hydrogen peroxide molecules break up. When this happens there are two products – water and oxygen.

hydrogen peroxide → water + oxygen

This is a **decomposition** reaction. In decomposition reactions, a compound breaks down into simpler compounds or elements.

A State what a decomposition reaction is.

Decomposition reactions

Copper carbonate is a green compound. It is made up of atoms of three elements – copper, carbon, and oxygen.

If you heat copper carbonate, it breaks down. The reaction makes copper oxide and carbon dioxide. Copper oxide is black. It remains in the test tube. Carbon dioxide forms as a gas.

copper carbonate → copper oxide + carbon dioxide

You can show that the gas is carbon dioxide by bubbling it through limewater. The limewater goes cloudy.

Other types of carbonate decompose on heating:

lead carbonate → lead oxide + carbon dioxide

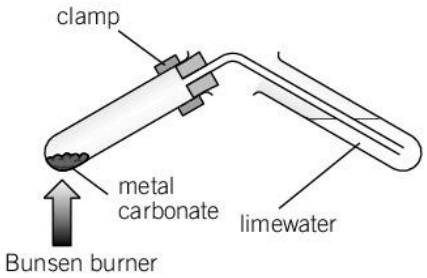
zinc carbonate → zinc oxide + carbon dioxide

When a substance breaks down on heating, the reaction is a **thermal decomposition** reaction.

B Name the products of the thermal decomposition reaction of lead carbonate.

Comparing reactions

Edward compares thermal decomposition reactions. He heats different carbonates. He measures the time for the limewater to start looking milky.

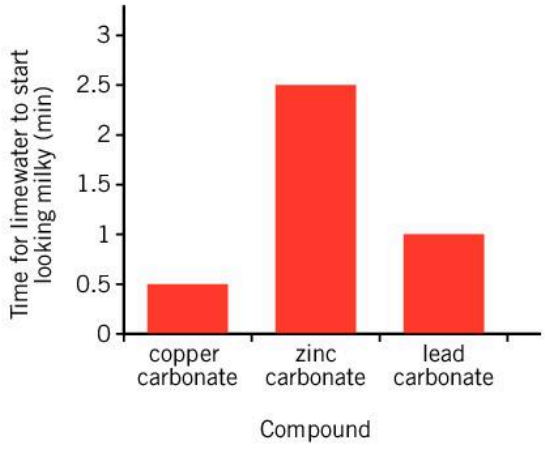


◀ Edward's apparatus.

Edward writes his results in a table.

Compound	Time for limewater to start looking milky (min)
copper carbonate	0.5
zinc carbonate	2.5
lead carbonate	1.0

He presents his results on a bar chart. This is because the variable he changes is **discrete**. A discrete variable is described by words, or by numbers that can only have certain values, such as shoe sizes.



▲ This bar chart shows the time for carbonate compounds to start decomposing.

C State what a discrete variable is.

All's fair?

Think about Edward's investigation. Discuss the variables with a partner. Which variable does he change and which does he measure? Which should he keep the same to make the investigation fair? What does the bar chart show? What conclusion could Edward make?

Summary Questions

1 Copy and complete the sentences below.

In a decomposition reaction, a _____ breaks down to make _____ compounds and elements. Copper carbonate decomposes to make _____ oxide and _____ dioxide gas. You can use _____ to test for the gas.

(5 marks)

2 Choose the reactions below that are decomposition reactions. Explain each choice.

a calcium + oxygen → calcium oxide *(1 mark)*

b zinc carbonate → zinc oxide + carbon dioxide *(1 mark)*

c hydrogen peroxide → water + oxygen *(1 mark)*

d aluminium + iodine → aluminium iodide *(1 mark)*

3 Compare combustion reactions with decomposition reactions. Include examples to illustrate your answer.

(6 marks QWC)

3.5 Conservation of mass

Learning objectives

After this topic you will be able to:

- explain conservation of mass in chemical reactions
- calculate masses of reactants and products.

▲ When it is burnt the substances in wood react with oxygen.

▲ Burning magnesium.

What happens to wood in campfires?

Wood is a mixture of many substances. On burning, the substances react with oxygen.

The reactions make many products, including ash and carbon dioxide. The total mass of reactants is equal to the total mass of products.

mass of wood + mass of oxygen = total mass of all products

In any chemical reaction, the total mass of reactants is equal to the total mass of products. This is called **conservation of mass**. Mass is also conserved in physical changes.

A State what conservation of mass means.

Calculating masses

Samindee has some magnesium. She finds its mass. She burns the magnesium. She finds the mass of the product.

mass of magnesium = 0.24 g

mass of product = 0.80 g

Samindee writes a word equation. She adds the masses she knows.

magnesium + oxygen → magnesium oxide

0.24 g 0.80 g

Samindee calculates the mass of oxygen that reacted:

total mass of reactants = total mass of products

0.24 g + mass of oxygen = 0.80 g

mass of oxygen = 0.80 g − 0.24 g

mass of oxygen = 0.56 g

Writing balanced equations

Word equations show reactants and products in reactions.
Balanced symbol equations also show:

- the formulae of reactants and products
- how the atoms are rearranged
- the relative amounts of reactants and products.

Burning carbon

- First, write a word equation:

carbon + oxygen → carbon dioxide

- Write chemical symbols or formulae for each reactant and product. You cannot guess these.

$$C + O_2 \rightarrow CO_2$$

- Now balance the equation. There must be the same number of atoms of each element on each side of the equation. The equation shows one atom of carbon on each side of the arrow, and two atoms of oxygen. It is balanced.

B State what balanced symbol equations show.

Burning magnesium

- Write a word equation and add symbols and formulae:

magnesium + oxygen → magnesium oxide

$$Mg + O_2 \rightarrow MgO$$

- Balance the amounts of oxygen. There are two atoms on the left of the arrow, and one on the right. Add a big 2 to the left of the MgO. Do not add or change any little numbers:

$$Mg + O_2 \rightarrow 2MgO$$

The big 2 applies to both Mg and O in magnesium oxide.

- Now balance the amounts of magnesium. There is one atom on the left, and two on the right.
Add a big 2 to the left of the Mg. The equation is balanced.

$$2Mg + O_2 \rightarrow 2MgO$$

Mass matters

Look at Samindee's calculation. Calculate the masses of reactants and products if she started with 0.48 g of magnesium.

Key Words

conservation of mass, balanced symbol equation

Summary Questions

1 Copy and complete the sentences below.

In chemical reactions, the total mass of reactants _____ the total mass of products. This is called _____ of mass.

(2 marks)

2 Kezi heats 12.5 g of zinc carbonate. It decomposes to make 8.1 g of zinc oxide. Calculate the mass of carbon dioxide made.

(2 marks)

3 Copper carbonate ($CuCO_3$) decomposes to make copper oxide (CuO) and carbon dioxide (CO_2). Write a balanced equation for the reaction.

(3 marks)

4 Draw diagrams to show how you could make models to represent the equations on this page. If possible, make the models.

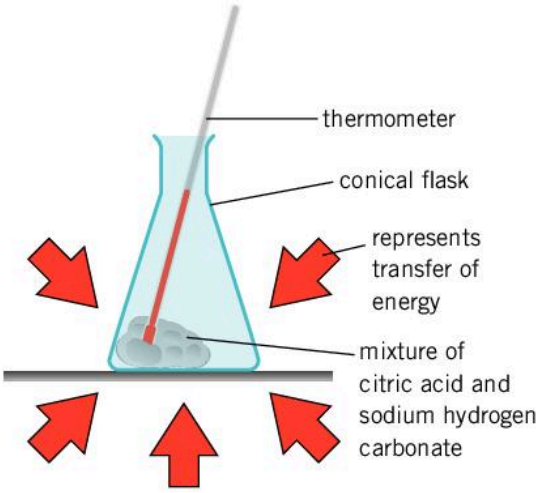
(6 marks)

3.6 Exothermic and endothermic

Learning objectives

After this topic you will be able to:

- describe the characteristics of exothermic and endothermic changes
- classify changes as exothermic or endothermic.



▲ The reaction of citric acid with sodium hydrogen carbonate is endothermic.

Have you ever used a cold pack on an injury? How did the pack get cold?

One type of cold pack includes two substances. An outer bag contains liquid water. An inner bag contains solid ammonium nitrate. When you break the inner bag, the water and ammonium nitrate mix. The solid dissolves in the water, and the mixture cools. The injury transfers energy to the mixture. The mixture slowly returns to the temperature of the surroundings.

▲ A cold pack on a sports injury.

What is an endothermic change?

The process in the cold pack is an **endothermic change**. The surroundings transfer energy to substances in an endothermic change. Some chemical reactions are endothermic. Melting and boiling are also endothermic. So is the formation of some solutions.

Tom has some citric acid crystals. Their temperature is 20 °C. He adds sodium hydrogen carbonate powder. There is a chemical reaction. The reacting mixture feels cold. Its temperature goes down to 10 °C. The temperature decrease shows that the reaction is endothermic.

Once the reaction is complete, Tom leaves his mixture of products in the lab. After a while its temperature returns to 20 °C.

A State what an endothermic change is.

Foul Fact!

You can get frostbite from cold packs if you don't use them properly. Never leave them on your skin for longer than the pack says.

What is an exothermic change?

Some changes transfer energy to the surroundings. These are **exothermic changes**. Burning wax warms up the surroundings. All burning reactions do the same. They are exothermic.

▲ Burning reactions transfer energy to the surroundings. They are exothermic.

Zoe has some dilute sulfuric acid. She also has some sodium hydroxide solution. The temperature of both solutions is 20 °C. Zoe mixes them. There is a chemical reaction. She measures the temperature again. It is 30 °C. The temperature increase shows that the reaction is exothermic.

Once the reaction is complete, Zoe leaves the mixture of products in the lab. After a while its temperature returns to 20 °C. Some changes of state are examples of exothermic changes, for example, condensing and freezing.

Literacy

Here's an easy way to remember the difference between exothermic and endothermic reactions:

Exothermic reactions transfer energy out. You go out through an **ex**it.

Endothermic reactions transfer energy in. You go in through an **en**trance.

Key Words

endothermic change, exothermic change

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

All chemical reactions involve **colour/energy** transfers. If the temperature increases, the change is **exothermic/endothermic**. If the temperature decreases, the change is **exothermic/endothermic**. Boiling and melting are **exothermic/endothermic** changes.

(4 marks)

2 The table shows the temperature changes when some substances dissolve in water. Write down the names of the substances that dissolve exothermically. Explain your choices.

(3 marks)

Name of substance	Temperature before dissolving (°C)	Temperature after dissolving (°C)
potassium chloride	20	10
calcium chloride	20	35
sodium hydrogen carbonate	20	15
sodium carbonate	20	24

3 Write a paragraph to compare exothermic and endothermic changes. Include examples to illustrate your answer.

(6 marks QWC)

C1 Chapter 3 Summary

Key Points

- Physical changes are reversible. They include changes of state and dissolving.
- Chemical reactions are not reversible.
- In a chemical reaction, atoms are re-arranged to make new substances.
- In a chemical reaction, the total mass of reactants is equal to the total mass of products. This is conservation of mass.
- In a chemical reaction, the starting substances are called reactants. The substances that are made in the reaction are called products.
- Word equations represent reactions simply. They show reactants on the left and products on the right. The arrow means *reacts to make*.
- In a balanced symbol equation, chemical formulae represent the reactants and products. The equation shows how atoms are re-arranged. It gives the relative amounts of reactants and products.
- Chemical reactions can make useful products and transfer energy.
- In oxidation reactions, substances join with oxygen to form oxides.
- Oxidation reactions include burning and rusting. Burning is also called combustion.
- In a thermal decomposition reaction, a compound breaks down when it is heated. The products are simpler compounds, and elements.
- Exothermic changes transfer energy to the surroundings.
- Endothermic changes transfer energy from the surroundings.
- A hazard is a possible source of danger.
- A risk is the chance of damage or injury from a hazard.

Key Words

chemical reaction, physical change, catalyst, reactant, product, word equation, hazard, risk, fuel, combustion, fossil fuel, non-renewable, oxidation, decomposition, thermal decomposition, discrete, conservation of mass, balanced symbol equation, endothermic change, exothermic change

BIG Write

Tune in

Radio 99 makes exciting discussion programmes. And you will be on next week! A listener has sent in this text: "Rusting, explosions, making drugs… They are all chemical reactions. Chemistry should be banned."

Task

Plan what to say to convince listeners that chemical reactions are very important, and that chemistry must not be banned.

Tips

- Give examples of useful chemical reactions, and ask listeners to imagine a world without chemistry. What would they miss?

End-of-chapter questions

1 Izzy heats some magnesium in a Bunsen burner. It burns with a bright flame. A white ash forms.

a Describe **two** observations that show this is a chemical reaction. *(2 marks)*

b State what happens to the atoms in a chemical reaction. *(1 mark)*

(3 marks)

2 Marcus plans an investigation to find out which fuel makes water hotter, ethanol or propanol.Marcus burns each fuel in turn to heat water. He measures how hot the water gets.

a State whether the burning reactions are exothermic or endothermic. Explain your decision. *(2 marks)*

b Name the independent variable in the investigation. *(1 mark)*

c Name **two** variables that Marcus must keep the same. *(2 marks)*

d Explain why he must keep these variables the same. *(1 mark)*

(6 marks)

3 Sze-Kie heats some calcium carbonate in a test tube. There is a chemical reaction:

calcium carbonate → calcium oxide + carbon dioxide

a State what type of reaction the word equation shows. Choose from the list below. *(1 mark)*

combustion
oxidation
thermal decomposition
exothermic

b Name the product(s) of the reaction. *(1 mark)*

c Sze-Kie started with 100 g of calcium carbonate. At the end of the reaction, there was 56 g of calcium oxide in the test tube. Calculate the mass of carbon dioxide made. Show your working. *(2 marks)*

(4 marks)

4 Burning methane is a chemical reaction. Here are some ways of representing this reaction.

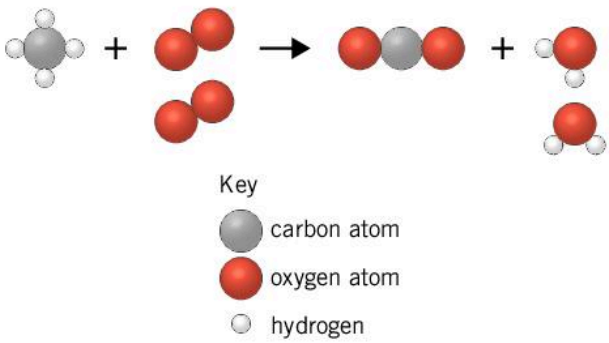
Equation X

methane + oxygen → carbon dioxide + water

Equation Y

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Diagram Z



a Explain how Equation X, Equation Y, and Diagram Z all show that burning methane is a chemical reaction. *(2 marks)*

b Compare the advantages and disadvantages of representing the reaction with Equation X, Equation Y, and Diagram Z. *(6 marks QWC)*

(8 marks)

4.1 Acids and alkalis

Learning objectives

After this topic you will be able to:

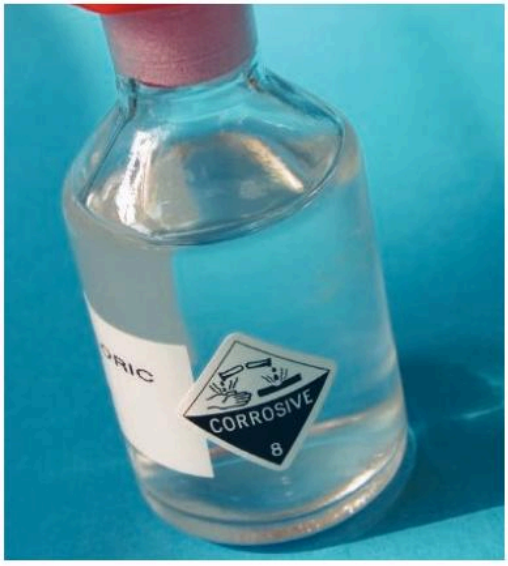
- compare the properties of acids and alkalis
- describe differences between concentrated and dilute solutions of an acid.

What do vomit, vinegar, and lemons have in common?

They all taste sour. This is because they contain **acids**. Vomit includes an acid from the stomach, hydrochloric acid. This acid helps digest foods. Vinegar is a solution of ethanoic acid and other substances. Lemons contain citric acid.

Alkalis are the chemical opposite of acids. Soap solution is an alkali, and so is toothpaste. Most alkalis feel soapy.

A List the chemical names of three acids.



▲ These solutions are corrosive.

Using acids and alkalis safely

It is safe to eat the acid in lemons, and to use alkaline soap. But there are hazards linked to some acids and alkalis.

The bottle opposite has a hazard symbol. The symbol shows that the solution in the bottle is **corrosive**. It could burn your skin and eyes.

You can control risks from corrosive solutions by:

- wearing eye protection
- keeping the solution off your skin.

If a solution is very corrosive, a teacher might wear protective gloves when using it.

B State two hazards of using a corrosive solution.

▲ Vinegar contains ethanoic acid.

Concentrated or dilute?

Pure ethanoic acid causes severe burns. It catches fire easily.

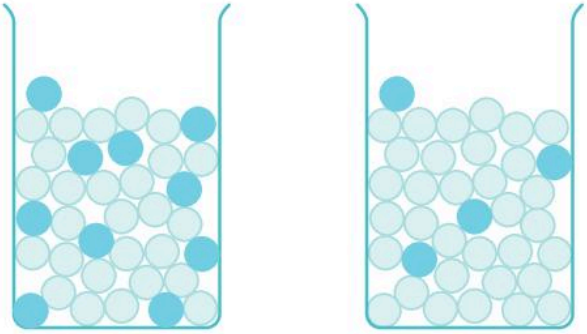
Vinegar contains ethanoic acid. It is safe to eat, and does not catch fire. Why is there a difference? Pure ethanoic acid contains no water. Dissolving in water changes some properties.

The amount of water makes a difference, too. Both the bottles at the top of the next page contain hydrochloric acid. Hydrochloric acid is a solution of hydrogen chloride in water.

Bottle A Bottle B

- Acid A has 370 g of hydrogen chloride in 1 litre of solution.
- Acid B has 3.70 g of hydrogen chloride in 1 litre of solution.

Acid A has more hydrogen chloride per litre than acid B. Acid A is **concentrated**. Acid B is **dilute**. The concentrated solution burns skin and eyes. The dilute solution hurts if it gets into a cut but has no other hazards.



▲ The solution on the left is more concentrated. It has more acid particles per litre. Not to scale.

The hazards of using acids and alkalis depend on:

- the acid or alkali you are using
- whether the solution is concentrated or dilute.

C State one difference between a concentrated solution of an acid and a dilute solution of the same acid.

Safe handling

A teacher has a solution of an alkali. The solution is corrosive – it causes severe burns and is dangerous to the eyes. Describe how to control the risks from these hazards. Do you think the teacher should allow your class to use the alkali? Explain your decision.

Foul Fact!

William Beaumont discovered stomach acid when treating a shooting victim. Beaumont removed stomach juices through holes in the skin and stomach. He tested the juices with different foods.

Key Words

acid, alkali, corrosive, concentrated, dilute

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

Acids **taste sour/feel soapy**. Some acidic and alkaline solutions are **corrosive/correlated**. A concentrated solution of an acid is **more/less** corrosive than a dilute solution. A concentrated solution has **fewer/more** acid particles per litre than a dilute solution.

(4 marks)

2 Calculate which is more concentrated – 20 g of alkali in 250 cm^3 of solution or 10 g of the same alkali in 500 cm^3 of solution. Show your working.

(3 marks)

3 Use the information on this spread to compare the properties of acids and alkalis.

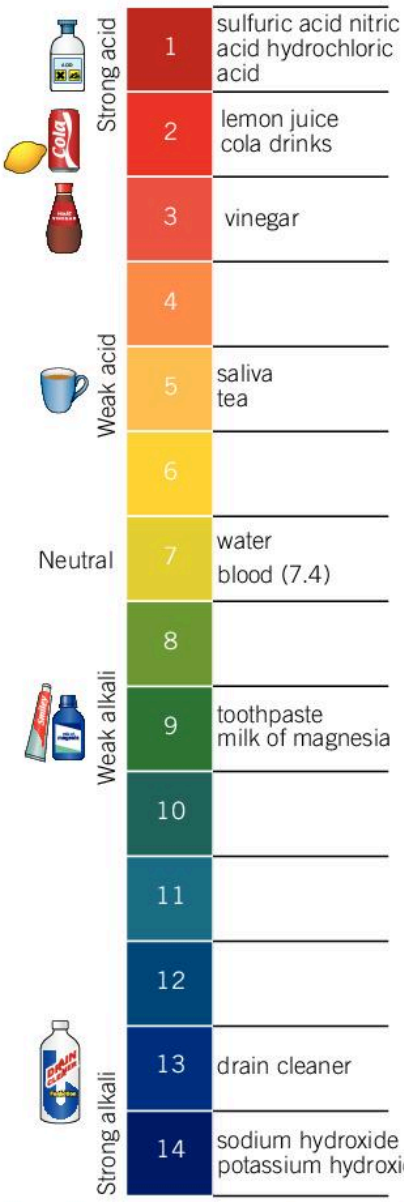
(6 marks QWC)

4.2 Indicators and pH

Learning objectives

After this topic you will be able to:

- use the pH scale to measure acidity and alkalinity
- describe how indicators categorise solutions as acidic, alkaline, or neutral.



▲ Universal indicator changes colour depending on the pH.

A student has two beakers. One contains an acid and the other contains an alkaline solution. How can he find out which is which?

You can use an **indicator** to find out whether a solution is acidic or alkaline. An indicator contains a dye. The dye turns a different colour in acidic and alkaline solutions.

A State what an indicator is.

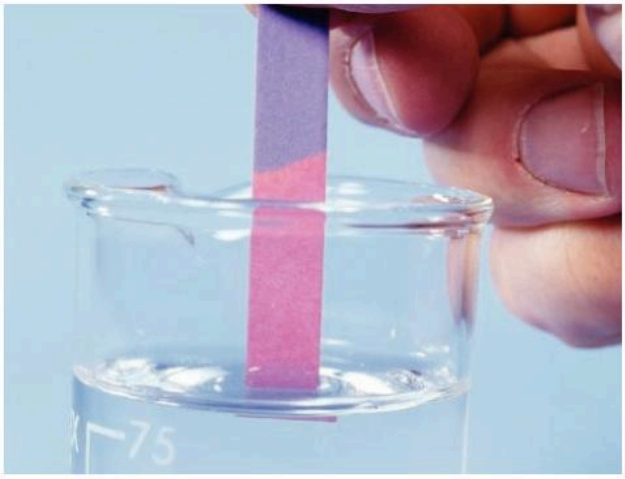
Which plants make good indicators?

You can make indicators from plants. The table shows the colours of some plant indicators in acidic and alkaline solutions.

