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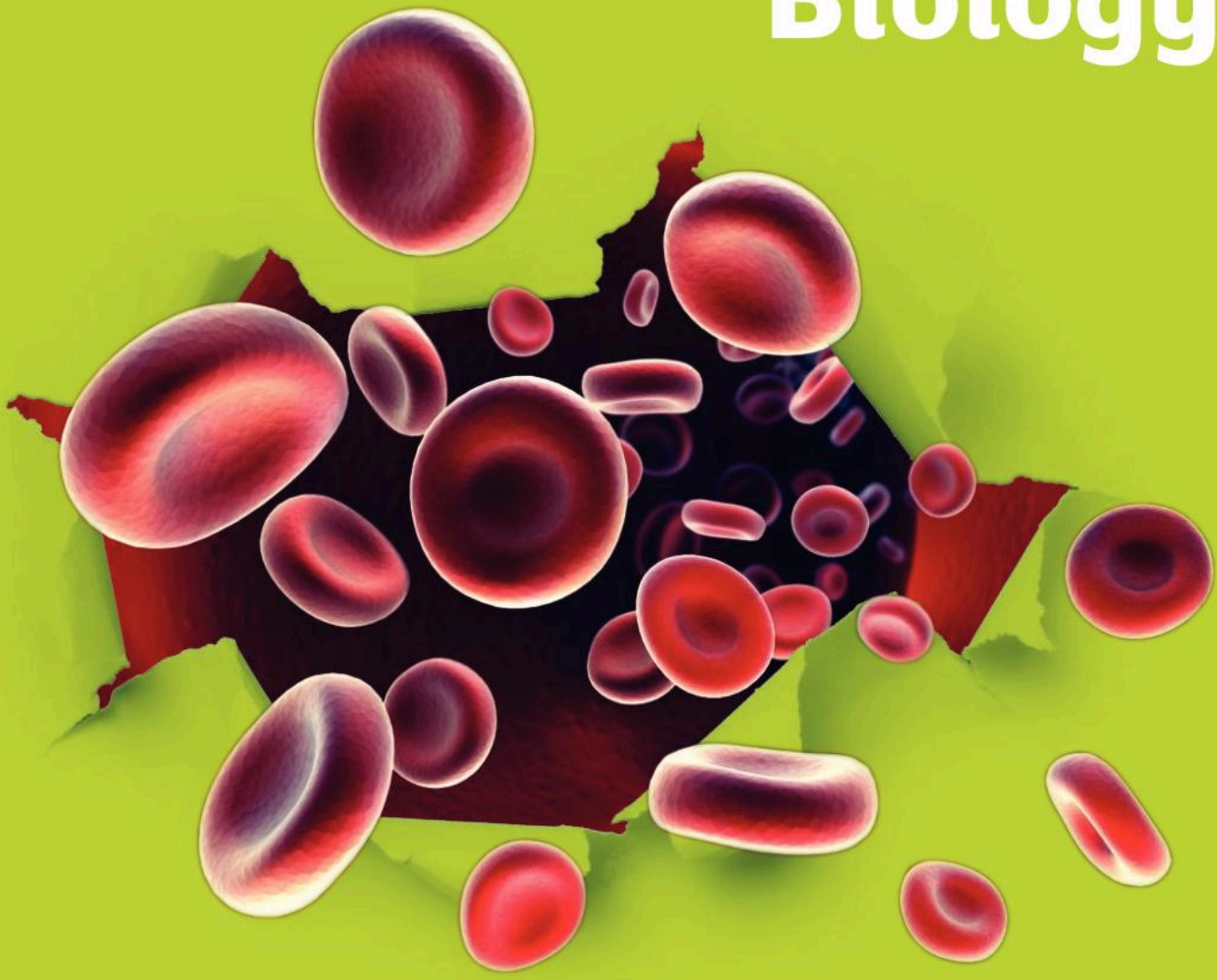

Jo Locke

Assessment Editor
Dr Andrew Chandler-Grevatt

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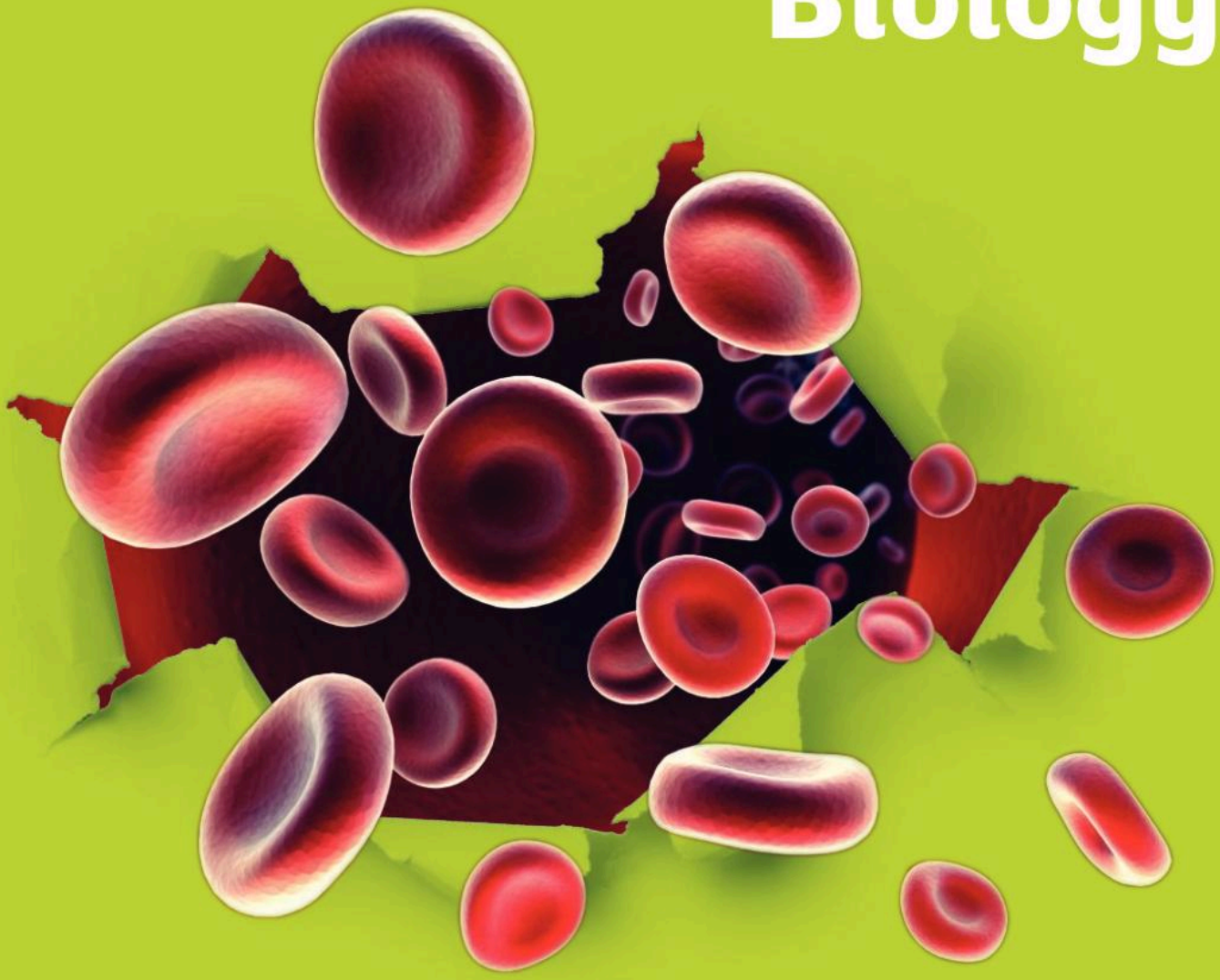

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Introduction

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

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

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

Maths skills

Biologists 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 biology. They also contain useful hints and tips.

Literacy skills

Biologists 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

Biologists 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!

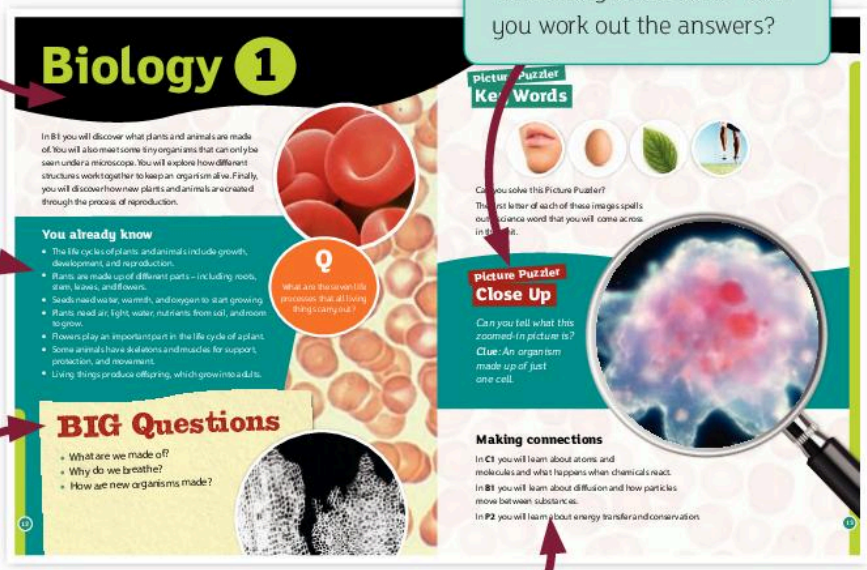
These interesting facts relate to something in the topic.

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.

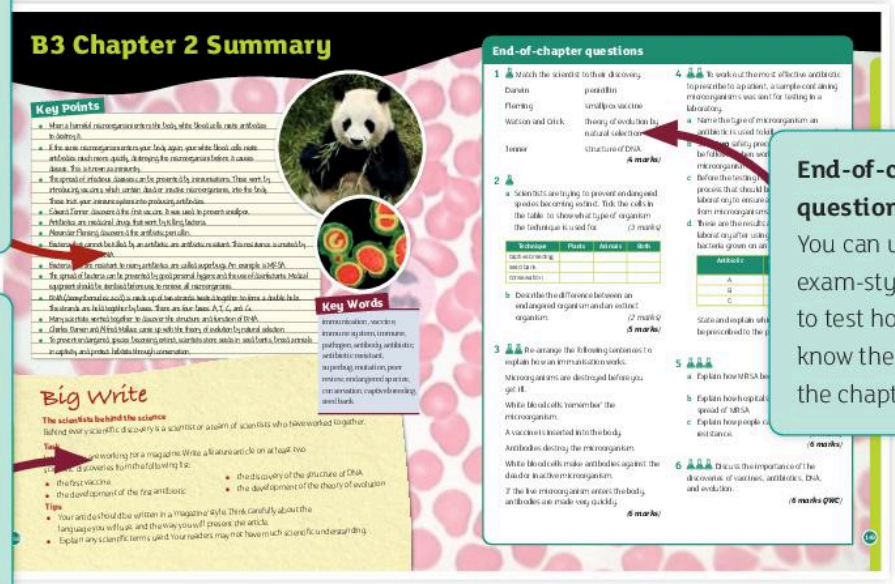
Big questions
These are some of the important questions in science that the unit will help you to answer.



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?

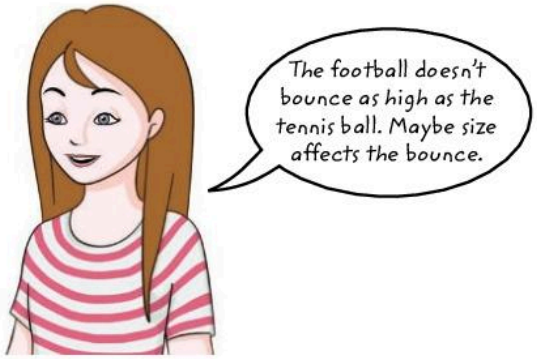
What's the question?

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:

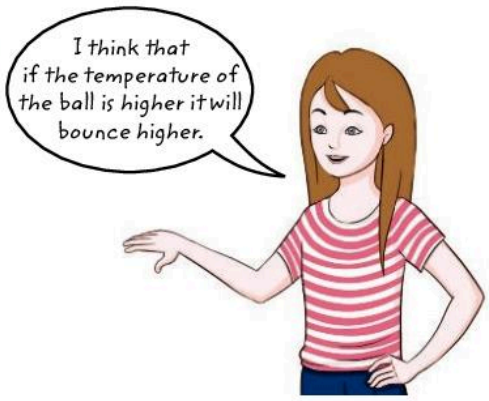
- the height you drop the ball from
- the type of ball
- the surface that you drop it onto
- the size of the ball

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.

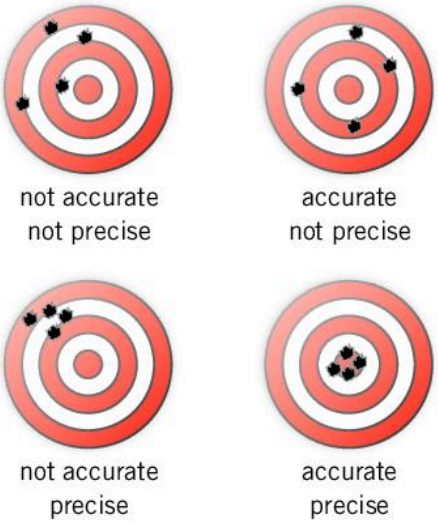
Have you ever cooked from a recipe? Did it turn out the way you wanted? The plan for an investigation or experiment is a bit like a recipe. It says what equipment and materials you are going to use, and what you are going to do with them.

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.



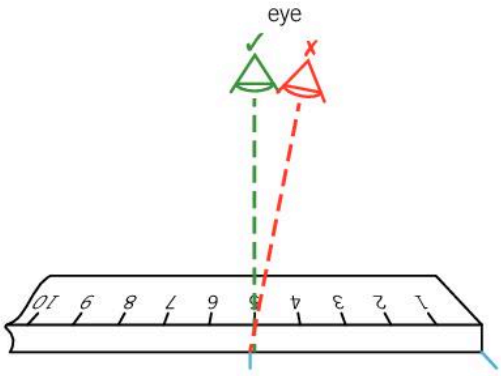
▲ Readings can be precise but not accurate.

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?

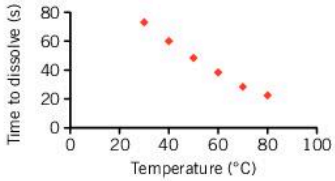
Tom and Katie have collected lots of data. They want to present their results in a graph or chart. To work out which graph or chart to plot you need to look at the variables in your investigation.

- 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.

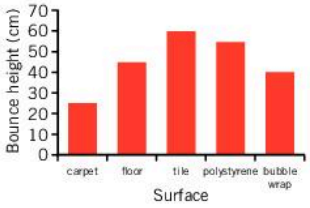
Temperature (°C)	Time to dissolve (s)
30	75
40	60

Surface	Height of bounce (cm)
Carpet	25
Floor	45

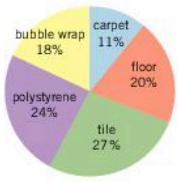
You plot a line graph:



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)*

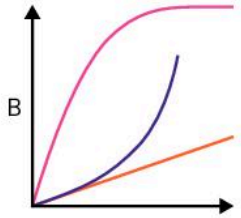
3 Design a hint sheet for students carrying out investigations. *(6 marks)*

1.4 Analysing data

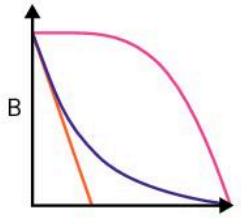
Learning objectives

After this topic you will be able to:

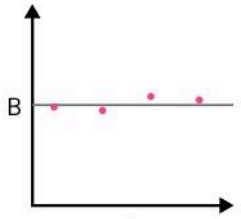
- find a pattern in data using a graph or chart
- interpret data to draw conclusions.



In these graphs, if A increases then B increases.



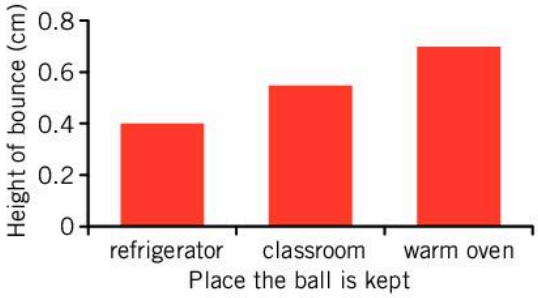
In these graphs, if A increases then B decreases.



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.

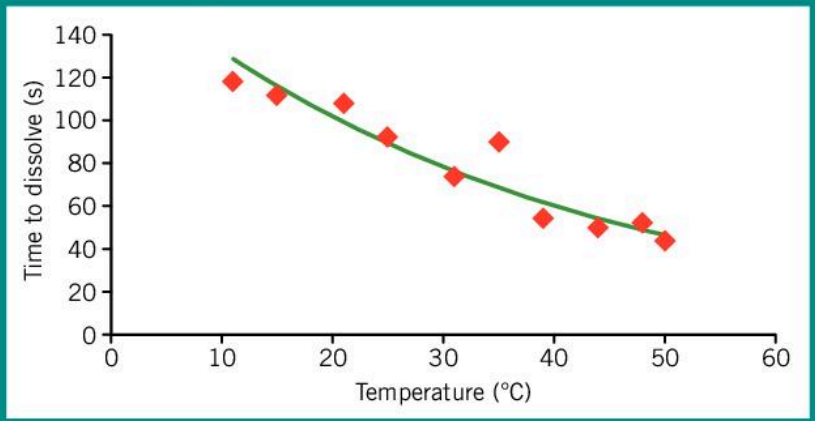
Tom begins to explain the relationship between temperature and the height of the bounce. However, to come up with a good explanation he needs to understand why balls bounce.

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

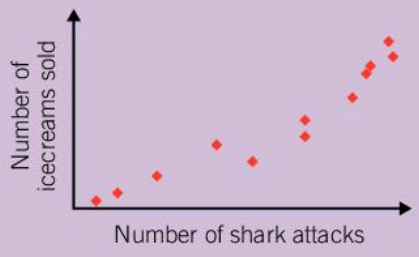
Summary Questions

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

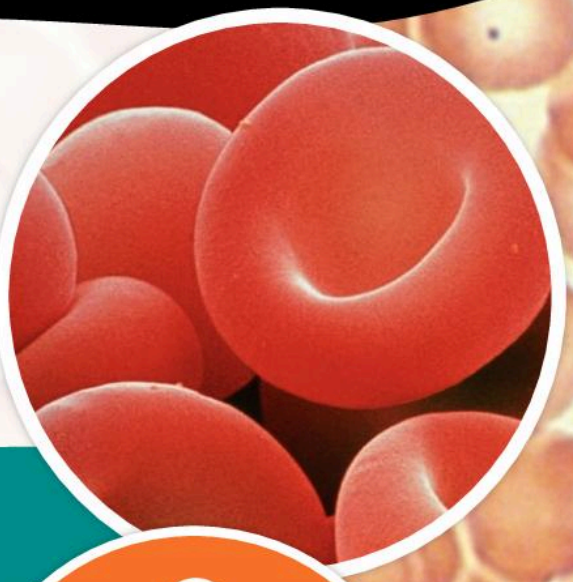
a State two ways that Katie and Tom could improve their data. *(2 marks)*

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.