Juice extracted from...	Colour in dilute hydrochloric acid	Colour in dilute sodium hydroxide solution (an alkali)
red cabbage	red	yellow/green
hibiscus flower	dark pink/red	dark green
beetroot	red/purple	yellow

At school, you might use **litmus** indicator. Litmus is a solution of dyes from lichens.

- Red litmus paper turns blue on adding alkali.
- Blue litmus paper turns red on adding acid.



◀ Using litmus paper.

B State the colour change when a student adds an acid to blue litmus paper.

How acidic? How alkaline?

Which is more acidic, vinegar or stomach acid? How can you find out? You cannot use blue litmus paper. Both acids would make it red.

Instead, you need **universal indicator**. Universal indicator is a mixture of dyes. It changes colour to show how acidic or alkaline a solution is.

What is the pH scale?

The **pH scale** is a measure of how acidic or alkaline a solution is. On the pH scale:

- An acid has a pH of less than 7. The lower the pH, the more acidic the solution.
- An alkaline solution has a pH of more than 7. The higher the pH, the more alkaline the solution.

Some solutions are **neutral**. This means they are neither acidic nor alkaline. The pH of a neutral solution is exactly 7.

Universal indicator is a different colour at each pH. The scale shows the colours of universal indicator in solutions of different pH.

Acidity

Amie collected the data in the table. Use the data to list the names of the solutions in order of increasing acidity, starting with the least acidic.

Solution	pH
milk	6.6
urine	6.1
orange juice	3.2
black coffee	5.5
lemon juice	2.3
vinegar	2.8

▲ Universal indicator turns orange in vinegar. It turns red in stomach acid.

C State the pH of a neutral solution.

Foul Fact!

Murderer John Haig, also known as the Acid Bath Murderer, disposed of the bodies of his victims in baths of concentrated sulfuric acid. The acid pH was between 0 and 1.

Key Words

indicator, litmus, universal indicator, pH scale, neutral

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

Adding an acid to red litmus paper makes the litmus paper go **red/blue**. On the pH scale, acids have a pH of **less than/more than** 7. The higher the pH, the **more/less** acidic the solution. A solution is alkaline if its pH is **more than/less than** 7. A solution of pH of **7/0** is neutral.

(5 marks)

2 John has a solution. It turns yellow when he adds red-cabbage juice. Predict what colour the solution would turn if he added hibiscus-flower juice. Explain your answer.

(2 marks)

3 Using information from this page, create a chart to show the colours of dilute hydrochloric acid and dilute sodium hydroxide solution in five different indicators.

(6 marks)

4.3 Neutralisation

Learning objectives

After this topic you will be able to:

- describe how pH changes in neutralisation reactions
- state examples of useful neutralisation reactions.

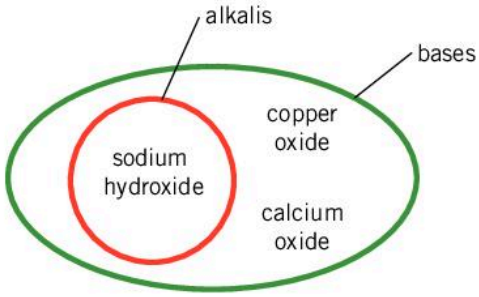
Have you ever had stomach ache? Did you take an indigestion tablet?

Extra stomach acid makes your stomach hurt. An indigestion tablet reacts with this acid in a **neutralisation** reaction. In a neutralisation reaction an acid reacts with a substance that cancels it out. The pH gets closer to 7.

▲ Indigestion tablets neutralise stomach acid.

Which substances neutralise acids?

A **base** is a substance that neutralises an acid. Bases include sodium hydroxide, calcium oxide, and copper oxide. Some bases are soluble in water. A soluble base is an alkali.



◀ Alkalis are bases that dissolve in water.

A State one difference between a base and an alkali.

pH changes in neutralisation reactions

Gwil has 10 cm^3 of acid. He adds universal indicator. He looks at the colour of the mixture, and compares it to the indicator colour chart. He records the pH.

Then Gwil adds 1 cm^3 of sodium hydroxide solution. The pH increases. Gwil writes down the new pH. He continues to add sodium hydroxide solution. The pH gets closer to 7. The alkali is neutralising the acid. Gwil stops adding alkali when the pH is 7. His mixture is neutral.

Volume of sodium hydroxide added (cm^3)	pH
0	1
1	2
2	2
3	2
4	3
5	4
6	5
7	7

B State what volume of sodium hydroxide solution was needed to neutralise the acid.

Key Words

neutralisation, base

How is neutralisation useful?

Soil for crops

Some soils are more acidic than others. Every plant has its favourite soil pH.

Deepa lives in India. She has a farm. She wants to grow tea. She tests the soil. Its pH is 4.5. The soil is too acidic to grow tea.

Plant	Soil pH range that the plant grows best in
apple tree	5.0–6.8
cabbage	6.0–7.0
onion	6.0–6.5
tea	5.0–6.0
tomato	5.5–7.0

▲ Tea plants grow best in soil of pH 5.0 to 6.0.

Deepa adds a base to the soil. The base neutralises some of the soil acid. The soil pH increases to pH 5.0. It is now suitable for growing tea.

Acidic lakes

◀ Adding a base to an acidic lake.

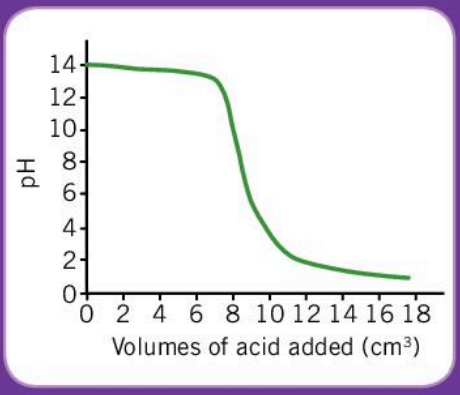
In some places, gases from burning coal make sulfur dioxide gas. The gas dissolves in rainwater to make acid rain. The rain falls in lakes, making lakes more acidic. Some water animals and plants cannot live in these lakes.

Environment organisations may add bases to acid lakes. The pH of the lake water increases.

C Describe two situations in which neutralisation reactions are useful.

Data logger details

Ralph has a solution. He adds acid to the solution. A pH probe reads the pH. The probe is attached to a data logger, which sends the data to a computer. The computer draws a graph of the data. Describe in detail what the graph shows.



Summary Questions

1 Copy and complete the sentences below.

A base cancels out an acid in a _____ reaction. An alkali is a soluble _____. You can measure pH with an _____ or a pH probe attached to a _____ logger.

(4 marks)

2 The soil in Freya's farm is pH 7.0. Use data from this page to suggest three crops she could try growing. Explain your choices.

(2 marks)

3 Explain to gardeners why they should measure soil pH, and how they can change soil pH.

(6 marks QWC)

4.4 Making salts

Learning objectives

After this topic you will be able to:

- describe what a salt is
- predict the salts that form when acids react with metals or bases.

▲ Sodium chloride.

▲ Copper sulfate.

▲ Bolivian salt flats.

Here are the formulae of three acids. What do they have in common?

- HCl – hydrochloric acid
- HNO_3 – nitric acid
- H_2SO_4 – sulfuric acid

The formulae show that the acids are compounds. They all include hydrogen atoms.

What are salts?

A **salt** is a compound that forms when an acid reacts with a metal element or compound. The hydrogen atoms of the acid are replaced by atoms of the metal element. The pictures on the left show two salts.

Sodium chloride is the salt you may add to food. Its formula is NaCl. A sodium atom has replaced the hydrogen of hydrochloric acid.

Farmers use copper sulfate to kill fungus. Its formula is $CuSO_4$. Copper atoms have replaced the hydrogen atoms of sulfuric acid.

A Describe what a salt is.

Which reactions make salts?

Many salts exist naturally. Sodium chloride makes the sea salty. It also exists underground. There are huge amounts of salts in Bolivian salt flats.

You can also make salts in chemical reactions.

Acids and metals

Reacting an acid with a metal makes two products – a salt, and hydrogen. For example:

magnesium + hydrochloric acid → magnesium chloride + hydrogen

zinc + sulfuric acid → zinc sulfate + hydrogen

Key Words

salt

Acids and bases

Reacting an acid with a base also makes a salt. The products are a salt, and water. For example:

sodium hydroxide + hydrochloric acid → sodium chloride + water

copper oxide + nitric acid → copper nitrate + water

The reactions show that:

- hydrochloric acid is a chloride maker
- sulfuric acid is a sulfate maker
- nitric acid is a nitrate maker.

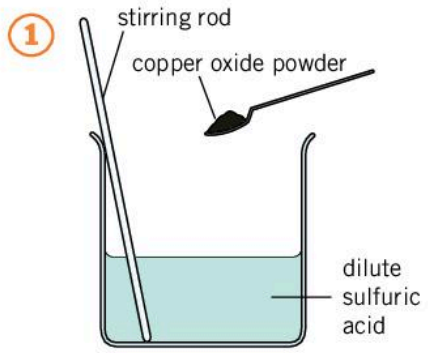
B Name the salt made when sodium hydroxide reacts with hydrochloric acid.

Making magnesium salts

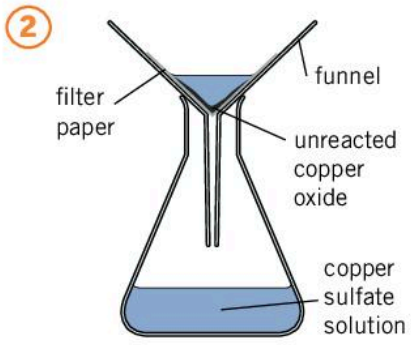
You can make magnesium chloride crystals from magnesium and hydrochloric acid. The method is similar to that for making copper sulphate. The only difference is that magnesium, not copper oxide, is left over in the first stage. Write clear and detailed instructions for making magnesium chloride.

How can you make salt crystals?

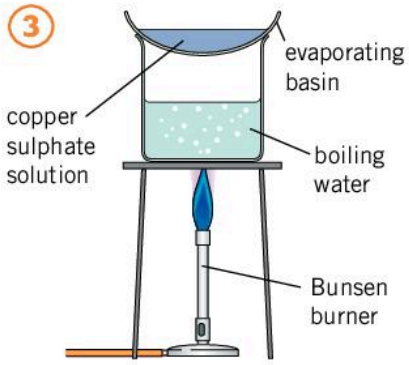
The reactions of acids with metal or bases make salt solutions. Removing water makes salt crystals. The diagrams show how to make copper sulfate crystals.



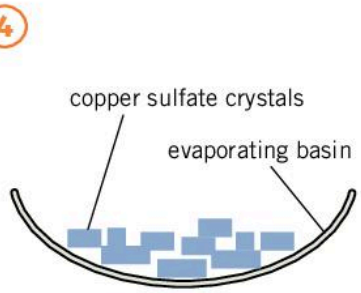
▲ Add copper oxide powder (a base) to dilute sulfuric acid. Keep adding until some copper oxide is left over. All the acid has now reacted.



▲ Filter to remove the extra copper oxide.



▲ Heat the copper sulfate solution in an evaporating basin until most of the water evaporates.



▲ Leave the evaporating basin in a warm place. The rest of the water evaporates. Copper sulfate crystals remain.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

A salt is **an element/a compound**. In a salt, the **hydrogen/oxygen** atoms of an acid are replaced by metal atoms. When an acid reacts with a metal, the products are a salt and **water/hydrogen**. When a base reacts with an acid, the products are a salt and **water/hydrogen**.

(4 marks)

2 Predict the products of the reaction of magnesium with sulfuric acid.

(2 marks)

3 Predict the products of the reaction of zinc oxide with nitric acid.

(2 marks)

4 Describe and explain the stages in making copper chloride crystals from an insoluble base and an acid.

(6 marks)

C1 Chapter 4 Summary

Key Points

- The pH scale shows how acidic or alkaline a solution is.
- Acids have pH values below 7. The lower the pH, the more acidic the solution.
- Alkaline solutions have pH values above 7. The higher the pH, the more alkaline the solution.
- Neutral solutions are neither acidic nor alkaline. Their pH is exactly 7.
- Indicators change colour to show whether a solution is acidic or alkaline.
- Universal indicator changes colour to show the pH of a solution.
- Litmus is an indicator. Blue litmus paper turns red on adding acid. Red litmus paper turns blue on adding an alkaline solution.
- In a neutralisation reaction, an acid cancels out a base, or a base cancels out an acid.
- A base is a substance that neutralises an acid.
- An alkali is a soluble base.
- Adding bases or acids to soil can change its pH, making it suitable for different crops.
- Adding a base to an acidic lake increases the lake pH, making it suitable for different plants and animals.
- If an acid reacts with a base, there are two products – a salt, and water.
- If an acid reacts with a metal, there are two products – a salt, and hydrogen.
- Sulfuric acid makes sulfate salts, hydrochloric acid makes chloride salts, and nitric acid makes nitrate salts.

Key Words

acid, alkali, alkaline solution, acidic solution, corrosive, concentrated, dilute, indicator, litmus, universal indicator, pH scale, neutral, neutralisation, base, salt

Case study

Useful neutral

Neutralisation happens when an acid cancels out a base or when a base cancels out an acid.

Task

Prepare a piece of writing that explains how neutralisation reactions are useful.

Tips

- Start by drawing a visual summary to help you organise your ideas.
- Make sure your paragraphs are in a sensible order.
- Swap your work with another student and discuss improvements.

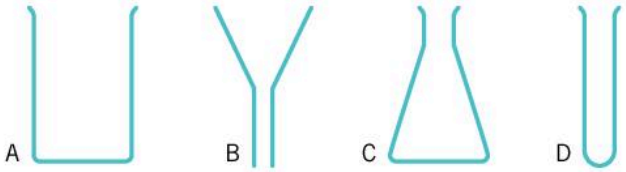
End-of-chapter questions

1 A scientist measures the pH of samples of sweat, blood, and urine from one person. Copy the table. Write down whether each sample is acidic, alkaline, or neutral.

Name of mixture	pH	Acidic, alkaline, or neutral?
sweat	5.3	
blood	7.4	
urine	6.8	

(3 marks)

2 Joe wants to make a red-cabbage indicator. He has the apparatus below.



a First, Joe heats a mixture of chopped red cabbage and water. Write the letter of the best apparatus for this. *(1 mark)*

b Next, Joe filters the mixture. He keeps the solution. Write the letters of the best **two** pieces of apparatus for this. *(2 marks)*

c Lastly, Joe adds the red-cabbage solution to acidic and alkaline solutions. Write the letter of the best apparatus for this. *(1 mark)*

(4 marks)

3 The table below gives the preferred soil pH of some fruit plants.

Fruit plant	Preferred soil pH
blueberry	4.0–5.0
sweet cherry	6.0–7.5
cranberry	4.2–5.0
pineapple	5.0–6.0
strawberry	5.0–6.5

a Name the plant in the table that can grow well in alkaline soil. *(1 mark)*

b Name the plant in the table that can grow in the most acidic soil. *(1 mark)*

c The soil pH in Andy's garden is 6.0. Name **three** fruit plants that might grow well in this soil. *(3 marks)*

d The soil pH in Clare's garden is 8.0. She wants to grow strawberry plants. State the type of substance she should add to the soil so that the pH is suitable. Explain your answer. *(2 marks)*

(7 marks)

4 Describe and explain the stages in making magnesium chloride crystals from an acid and a metal. Include the names of the acid and the metal.

(6 marks QWC)

Physics 1

The first astronaut to walk on the Moon, Neil Armstrong, looked back and saw the Earth as no-one had ever seen it before. In P1 you will learn about how you see, and how light and sound waves behave. You will learn about the place of the Earth in the Universe. You will also learn about the forces that keep you from falling through the floor and allow astronauts to stand on the Moon.

You already know

- The force of gravity pulls objects to the Earth.
- Friction, air resistance, and water resistance slow down moving objects.
- You see things because light reflects off them.
- Light travels in straight lines, which explains the size and shape of shadows.
- Vibrating objects make sound, which varies in pitch and loudness, and gets fainter as you move away.
- The Earth orbits the Sun and the Moon orbits the Earth.
- The length of a day and the temperature change during the year.
- Day and night and the Sun's movement across the sky happen because the Earth spins on its axis.

Q

What happens to the length of a day during the year?

BIG Questions

- Where do forces come from?
- How do we hear and see things?
- What is outside the Solar System?

Picture Puzzler
Key Words

Can you solve this Picture Puzzler?

The first letter of each of these images spells out a science word that you will come across in this book.

Picture Puzzler
Close Up

Can you tell what this zoomed-in picture is?

***Clue**: The person floating in the sea is reading one.*

Making connections

In **P1** you will learn about the Earth and our place in the Solar System.

In **C1** you will learn about how everything is made up of atoms and elements.

In **B1** you will learn about what makes up living things and how they reproduce.

1.1 Introduction to forces

Learning objectives

After this topic you will be able to:

- explain what forces do
- describe what is meant by an interaction pair.

▲ This rocket took a rover to Mars.

What does a rocket have in common with you? There are forces acting on you and on the rocket.

What do forces do?

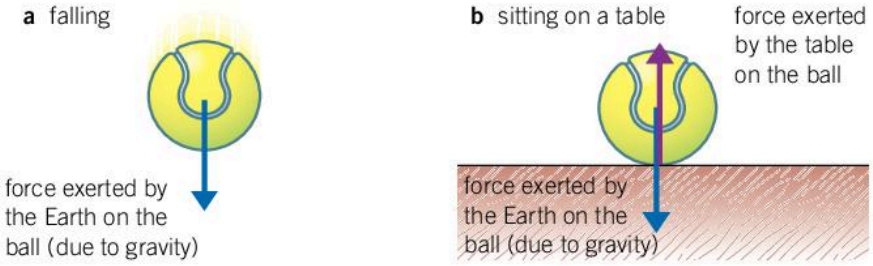
A rocket going to Mars moves away from the surface of the Earth very quickly. There is a force pushing the rocket up and forces pulling it down. A force can be a **push** or a **pull**.

Forces explain *why* objects move in the way that they do, or why they don't move at all. That's not all. Forces can change the direction that objects are moving in, and change their shape.

A List three things that forces do.

Describing forces

You can't see forces but you can see the effect of them. When you draw a diagram you add arrows to show the forces that are acting. 'Force arrows' show the direction *and* the size of the force. Forces act on objects so the arrow must touch the object in the diagram.



▲ These force arrows show the forces acting on a tennis ball.

Different types of force

Some forces act when you are touching something. This is a **contact force**. **Friction** and **air resistance** are contact forces. Support forces, like upthrust, are also contact forces.

The force of **gravity** acts on a tennis ball travelling through the air. The Earth pulls the ball down even though it is not touching it. Gravity is a **non-contact force**. The force between magnets is another non-contact force.

B Describe the difference between a contact force and a non-contact force.

Foul Fact!

Astronauts on the International Space Station cannot burp. The gas and liquid does not separate in their stomachs while they are in orbit.

Pairing up

A girl and her sister are hanging from a bar in a playground. Think about the forces acting on the girls.

▲ Forces act on the girls hanging from a bar.

- Gravity pulls the girls down. *This is the force of the Earth on the girls.*
- The girls pull the Earth up. *This is the force of the girls on the Earth.*

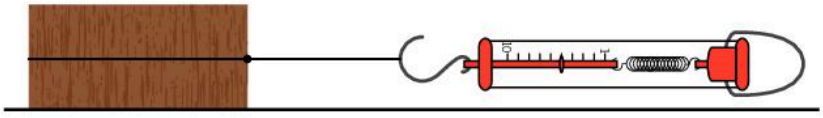
Forces always come in pairs. The pairs are called **interaction pairs**.

There is another interaction pair of forces acting on the girls.

- The bar supports the girls. *This is the force of the bar on the girls.*
- The girls pull on the bar. *This is the force of the girls on the bar.*

How do you measure forces?

You can measure force with a **newtonmeter** (sometimes called a spring balance). All forces are measured in **newtons** (N).



▲ A student is pulling the block with a force of 5 N.

C State the unit of force.

Newton predicts...

In the 1600s, Isaac Newton first explained how gravity affects objects. Scientists later used his ideas to predict that there was a planet beyond Uranus. In 1846 they discovered Neptune. A good explanation means that you can make predictions and test them.

▲ Upthrust supports you when you float.

Link

You can learn more about non-contact forces in P1 1.4 Forces at a distance

Key Words

push, pull, contact force, friction, air resistance, gravity, non-contact force, interaction pair, newtonmeter, newton (N)

Summary Questions

1 Copy and complete the sentences below.

A force is a _____ or a _____. We can show the forces acting on an object using force _____. Forces come in pairs, called _____ pairs. To measure forces you use a _____.

(5 marks)

2 Describe one of the interaction pairs for an apple hanging from the branch of a tree.

(2 marks)

3 You are probably sitting on a chair as you read this book. Explain in detail why the two forces acting on you are not two forces in the same interaction pair.

(6 marks QWC)

1.2 Squashing and stretching

Learning objectives

After this topic you will be able to:

- describe how forces deform objects
- explain how solid surfaces provide a support force
- use Hooke's Law.

▲ Even a solid golf ball changes shape when you hit it.

Foul Fact!

When a footballer heads a ball the forces deform both the ball and the footballer's head.

Link

You can learn more about particles in solids, liquids, and gases in C1 1.1 The particle model

Key Words

deform, compress, stretch, reaction, extension, tension, elastic limit, Hooke's Law, linear

Why don't you fall through the chair you're sitting on? The chair changes shape, or deforms, when you sit on it. This produces the force that pushes you up.

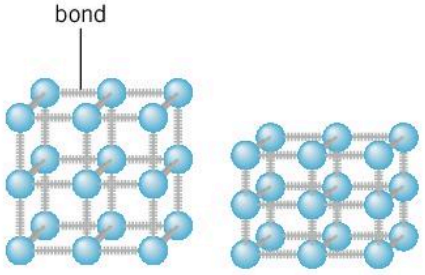
Changing shape

When a ball hits the floor the ball **deforms**. Forces can **compress** (squash) or **stretch** objects. When you exert a force you can deform an object. You can compress it or you can stretch it.

A Describe what happens to a tennis ball when it hits the ground.

How can the floor push you up?

The floor pushes up on you when you stand on it. It seems strange to talk about the floor exerting a force on you. You can't see anything happening.



◀ These diagrams show what happens when you exert a force on a solid object.

You compress the bonds when you exert a force.

The floor is a solid; solids are made up of particles arranged in a regular pattern. The particles are joined strongly together by bonds. This is what happens when you stand on the floor:

- Your weight pushes the particles together.
- The bonds are compressed.
- They push back and support you.

Solid materials are only compressed a very small amount when you apply a force to them. A support force from a chair or the floor is called the **reaction** force.

Stretching

Bungee cords, springs, and even lift cables all stretch when you exert a force on them. The amount that they stretch is called the **extension**.

A bungee cord stretches as the jumper falls. When the bungee cord has stretched as far as it will go, it pulls her back up. This force is called **tension**.

What happens when you stretch a spring?

Springs are special. If you ***double*** the force on the spring the extension will ***double***. You can use the length of the spring to measure the size of a force. When you remove the force the spring goes back to its original length.

What's the limit?

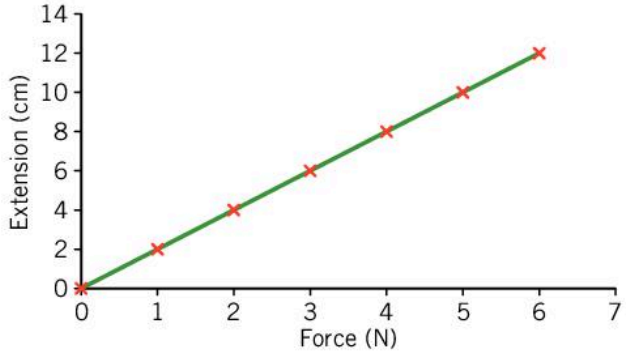
At some point the spring will not go back to its original length when you remove the force. This is the **elastic limit**. Trampoline springs are designed to never go past their elastic limit.

◀ The shape of a bungee cord changes when you stretch it.

Hooke's Law

If the extension doubles when you double the force then the object obeys **Hooke's Law**. The graph of force against extension is a straight line, or **linear**. Hooke's Law is a special case. Not everything behaves like a spring when you stretch it. If you double the force on an elastic band the extension may not double.

B State Hooke's Law.



▲ This graph shows how the extension of a spring changes as you pull it.

A straight-line graph

Using the graph below, find the extension when the force is 3 N and again when it is 6 N. Does this spring obey Hooke's Law? Explain your answer.

How long?

You have a spring that is 4 cm long. When you exert a force of 3 N it stretches to a length of 6 cm. What is the extension? What would the extension be if you doubled the force?

Summary Questions

1 Copy and complete the sentences below.

Forces can change the shape of objects or _____ them. Solid surfaces are made of _____. The bonds between particles are compressed when you apply a force. They _____ back on you. This provides a _____ force called the _____ force.

(5 marks)

2 Describe how your chair pushes you up.

(2 marks)

3 Design a new style of trampoline that would make trampolining more fun. Use the ideas on this page to explain how it works.

(6 marks)

1.3 Drag forces and friction

Learning objectives

After this topic you will be able to:

- describe the effect of drag forces and friction
- explain why drag forces and friction arise.

Slide your finger along the desk. Does the surface feel smooth or rough? Even really smooth surfaces exert a force.

What is friction?

A surface such as a metal slide in a playground looks and feels really smooth. Now imagine zooming in on it; you will see that it is actually rough.

When a book is resting on the table you can push on it but it may not move. **Friction** grips objects. As you increase the force by pushing harder the book will start to move. If you remove the force the book slows down and stops. This is because the rough surfaces can no longer move past each other.

A State two things that friction does.

Fantastic Fact!

Which material has the lowest friction? BAM is a material that contains aluminium, magnesium, and boron. It is twice as slippery as ice.

Is friction useful?

Friction can be a good thing. You need friction to walk, as the friction between your foot and the road produces the force to move you forward. The brakes on your bike and in a car work because of friction.

▲ You need friction to move across surfaces.

B Describe how friction helps you to walk.

How can you reduce friction?

One way to reduce friction is by using oil or grease. This is called **lubrication**. When you oil the chain of your bike the surfaces move past each other more easily. Snowboarders wax their boards to reduce the friction between the board and the snow.

C Suggest why the hinges of a door need to be lubricated.

Fantastic Fact!

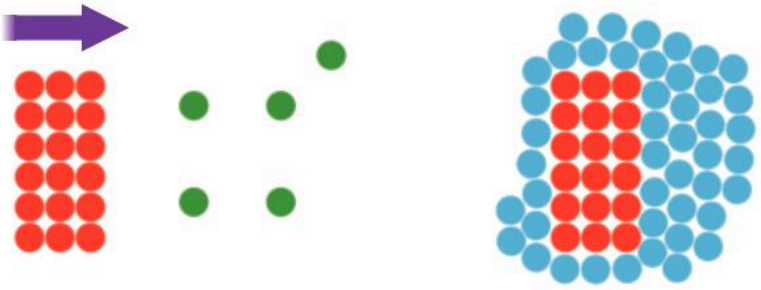
In 1995 Fred Rompelberg travelled at 167 mph.... on a bicycle! He did it by cycling behind a lorry where there was very little air resistance.

What are drag forces?

A dolphin swimming through the water and a surfer paddling through water will both experience **water resistance**. As a snowboarder jumps through the air he will experience **air resistance**. Water resistance and air resistance are **drag forces**.

▲ When you move through water you experience water resistance.

To understand drag forces you need to think about the particles in the air and the water.



A solid moves through a gas. A solid moves through a liquid.

▲ A moving object is in contact with air or water particles.

As a dolphin moves through the water it pushes the water particles out of the way. This produces a drag force, which slows it down.

D Name the drag force acting on an aeroplane in flight.

How can you use drag forces?

Parachutes are used to slow down drag-racing cars and skydivers. The contact with the air produces a drag force.

How can you reduce drag forces?

An Olympic cyclist will tuck her arms in close to her body as she cycles. She will even make sure that her thumbs are as close to the handlebars as possible. This makes her more **streamlined**, which reduces the force of air resistance.

Testing a parachute

A company wants to compare different materials for making parachutes. Name **three** ways that they could make it a fair test.

Key Words

friction, lubrication, water resistance, air resistance, drag force, streamlined

Summary Questions

1 Copy and complete the sentences below.

The force of _____ acts between two solid surfaces in contact that are sliding across each other. The surfaces are _____ and will grip each other. This is why you need to exert a _____ to make something move. There are two drag forces: _____ and _____. When a moving object is in contact with _____ or _____ particles it has to push them out of the way.

(7 marks)

2 Describe the effect of water resistance acting on a bird diving into a lake to catch a fish.

(1 mark)

3 Suggest and explain a reason why the brake blocks on a bicycle need to be replaced from time to time.

(2 marks)

4 A dragster is a car that uses a parachute as a brake. Use the ideas on this page to compare the drag force due to the parachute acting on cars travelling at different speeds, or using parachutes of different sizes.

(6 marks QWC)

1.4 Forces at a distance

Learning objectives

After this topic you will be able to:

- describe the effects of a field
- describe the effect of gravitational forces on Earth and in space.

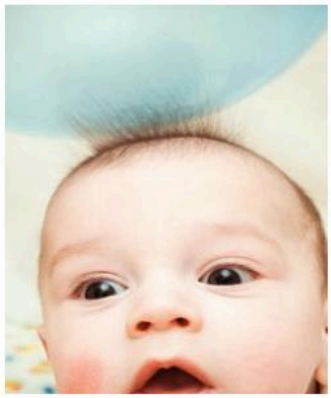
If you let go of your pen and it moved upwards you'd be very surprised. We are so familiar with the force of gravity that sometimes we don't even think of it as a force.

Gravitational forces

A gravitational force acts on a diver jumping off a diving board. It is a non-contact force. There are other types of non-contact force.

Magnets exert a **magnetic force** on magnetic materials or other magnets without touching them. If you rub a balloon you can pick up bits of paper with it. This is an electric or **electrostatic force**. Magnetic and electrostatic forces are non-contact forces.

▲ A magnet picks up filings.



▲ A balloon rubbed on your jumper attracts a baby's hair.

A Identify three forces that act at a distance.

Force fields

In physics a **field** is a special region where something experiences a force. There is a magnetic field around a magnet where magnetic materials experience a force. There are gravitational fields where things with mass experience a force.

Gravitational, magnetic, and electrostatic fields have something in common. As you get further away from the mass, magnet, or charge, the field gets weaker. Contact forces only act when the objects are touching each other. Non-contact forces act at any distance, even if the objects are not touching.

B Describe what is meant by a field.

Link

You can learn more about electrostatic forces in P2 1.1 Charging up

Foul Fact!

The strongest gravitational field in the Universe is made by a black hole. It is called a 'black' hole because even light cannot escape from its gravitational field. If you stood close to a black hole, the force of gravity on your feet would be much bigger than the force of gravity on your head. You'd be stretched. This is called 'spaghettification'.

Key Words

magnetic force, electrostatic force, field, weight, mass, kilogram (kg), gravitational field strength

What do I weigh?

You can use a newtonmeter to find the **weight** of an apple. The Earth pulls the apple downwards. Measuring the weight of the apple means measuring the force of the Earth on it.

What is the difference between weight and mass?

Weight is a force so it is measured in newtons (N). **Mass** is the amount of 'stuff' something is made up of. It is a measure of how hard it is to get something to move. Mass is measured in **kilograms** (kg).

An apple has a weight of about 1 N.

Units of mass

Smaller masses are measured in grams (g).

There are 1000 g in 1 kilogram (kg).

Convert these masses into grams: **a** 2 kg **b** 3.5 kg **c** 0.4 kg

Convert these masses into kilograms: **d** 4700 g **e** 250 g

You can calculate weight using an equation.

weight (N) = mass (kg) x **gravitational field strength**, *g* (N/kg)

On Earth gravitational field strength is about 10 N/kg.

This means that, if your mass is 50 kg, for example, then your weight on Earth is:

weight = 50 kg × 10 N/kg

= 500 N

Gravitational field strength is different on other planets and stars. Your weight would be different on different planets because *g* would be different.

The Apollo astronauts could jump much higher on the Moon because *g* on the Moon is about one sixth of *g* on Earth.

C State the unit of mass and the unit of weight.

What would happen to my weight in space?

Imagine blasting off from the Earth in a spacecraft. As you move away from the Earth the gravitational field gets weaker. If you stood on scales in the spacecraft the reading would be less than it would be on Earth.

The amount of 'you' would not change. Your mass stays the same. It is the force of the Earth on you, your weight, that is less.

Summary Questions

1 Copy and complete the sentences below.

Some forces act a distance. The force of gravity acts on things that have _____. A balloon has an _____ force when you rub it. You can feel a _____ force between two magnets. Your weight is a _____ and is measured in _____. Your _____ is the amount of stuff you are made up of and is measured in _____.

(7 marks)

2 Explain one reason why your weight on Jupiter is 2.7 times your weight on Earth.

(3 marks)

3 Describe what happens to the force of gravity as you move away from the Earth.

(1 mark)

4 Imagine the first Olympic Games conducted on the Moon in a specially designed dome. Use the ideas on this page to state and explain which sports would produce new records, and which would not.

(6 marks)

1.5 Balanced and unbalanced

Learning objectives

After this topic you will be able to:

- describe the difference between balanced and unbalanced forces
- describe situations that are in equilibrium
- explain why the speed or direction of motion of objects can change.

▲ When the teams pull with the same force the forces are balanced.

Equal and opposite...?

Isaac Newton said, 'For every action there is an equal and opposite reaction'. The forces in an interaction pair are equal and opposite. Is lying in bed an example of this law? No, it is not. Each of the forces acting on you comes from a *different* interaction pair.

Key Words

balanced, equilibrium, unbalanced, driving force, resistive force

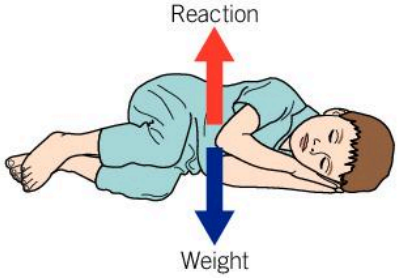
To get out of bed in the morning you need a force to get you moving.

What are balanced forces?

When the forces acting on an object are the same size but in opposite directions we say that they are **balanced**. You can think of balanced forces like two teams in a tug of war. If each team pulls with the same force the rope doesn't move. The forces cancel out. The object is in **equilibrium**.

A State what equilibrium means.

All stationary objects are in equilibrium. There has to be a support force acting on them to balance out their weight.



◀ You are in equilibrium when lying in bed.

B Draw a diagram showing the forces acting on a stationary mass hanging on a spring.

What are unbalanced forces?

The forces acting on this rocket-powered car are **unbalanced**. They are not the same size so they do not cancel out.

The **driving force** from the engine is much, much bigger than the **resistive forces** from air resistance and friction.

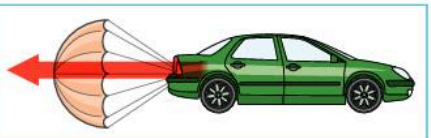
▲ The Thrust SSC was the first car to travel faster than sound.

C State the difference between balanced forces and unbalanced forces.

How do unbalanced forces change speed?

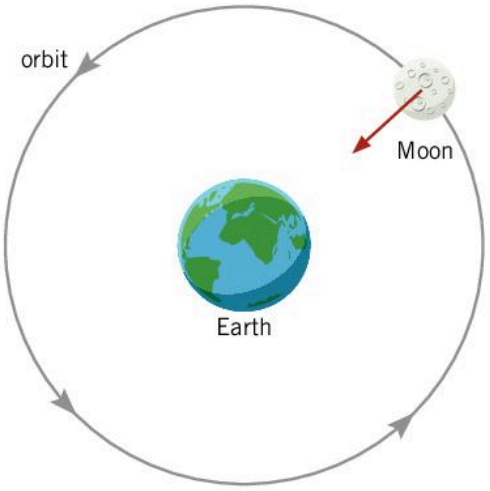
When the car's rocket-powered engine starts up the driving force will become very big very quickly. When the driver wants to stop he will fire a parachute to slow the car down. In both cases the forces on the car are unbalanced.

The driver uses a parachute because this gives a much bigger resistive force on the car than just using the brakes. The speed of the car will change much more quickly. The car will stop in a much shorter time.

	
The driving force is bigger than the resistive forces acting on the car.	The only forces acting on the car are resistive forces.
The speed of the car increases.	The speed of the car decreases.

How do unbalanced forces change direction?

Isaac Newton worked out that the Earth exerts a force on the Moon. The force of gravity acting on the Moon keeps the Moon in orbit around the Earth. It is this same force that acts on an apple and pulls it to the ground. It changes the *direction* of motion, not the speed.



◀ The force of gravity keeps the Moon in orbit.

Every time you go around a corner in a car the friction between the tyres and the road changes the direction of the car.

Link

You can learn more about speed in P2 3.1 Speed

▲ Friction changes the direction of a motorbike.

Summary Questions

1 Copy and complete the sentences below.

If the forces on an object are the same_____ but act in _____ directions they are balanced. This is called _____. The forces acting on any stationary object are _____. If the forces on an object are unbalanced the _____ will change. If the _____ force is bigger than the _____ force it speeds up. If the _____ force is bigger than the _____ force it slows down.

(9 marks)

2 A cyclist is slowing down as she is cycling along a road.

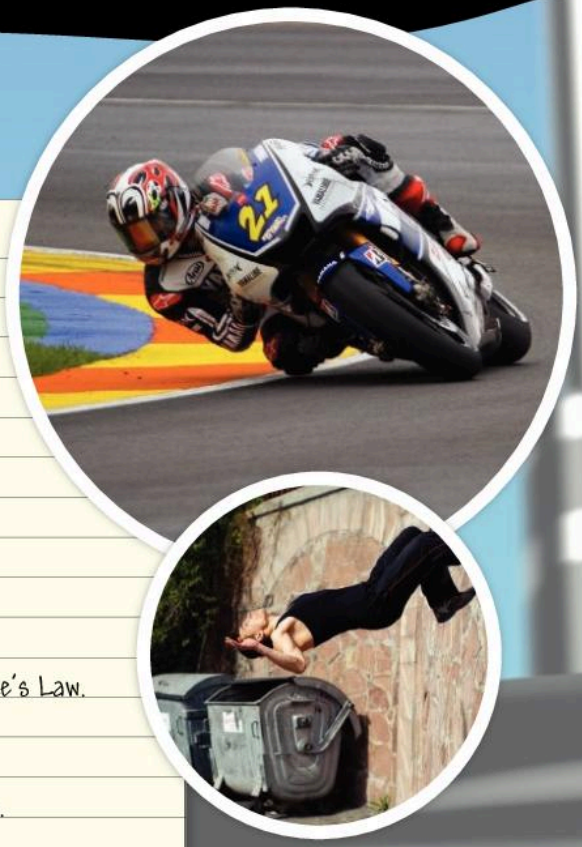
a Draw a diagram to show the forces acting on the cyclist. *(1 mark)*

b Label the forces using the words 'resistive' and 'driving'. *(1 mark)*

c Explain why her speed is decreasing. *(1 mark)*

3 Design a new ride for a theme park. Describe and explain the motion of people who go on the ride using the ideas on this page. *(6 marks)*

P1 Chapter 1 Summary



Key Points

- Forces are pushes or pulls, measured in newtons (N) using a newtonmeter.
- Forces exist when objects interact – this produces an interaction pair.
- Forces can deform objects, change their speed, or the direction of motion.
- Contact forces occur when objects are touching.
- Friction, air resistance, and water resistance are contact forces.
- Friction can be reduced by lubrication. Air resistance and water resistance can be reduced by streamlining.
- Non-contact forces occur when objects are not touching.
- Gravitational, electrostatic, and magnetic forces are non-contact forces.
- Solid surfaces provide a support force when they are compressed.
- Springs or ropes extend when you apply a force.
- For some objects if you double the force the extension doubles. This is Hooke's Law.
- A field is a region where something feels a force, for example, a mass in a gravitational field.
- Mass is the amount of stuff an object is made up of, measured in kilograms.
- Weight is the force of the Earth on an object, measured in newtons.
  Weight (N) = mass (kg) x g (N/kg)
- When the forces acting on an object are equal in size and acting in opposite directions they are balanced. The object is in equilibrium.
- If the forces are not balanced the object will speed up, slow down, or change direction.

BIG Write

Mission to Mars

NASA's Curiosity rover landed on Mars in August 2012. Imagine that the first astronauts have just returned from Mars in the year 2034.

Task

You were one of the astronauts on the mission. Write a blog that covers the whole mission. Start from when you take off from the Earth and finish with splash down when you return home.

Tips

- Explain the motion of the rocket during each stage of the journey to and from Mars.
- Use what you have learnt about where forces come from and how they affect motion.

Key Words

push, pull, contact, non-contact, interaction pair, newtonmeter, weight, newton (N), deform, compress, stretch, reaction, extension, tension, elastic limit, Hooke's Law, linear, friction, lubrication, water resistance, air resistance, drag forces, streamlined, gravity, magnetic, electrostatic, field, mass, weight, kilograms (kg), gravitational field strength, balanced, equilibrium, unbalanced, driving force, resistive force

End-of-chapter questions

1 State which of the forces below are contact forces and which are non-contact forces.

magnetic force, friction, air resistance, gravitational force, electrostatic force, upthrust

*(**6 marks**)*

2 For each object below state whether the forces on it are balanced or unbalanced.

a a boat that is speeding up *(1 mark)*

b a boy who is floating in a swimming pool *(1 mark)*

c a cyclist who is slowing down *(1 mark)*

*(**3 marks**)*

3 A student is investigating friction. She puts a block of wood on a ramp and lifts the ramp until the block starts to move. She repeats the experiment with different types of surface on the ramp.

a State the variable that she is changing (the independent variable). *(1 mark)*

b State the variable that she is measuring (the dependent variable). *(1 mark)*

c State the variable or variables that she should control. *(1 mark)*

d Explain why she will need to plot a bar chart in this investigation. *(2 marks)*

*(**5 marks**)*

4 A cyclist is sitting on her bicycle at the start of a race.

a Draw a diagram of the cyclist and label the forces acting on her. *(2 marks)*

b Explain how the bicycle seat exerts a force on the cyclist. *(2 marks)*

c The race begins. State whether the forces on her when she goes around a corner are balanced or unbalanced. *(1 mark)*

*(**5 marks**)*

5 A student wants to make a newtonmeter. He coils a piece of wire around his pencil to make a spring. He puts a 100 g mass on the spring. A 100 g mass has a weight of 1 N. He measures the extension.

a Describe how to measure the extension of a spring. *(3 marks)*

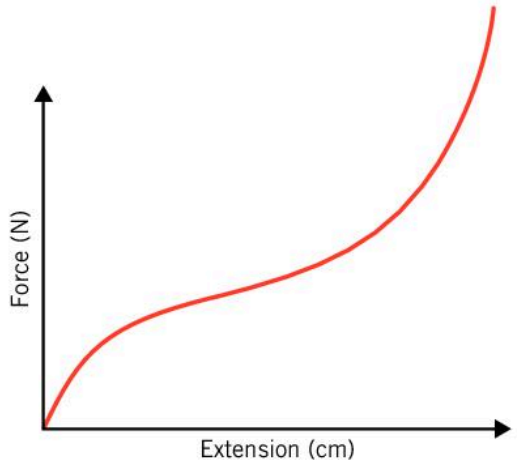
b Explain the difference between a mass of 100 g and a weight of 1 N. *(2 marks)*

The student measures the extension for different forces and plots his results on a graph. The line on the graph is a straight line.

c Use the shape of the graph to explain why the spring obeys Hooke's Law. *(2 marks)*

*(**7 marks**)*

6 Another student decides to use an elastic band as a newtonmeter and plots these results.



Explain in detail why the elastic band cannot be used as a newtonmeter but a spring can.

*(**6 marks QWC**)*

2.1 Waves

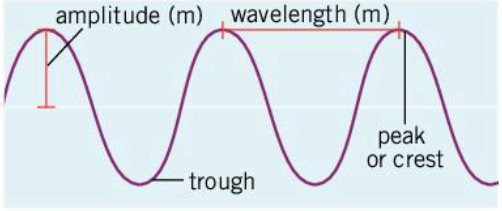
Learning objectives

After this topic you will be able to:

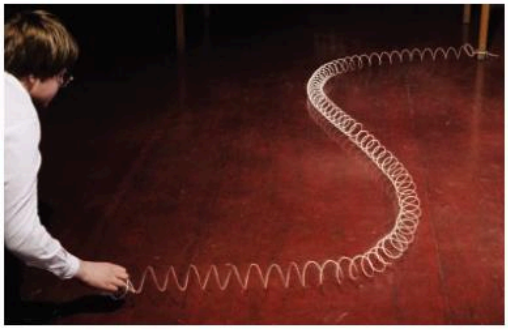
- describe the different types of wave and their features
- describe what happens when water waves hit a barrier
- describe what happens when waves superpose.

Key Words

oscillation, vibration, energy, undulation, sound, amplitude, frequency, wavelength, peak, crest, trough, transverse, longitudinal, compression, rarefaction, reflection, incident wave, reflected wave, superpose



▲ This diagram shows the amplitude and wavelength of a wave.



▲ You can make a transverse wave on a slinky.

Mexican waves are very popular at concerts and sporting events. But what is a wave?

What is a wave?

In science a wave is an **oscillation** or **vibration** that transfers **energy** or information. A wave can also be an **undulation** on the surface of water. Matter does not get transferred. Waves have many uses, for example, microwaves cook food, and **sound** waves help you communicate.

Features of a wave

All waves have three important features:

- an **amplitude**, which is the distance from the middle to the top or bottom of a wave
- a **frequency**, which is the number of waves that go past a particular point per second
- a **wavelength**, which is the distance from one point on a wave to the same point on the next wave.