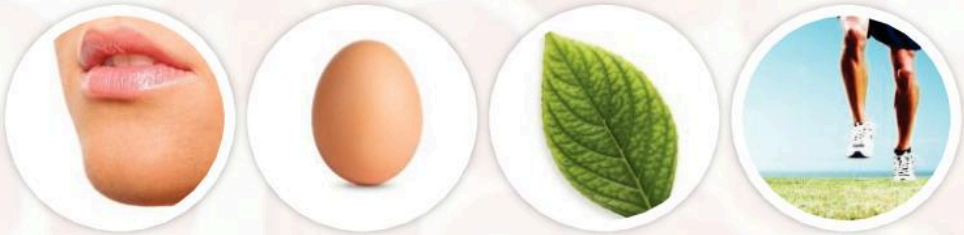
Q

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 **B1** you will learn about different types of cells.

In **B2** you will learn about how cells interact with matter.

In **B3** you will learn about how cells are used for genetic engineering and cloning.

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.

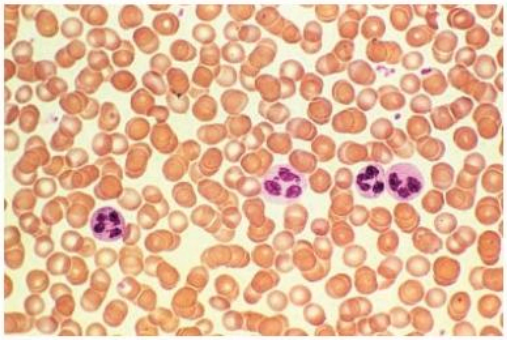
What are living organisms made of?

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.

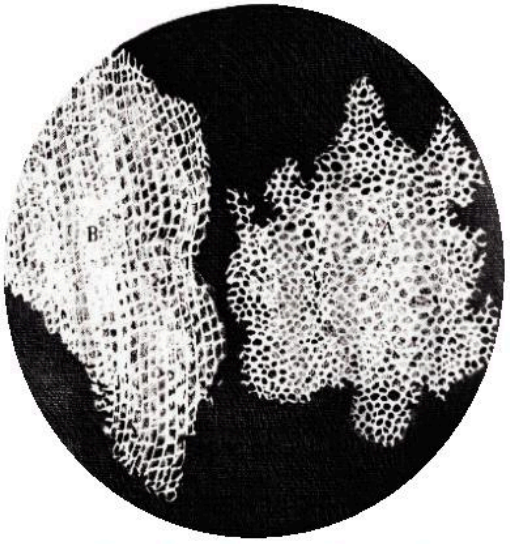
B Write down what Robert Hooke saw when he looked at cork using a microscope.

Making an observation

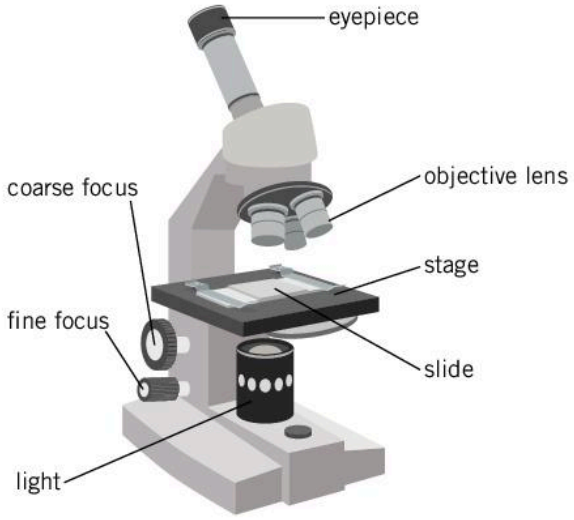
To see a very small object in detail, you need to use a microscope. This magnifies the image using lenses. Looking carefully and in detail at an object is called making an **observation**.

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.

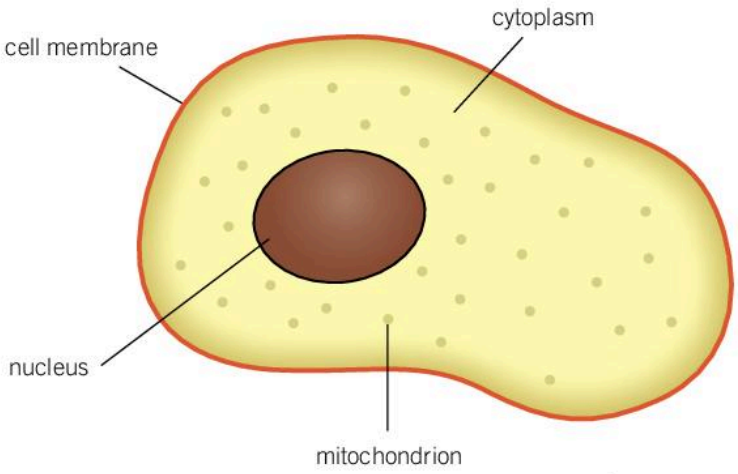
Key Words

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).

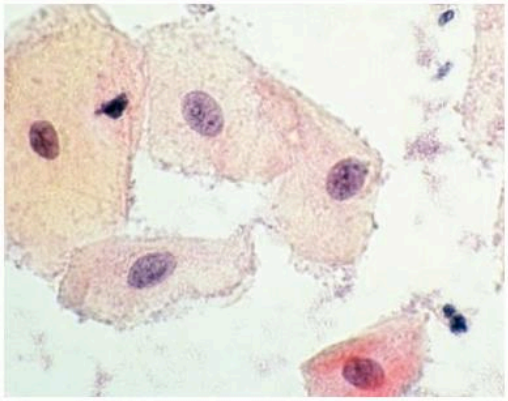
A Name the four components found in an animal cell.



▲ 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:

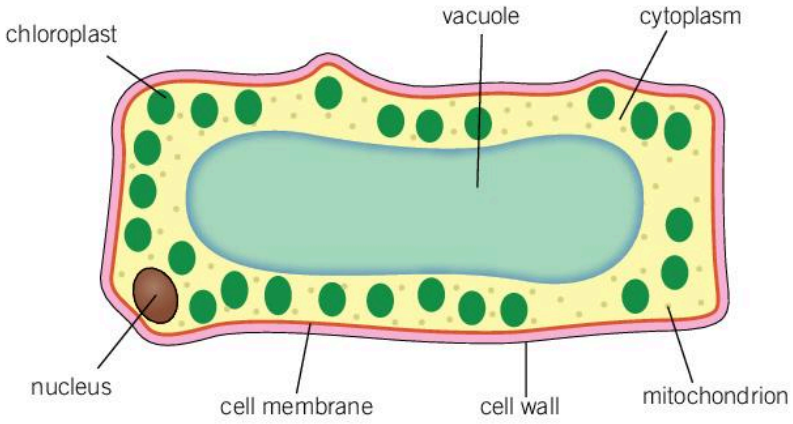
- Cytoplasm – this is a 'jelly-like' substance where the chemical reactions in a cell take place.
- Cell membrane – this is a barrier around the cell. It controls what can come in and out of the cell.
- Nucleus – this controls the cell and contains genetic material. Genetic information is needed to make 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.

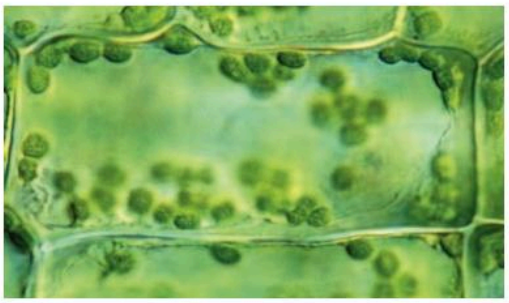
These components each have their own function:

- 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

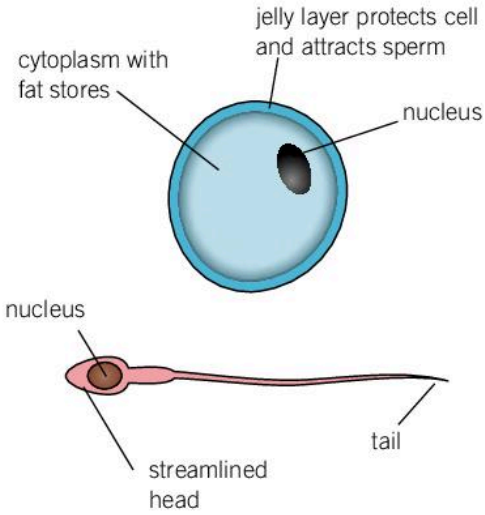
Red blood cells transport oxygen around the body. They contain haemoglobin, a red pigment that joins to oxygen. Unlike most animal cells they have no nucleus. They also have a disc-like shape. This increases their surface area for carrying oxygen.

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.

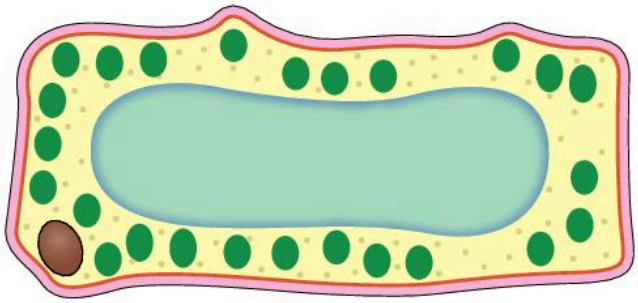


▲ An egg cell and a sperm cell.