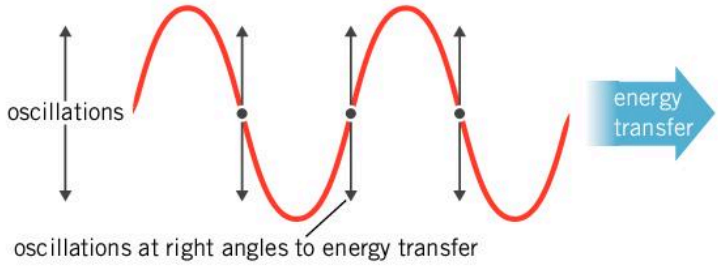
The top of a wave is called a **peak** or **crest**, and the bottom of a wave is called a **trough**.

A Name three properties of a wave.

Transverse or longitudinal?

You can send pulses down a slinky spring. You can make the pulses in two ways.

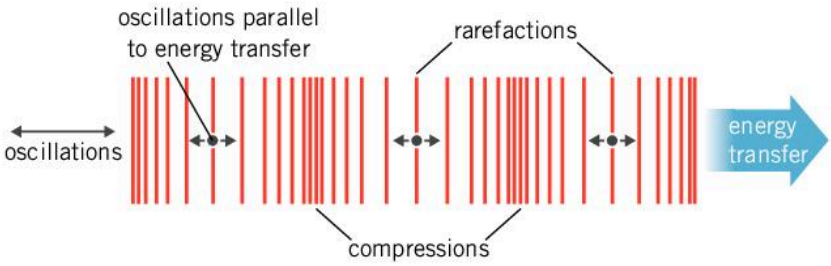
You can move your hand at right angles to the spring. This produces a **transverse** wave on the slinky. In a transverse wave the oscillation is at 90° to the direction of the wave.



▲ In a transverse wave the oscillation is at 90° to the direction of the wave.

You can also push and pull the spring. This produces a **longitudinal** wave on the slinky. The oscillation is parallel to the direction of the wave – it is in the same direction as the spring itself.

In a **compression** the coils of the spring are close together. In a **rarefaction** the coils are further apart. Sound is a longitudinal wave and light is a transverse wave.



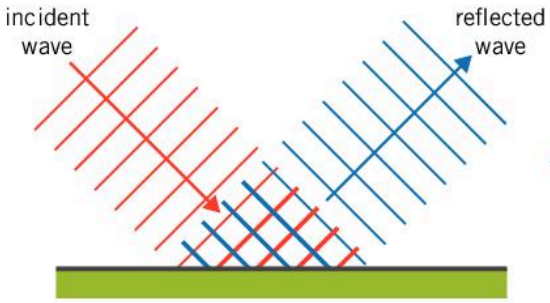
▲ In a longitudinal wave the oscillation is parallel to the direction of the wave.

B State the direction of the oscillation of a longitudinal wave.

Reflecting waves

Waves bounce off surfaces and barriers, just like a football bounces off a wall. This is called **reflection**.

The wave coming into the barrier is called the **incident wave**. The wave bouncing off is called the **reflected wave**.



◀ A wave reflects off a barrier.

C State the name of the wave that hits the barrier.

Adding waves

When waves are put together they **superpose**. This means that they add up or they cancel out.

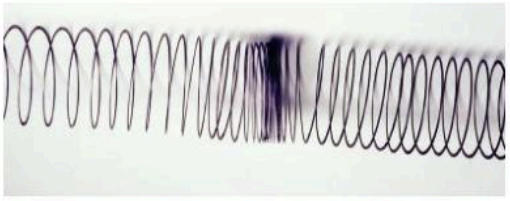
If the waves are in step they will add up. You get more than you had before. If they are not in step then they cancel out and you get less than you had before.

Spot the word

Write the word from each of these definitions:

a the distance from the top to the bottom of a wave

b where the links of a spring are squashed together



▲ You can make a longitudinal wave on a slinky.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

A wave is an oscillation or vibration that transfers **energy/matter**. The distance from the centre to the top of the wave is the **amplitude/wavelength**. The distance from one crest to the next crest is the **amplitude/wavelength**. Waves can **reflect/superpose** when they hit a barrier, and cancel out or add up when they **reflect/superpose**.

(5 marks)

2 Describe the difference between a compression and a rarefaction in a longitudinal wave on a spring.

(2 marks)

3 Explain in detail the difference between longitudinal and transverse waves, giving examples of each.

(6 marks QWC)

2.2 Sound and energy transfer

Learning objectives

After this topic you will be able to:

- describe how sound is produced and travels
- explain why the speed of sound is different in different materials
- contrast the speed of sound and the speed of light.

If you very gently press the front of your throat while you are talking you will feel a vibration. This is your vocal chords vibrating. The vibration produces the sound waves that travel through the air from your mouth.

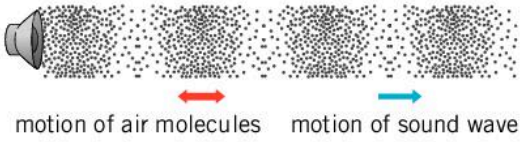
What is a sound wave?

A **vibration** produces a sound wave. All speakers, like the ones in your headphones, have something that moves backwards and forwards, or vibrates. This makes the air molecules move backwards and forwards, which produces a sound wave.

Some people think that sound just 'dies away'. It doesn't. It spreads out as it moves away from the source.

A State what produces a sound wave.

▲ The ends of a tuning fork are vibrating.



▲ Air molecules move backwards and forwards.

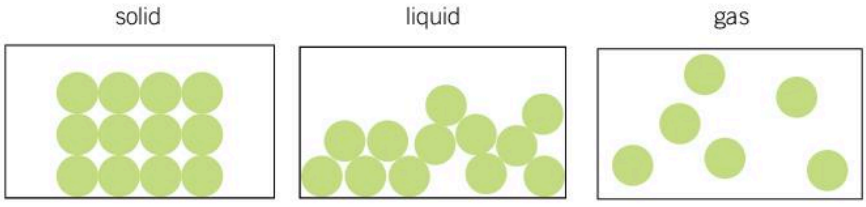
▲ Dolphins communicate underwater.

What does sound travel through?

Dolphins and whales use sound waves to communicate underwater. Elephants stamp their feet when a predator comes near – the warning travels through the ground to other elephants. Sound needs a **medium** like a solid, liquid, or gas to travel through. It cannot travel through empty space, a **vacuum**, because there are no air molecules to vibrate.

How fast does sound travel?

Sound travels at 340 m/s in air. Sound travels much faster in liquids, about 1500 m/s. Sound travels fastest in solids. In metals like steel it can travel at 5000 m/s. You can explain why a sound wave travels faster in a solid than in a gas if you think about particles. The particles in a solid are very close together, so the vibration is passed along more quickly than in a gas.



▲ The arrangement of particles explains the speed of sound in different materials.

Some people talk about the 'sound barrier'. There is no difference between travelling at or beyond the **speed of sound**.

Felix Baumgartner found this out when he became the first human to travel faster than the speed of sound when he jumped from a balloon 24 miles above the surface of the Earth.

◀ Felix Baumgartner travelled faster than sound.

B State the speed of sound.

How fast?

A student uses some secondary sources of information to make a list of the speed of sound in different materials.

a Draw a suitable table that she could use to record the data.

b State and explain which type of graph she could plot to show the data.

C Name the three types of medium that sound can travel through.

Which is faster: sound or light?

Light travels much faster than sound. The **speed of light** is 300 000 000 m/s, so it is almost a million times faster than sound. You notice this difference during a thunderstorm. The thunder and lightning are produced at the same time. You see the lightning immediately but it takes time for the sound of thunder to reach you.

Light can travel through a vacuum. It doesn't need a medium to travel through.

Key Words

vibration, medium, vacuum, speed of sound, speed of light

Stormy night

A girl sees a flash of lightning and then hears the thunder four seconds later.

a How far away is the storm? State your answer in kilometres.

b What would she notice about the thunder and lightning when the storm is directly overhead?

Summary Questions

1 Copy and complete the sentences below.

Sound is produced by objects that are _____ . This makes the air molecules _____ and produces a sound wave. Sound travels fastest in _____ and slowest in _____, and it cannot travel through a _____.

(5 marks)

2 Explain why sound travels slower in a gas compared to a liquid.

(2 marks)

3 Compare the time it takes the light to travel from your teacher to your eye with the time it takes sound to travel the same distance.

(6 marks QWC)

2.3 Loudness and pitch

Learning objectives

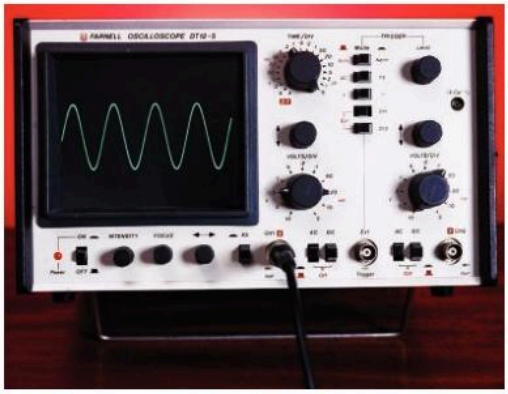
After this topic you will be able to:

- describe the link between loudness and amplitude
- describe the link between frequency and pitch
- state the range of human hearing and describe how it differs from the range of hearing in animals.

If you play a loud note of exactly the right pitch then you can shatter a glass. What's the difference between loudness and pitch?

Seeing sound

You can plug a **microphone** into an **oscilloscope** to see what the sound of your voice looks like. The wave on the screen is transverse but the wave that you are making when you talk is longitudinal. The microphone produces a signal that represents the sound wave.

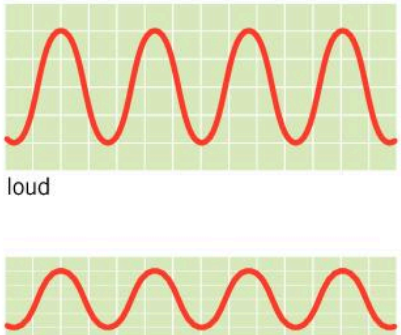


▲ An oscilloscope shows a representation of a sound wave made, for example, by a tuning fork.

What affects the loudness of a sound?

If a drummer hits the drum harder the sound is louder.

▲ A drum produces a sound with a large amplitude.



▲ A loud sound has a bigger amplitude than a soft sound.

You bang a drum harder or pull a guitar string more to produce a louder sound. A loud sound has a bigger amplitude than a soft sound. It transfers more energy than a soft sound. To make a louder sound you need to make the vibration bigger.

A State the property of a sound wave that affects the loudness of the sound.

What affects the pitch of a sound?

Some singers can sing higher-pitched notes than others. The **pitch** of a note depends on the frequency. High-pitched sounds have a high frequency and low-pitched sounds have a low frequency. Frequency is measured in **hertz** (Hz) or **kilohertz** (kHz).

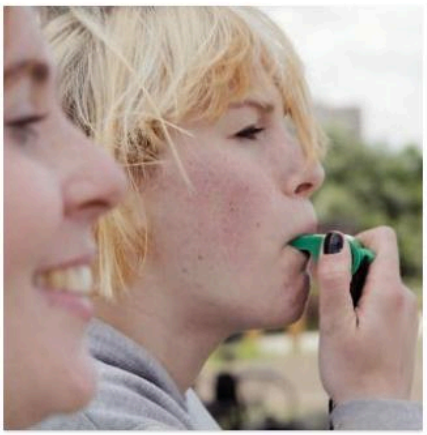
1 kHz = 1000 Hz. To make a higher-pitched sound you need to make something vibrate faster, so that there are more waves per second.

Key Words

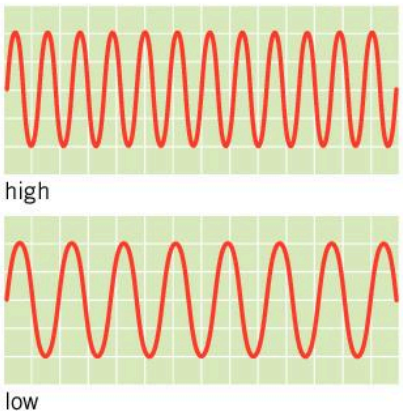
pitch, loudness, microphone, oscilloscope, hertz, kilohertz, audible range, infrasound, ultrasound

Fantastic Fact!

Grasshoppers make sounds that they cannot even hear.



▲ A whistle produces a sound with a high frequency.



▲ A high sound has a higher frequency than a low sound.

You can have a loud, high-pitched sound or a loud, low-pitched sound. Changing the frequency does not affect the amplitude.

B State the property of a sound wave that affects the pitch of the sound.

What frequencies can you hear?

You can only hear a particular range of frequencies, called the **audible range**. You have the biggest audible range when you are young: 20–20 000 Hz. Your audible range changes as you get older. You will find it more difficult to hear high-frequency sounds.

What frequencies can other animals hear?

Bats, dolphins, and grasshoppers have a completely different audible range to humans. Lots of animals can hear frequencies that are much higher than the frequencies we can hear. Frequencies below 20 Hz are called **infrasound**. Frequencies above 20 000 Hz are called **ultrasound**.

Species	Audible range (Hz)
bat	2000–110 000
cat	45–64 000
dog	67–45 000
dolphin	1000–100 000
goldfish	20–3000
hedgehog	250–45 000
whale	1000–123 000

Conversions

a Convert the audible range for humans into kilohertz.

b Convert the audible range of the whale into kilohertz.

Link

You can learn more about ultrasound in P1 2.5 Echoes and ultrasound

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

The loudness of a sound depends on the **amplitude/frequency** and the pitch of the sound depends on the **amplitude/frequency**. Frequency is measured in **hertz/metres**. The range of frequencies you can hear is called the **audible/visible** range.

(4 marks)

2 State the range of human hearing and compare it to the range of dolphin hearing.

(2 marks)

3 A singer produces sounds that vary in pitch and loudness. Use the ideas above to suggest and explain in detail what her vocal chords do to produce different types of sound wave.

(6 marks QWC)

2.4 Detecting sound

Learning objectives

After this topic you will be able to:

- describe how the ear works
- describe how your hearing can be damaged
- describe how a microphone detects sound.

Your ear is your body's microphone. If you listen to really loud music it doesn't hurt but can it damage your hearing?

How do you hear?

Your **ear** detects sound waves. The part of your ear that you can see, called the **pinna**, directs the sound wave into your auditory canal towards your ear drum. The pinna, **auditory canal**, and **eardrum** make up your **outer ear**.

Your eardrum vibrates and passes the vibration on to the **ossicles**. The ossicles make up your **middle ear**. They are tiny bones that **amplify** the sound. They make the **oval window** vibrate.

This passes the vibration on to liquid in the **cochlea**. This contains thousands of tiny hairs. As the liquid moves the hairs move. Specialised cells at the base of the hairs convert the movement to an electrical signal. The signal travels down the **auditory nerve** to your brain. You hear the music.

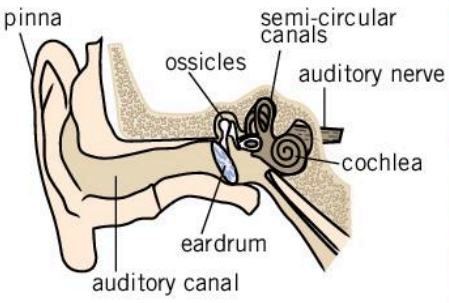
The cochlea and the semi-circular canals make up your **inner ear**. The semi-circular canals help you to balance.

Link

You can learn more about specialised cells B1 1.3 Specialised cells

Key Words

ear, pinna, auditory canal, eardrum, outer ear, ossicle, middle ear, amplify, oval window, cochlea, auditory nerve, inner ear, decibel, diaphragm, amplifier



▲ Structure of the ear.

▲ Without these tiny hairs inside your cochlea you would not be able to hear.

A Name the first part of the ear that vibrates when a sound wave enters it.

Foul Fact!

Your ossicles don't grow. They are the correct size when you are born. They are the smallest bones in your body.

How do you measure loudness?

In the 2010 World Cup in South Africa the crowd used vuvuzelas to make very loud sounds. Vuvuzelas can be so loud that they are painful.

You measure sound intensity in **decibels** (dB). The decibel scale is not like a ruler. Each increase of 10 dB increases the sound intensity by 10 times. A 40 dB sound is 100 times more intense than a 20 dB sound.

0 dB	20 dB	40 dB	60 dB	80 dB	100 dB	120 dB	140 dB
cannot be heard	leaves rustling	talking quietly	normal speech	heavy traffic	jet taking off	pain threshold	gun shot

What protection?

Two companies make ear defenders. Plan an experiment to find out which pair is best at reducing sound intensity.

How can you damage your hearing?

Your hearing can be damaged if a sharp object makes a hole in your eardrum but your eardrum will grow back. A build-up of ear wax can also be damaging. Very loud sounds or head injuries can permanently damage your hearing.

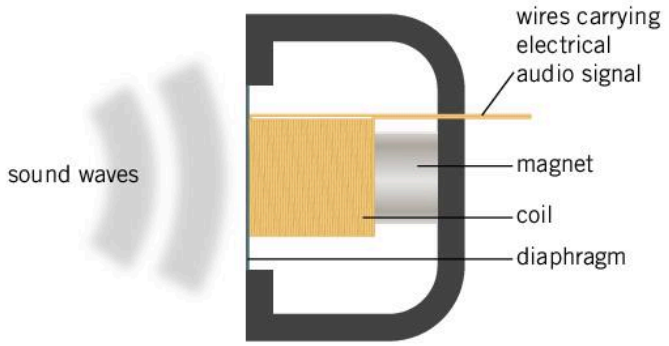
You can reduce the risk of damage by turning down the volume or using ear defenders.

B Describe one way that your hearing can be damaged.

How does a microphone work?

When a singer sings into a microphone the sound wave hits a flexible plate called a **diaphragm**. The diaphragm vibrates, like your eardrum. It produces an electrical signal, just like the cells in your cochlea. The signal carries the information that the sound wave carried.

You can use an **amplifier** to make the sound louder. Loudspeakers convert the electrical signal back into sound when they vibrate.



▲ A microphone detects sound in a similar way to your ear.

Summary Questions

1 Copy and complete the sentences below.

When a sound wave enters your ear it makes the _____ vibrate. This makes the _____ vibrate. The _____ vibrates and this makes the liquid inside your _____ vibrate. Cells at the base of _____ inside your _____ produce an electrical signal that travels up your _____ to your brain. Sound intensity is measured in _____. Your hearing can be _____ by loud sounds. In a microphone a _____ vibrates, which produces an electrical signal.

(10 marks)

2 Describe one way that your hearing can be damaged that is not permanent, and one way that it can be permanently damaged.

(2 marks)

3 Compare the ear and the microphone.

(6 marks QWC)

2.5 Echoes and ultrasound

Learning objectives

After this topic you will be able to:

- describe what ultrasound is
- describe some uses of ultrasound.

▲ This room is designed to produce no echoes.

Where is the quietest place in the world? Scientists have designed a room where it is so quiet you can hear your own heartbeat. The surfaces are designed to absorb sounds. There are no echoes.

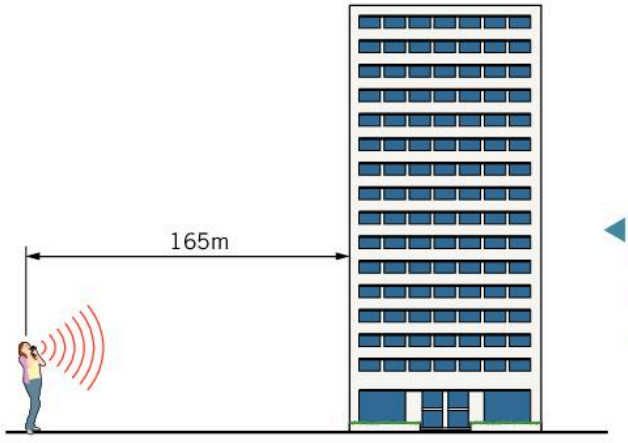
What is an echo?

When sound reflects off a surface it produces an **echo**. Sound takes time to travel. There is a time delay between making a sound and hearing an echo.

Measuring distances

Imagine that you are standing a long way from the school sports hall. You clap and you hear an echo one second later. How far away is the wall?

The speed of sound in air is 340 m/s. The sound travels a total distance of 340 m in one second. The distance to the wall is 165 m because the sound has travelled there and back. You can use the time taken to hear the echo to work out distance.



◀ You can work out how far away a wall is using echoes.

A State what an echo is.

How do you reduce echoes?

If lots of echoes join together to produce a longer sound this is called a **reverberation**. Reverberations can be a nuisance in concert halls or cinemas. You can reduce the effect of echoes by covering the walls with soft materials and putting carpet on the floor.

Key Words

echo, reverberation, transmitter, receiver

Fantastic Fact!

People used to think that a duck's quack and a wolf's howl don't echo. They do. Sometimes the echo gets mixed in with noise so you don't hear it.

What is ultrasound?

Bats use ultrasound to find their food. Doctors use ultrasound to make images of unborn babies. Ultrasound is sound with a frequency above 20 000 Hz.

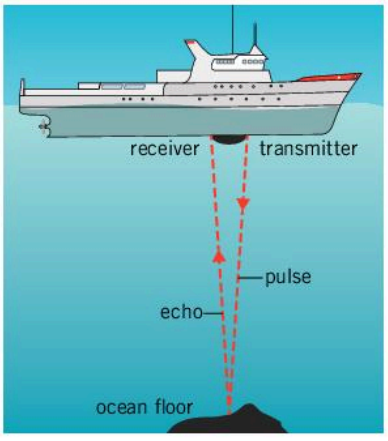
B State the frequency of ultrasound.

When doctors make images of unborn babies, the ultrasound wave travels through the woman and reflects off the fetus. The machine detects the echo. It uses the time taken for the echo to build up an image of the fetus.

This shows an ultrasound image of a baby and a photograph of the same baby after he was born.

Doctors also use ultrasound in physiotherapy. For example, ultrasound reduces the pain and swelling of a damaged tendon. They can also look for cancer..

Another use of ultrasound is sonar, used on ships. A **transmitter** under the ship sends out a beam of ultrasound. It travels through the water and reflects off the seabed. A **receiver** detects the reflection and uses the time taken to work out the depth of the water.



Ships use ultrasound to work out the depth of the ocean.

C State a use of ultrasound.

How deep?

A ship's sonar detects an echo 1.6 s after it sends the pulse. The speed of sound in water is 1500 m/s. Work out how deep the water is.

Literacy

The word "sonar" is an acronym. It comes from the term "Sound Navigation And Ranging'.

Summary Questions

1 Copy and complete the sentences below.

An echo is a _____ of sound. You can use the _____ between making a sound and hearing an echo from a surface to calculate the _____ to it. Soft materials _____ sound and reduce echoes. Animals use ultrasound to _____ and _____. Ultrasound is used to make an _____ of a fetus, or break down _____ . Fishermen can use ultrasound to find the _____ of the ocean.

(9 marks)

2 Describe one way that a doctor might use ultrasound.

(2 marks)

3 Imagine that you are the captain of a fishing boat. Write a detailed presentation that you will show to the fishermen, explaining how to use sonar to detect shoals of fish.

(6 marks)

P1 Chapter 2 Summary

Key Points

- Waves are oscillations or vibrations that have an amplitude, wavelength, and frequency. The top of a wave is a crest and the bottom is a trough.
- In a transverse wave the oscillation is at 90° to the wave direction, and in a longitudinal wave it is parallel to the wave direction.
- Waves can reflect from barriers and add up or cancel out.
- A sound wave is produced by vibrating objects and is longitudinal.
- Sound travels at 340 m/s. Sound travels fastest in solids and slowest in gases and cannot travel through a vacuum.
- The loudness of a sound depends on its amplitude, and the pitch depends on its frequency. Frequency is measured in hertz (Hz).
- A human's audible range is from 20–20 000 Hz.
- Your outer ear consists of the pinna, auditory canal, and eardrum. Your middle ear contains your ossicles. Your inner ear contains your cochlea and semi-circular canals.
- Vibrations travel from your eardrum to the hairs in your cochlea. This produces a signal that is sent to your brain.
- Loudness is measured in decibels (dB).
- An echo is a reflection of sound that you can use to work out distance. Soft materials absorb sound and don't produce echoes.
- Ultrasound is sound with a frequency of more than 20 000 Hz. Humans use ultrasound to produce images of inside the body, and to find the depths of water.

Big Write

Sound campaign

You are a scientific advisor to a council. There are several issues to do with sound in the area:

- Shopkeepers want to install high-frequency speakers to put off young people hanging around outside their shops.
- People who live near a busy road are concerned about the traffic noise.

Task

Produce an information pack that includes:

- what a sound wave is, its properties, and how it behaves
- how you hear, and how hearing can be damaged.

Key Words

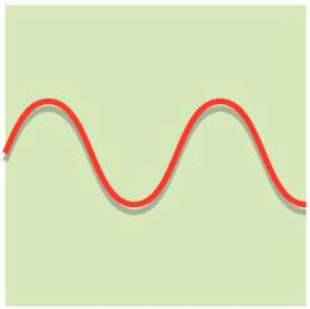
oscillation, vibration, energy, undulation, sound, amplitude, frequency, wavelength, peak, crest, trough, transverse, longitudinal, compression, rarefaction, reflection, incident wave, reflected wave, superpose, vibration, medium, vacuum, speed of sound, speed of light, pitch, loudness, microphone, oscilloscope, hertz, kilohertz, audible range, infrasound, ultrasound, ear, pinna, auditory canal, eardrum, outer ear, ossicles, middle ear, amplify, oval window, cochlea, auditory nerve, inner ear, decibels, diaphragm, amplifier, echo, reverberation, transmitter, receiver

End-of-chapter questions

1 Draw a wave and label the amplitude and the wavelength.

(2 marks)

2 A tuning fork produces this wave on an oscilloscope:



a Draw the wave you would see if the sound was louder. *(1 mark)*

b Draw the wave you would see if the sound had a higher pitch. *(1 mark)*

(2 marks)

3 A note has a frequency of 400 Hz. State how many sound waves pass a point per second.

(1 mark)

4

a Describe what happens when a wave hits a barrier. *(1 mark)*

b Describe what happens when waves superpose. *(2 marks)*

(3 marks)

5

a Explain why a Mexican wave is transverse. *(1 mark)*

b Explain why sound is a longitudinal wave. *(1 mark)*

(2 marks)

6 Suggest a situation where you might need to use ear defenders.

(1 mark)

7 Here is a table showing the speed of sound in three different materials: A, B, and C.

Material	Speed (m/s)
A	1250
B	300
C	5000

a State which material, A, B or C, is probably a solid. *(1 mark)*

b State which material, A, B or C, is probably a gas. *(1 mark)*

c Suggest a reason why the three speeds are different. *(3 marks)*

(5 marks)

8 A student is measuring sound intensity with a meter. He wonders if there is a link between the loudness of a sound and how far away you are from the source.

a Suggest a question that the student could investigate based on this idea. *(1 mark)*

b Name the independent, dependent, and control variables in the investigation. *(1 mark)*

c State the type of graph that he could plot with the results of this investigation. *(1 mark)*

(3 marks)

9 A loudspeaker produces a sound wave that you can hear. Describe in detail how the sound is produced, travels, and is detected by your ear.

(6 marks QWC)

3.1 Light

Learning objectives

After this topic you will be able to:

- describe what happens when light interacts with materials
- state the speed of light.

▲ You can see a starfish through water.

▲ Frosted glass is translucent.

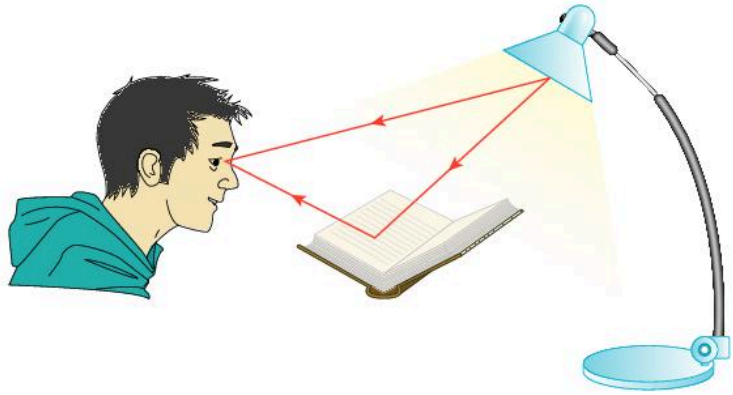
How long? How far?

It takes light eight minutes to travel here from the Sun. Sound is about a million times slower. Calculate how long it would take sound to travel the same distance. Convert your answer to years.

As you go deeper and deeper into an ocean it gets darker and darker until you can hardly see a thing. Some fish that live there make their own light. Why is it so dark?

What happens to light as it travels?

You look at a book. A **source** of light, like a light bulb, **emits** light. This light **reflects** off the book and into your **eye**. You see the book when the light is **absorbed** in your eye.



▲ You see objects because light reflects off them.

Something that gives out light is **luminous**. Most objects that you look at are **non-luminous**. You see them because they reflect light into your eyes. Light spreads out, just like sound.

When you look through a window, light travels through the glass and into your eye. The glass **transmits** the light. When light travels through glass, Perspex, or shallow water most of the light goes through but a small amount is absorbed. They are **transparent** and you can see through them. In very deep water most of the light is absorbed.

A State the difference between 'emit' and 'transmit'.

Materials like frosted glass or tissue paper are **translucent**. Light can travel through them but it is scattered so you cannot see clearly. Materials that do not transmit light are **opaque**.

Opaque materials produce shadows. You can predict the size and shape of shadows. This is because light travels in straight lines.

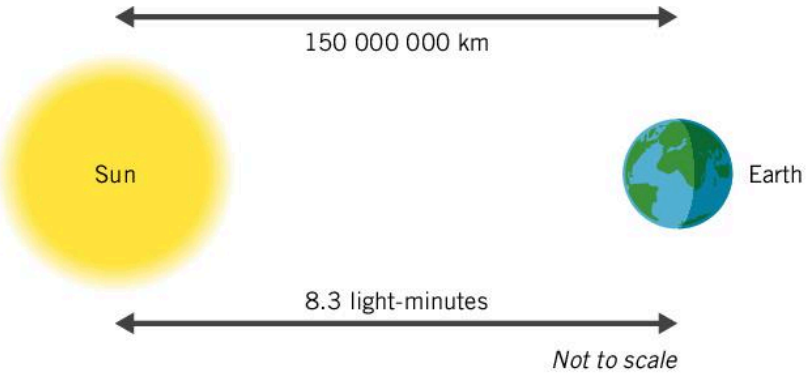
B State the difference between a translucent and a transparent material.

What can light travel through?

Light can travel through gases like the air, some liquids like water, and some solids like glass. It can even travel through completely empty space, which is called a **vacuum**. It does not need a medium to travel in. Light travels as a **wave**.

How fast does light travel?

It takes light about eight minutes to reach the Earth from the Sun, a distance of 150 million km. The speed of light is about 300 000 km/s. Sound travels about a million times slower than light. Astronomers use '**light-time**' to measure distances in space. A light-minute is the distance that light travels in one minute. A light-year is how far it travels in a year. Light-time is a measure of distance, not time.



▲ There are two ways of showing the distance to the Sun.

C State what is meant by a light-year.

Sort those words

Use the words below to make up three sentences involving a light bulb and a flower in a vase of water. The words can be used more than once but try to use them only once if you can.

emit transmit reflect absorb luminous non-luminous transparent opaque

Key Words

source, emit, reflect, eye, absorb, luminous, non-luminous, transmit, transparent, translucent, opaque, vacuum, wave, light-time

Link

You can learn more about the properties of waves in P1 2.1 Waves

Fantastic Fact!

If light from the Sun travelled at 100 mph it would take 100 000 years to reach Earth.

Summary Questions

1 Copy these sentences, choosing the correct bold words.

The Sun is **luminous/non-luminous** because it **emits/transmits** light. The light **reflects/transmits** off an object that is **luminous/non-luminous** into your eye so that you see it. Most objects do not transmit light; they are **translucent/opaque**.

(5 marks)

2 Explain why it is so dark at the bottom of the ocean even though water is transparent.

(2 marks)

3 Describe the journey that light takes from the Sun to your eye when you are looking at fish in a pond.

(6 marks QWC)

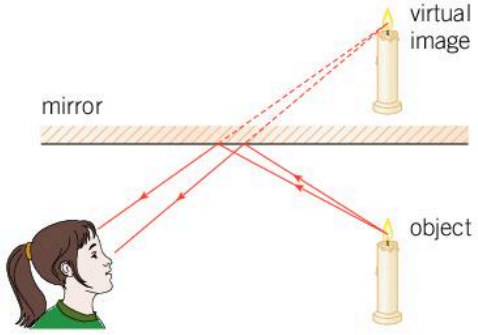
3.2 Reflection

Learning objectives

After this topic you will be able to:

- explain how images are formed in a plane mirror
- explain the difference between specular reflection and diffuse scattering.

▲ You see a reflection in a window.



▲ You see an image in a mirror.

Fantastic Fact!

The Salar de Uyuni in Bolivia, South America is a huge dry salt lake that acts like a mirror. It is so big that you can see it from space.

There are lots of places that you see your reflection every day. Shop windows, saucepans, car doors . . . but why do you see your image in some surfaces but not others?

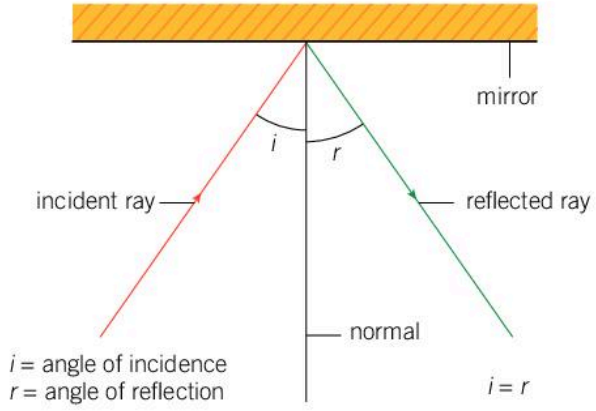
Why do I see an image in the mirror?

When you look in the mirror it appears that there is someone who looks just like you behind the mirror. The **image** is a **virtual** image. Your brain uses the fact that light travels in straight lines to work out where the light appears to come from. This is where you see the image.

When you look at your mirror image in a flat, or **plane**, mirror, it is the same shape and size as you are. It appears to be as far behind the mirror as you are in front of the mirror. Left and right appear swapped.

The law of reflection

You know that you need light to reflect from an object for you to see it. Light reflects off a mirror in the same way that a wave reflects off a barrier.



▲ Light is reflected at equal angles.

The ray that hits the mirror from your ray box is called the **incident ray**. The ray that reflects off the mirror is called the **reflected ray**.

There is an imaginary line at 90° to the mirror called the **normal**. You measure angles from the normal to the rays of light. The angle between the incident ray and the normal is the **angle of incidence**. The angle between the normal and the reflected ray is the **angle of reflection**.

When light is reflected from a mirror, the angle of incidence is equal to the angle of reflection. This is the **law of reflection**.

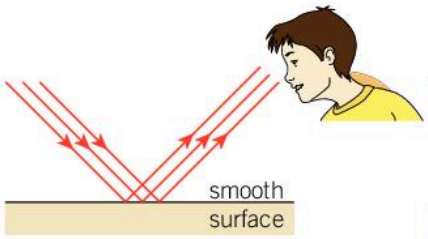
A State the law of reflection.

Rough surfaces

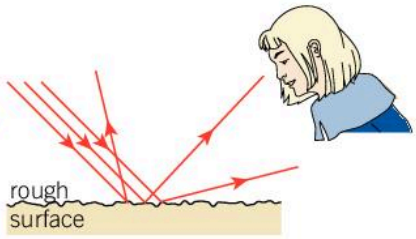
Every surface reflects at least some light. You can only see your image in surfaces that reflect light in a regular way.

Reflection from a smooth surface is called **specular reflection**. Reflection from a rough surface is called **diffuse scattering**.

To form an image, the rays from each part of the object have to reflect off a surface in the same way. If two rays that are parallel are reflected at different angles you won't see an image.



▲ Reflection from a smooth surface (specular reflection).



▲ Reflection from a rough surface (diffuse scattering).

B State the type of reflection when light hits a mirror.

Bouncing light

A student wants to investigate the light that is reflected from different types of material using a light meter.

a Explain why the student should repeat the experiment several times.

b State and explain which type of graph she should plot from the data that she collects.

Key Words

image, virtual, plane, incident ray, reflected ray, normal, angle of incidence, angle of reflection, law of reflection, specular reflection, diffuse scattering

Angular problem

A student makes a mistake and measures the angle between the mirror and the incident ray.
It is 40°.

a What is the angle of incidence?

b What is the angle of reflection?

c He says the angle of incidence and the angle of reflection always add up to 90°. Is he correct? Explain your answer.

Summary Questions

1 Copy and complete the sentences below.

When you look in a mirror you see a _____ image of yourself. The image is the same _____, _____, and _____ from the mirror. When you close your left eye the image appears to close their _____ eye. The image is formed because light reflects off the mirror so that the angle of _____ is equal to the angle of _____.

(7 marks)

2 Explain why you cannot see an image of your face when you look at a white wall, even though most of the light hitting it is reflected.

(2 marks)

3 Design a model to demonstrate how light can be diffusely scattered but still obey the law of reflection. Use marbles and footballs instead of light in your model. Explain how it works.

(6 marks)

3.3 Refraction

Learning objectives

After this topic you will be able to:

- describe and explain what happens when light is refracted
- describe what happens when light travels through a lens.

▲ A pencil looks bent when you put it in a glass of water.

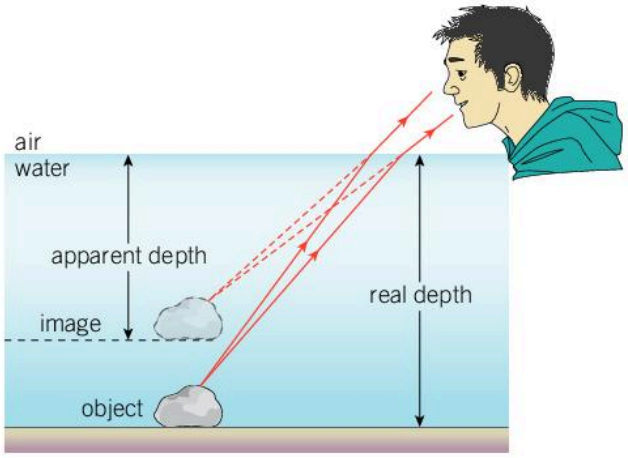
You can bend a pencil without touching it. Put it in a glass and fill it with water. It looks bent but it isn't. Why?

Optical illusions

The pencil reflects light and the light travels from the pencil through the water. It then travels through the air into your eye. As the light leaves the water, the direction it is travelling in changes. This is called **refraction**.

Refraction happens whenever light travels from one **medium** (material) to another.

The change in direction explains why the pencil appears to be bent. Your brain thinks that the light has travelled in a straight line. You see the end of the pencil in a different place to where it actually is. The pencil looks bent. Refraction also explains why a swimming pool looks shallower than it actually is.



▲ A rock at the bottom of a pool looks closer to the surface than it actually is.

A State the difference between reflection and refraction.

Why does light change direction?

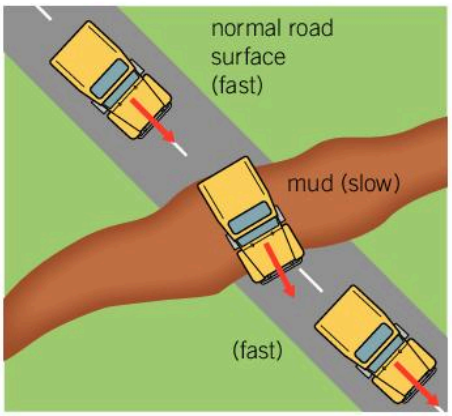
Imagine a truck driving from a road onto mud. When the first wheel of the truck hits the mud it slows down. The other wheels keep going – this pushes the truck in another direction. This is similar to what happens when light travels from air into water or glass, or when water waves go from deep to shallow.

Fantastic Fact!

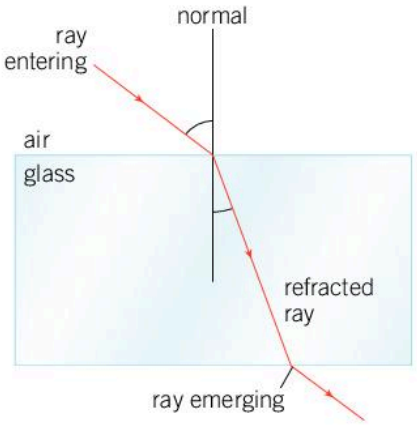
Stars twinkle because light is refracted as it travels through the atmosphere.

Key Words

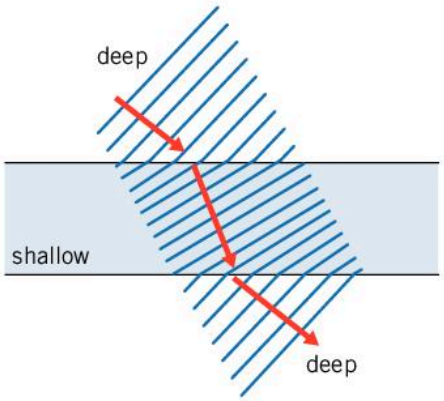
refraction, medium, lens, convex, converging, focus, focal point



▲ A truck changes direction as it slows down.



▲ Light is refracted when it slows down.

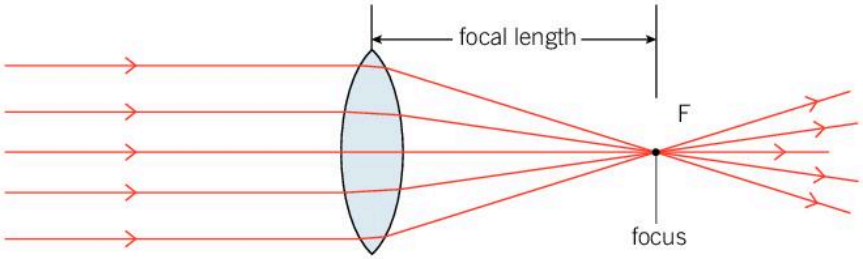


▲ Waves are refracted when they slow down.

When light travels through a glass block it slows down when it goes in, and speeds up again when it comes back out. The direction changes twice. Light bends towards the normal when it goes into glass. It bends away from the normal when it comes out. The two rays outside the block are parallel.

What does a lens do?

There are two lenses in your body. The **lens** in each of your eyes is a **convex** or **converging** lens. It focuses the light and enables you to see. The point where the rays cross is called the **focus** or **focal point**. The light is refracted as it goes into the lens and as it comes back out.



▲ A piece of glass shaped like a lens focuses light.

B Describe what a lens does to light.

Watch that spelling!

In each list below, choose the correct spelling of the word. Make up a rule that will help you to remember the spelling.

a lense, lenz, lens

b parallel, parrallel, paralell

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

When you look at a rock in the bottom of a swimming pool it appears **above/below** where it actually is. That is because the light **reflects/refracts** when it travels from water into air. It bends **towards/away from** the normal as it goes into the air. This is because it **slows down/speeds up**.

(4 marks)

2 Explain what would happen to:

a the speed and direction of water waves if they went straight into the area of shallow water rather than at an angle *(2 marks)*

b the speed and direction of light waves if they went straight into the glass block rather than at an angle. *(2 marks)*

3 Describe in detail how you could use the idea of marching soldiers to make a model of light refracting as it goes through a glass block.

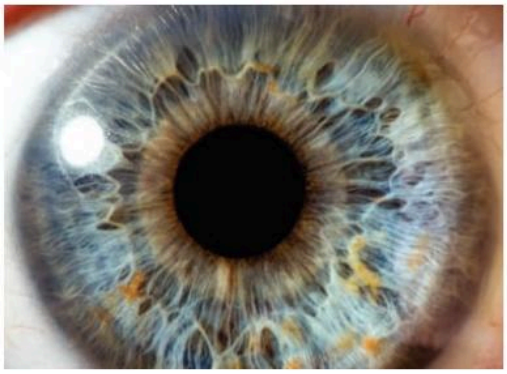
(6 marks QWC)

3.4 The eye and the camera

Learning objectives

After this topic you will be able to:

- describe how the eye works
- describe how a simple camera forms an image.



▲ No-one has the same pattern in their iris as you.

Key Words

retina, pupil, iris, cornea, inverted, photoreceptor, optic nerve, brain, pinhole camera, real (image), pixel, charge-coupled device (CCD)

Foul Fact!

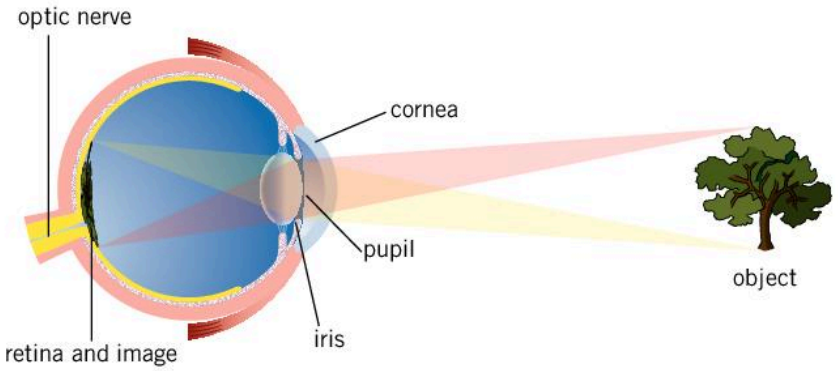
The pupil is a hole in the front of your eye. If you dissect a cow's eye you can put your finger through it.