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

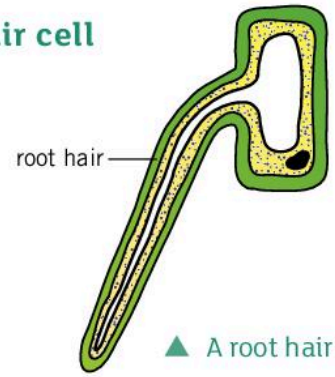


◀ A cell from the top of a leaf. Its scientific name is a palisade cell.

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.

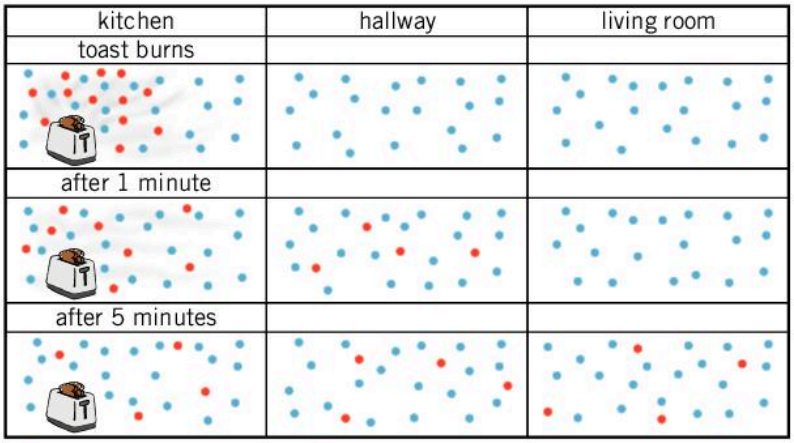
B Name one substance that moves out of a body cell.

How do substances move in and out of cells?

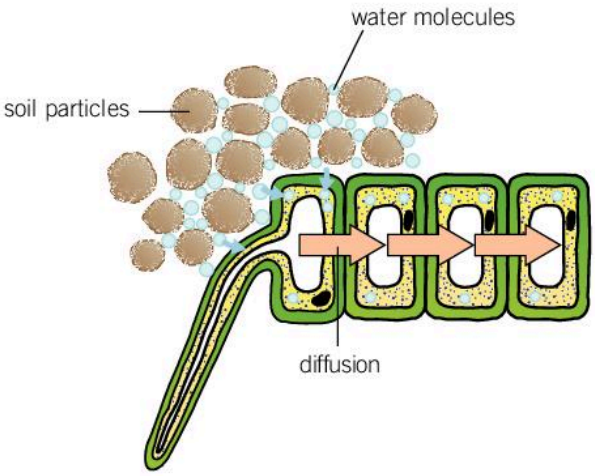
Substances move in and out of cells by **diffusion**. Diffusion is the movement of particles from a place where they are in a high **concentration** to a place where they are in a low concentration. The concentration of a substance means the number of particles of a substance present in an area.

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.

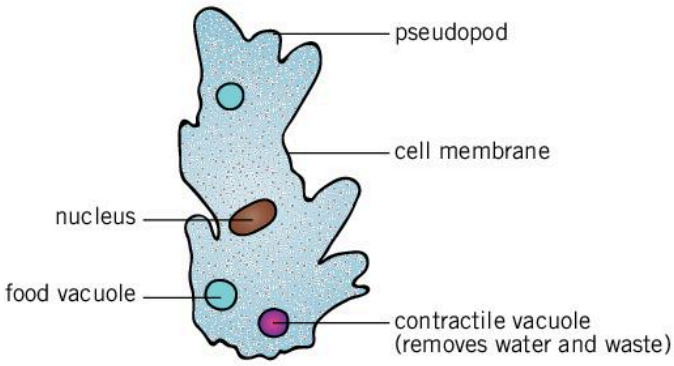
A State what unicellular means.

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.

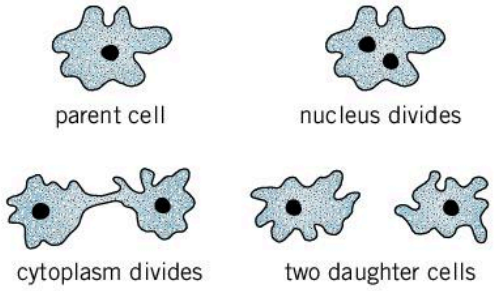
B Name two structures found in both an animal cell and an amoeba.

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?

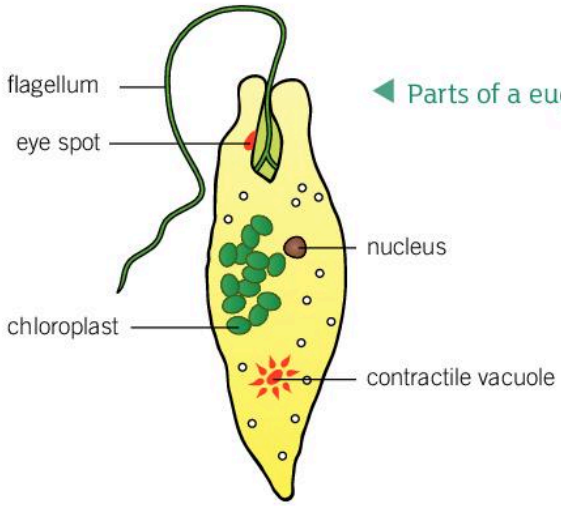
To reproduce, an amoeba splits itself into two cells. This is known as binary fission. First, the nucleus in the cell divides. Then the cytoplasm divides, producing two identical cells.



▲ 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)

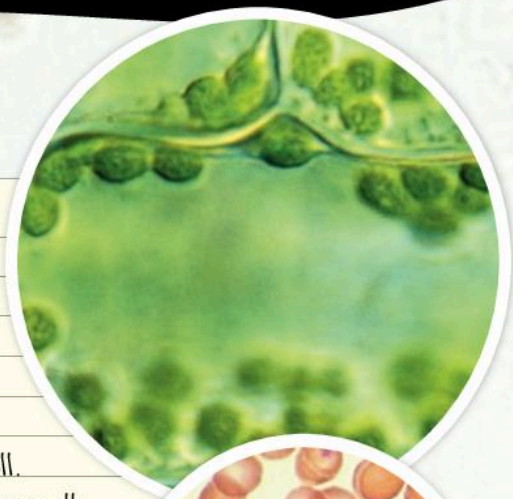
2 Describe how amoebas and euglenas reproduce.

(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

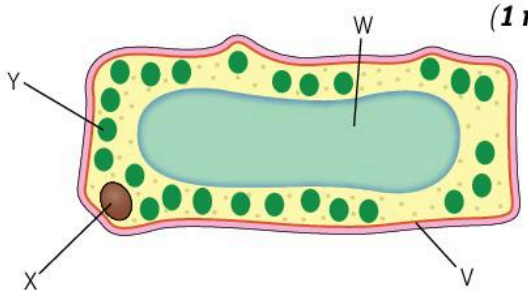
1 Choose the correct definition of the word 'cell'.

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)*

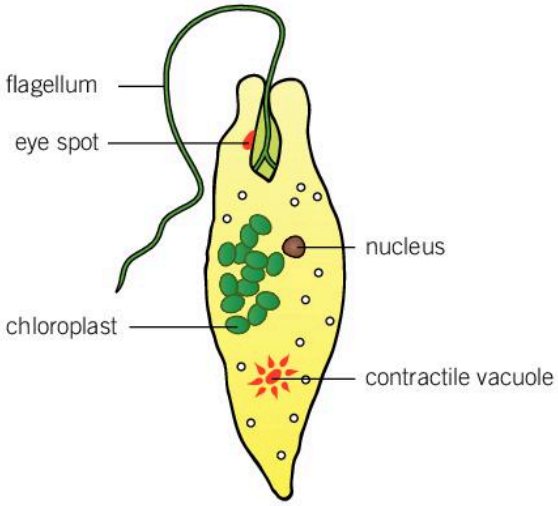
b Complete the table to show how **three** types of cell are adapted to their function. *(5 marks)*

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?

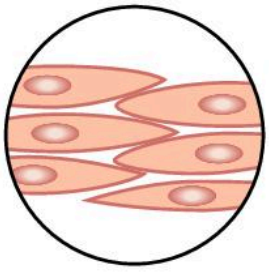
The third level of organisation is an **organ**. An organ is made up of a group of different tissues that work together to perform a certain function. The main organs in a plant and animal are shown below.

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.

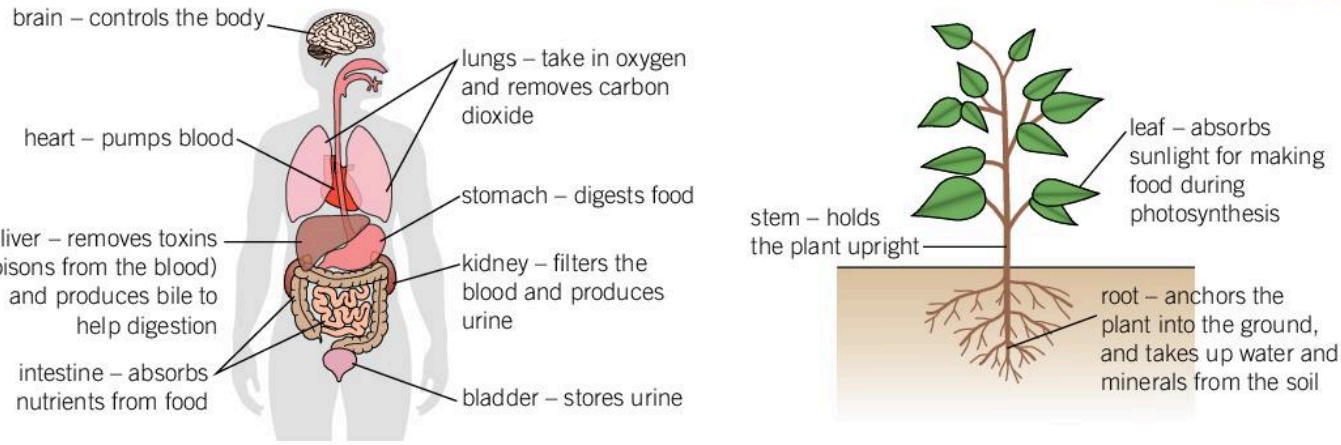


◀ Muscle tissue is a type of animal tissue.