Link

You can learn more about specialised cells in B1 1.3 Specialised cells

The iris is the coloured part of your eye. Everyone's iris is unique. It is like a fingerprint.

How do you see?



▲ How an image is formed in your eye.

When you look at your friend, an image of your friend is formed on the **retina** of your eye. Light reflected from your friend goes through the **pupil** of your eye. The **iris** is a muscle that controls the size of the pupil. The **cornea** (the transparent outer part of your eye) and the lens focus the light onto the retina. This forms an image. The image is **inverted** (upside down) but your brain sorts it out so you see an image of your friend that is the right way up.

A State which parts of the eye focus the light.

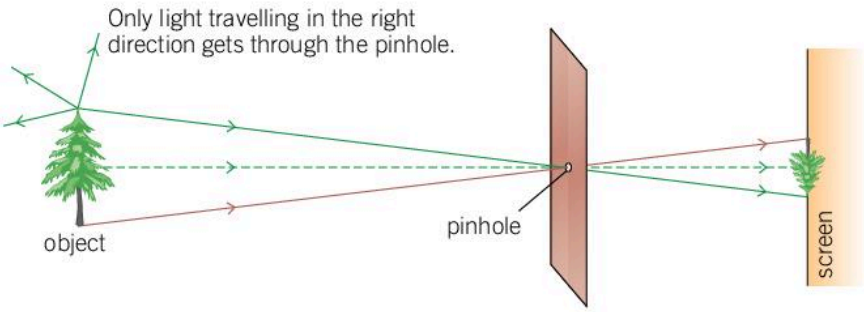
What happens in the retina?

The retina is a photosensitive material that contains cells that respond to light. They are called photoreceptors. There are two types of **photoreceptor**: rods and cones. Rods are sensitive to movement and dim light. Cones are sensitive to bright light and colour. When light hits the rods and cones, chemical reactions produce an electrical impulse that travels up the **optic nerve** to your **brain**.

B State the type of reaction that takes place in the retina.

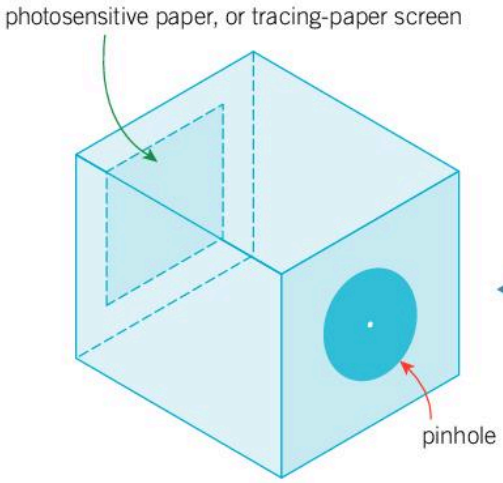
How is the eye like a camera?

A camera produces an image, just like your eye. One of the simplest cameras is a **pinhole camera**.



▲ An image is formed in a pinhole camera.

Light enters the camera through the pinhole, just like it does through your pupil. An image is formed on the screen, just like it is on your retina. The image is a **real** image, not like your image in a mirror. Any image that you can make on a screen is a real image.



◀ This is a simple pinhole camera.

Cameras used to contain photographic film, which was photosensitive. When light hit the film there was a chemical reaction that changed the chemicals in the film. When you processed the film you saw the image.

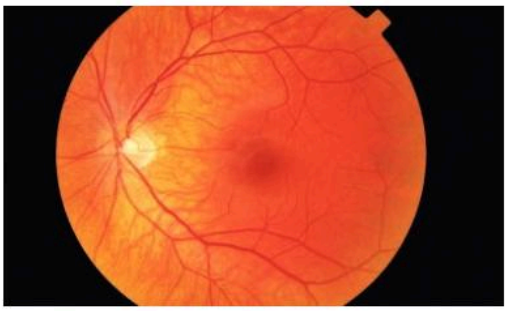
At the back of a digital camera there is a grid of photosensitive picture elements, or **pixels**. This is called a **charge-coupled device** (CCD). When light hits each pixel it produces charge. The light produces an electrical, not chemical, effect. When you take a picture, this charge is moved off each of the pixels and stored. That is why there is a slight delay before you can take another picture.

C Name the photosensitive grid at the back of a digital camera.

Real or virtual?

Here are some words that describe real and virtual images. Use these words to explain the difference between the two types of image.

screen **virtual** **real** **mirror**



▲ This is the view of your retina that an optician would see.

Summary Questions

1 Copy and complete the sentences below.

When you look at an apple, light _____ off the apple into your eye. The light enters your eye through the _____. The _____ and the _____ focus the light onto the _____. The light forms a _____ image. A chemical reaction produces an _____ signal that is sent down your _____ _____ to your brain.

(9 marks)

2 Describe how the camera in your phone is different to a pinhole camera.

(2 marks)

3 Compare the eye and the pinhole camera.

(6 marks QWC)

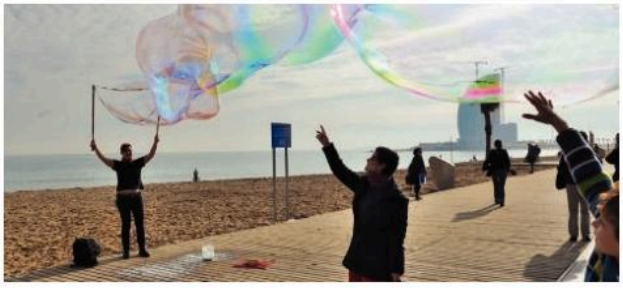
3.5 Colour

Learning objectives

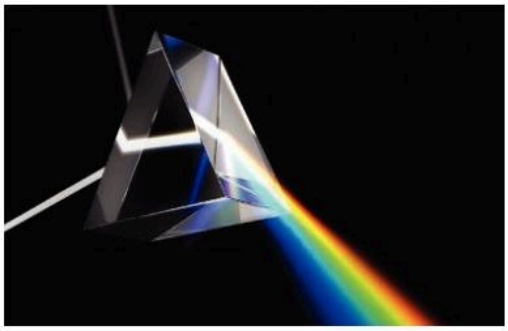
After this topic you will be able to:

- explain what happens when light passes through a prism
- describe how primary colours add to make secondary colours
- explain how filters and coloured materials subtract light.

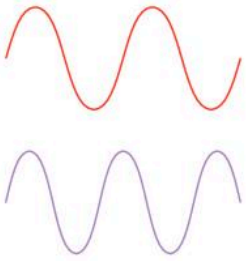
Have you ever seen really big bubbles? There are colours on the bubbles just like the colours in a rainbow or on a CD or DVD.



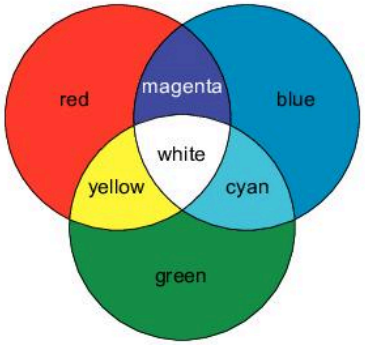
◀ Where do the colours come from?



▲ A prism splits white light into a spectrum.



▲ Red light has a lower frequency than blue light.



▲ This Venn diagram shows the primary and secondary colours of light.

Splitting white light

White light is made up of seven different colours of light. You can use a **prism** to split white light into a **spectrum**. This is called **dispersion**. The spectrum of white light is **continuous**. There are no gaps between the colours. Sir Isaac Newton first did this experiment in about 1666.

Dispersion happens because different colours of light are refracted by different amounts. Violet is refracted the most and red is refracted the least. Violet light has a higher **frequency** than red. Light with a higher frequency is refracted more than light with a lower frequency.

A State what a prism does to light.

Adding colours

You can make all the colours of light from just three colours: red, green, and blue. These are called the **primary colours** of light. Your eye detects these three colours. You can make any colour from different amounts of red, green, and blue. When you mix two primary colours you get **secondary colours** of light: cyan, yellow, and magenta. You get white light when you mix all three colours of light.

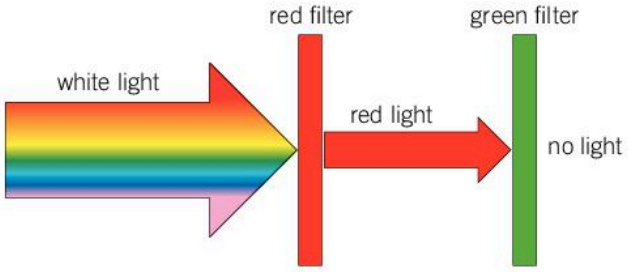
B Name the secondary colours of light.

Subtracting colours

Coloured lights on a stage can make a spectacular display. White light contains all the colours of light so if you want blue light you need to get rid of all the other colours.

What do filters do to light?

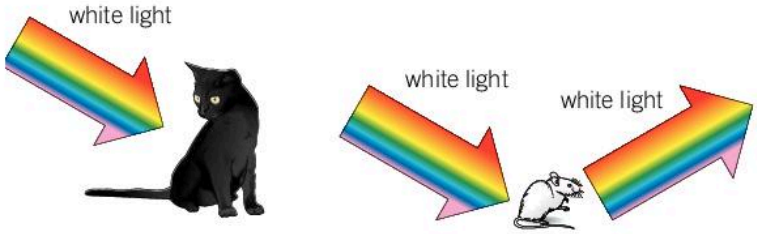
A red **filter** subtracts colours from white light. It transmits red light and absorbs the rest. It does not change the colour of light. If you put a red and a green filter together no light would get through them.



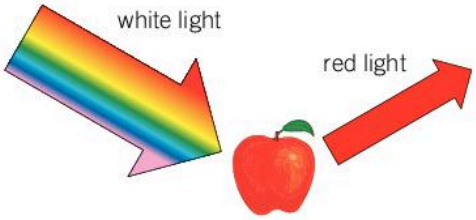
▲ Filters transmit the colours that they are and absorb the rest.

Why are objects different colours?

A red car reflects red light into your eyes. When the white light from the Sun hits the car, the paint absorbs all the other colours except red. Any coloured object reflects the colour that it is and absorbs the rest. Black objects absorb all the colours. White objects absorb no colours and reflect all the light.



▲ Black objects absorb all the colours of light and white objects reflect all the colours of light.



◀ An apple reflects red light and absorbs the other colours.

What table?

A student wants to record data in an experiment where she is shining all the primary and secondary colours of light onto pieces of coloured material. Draw a table to show how she could record her results.

C State what a black object does to white light.

Fantastic Fact!

You can never see a rainbow when the Sun is in front of you.

Key Words

prism, spectrum, dispersion, continuous, frequency, primary colour, secondary colour, filter

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

When white light goes through a prism, red light is **reflected/refracted** the **most/least** and violet light is refracted the **most/least**. This is called **dispersion/refraction**. A green filter **absorbs/transmits** green light and **absorbs/transmits** the rest.
A cyan object **absorbs/reflects** red light, **absorbs/reflects** blue light, and **absorbs/reflects** green light. A magenta object would look black in **blue/green** light.

(10 marks)

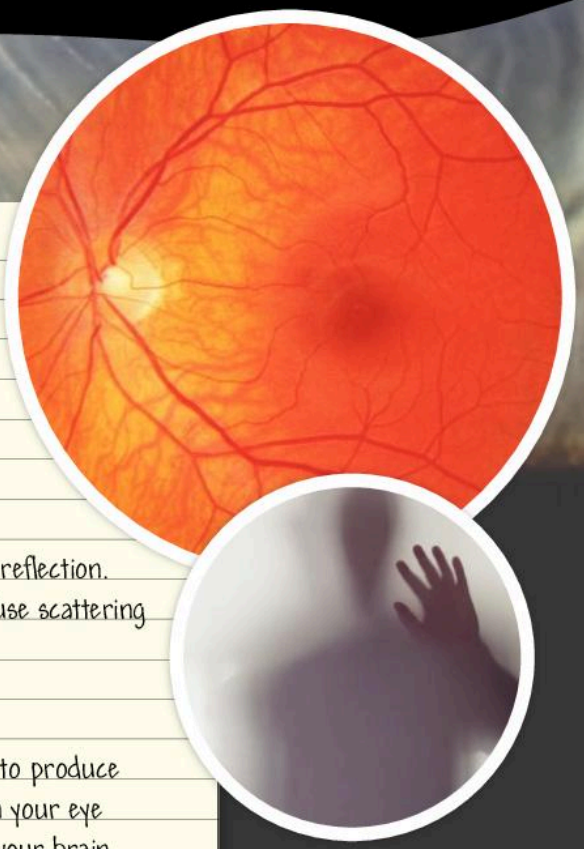
2 Explain why a green shirt looks black in red light.

(2 marks)

3 Explain in detail why you cannot have a white filter or a black filter.

(6 marks QWC)

P1 Chapter 3 Summary



Key Points

- Light is emitted from luminous sources. It can be transmitted through, reflected, or absorbed by non-luminous objects.
- Objects are transparent, translucent, or opaque.
- Light travels through a vacuum at 300 000 km/s.
- A light-year is the distance light travels in one year. Light-years are used to measure very large distances.
- Your brain uses the fact that light travels in straight lines and you see a virtual image when you look in the mirror.
- The law of reflection says that the angle of incidence equals the angle of reflection.
- Images are formed when reflection is specular but not when there is diffuse scattering from a surface.
- When light slows down it is refracted towards the normal.
- A lens can focus light to a focal point.
- Light enters your eye through the pupil. The cornea and lens focus light to produce a real image on your retina. A chemical reaction in the photoreceptors in your eye produces an electrical signal. The signal travels down the optic nerve to your brain.
- Light forms an image in a camera in the same way. Digital cameras store images produced when light hits a charge-coupled device (CCD).
- Prisms disperse white light to produce a continuous spectrum. Primary colours of light add up to make secondary colours. All three colours add to make white light.
- Filters and coloured objects subtract colours from white light by transmitting or reflecting the colour that they are and absorbing the rest.

Key Words

source, emit, reflect, eye, absorb, luminous, non-luminous, transmit, transparent, translucent, opaque, umbra, penumbra, vacuum, wave, light-time, image, virtual, plane, incident ray, reflected ray, normal, angle of incidence, angle of reflection, law of reflection, specular reflection, diffuse scattering, refraction, medium, lens, convex, converging, focus, focal point, retina, iris, pupil, cornea, inverted, photoreceptor, optic nerve, brain, pinhole camera, real (image), pixel, charge-coupled device (CCD), prism, spectrum, dispersion, continuous, frequency, primary colour, secondary colour, filter

Big write

The big production

A theatre has asked you to come up with some ideas for a play about ghost hunters.

Task

Write a plan for your team to do some investigations to produce special effects. The effects could include reflection in mirrors and glass and different-coloured lights and materials.

Tips

- As well as what happens on the stage, you could design posters and programmes that look different in different-coloured lights.

End-of-chapter questions

1 Mirrors reflect light. State which capital letters of the alphabet would look the same if you saw them in a mirror.

(1 mark)

2 An actor is wearing a uniform that has a blue jacket and red trousers. Suggest and explain what the audience would see if he stood on stage in:

a white light *(2 marks)*

b green light *(2 marks)*

(4 marks)

3 A hunter is trying to spear a fish.

a Explain why he aims above where he sees the fish. *(2 marks)*

b Explain why diving birds dive straight down to catch fish. *(2 marks)*

(4 marks)

4 A student has collected data about different types of plastic block. He measured the mass and the angle of refraction of a ray of light going into the block. Each block is the same size.

Here are his results:

Mass of block (g)	Angle of refraction (°)
250	27
220	32
275	24
300	21

a State **one** variable that the student must keep the same during this investigation. *(1 mark)*

b State the name of the independent variable. *(1 mark)*

c State the name of the dependent variable. *(1 mark)*

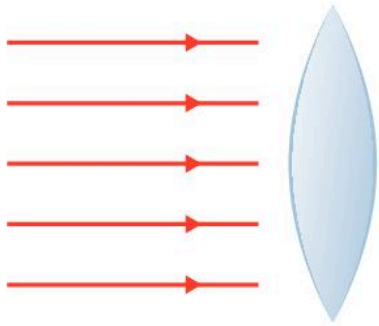
d Describe the relationship between the mass and the angle of refraction. *(1 mark)*

e Describe **one** way that the student could improve the way that the results are presented in the table *(1 mark)*

(5 marks)

5 Copy and complete the diagram below to show what happens when light goes through a lens.

(4 marks)



6 Light slows down from 300 000 km/s to 200 000 km/s in glass and to 226 000 km/s in water. A ray of light enters each medium with an angle of incidence of 40°. State and explain whether the angle of refraction would be bigger or smaller in water than in glass.

(2 marks)

7 Here is some information about the speed of light in different materials. Describe and explain what you would see if you shone rays of light through a lens made of each material.

Material	Speed of light in the material (million km/s)
diamond	125
glass	200
plastic	187

(6 marks QWC)

4.1 The night sky

Learning objectives

After this topic you will be able to:

- describe the objects that you can see in the night sky
- describe the structure of the Universe.

▲ An astronaut on a spacewalk is building part of the ISS.

Foul Fact!

The odds of being killed by falling space debris are one in five billion.

Key Words

artificial satellite, orbit, Earth, Moon, natural satellite, planet, Sun, Solar System, comet, meteor, meteorite, star, galaxy, Milky Way, Universe, astronomer

When you look at the stars in the night sky you do not see them as they are today. The light from them has taken years to get here. You are looking back in time.

Satellites

The nearest objects that you can see without a telescope are **artificial satellites**. They **orbit** the **Earth**. You can see the International Space Station (ISS) with the naked eye (without using binoculars or a telescope). The light reflected from the ISS reaches us in a fraction of a second.

Light reflected from the **Moon** reaches us in just over a second. The Moon orbits the Earth. It is the Earth's only **natural satellite**.

A Name the natural satellite that orbits the Earth.

What is wandering across the sky?

There are five **planets** that most people can see with the naked eye: Mercury, Venus, Mars, Jupiter, and Saturn. Like the Earth they orbit the **Sun**. Venus gets closest to the Earth, about two light-minutes away. Light from Saturn takes about 1.5 hours. The planets form part of the **Solar System**.

B Name the planets that are visible to the naked eye.

Comets and meteors

A **comet** is one of the most spectacular sights in the night sky. They are huge snowballs that orbit the Sun.

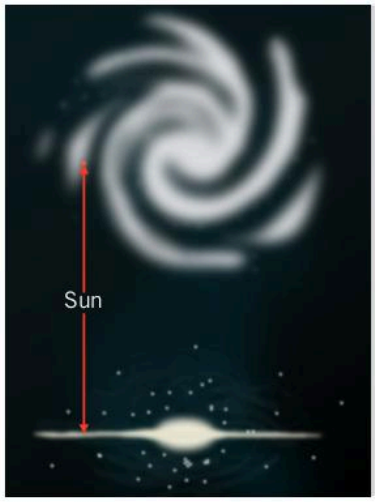
Meteors are bits of dust or rock that burn up as they move through the Earth's atmosphere and produce streaks of light. Any meteor that makes it to the ground is called a **meteorite**.

C Describe how the appearance of a comet is different to the appearance of a meteor.

Lights in the sky

Most of the dots of light that we see are **stars** in our **galaxy**, the **Milky Way**. A galaxy is a collection of stars and there are billions of stars in the Milky Way.

Light takes about eight minutes to get to us from the Sun, our nearest star. Our next nearest star is over four light-years away.



This shows our Sun in our galaxy, the Milky Way. ▶

Some of the dots of light in the night sky are other galaxies. A galaxy contains billions of stars. The Milky Way is just one of billions of galaxies that make up the **Universe**. Our nearest large galaxy is Andromeda, which you can see with the naked eye. Light from Andromeda takes 2 million years to get to Earth.

◀ The Andromeda galaxy is the nearest large galaxy to us.

D State what is meant by a 'galaxy'.

How do we know?

Astronomers have learned about the objects that we see in the night sky from the observations they have made. You cannot do experiments in astronomy. Astronomers use models to work out what makes up the Solar System, the Milky Way, and the Universe.

▲ Comet Hale–Bopp was visible in the night sky in 1997.

Fantastic Fact!

All the elements that you are made of were made in the centre of stars in galaxies.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

There are thousands of satellites in orbit around the **Sun/Earth**. The Moon is a natural satellite of the **Sun/Earth**. Comets are huge snowballs that orbit the **Sun/Earth**. Planets orbit the **Sun/Earth**.

(4 marks)

2 Describe the difference between a meteor and a meteorite.

(2 marks)

3 When you look up at the night sky you see dots of light that don't appear to move. List what the dots of light could be.

(2 marks)

4 Compare the time it takes light to reach us from the different objects that you can see in the night sky.

(6 marks QWC)

4.2 The Solar System

Learning objectives

After this topic you will be able to:

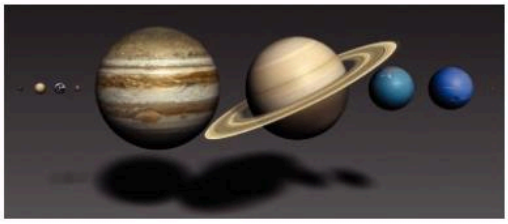
- name the objects in the Solar System
- describe some similarities and differences between the planets of the Solar System.

No-one has ever seen all of the Solar System at once because it is too big. Scientists have used observations to build a model of the Solar System.

What's in our Solar System?

Starting from the Sun and moving outwards the Solar System contains four inner planets and four outer planets. All of the planets orbit the Sun. Each orbit is a slightly squashed circle called an **ellipse**. Between the orbits of Mars and Jupiter there is an **asteroid** belt.

A State the number of planets in the Solar System.



▲ These are NASA images of the planets of the Solar System.

Remember that order!

Before Pluto was renamed a dwarf planet, people used to remember the order of the planets using this mnemonic:
My Very Easy Method Just Speeds Up Naming Planets. A mnemonic uses first letters to make up a sentence. Make up your own mnemonic for the planets as they are now: M, V, E, M, J, S, U, N.

The planets

The inner planets, **Mercury**, **Venus**, Earth, and **Mars**, are all **terrestrial** planets; they are made of rock. The conditions on the planets are very different. Mercury does not have an atmosphere. At night the temperature drops to –170 °C and during the day it can reach 430 °C. Venus has an atmosphere of carbon dioxide that traps energy from the Sun.

◀ The Curiosity rover on Mars takes a picture of itself.

The outer planets are called **gas giants**; they are made mainly of gases such as hydrogen and helium. All of the gas giants are very cold and are much bigger than the inner planets.

Many of the planets have moons in orbit around them. Saturn has 60 moons but Earth has only one.