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?

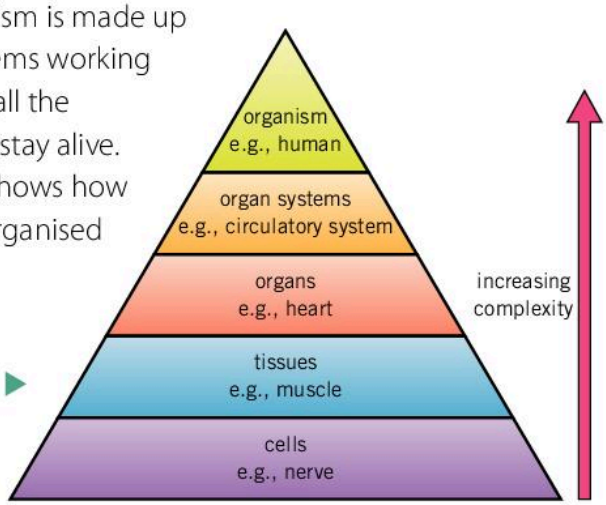
The fourth level of organisation is an **organ system**. An organ system is a group of different organs that work together to perform a certain function. Some examples of organ systems are:

- 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.

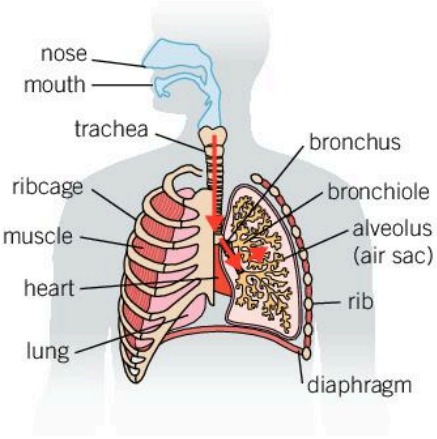
If you are travelling on a bus, the windows may sometimes steam up. This is because it contains lots of water vapour.

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.

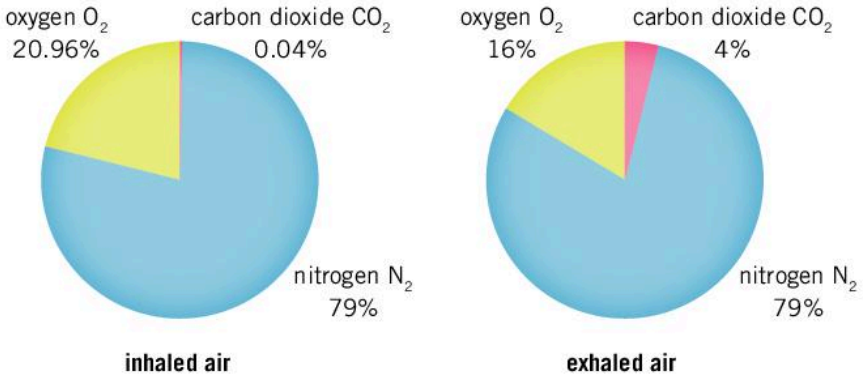
There are millions of alveoli (plural of alveolus) in your lungs. They create a large surface area. They also have thin walls that are only one cell thick. This means that gas exchange can occur quickly and easily.

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:

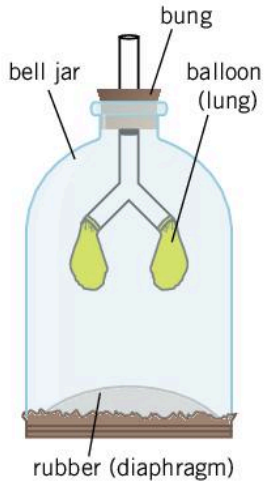
- describe the processes of inhaling and exhaling
- describe how a bell jar can be used to model what happens during breathing
- explain how to measure lung volume.

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?

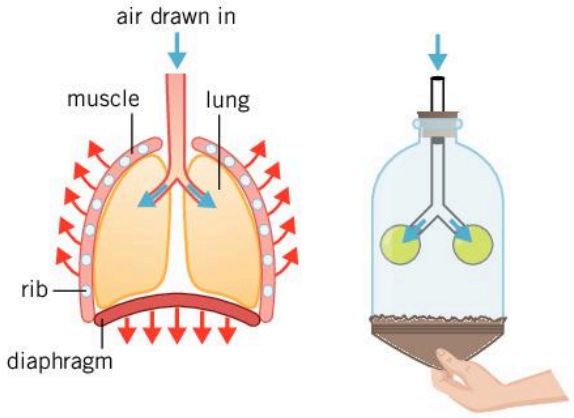
When you breathe, muscles in your chest tighten or **contract**.

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.

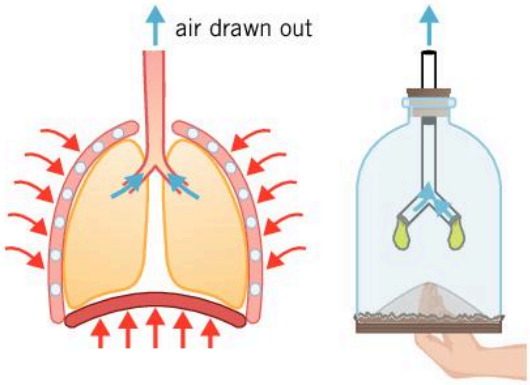
Link

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.

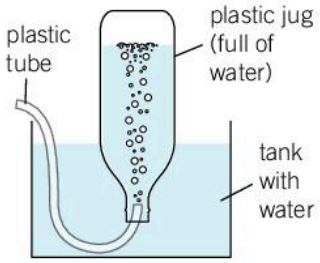
B State what happens to your diaphragm when you breathe out.

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

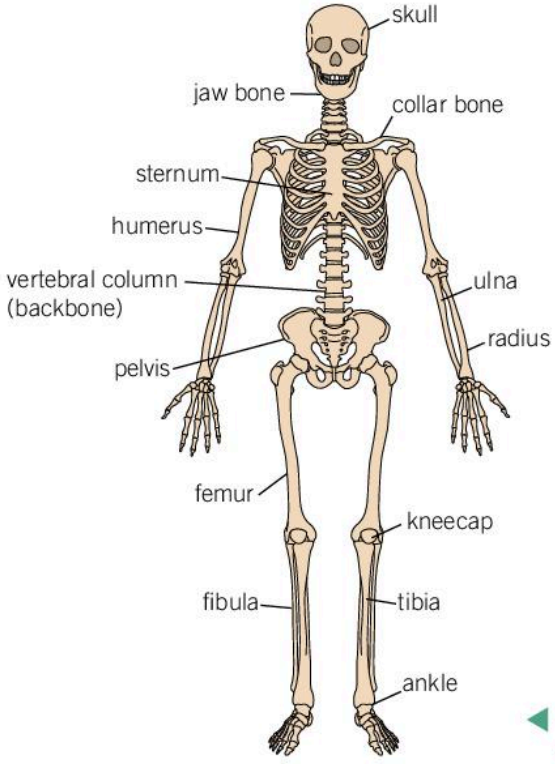
Find out the scientific names for these parts of the body:
kneecap, shoulder blade, jaw

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.

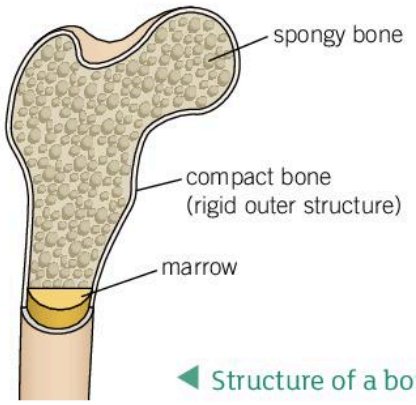
Making blood cells

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?

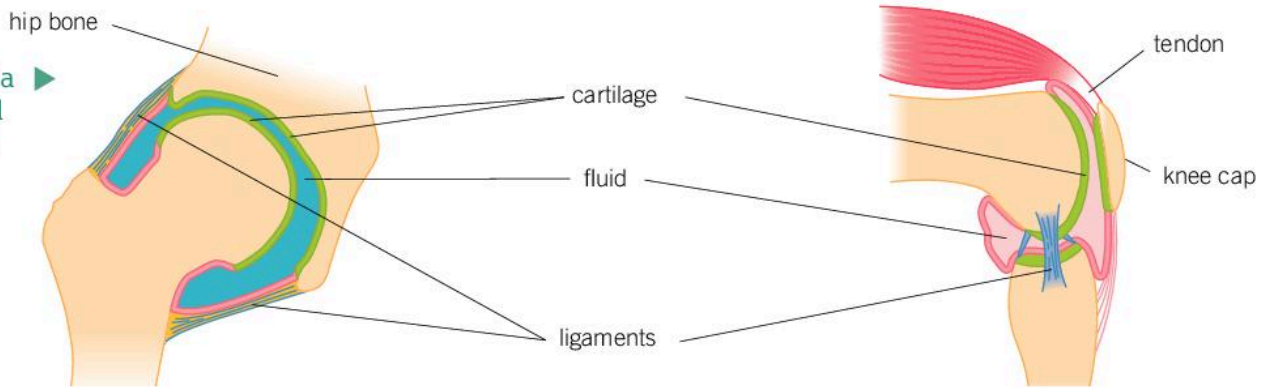
Your joints need to be strong enough to hold your bones together but flexible enough to let them move. Different types of joint allow movement in different directions. Three types of joint are:

- 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.