Key Words

ellipse, asteroid, Mercury, Venus, Mars, terrestrial, gas giant, dwarf planet, gravity

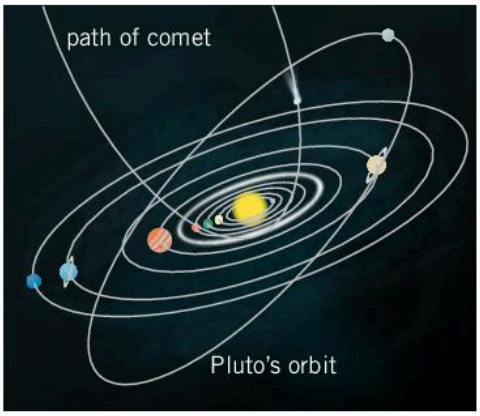
Planet	Diameter (km)	Distance from Sun (million km)	Distance from Sun	Temperature (°C)
Sun	1 391 000	–	–	–
Mercury	4879	58	3.2 light-minutes	–180 to 430
Venus	12 104	108	6.0 light-minutes	465
Earth	12 756	150	8.3 light-minutes	–89 to 58
Mars	6787	228	12.7 light-minutes	–82 to 0
Jupiter	142 800	778	43.3 light-minutes	–150
Saturn	120 660	1427	1 light-hour 19 light-minutes	–170
Uranus	51 118	2871	2 light-hours 39 light-minutes	–200
Neptune	49 528	4498	4 light-hours 10 light-minutes	–210

B List the planets in size order, starting with the smallest.

The asteroid belt

There are thousands of pieces of rock in the asteroid belt. Some are tiny specs of dust but one is large enough to be called a **dwarf planet**. Ceres is the only dwarf planet inside the orbit of Neptune.

Outside the Solar System



◀ This diagram shows how the orbits of Pluto and a comet are different to the orbits of the planets.

Pluto used to be called a planet but in 2006 it was renamed a dwarf planet. Beyond Pluto's orbit is a region called the Kuiper Belt. Astronomers think that most comets come from outside our Solar System in a region called the Oort Cloud, beyond the Kuiper Belt.

How did our Solar System form?

Scientists think that **gravity** pulled the gas and dust together to form our Sun about 5 billion years ago. They think planets formed from a disc of gas and dust surrounding the Sun. Astronomers are looking for evidence from observations of other clouds of gas and dust to see if they can detect planets forming.

Fantastic Fact!

Venus spins in the opposite direction to all the other planets in the Solar System.

Summary Questions

1 Copy and complete the sentences below.

There are _____ inner and _____ outer planets in the Solar System. The band of dust and rocks between Jupiter and Mars is called the _____ _____. Pluto is a _____ planet. Scientists think that most comets come from a region outside the Solar System called the _____ _____.

(5 marks)

2 State one similarity and one difference between the inner and outer planets.

(2 marks)

3 Compare planets and asteroids.

(2 marks)

4 Describe and explain the link between distance from the Sun and temperature of the planets. Explain why Venus is the odd planet out.

(6 marks QWC)

4.3 The Earth

Learning objectives

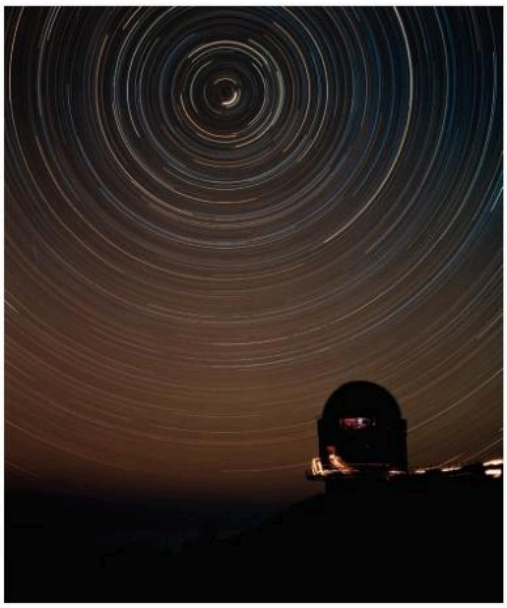
After this topic you will be able to:

- explain the motion of the Sun, stars, and Moon across the sky
- explain why seasonal changes happen

Is the Earth special? Astronomers have discovered hundreds of planets orbiting other stars. They call these exoplanets. So far Earth is the only planet known to contain life.

The spinning Earth

The Earth spins on its **axis**. If you take a photograph over a long time the stars appear to move in circles. This shows that the Earth is spinning.



▲ This photograph of the night sky was taken over 10.5 hours.

A Describe how you can demonstrate that the Earth is spinning.

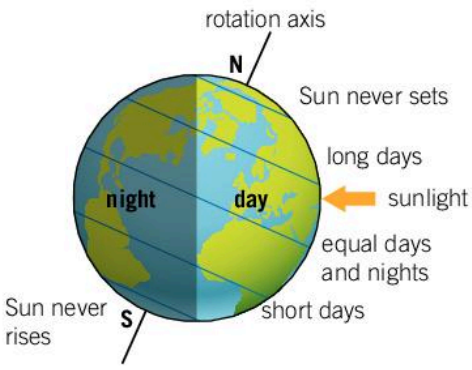
There is **day** and **night** on Earth because Earth spins on its axis. It takes 24 hours to complete one full spin.

The Sun rises in the east each morning, reaches its highest point at noon, and then sets in the west in the evening. The Sun isn't moving. You are.

B State the direction in which the Sun rises.

The orbiting Earth

The Earth moves around the Sun once each **year**. The Earth takes 365.2422 days to orbit the Sun. There is an extra day in a leap year every four years.



▲ When the Earth spins, half the Earth is in the light and half is in the dark.

Spin and orbit

Write the shortest sentence that you can to explain day length and year length using these words:

spin, day, night, orbit, year

Over the year the height of the Sun at noon, average daily temperature, and stars that you see at night all change during the different **seasons**.

The Earth's axis is tilted by 23.4°.

It is hotter in the summer than the winter because the tilt of the Earth's axis means that the Sun's rays spread over a smaller area and the days are longer.

In the summer in the North Pole the tilt of the axis means that the Sun doesn't set. This is called the 'Land of the Midnight Sun'. In the winter the Sun does not rise, giving a 'polar night'. This also happens at the South Pole.

Key Words

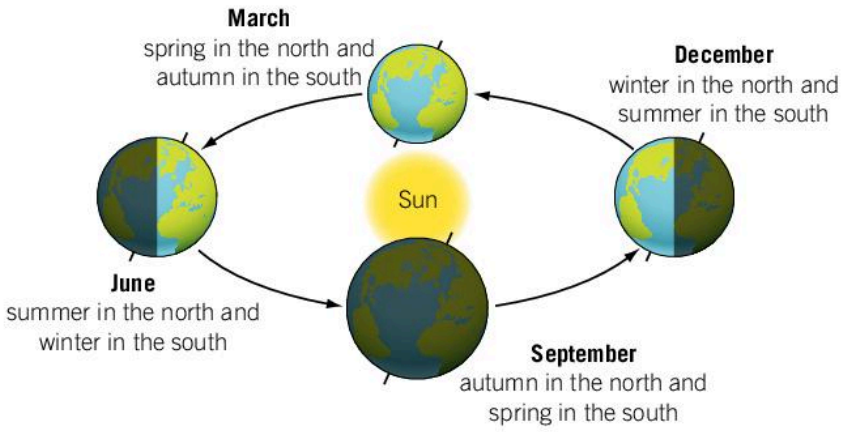
exoplanet, axis, day, night, year, season, constellation

▲ The Sun never sets – this shows the Sun in the Arctic over a 24-hour period in the summer.

February 29th?

It takes 21 600 seconds longer to orbit the Sun than just the 365 days you use for one year. Show that in 4 years these extra seconds add up to one whole day.

The groups of stars, or **constellations**, that we see in the summer at night are different to the stars that we see in the winter. This is because the Earth is moving around the Sun. The side of the Earth that has night is facing different stars at different times of the year.



▲ The Sun's light is spread out over a bigger area in the winter.

Summary Questions

1 Copy the sentences below, choosing the correct bold word.

You see the Sun rise in the **east/west** and set in the **east/west** because the Earth **spins/orbits**. A **month/year** lasts approximately 365 days. This is the time that it takes the Earth to **orbit the Sun/spin once**. The days are **longer/shorter** in the summer and the Sun is **higher/lower** in the sky at noon.

(7 marks)

2

a Explain why it is hotter in the summer than it is in the winter.

(2 marks)

b Explain why the shadow of a fence post is longer in the winter than in the summer.

(1 mark)

3 Explain in detail what you would experience throughout the year if the axis of the Earth was not tilted.

(6 marks QWC)

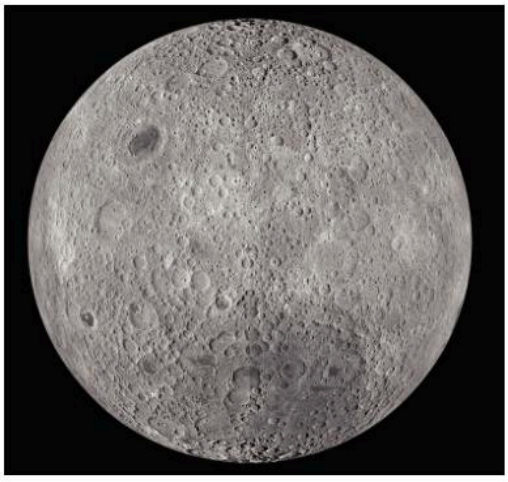
4.4 The Moon

Learning objectives

After this topic you will be able to:

- describe the phases of the Moon
- explain why you see phases of the Moon
- explain why eclipses happen.

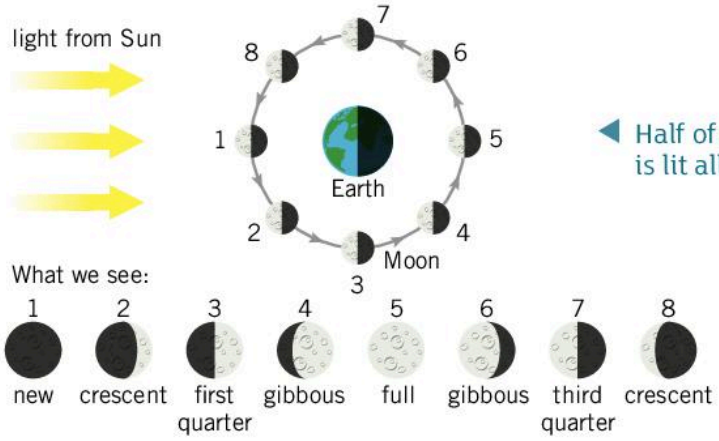
Many years ago, people used to have different ideas about space. The Ancient Chinese thought a solar eclipse was a demon eating the Sun. In other civilisations, people linked the changing appearance of the Moon with strange changes in behaviour.



▲ There is a side of the Moon that you never see from Earth.

Why does the Moon look different?

The Moon takes 27 days and 7 hours to orbit the Earth once.



◀ Half of the Moon is lit all the time.

A List the phases of the Moon, starting with a full moon.

Half the Moon is lit up by the Sun all the time. As the Moon moves around the Earth it looks different from the Earth. The changing shapes are called **phases of the Moon**. When the Moon is in position 1 you see a 'new' moon. You see the side of the Moon that is in shadow. The Moon moves around the Earth to position 2 and you see a crescent moon. In position 5, the Sun lights up the whole of the side that you can see from the Earth and you see a full moon.

A lunar month is the period of time from one new moon to the next new moon.

B State how much of the Moon's surface is lit up by the Sun during a new moon.

Farewell, Moon

The Moon is 38 000 000 000 cm away and is moving away from the Earth at a rate of about 3.8 cm per year. Work out how much closer to the Earth it was when you were born.

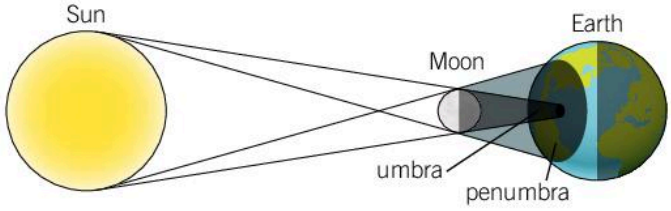
Fantastic Fact!

A 'blue' moon happens when there are two full moons in one calendar month. It happens quite often, about once every three years.

Why do we see eclipses?

Solar eclipses

When the Moon comes between the Sun and the Earth it makes a shadow on the Earth's surface. If you are standing in the **umbra**, the Moon completely blocks the light from the Sun and you see a **total solar eclipse**. If you are standing where only part of the Sun's light is blocked (the **penumbra**) you will see a **partial solar eclipse**.

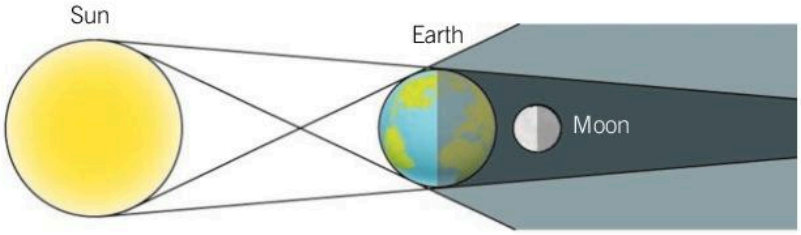


▲ A solar eclipse happens when the Moon blocks the light from the Sun.

C State the name of the deep shadow that produces a total solar eclipse.

Lunar eclipses

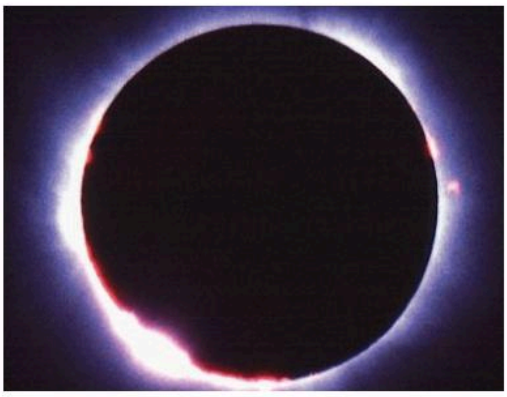
A **lunar eclipse** happens when the Earth comes between the Sun and the Moon.



Far side of the Moon

The Moon spins on its axis but the time it takes to spin all the way around is the same time that it takes to orbit the Earth. This means that the same side of the Moon always faces the Earth. There is a side that you never see.

This doesn't mean there is a side of the Moon that is always in the dark. When you are looking at a new moon the Sun is lighting up the side of the Moon that you can't see.



▲ You can see a total eclipse of the Sun.

Key Words

phases of the Moon, umbra, total solar eclipse, penumbra, partial solar eclipse, lunar eclipse

Summary Questions

1 Copy and complete the sentences below.

You see a _____ moon when the Sun lights up the whole of the side that you can see. When the side of the Moon that you can see is in shadow you see a _____ moon. A solar eclipse happens when the _____ comes between the Sun and the _____. A lunar eclipse happens when the _____ comes between the Sun and the _____.

(6 marks)

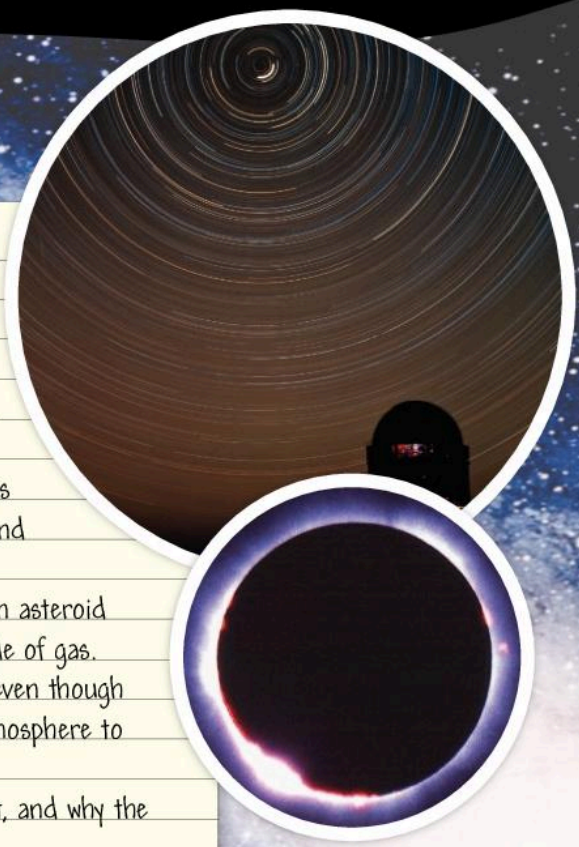
2 Explain why you would see an eclipse on some of the planets in the Solar System but not others.

(1 mark)

3 Describe how you could use a torch, a beach ball, and a tennis ball to demonstrate the difference between a solar eclipse and a lunar eclipse.

(6 marks QWC)

P1 Chapter 4 Summary



Key Points

- You can see satellites, the International Space Station, the Moon, comets, meteors, planets, stars, and galaxies in the night sky.
- The distances to objects in the night sky can be measured in light-time (light-seconds, light-minutes, light-hours, and light-years).
- The natural objects that you see are made of mixtures of gas, dust, rock, and ice.
- The Universe consists of millions of galaxies. Each galaxy contains billions of stars. Each star may have planets, asteroids, and comets in orbit around them. Each planet may have moons in orbit around them.
- There are four rocky inner planets (Mercury, Venus, Earth, and Mars), an asteroid belt, and four outer planets (Jupiter, Saturn, Uranus, and Neptune), made of gas.
- Planets further from the Sun are colder. Venus is hotter than Mercury, even though it is further from the Sun. This is because Mercury does not have an atmosphere to trap energy.
- The Earth spins on its axis once a day. This is why we have day and night, and why the Sun and stars appear to move across the sky.
- The Earth orbits the Sun in one year. The axis of the Earth is tilted and this explains the height of the Sun at noon, day length, temperature, and constellations that you see change during the year.
- You see phases of the Moon because the Moon is orbiting the Earth. Half of the Moon is always lit by the Sun.
- A solar eclipse happens when the Moon is between the Sun and the Earth. A lunar eclipse happens when the Earth is between the Sun and the Moon.

Key Words

star, artificial satellite, orbit, Earth, Moon, natural satellite, planet, Sun, Solar System, comet, meteor, meteorite, star, galaxy, Milky Way, Universe, astronomer, ellipse, asteroid, Mercury, Venus, Mars, terrestrial, gas giant, dwarf planet, gravity, exoplanet, axis, day, night, year, season, constellation, phases of the Moon, umbra, total solar eclipse, penumbra, partial solar eclipse, lunar eclipse

BIG Write

A new Earth...?

The table shows some information about the planet Pegasi b and Earth.

	51 Pegasi b	Earth
Distance from the star (million km)	7.7	150
Time to orbit the Sun (days)	4	365
Time to spin once on its axis (days)	4	1
Tilt of the axis (degrees)	79	23.5

Task

Write a guide to the new planet, comparing it to Earth and other planets in the Solar System.

Tips

- Could there be life on Pegasi b?

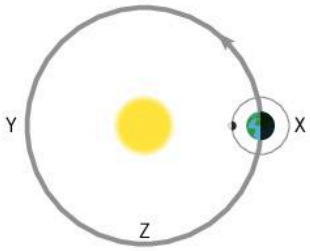
End-of-chapter questions

1 Here is a list of objects that you can see in the night sky. Sort the objects into those that are in orbit around the Sun and those that are in orbit around the Earth.

comet planet Moon satellite asteroid International Space Station

*(**2 marks**)*

2 The diagram shows the Earth in orbit around the Sun:



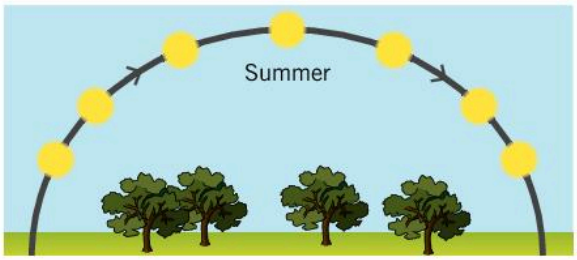
a Copy the diagram and label the Sun, the Earth, and the Moon. *(3 marks)*

b It is summer in the southern hemisphere when the Earth is at position X. State which season it would be when the Earth is at position Y. *(1 mark)*

c State how many months it would take the Earth to move between X and Z. *(1 mark)*

*(**5 marks**)*

3 This diagram shows how the Sun moves across the sky during the day in summer:



a Copy the diagram and add these labels: east, west, sunrise, sunset, noon *(2 marks)*

b On the diagram sketch the path of the Sun in winter. *(2 marks)*

c Explain why the path of the Sun in the sky is different in autumn and in winter. *(2 marks)*

*(**6 marks**)*

4 Here are some objects in the Universe:

Sun inner planet outer planet galaxy our nearest star Moon

a State which object or objects are a distance of light-seconds away and which are light-years away. *(2 marks)*

b Describe a problem with communicating with people on a spacecraft travelling through the Solar System. *(2 marks)*

*(**4 marks**)*

5 The table below shows the angle of tilt of the axes of all the planets in the Solar System.

Use the information in the table and your scientific knowledge to describe the seasonal changes on each of the planets and compare them to conditions on Earth.