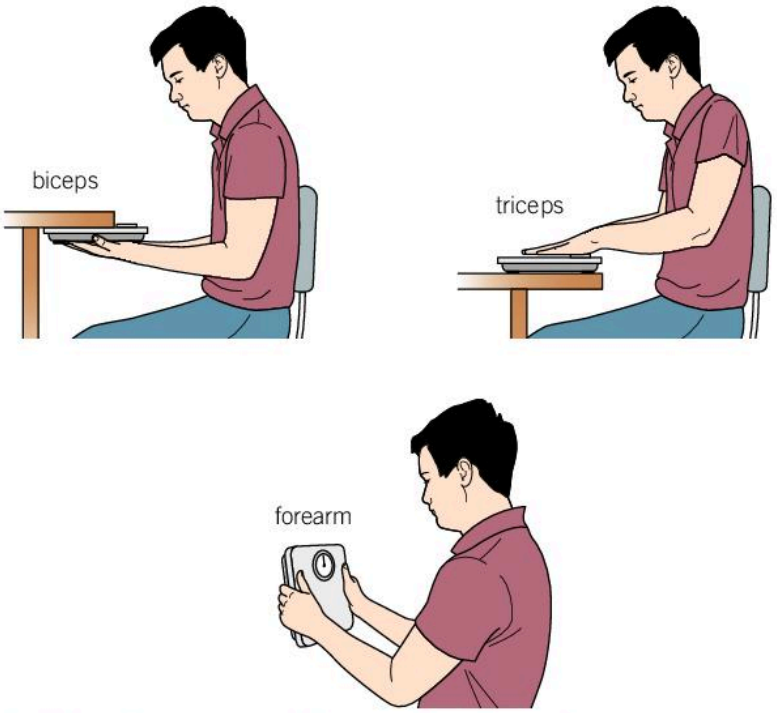
The strength of a muscle can be measured by how much force it exerts. You can measure the strength of your muscles using a Newton scale. The harder you can push on the scale, the greater the force exerted. Force is measured in **newtons** (N).

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.

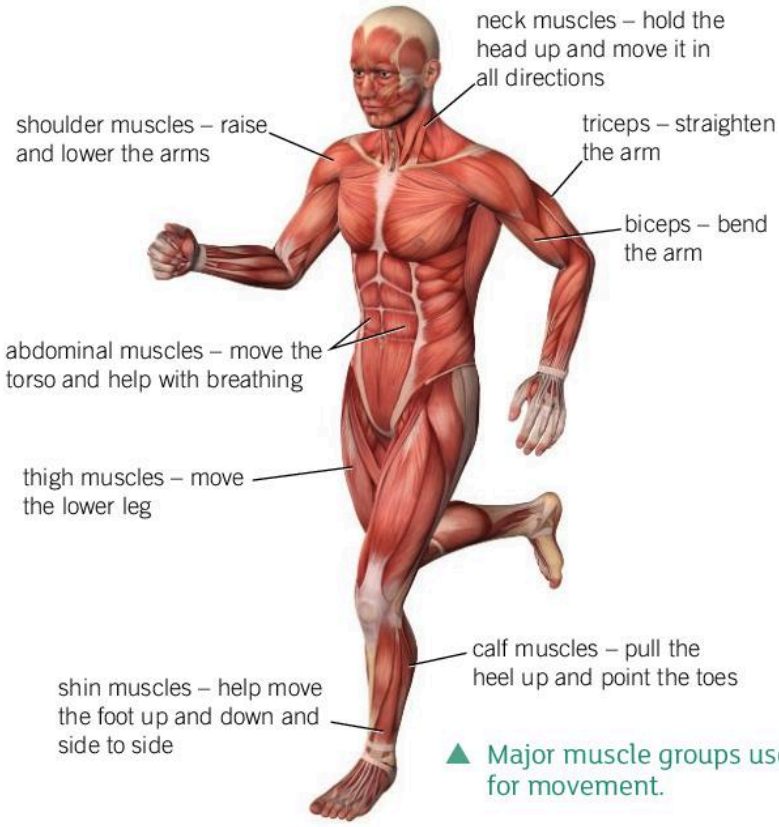
Can you feel the muscle in the front of your arm working as you bend it? The muscle is pulling on one of the bones in your forearm, causing it to move upwards.

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?

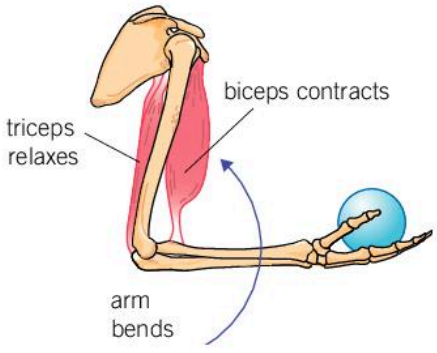
Muscles can only pull. They cannot push. This means that two muscles have to work together at a joint. If you only had one muscle in your arm, you may be able to bend your arm but you would not be able to straighten it again.

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:

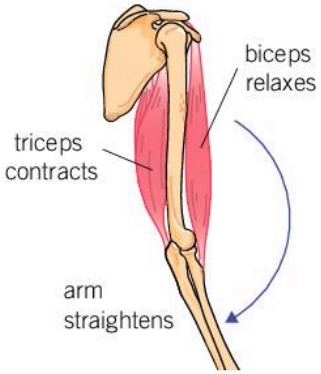
- the biceps muscle (on the front of the upper arm) contracts
- the triceps muscle (on the back of the upper arm) relaxes.



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

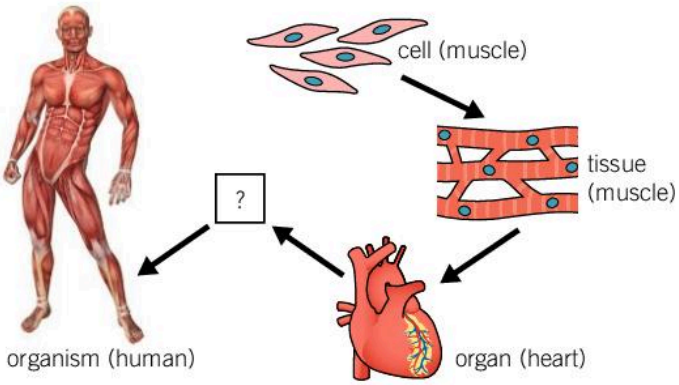
multicellular organism, tissue, organ, organ system, gas exchange, lungs, ribcage, respiratory system, trachea, alveolus, inhale, respiration, exhale, condense, contract, diaphragm, lung volume, bone, skeleton, support, protect, bone marrow, biomechanics, joint, cartilage, ligament, newtons, tendon,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

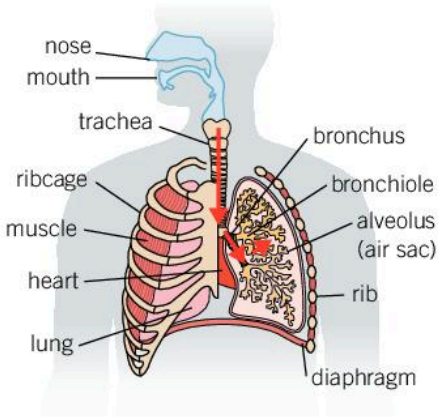
b State the unit of force that he should use. *(1 mark)*

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.

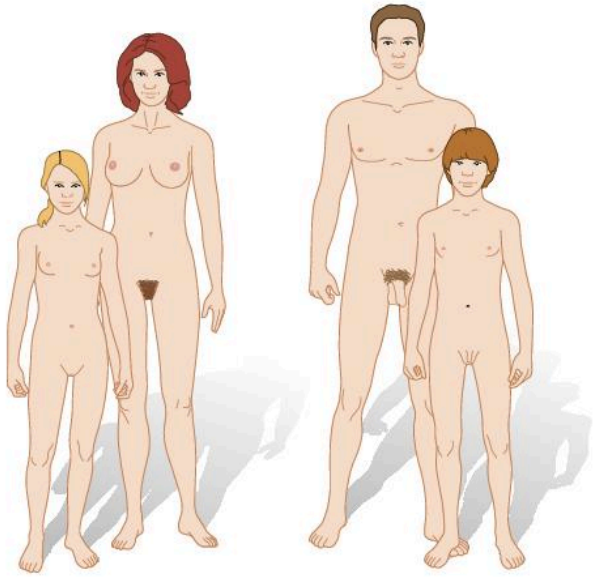
Think about yourself and your friends. Do you think of yourselves as children or adults? Everyone in your year group is at a different stage of their emotional and physical development. The time during which you change from a child to an adult is known as adolescence.

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:

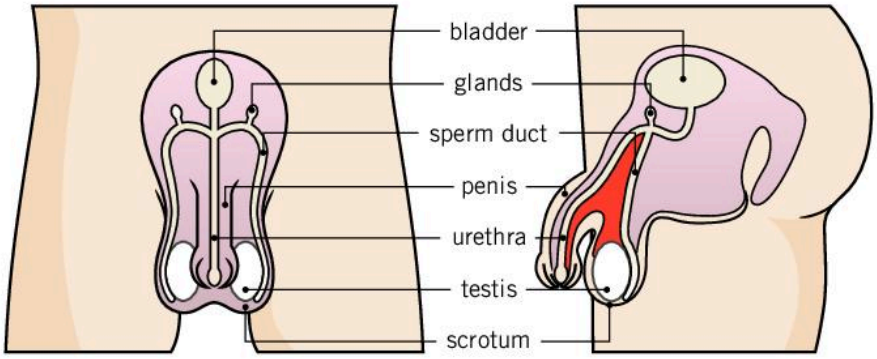
- describe the main structures in the male and female reproductive systems
- describe the function of the main structures in the male and female reproductive systems.

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

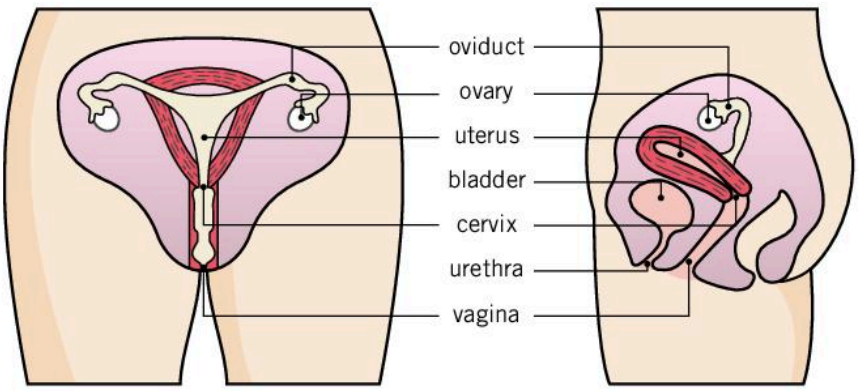
You can learn more about sexual intercourse in B1 3.3 Fertilisation and implantation

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.

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.

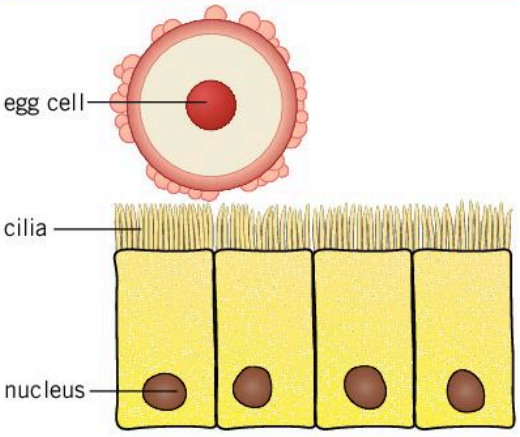
What are gametes?

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.

Link

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



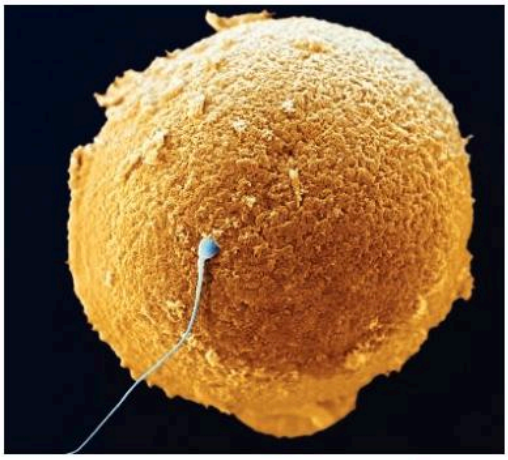
▲ Cilia in the oviduct waft the egg towards the uterus.

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.

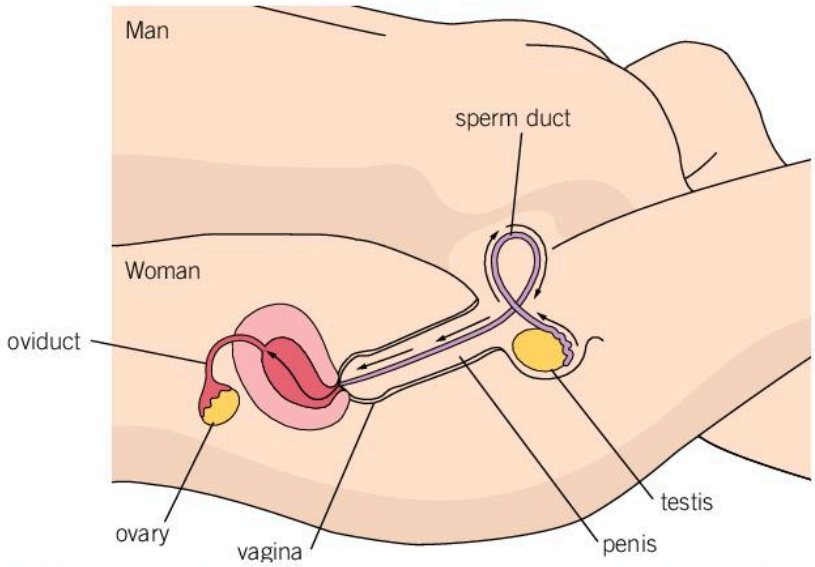


▲ During fertilisation, the head of the sperm burrows into the egg.

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.

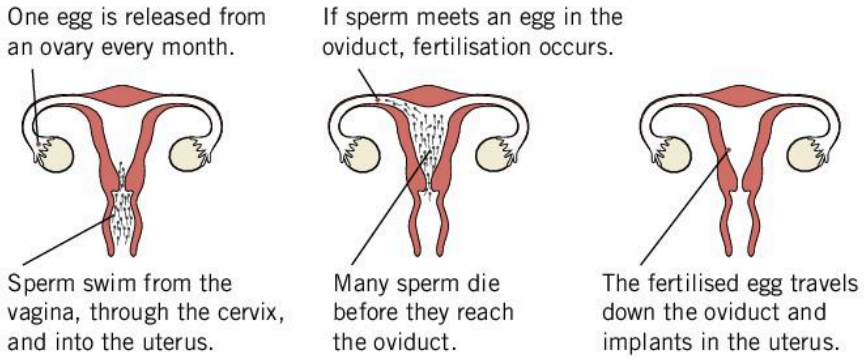


▲ During sexual intercourse, sperm are released into the vagina.

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?

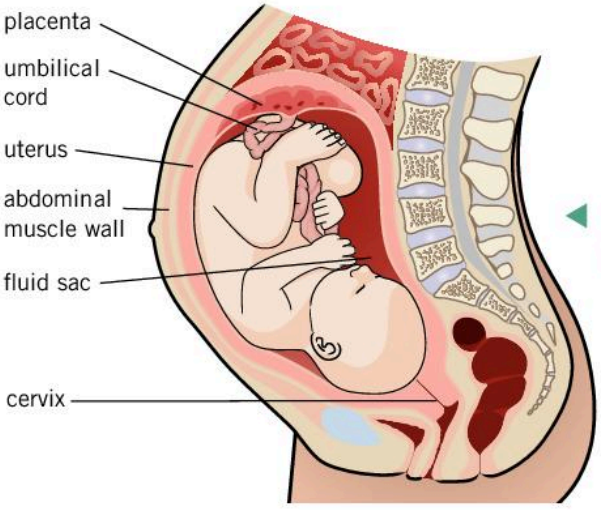
In all mammals the time in the uterus from fertilisation until birth is known as **gestation**. In humans we also call it pregnancy. It takes around 9 months (40 weeks) for a fertilised egg to develop into a baby.

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	o	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

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

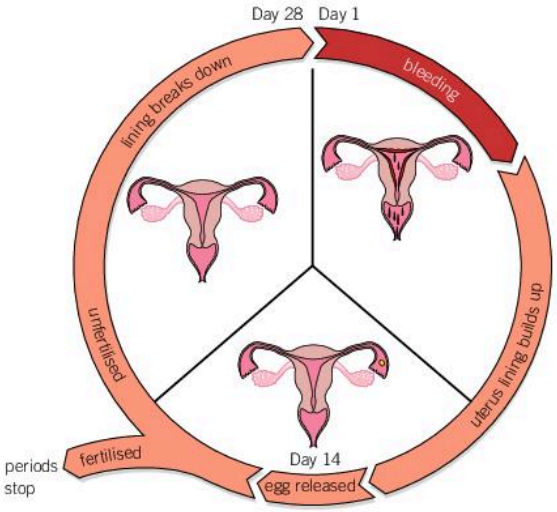
You may have heard your classmates talking about periods. You may know that only girls have them, but what are they and why do they happen?

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.

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:

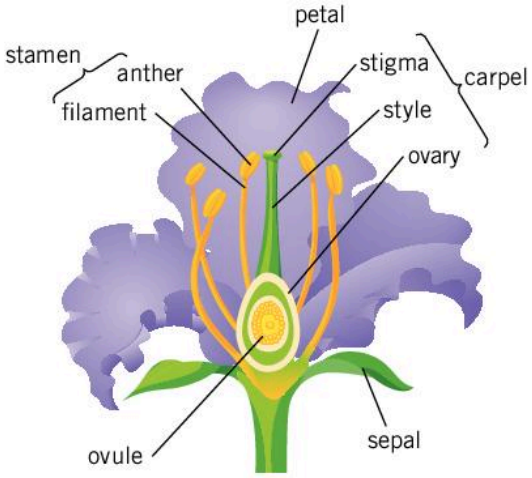
- identify the main structures of a flower
- describe the process of pollination
- describe the differences between wind-pollinated and insect-pollinated plants.

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.