*(**6 marks QWC**)*

Planet	Angle of tilt (°)	Planet	Angle of tilt (°)
Mercury	0	Jupiter	3
Venus	177	Saturn	27
Earth	23.5	Uranus	98
Mars	25	Neptune	30

Glossary

absorb Taken into a material.
accurate Close to the true value of what you are measuring.
acid An acid is a solution with a pH value less than 7.
acidic solution An acidic solution has a pH less than 7.
adolescence The period of time when a child changes into an adult.
air resistance The force on an object moving through the air that causes it to slow down (also known as drag).
alkali An alkali is a soluble base.
alkaline solution An alkaline solution has a pH greater than 7.
alveolus (air sac) A structure inside the lungs where gas exchange takes place with the blood.
amoeba A unicellular organism.
amplifier A device for making a sound louder.
amplify To increase the amplitude of a sound so that it sounds louder.
amplitude The distance from the middle to the top or bottom of a wave.
analyse The process of looking at data and writing about what you have found out.
angle of incidence The angle between the incident ray and the normal line.
angle of reflection The angle between the reflected ray and the normal line.
antagonistic muscles A pair of muscles that work together to control movement at a joint – as one muscle contracts, the other relaxes.
anther The part of a flower that produces pollen.
artificial satellite A manmade spacecraft.
asteroid Lumps of rock orbiting the Sun left over from when the Solar System formed.
astronomer A scientist who studies space.
atom The smallest part of an element that can exist.
audible range The range of frequencies that you can hear.
auditory canal The passage in the ear from the outer ear to the eardrum.
auditory nerve An electrical signal travels along the auditory nerve to the brain.
axis (Earth) The imaginary line that the Earth spins around.

balanced (forces) Forces acting on an object that are the same size but act in opposite directions.
balanced symbol equation In a balanced symbol equation, chemical formulae represent the reactants and products. The equation shows how atoms are rearranged, and gives the relative amounts of reactants and products.
bar chart A way of presenting data when one variable is discrete or categoric and the other is continuous.
base A base is a substance that neutralises an acid.
boiling The change of state from liquid to gas that occurs when bubbles of the substance in its gas state form throughout the liquid.
boiling point The temperature at which a substance boils.
bone A tissue that forms a hard structure, used to protect organs and for movement.
brain The organ in the human body that processes signals from receptors

carpel The female reproductive part of the flower.
cartilage The strong, smooth tissue that covers the end of bones to prevent them rubbing together.

categoric A variable that has values that are words.

cell The smallest functional unit in an organism – the building block of life.

cell membrane The cell component that controls which substances can move into and out of the cell.

cell wall The plant cell component that surrounds the cell, providing support.

cervix The ring of muscle at the entrance to the uterus. It keeps the baby in place while the woman is pregnant.

change of state The process by which a substance changes from one state to another.

charge-coupled device (CCD) A grid of pixels at the back of a digital camera that absorbs light and produces an image.

chemical formula A formula that shows the relative number of atoms of each element in a compound.

chemical reaction A change in which atoms are rearranged to create new substances.

chemical symbol A one- or two-letter code for an element that is used by scientists in all countries.

chloroplast The plant cell component where photosynthesis takes place.

cilia Tiny hairs on the surface of cells.

cochlea Snail-shaped tube in the inner ear with the sensory cells that detect sound.

collide To bump into, or hit, a particle or surface.

combustion A chemical reaction in which a subsance reacts quickly with oxygen and gives out light and heat. Also called burning.

comet Dust particles frozen in ice that orbit the Sun.

compound A substance made up of atoms of two or more elements, strongly joined together.

compress To squash into a smaller space.

compression The part of a longitudinal wave where the air particles are close together.

concentrated A solution is concentrated if it has a large number of solute particles per unit volume (litre or cubic metre).

concentration A measure of the number of particles of a substance in a given volume.

conclusion What you write down to say what you have found out during an investigation.

condense The change of state from gas to liquid.

condom A barrier method of contraception, which prevents semen being released into the vagina.

confidence (in a conclusion) How sure you are of your conclusion based on the data.

conservation of mass In a chemical reaction, the total mass of reactants is equal to the total mass of products. This is conservation of mass. Mass is conserved in chemical reactions and in physical changes.

constellation A collection of stars that make a pattern in the sky.

contact force A force that acts when an object is in contact with a surface, air, or water.

continuous A variable that has values that can be any number.

contraception A method of preventing pregnancy.

contraceptive pill A chemical method of contraception.

control variable A variable that you have to keep the same in an investigation.

converging (lens) Bringing rays of light together.

convex (lens) A lens that produces converging rays of light.

cornea The transparent layer at the front of the eye.

corrosive A substance is corrosive if it can burn your skin or eyes.

crest The top of a wave.

cytoplasm A 'jelly-like' substance found in cells, where all the chemical reactions take place.

data Words or numbers that you obtain when you make observations or measurements.

day The time it takes a planet to make one full spin on its axis.

decibel A commonly used unit of sound intensity or loudness (dB).

decomposition A chemical reaction in which a compound breaks down to form simpler compounds and/or elements.

deform To change shape.

dependent variable A variable that changes when you change the independent variable.

diaphragm (breathing) The sheet of muscle used in breathing.

diaphragm (microphone) The part of the microphone that vibrates when a sound wave hits it.

diffuse reflection Reflection from a rough surface.

diffusion The movement of liquid or gas particles from a place of high concentration to a place of low concentration.

dilute A solution is dilute if it has a small number of solute particles per unit volume (litre or cubic metre).

discrete A variable that can only have whole-number values.

dispersion The splitting up of a ray of light of mixed wavelengths by refraction into its components.

drag force The force acting on an object moving through air or water that causes it to slow down.

driving force The force that is pushing or pulling something.

dwarf planet A small lump of rock in orbit around the Sun.

ear The organ of the body that detects sound.

eardrum A membrane that transmits sound vibrations from the outer ear to the middle ear.

Earth A rocky inner planet, third from the Sun in the Solar System.

echo A reflection of a sound wave by an object.

ejaculation When semen is released from the penis.

elastic limit The point beyond which a spring will not return to its original length when the force is removed.

electrostatic force The force acting between two charged objects.

element A substance that cannot be broken down into other substances.

ellipse A squashed circle or oval shape.

embryo A ball of cells that forms when the fertilised egg divides.

emit To give out.

endoscope A medical instrument for seeing inside the human body.

endothermic change An endothermic change transfers energy from the surroundings.

energy Energy is needed to make things happen.

equilibrium Balanced.

euglena Unicellular organism that performs photosynthesis.

evaluate To discuss the quality of data collected during an investigation and suggest improvements to the method.

evaporate The change of state from liquid to gas that occurs when particles leave the surface of the liquid only. It can happen at any temperature.

evidence Observations and measurements that support or disprove a scientific theory.

exhale Breathing out, to remove carbon dioxide.

exoplanets A planet in orbit around a star other than our Sun.

exothermic change An exothermic change transfers energy to the surroundings.
extension The amount by which an object gets longer when a force is applied.
eye Organ of sight, which focuses and detects light.

fertilisation The process where the nucleus of a sperm cell joins with the nucleus of an egg cell.
fetus The name given to an unborn baby from eight weeks of development.
field A region where something feels a force.
filament The part of a flower that holds up the anther.
filter A piece of material that allows some radiation (colours) through but absorbs the rest.
flagellum A tail-like structure that allows euglenas to move.
fluid sac Contains fluid. This acts as a shock absorber, protecting the fetus from bumps.
focal point The point at which the rays refracted by a convex lens cross over.
focus Another name for the focal point.
fossil fuel A fuel made from the remains of animals and plants that died millions of years ago. Fossil fuels include coal, oil, and natural gas.
freezing The change of state from liquid to solid.
frequency The number of complete waves or vibrations produced in one second (measured in hertz).
friction The force that resists movement because of contact between surfaces.
fruit The part of a plant that contains seeds.
fuel A material that burns to transfer useful energy.

galaxy A number of stars and the solar systems around them grouped together.
gametes Reproductive cells. The male gamete is a sperm cell and the female gamete is an egg cell.
gas In the gas state, a substance can flow and can also be compressed.
gas exchange The transfer of gases between an organism and its environment.
gas giant An outer planet in the Solar System, made mainly from gas.
gas pressure The force exerted by gas particles per unit area of a surface.
germination The period of time when a seed starts to grow.
gravity A non-contact force that acts between two masses.

hazard A possible source of danger.
hertz The unit of frequency (Hz).
Hooke's Law A law that says that if you double the force on an object the extension will double.
hormones Chemical messengers that travel around the body in the blood.

image The point from which rays of light entering the eye appear to have originated.
implantation The process where an embryo attaches to the lining of the uterus.
incident ray The ray coming from a source of light.
incident wave The wave coming from a source.
independent variable A variable you change that changes the dependent variable.
indicator A substance that changes colour to show whether a solution is acidic or alkaline.
infrasound Sound below a frequency of 20 Hz.
inhale Breathing in, to take in oxygen.
inner ear The semi-circular canals that help you to balance, and your cochlea.
interaction pair When two objects interact there is a force on each one that is the same size but in opposing directions.
inverted Upside down.
investigation An experiment or set of experiments designed to produce data to answer a scientific question or test a theory.
iris The coloured part of your eye.

joint A part of the skeleton where two bones join together.

kilogram "A unit of mass, symbol kg.
kilohertz 1 kilohertz (kHz) = 1000 hertz (Hz)

law of reflection The angle of incidence is equal to the angle of reflection.
leaf cell The plant cells that contain chloroplasts, where photosynthesis takes place.
lens A device made of shaped glass that focuses light rays from objects to form an image.
ligament Joins two bones together.
light-time Distance measured in terms of how far light travels in a given time.
line graph A way of presenting results when there are two numerical variables.
line of best fit A smooth line on a graph that travels through or very close to as many of the points plotted as possible.
liquid In the liquid state, a substance can flow but cannot be compressed.
litmus An indicator. Blue litmus paper goes red on adding acid. Red litmus paper goes blue on adding alkali.
longitudinal A wave where the vibrations are in the same direction as the direction the wave moves.
loudness How loud you perceive a sound of a certain intensity to be.

lubrication A substance that reduces friction between surfaces when they rub together.
luminous Gives out light.
lunar eclipse An eclipse that happens when the Earth comes between the Sun and the Moon.
lungs The organ in which gas exchange takes place.

magnetic force The force between two magnets, or a magnet and a magnetic material.
Mars A rocky inner planet, fourth from the Sun in the Solar System.
mass The amount of matter (stuff) a thing is made up of.
material The different types of stuff that things are made from.
mean An average of a set of data, found by adding together all the values in the set and dividing by the number of values in the set.
medium The material that affects light or sound by slowing it down or transferring the wave.
melting The change of state from solid to liquid.
melting point The temperature at which a substance melts.
menstrual cycle The monthly cycle during which the uterus lining thickens, and then breaks down and leaves the body if an egg is not fertilised.
Mercury A rocky inner planet, closest to the Sun in the Solar System.
meteor A piece of rock or dust that makes a streak of light in the night sky.
meteorite A stony or metallic object that has fallen to Earth from outer space.
microphone A device for converting sound into an electrical signal.
microscope An optical instrument used to magnify objects, so small details can be seen clearly.
middle ear The ossicles (small bones) that transfer vibrations from the outer ear to the inner ear.
Milky Way The galaxy containing our Sun and Solar System.
mitochondria The cell component where respiration takes place.
mixture A material whose properties are not the same all the way through.

molecule A group of two or more atoms, strongly joined together.
Moon A rocky body orbiting Earth; it is Earth's only natural satellite.
multicellular Made of many cells.
multicellular organism An organism made up of many cells.
natural satellite A moon in orbit around a planet.
nerve cell An animal cell that transmits electrical impulses around the body.

neutral A solution that is neither alkaline nor acidic. Its pH is 7.
neutralisation In a neutralisation reaction, an acid cancels out a base or a base cancels out an acid.
newton The unit of force, symbol N.
newtonmeter A piece of equipment used to measure weight in newtons.
night The period on one section of the Earth or other planet when it is facing away from the Sun.
non-contact force A magnetic, electrostatic, or gravitational force that acts between objects not in contact.
non-luminous Objects that produce no light.
non-renewable Some fuels are non-renewable. They form over millions of years, and will one day run out.
normal An imaginary line at right angles to a surface where a light ray strikes it.
nucleus The cell component that controls the cell and contains genetic material.

observation Carefully looking at an object or process.
opaque Objects that absorb, scatter, or reflect light and do not allow any light to pass through.
optic nerve A paired sensory nerve that runs from each eye to the brain.
orbit The path taken by one body in space around another.
organ A group of tissues working together to perform a function.
organ systen A group of organs working together to perform a function.
organism A living thing.
oscillation Something that moves backwards and forwards.
oscilloscope A device that enables you to see electrical signals, like those made by a microphone.
ossicles The small bones of the middle ear (hammer, anvil, and stirrup) that transfer vibrations from the eardrum to the oval window.
outer ear The pinna, auditory canal, and eardrum.
outlier A result that is very different from the other measurements in a data set.
oval window The membrane that connects the ossicles to the cochlea.
ovary (human) Contains egg cells.
ovary (plant) The part of a flower that contains ovules.
oviduct Tube that carries an egg to the uterus.
ovulation The release of an egg from an ovary.
ovule The female gamete of a plant.
oxidation A chemical reaction in which substances react with oxygen to form oxides.

partial eclipse A solar eclipse where only part of the Sun is covered by the Moon.
particle The tiny things that materials are made from.
peak The top of a wave.
penis The structure that carries sperm and semen out of the body.
penumbra The area of blurred or fuzzy shadow around the edges of the umbra.
period Loss of uterus lining through the vagina.
Periodic Table A table of all the elements, in which elements with similar properties are grouped together.

petal The brightly coloured part of a flower that attracts insects.

pH scale The pH scale shows whether a substance is acidic, alkaline, or neutral. An acid has a pH below 7. An alkaline solution has a pH above 7. A solution of pH 7 is neutral.

phases of the Moon Shape of the Moon as we see it from Earth.

photoreceptor A specialised cell that is sensitive to light.

photosynthesis A chemical reaction where carbon dioxide and water are converted into oxygen and glucose.

physical change A change that is reversible, in which new substances are not made. Examples of physical changes include changes of state, and dissolving.

pie chart A way of presenting data when one variable is discrete or categoric and the other is continuous.

pinhole camera A simple camera made of a box with a small hole at the front and a screen at the back.

pinna The outside part of the ear that we can see.

pitch A property of sound determined by its frequency.

pixel A picture element found at the back of a digital camera.

placenta The organ where substances pass between the mother's and the fetus's blood. It acts as a barrier, stopping infections and harmful substances reaching the fetus.

plan A description of how you will use equipment to collect valid data to answer a scientific question.

plane A mirror with a flat, reflective surface.

planet Any large body that orbits a star in a Solar System.

pollen The male gamete of a plant.

pollination The transfer of pollen from the anther to the stigma.

precise This describes a set of repeat measurements that are close together.

prediction A statement that says what you think will happen.

pregnant When a baby is growing inside a woman she is pregnant.

primary colour The colours red, blue, and green.

prism A triangular-shaped piece of glass used to produce a spectrum of light.

product A substance that is made in a chemical reaction.

property A quality of a substance or material that describes its appearance, or how it behaves.

puberty The physical changes that take place during adolescence.

pull A type of force.

pupil The hole in the front of your eye where light goes in.

push A type of force.

random (error) A error that causes there to be a random difference between a measurement and the true value each time you measure it.

range The difference between the lowest and highest values a variable can have.

rarefaction The part of a longitudinal wave where the air particles are spread out.

reactant A starting substance in a chemical reaction.

reaction The support force provided by a solid surface like a floor.

real (image) An image that you can put on a screen; the image formed in your eyes.

receiver The device that absorbs the sound waves.

red blood cell An animal cell that transports oxygen around the body.

reflect Bounce off.

reflected ray The ray that is reflected from a surface.

reflected wave The wave that is reflected from a surface.

reflection The change in direction of a ray or wave after it hits a surface and bounces off.

refraction The change in direction of a ray or wave as a result of its change in speed.

repeatable (results) When you repeat measurements in an investigation and get similar results they are repeatable.

reproducible (results) When other people carry out an investigation and get similar results to the orginal investigation the results are repeatable.

resistive force Any force that acts to slow down a moving object.

respiration A chemical reaction where food and oxygen are converted into energy, water, and carbon dioxide.

respiratory system The organs involved in gas exchange.

retina The layer of light sensitive cells at the back of the eye.

reverberation The persistence of a sound for a longer period than normal.

ribcage The bones that protect the lungs.

risk The chance of damage or injury from a hazard.

risk assessment A description of how you will make it less likely that people will be injured, or equipment damaged, and what to do if this happens.

root hair cell A plant cell that takes in water and minerals from the soil.

salt A salt is a compound in which the hydrogen atoms of an acid are replaced by atoms of a metal element.

scrotum The bag of skin that holds the testes.

season Changes in the temperature during the year as the Earth moves around its orbit.

secondary colour Colours that can be obtained by mixing two primary colours.

seed The structure that develops into a new plant.

seed dispersal The movement of seeds away from the parent plant.

semen Fluid containing sperm.

sepal The special leaves found under the flower, which protect unopened buds.

sexual intercourse The process where the penis releases semen into the vagina.

skeleton All the bones in an organism.

solar eclipse An eclipse where the Moon comes between the Sun and the Earth.

Solar System The Sun and the planets and other bodies in orbit around it.

solid In the solid state, a substance cannot be compressed and it cannot flow.

sound A series of compressions and rarefactions that move through a medium.

source (light or sound) Things that emit (give out) light or sound.

specialised cell A cell whose shape and structure enable it to perform a particular function.

spectrum A band of colours produced when light is spread out by a prism.

specular reflection Reflection from a smooth surface.

speed of light The distance light travels in one second (300 million m/s).

speed of sound The distance sound travels in one second (330 m/s).

sperm cell A cell containing male genetic material.

sperm duct Tube that carries sperm from the testes to the penis.

spread The difference between the highest and lowest measurements of a set of repeat measurements.

stamen The male reproductive part of the flower.

star A body in space that gives out its own light.

states of matter The three forms in which a substance can exist – solid, liquid, and gas.

stigma The part of a flower that is sticky to catch grains of pollen.
streamlined Shaped to reduce resistance to motion from air or water.
stretch An object can be stretched if you exert a force on it.
style The part of a flower that holds up the stigma.
sublime The change of state from solid to gas.
substance A material that is not a mixture. It has the same properties all the way through.
Sun The star at the centre of our Solar System.
superpose When waves join together so that they add up or cancel out.
systematic (error) An error that causes there to be the same difference between a measurement and the true value each time you measure it.

tendon Joins a muscle to a bone.
tension A stretching force.
terrestrial Made of rock.
tertiary colour A colour made by mixing three primary colours.
testes The testes produce sperm and the male sex hormones.
tissue A group of similar cells working together to perform a function.
total eclipse An eclipse where all of the Sun is covered by the Moon.
translucent Objects that transmit light but diffusing (scattering) the light as it passes through.
transmit When light or other radiation passes through an object.
transmitter (light or sound) A device that gives out light or sound.
transparent Objects that transmit light and you can see through them.
transverse The vibrations are at right angles to the direction the wave moves.
trough The bottom of a wave.

ultrasound Sound at a frequency greater than 20 000 Hz, beyond the range of human hearing.
umbilical cord Connects the fetus to the placenta.
umbra The area of total shadow behind an opaque object where no light has reached.
unbalanced (forces) Opposing forces on an object that are unequal.
uncertainty The doubt in the result because of the way that a measurement is made.
unicellular Consisting of just one cell.
universal indicator An indicator that changes colour to show the pH of a solution. It is a mixture of dyes.
Universe Everything that exists.
upthrust The force on an object in a liquid or gas that pushes it up.
urethra Tube that carries urine or sperm out of the body.
uterus Where a baby develops until its birth.

vacuole The plant cell component that contains cell sap and helps to keep the cell firm.
vacuum A space in which there is no matter.
vagina Receives sperm during sexual intercourse. This is where the male's penis enters the female's body.
variable A quantity that can change, for example, time, temperature, length, mass.
Venus A rocky inner planet, second from the Sun in the our Solar System.
vibration Backwards and forwards motion of the parts of a liquid or solid.
virtual An image that cannot be focused onto a screen.
vocal chords The pieces of skin that vibrate to produce sound.

water resistance The force on an object moving through water that causes it to slow down (also known as drag).

wave A vibration that transfers energy.

wavelength The distance between two identical points on the wave.

weight The force of the Earth on an object due to its mass.

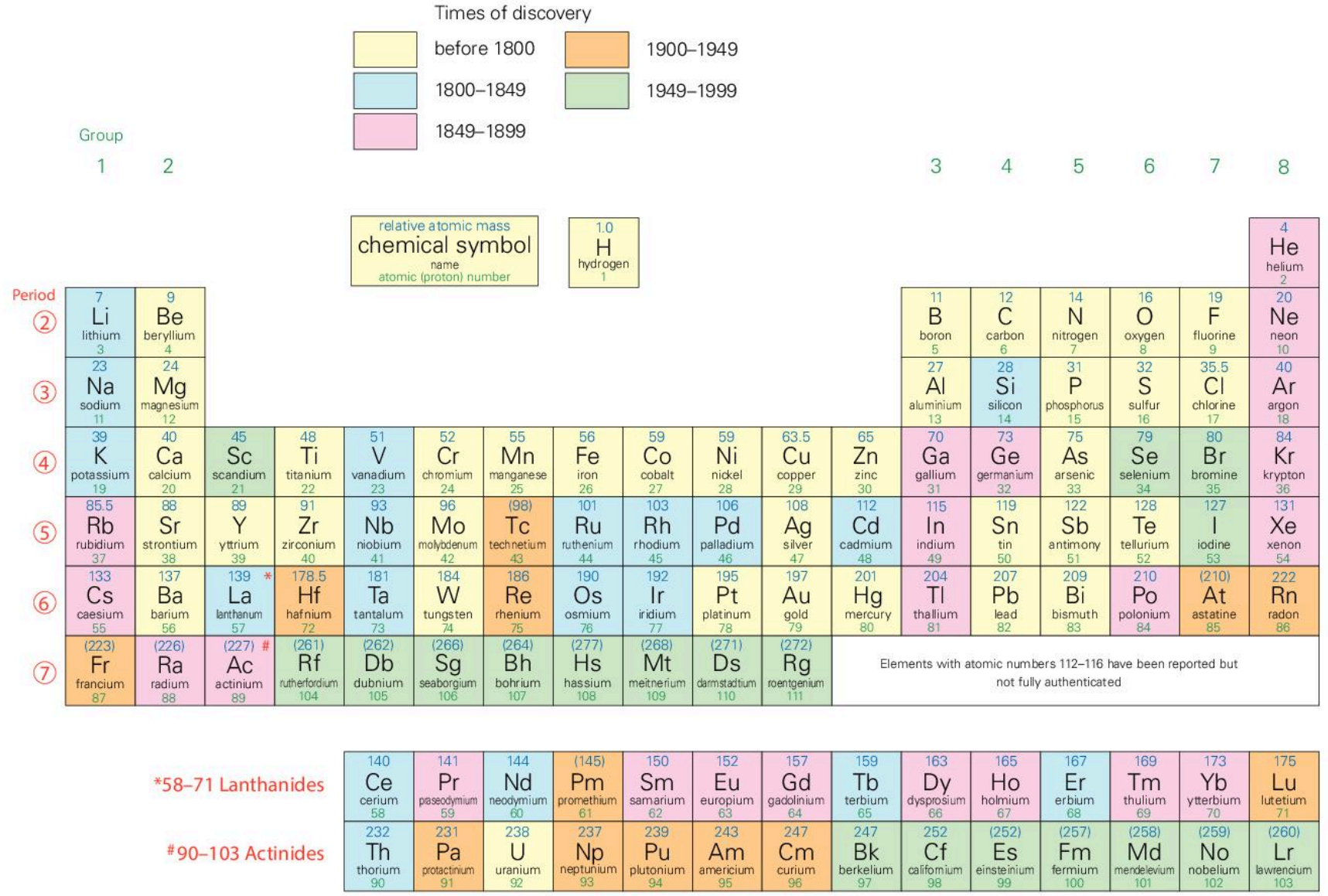
windpipe (trachea) The structure through which air travels from the mouth to the lungs.

word equation A way of representing a chemical reaction simply. The reactants are on the left of an arrow, and the products are on the right. The arrow means *reacts to make*.

year The length of time it takes for a planet to orbit the Sun.

Index

The Periodic Table



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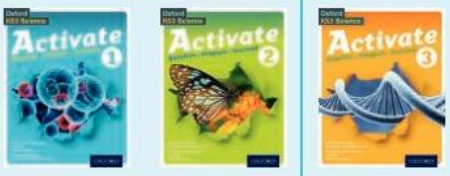
Student Books				Packed full of activities, questions, and interesting facts to engage and inspire students.
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