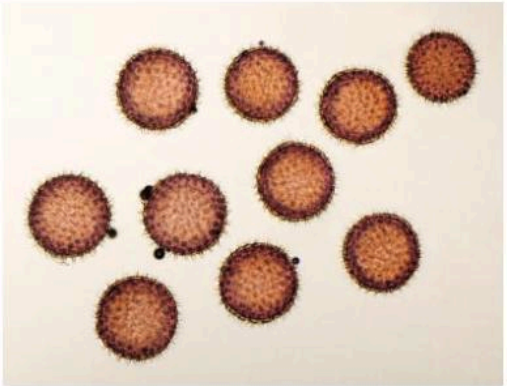
B State where pollen is made.

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.

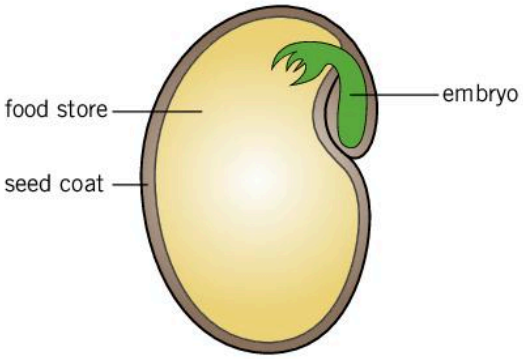
▲ Fruits contain seeds.

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.

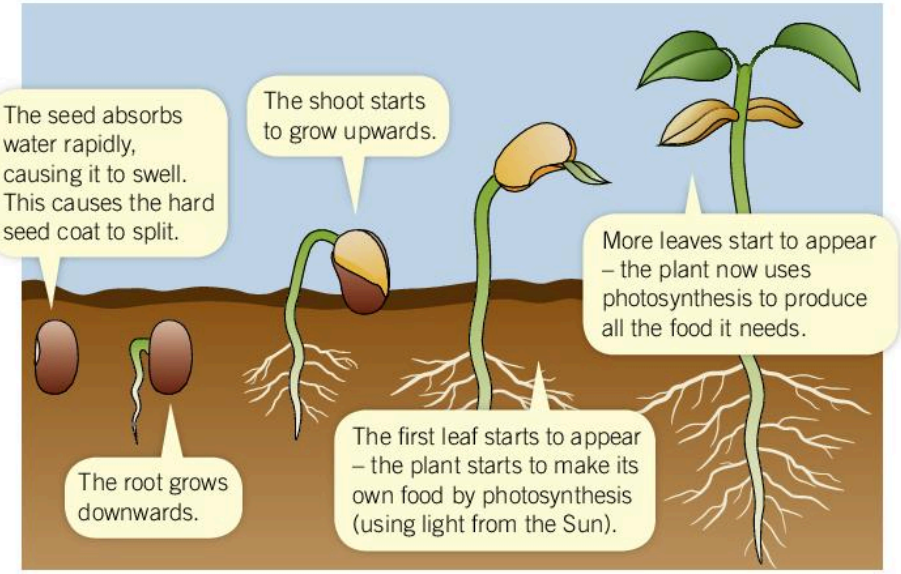
C State the three things needed for germination.

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:

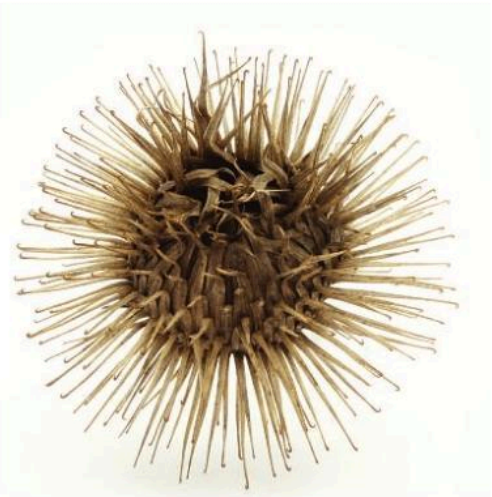
- internally – animals eat lots of fruit, including tomatoes, blackberries, and strawberries. Fruits are normally brightly coloured and taste sweet, which attracts animals to them. These fruits contain seeds with hard coats. This means the seeds pass through the animal without being damaged. When they 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

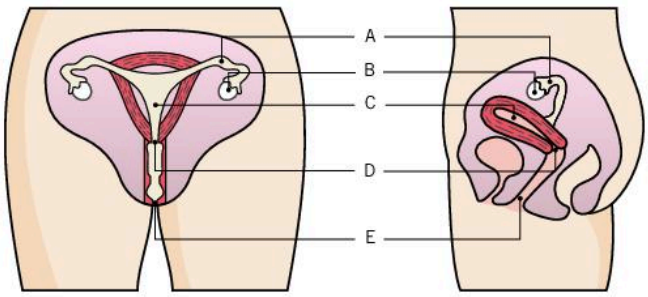
1 a Sort the physical changes that take place during adolescence into those that happen to boys, those that happen to girls, and those that happen to both.

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

Boys	Girls	Both

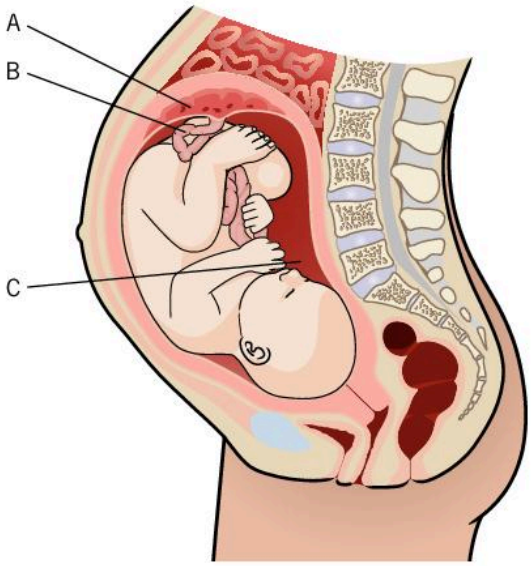
*(**6 marks**)*

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**)*

Biology 2

In this unit you will compare the effects of healthy and unhealthy lifestyles on your body. You will look at why organisms need energy to function effectively. Finally, you will investigate the differences that exist between organisms, and why this is important for their survival.

You already know

- The digestive system in humans is made up of different parts, each with its own special function.
- Diet, exercise, drugs, and lifestyle have an impact on the way the human body functions.
- Living things are classified into broad groups according to common characteristics.
- Fossils provide information about organisms that lived on Earth millions of years ago.
- Living things produce offspring of the same kind but normally offspring vary and are not identical to their parents.
- Animals and plants are adapted to suit their environment and adaptation may lead to evolution.
- Food chains include producers, predators, and prey.

Q

What are the five main groups that vertebrates (animals with a backbone) are classified into?

BIG Questions

- What is a healthy diet?
- Why do organisms need food to survive?
- Why don't we all look the same?

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**: It's made from flour.*

Making connections

In **B1** you learnt about the levels of organisation for different species.

In **B2** you will learn about how different organisms are linked in food chains and food webs.

In **B3** you will learn about natural selection, extinction, and the conservation of species.

1.1 Nutrients

Learning objectives

After this topic you will be able to:

- describe the components of a healthy diet
- explain the role of each food group in the body.

Foul Fact

If you eat a lot of beetroots your urine turns pink. Eating a lot of asparagus turns your urine bright yellow!

▲ Carbohydrate-rich foods.

▲ Fat-rich foods.

We all know that sweets should only be eaten as a treat and you have probably heard many times that you should eat a balanced diet. But what does this mean, and why is it important?

Nutrients are important substances that your body needs to survive and stay healthy. There are different types of nutrients. We get most of them from food. The types of nutrient are:

1. **carbohydrates** provide energy
2. **lipids** (fats and oils) provide energy
3. **proteins** are used for growth and repair
4. **vitamins** keep you healthy
5. **minerals** keep you healthy
6. water is needed in all cells and body fluids
7. **fibre** provides bulk to food to keep it moving through the gut. Fibre is not a nutrient but it is important for a healthy diet.

To remain healthy you must eat a **balanced diet**. This means eating food containing the right nutrients in the correct amounts.

A State what is meant by a nutrient.

Carbohydrates

Carbohydrates are your main source of energy. They are found in sugary foods such as sugar and fruit, where they provide a quick source of energy. They are also found in starchy foods such as pasta and bread. These foods have to be broken down by the body, so the energy is released more slowly.

B State the function of carbohydrates.

Lipids

Lipids include fats and oils. They have three important jobs. They:

- provide you with a store of energy
- keep you warm, by providing a layer of insulation under your skin
- protect organs like your kidneys and heart from damage.

Proteins

Proteins are needed to repair body tissues and to make new cells for growth. Your muscles, organs, and immune system are mostly made of proteins.

C State two functions of proteins.

Vitamins and minerals

Vitamins and minerals are essential substances for keeping you healthy but you only need tiny amounts. Vitamins are needed for you to grow, develop, and function normally. For example, vitamin A is needed for good eyesight. Vitamin D is needed with the mineral calcium to maintain healthy teeth and bones.

Fruits and vegetables are a good source of vitamins and minerals.

Water

Your cells are made up of about 70% water. To keep them healthy you need to constantly replace the water your body loses in sweat, tears, urine, feces, and exhaling. You should drink over a litre of water every day. This can come from drinking water but tea, fruit juice, and squash all count.

D List four ways in which you lose water from the body.

Fibre

Fibre is a type of carbohydrate but it is not classed as a nutrient. However, it is an important part of your diet as it adds bulk to your food. This means it keeps food moving through the gut, and waste is pushed out of the body more easily, helping to prevent constipation.

◀ Fibre-rich foods.

Healthy eating

Design and film a healthy-eating TV advert on behalf of the government. The advert should aim to encourage young people to eat a balanced diet.

▲ Protein-rich foods.

Link

You can learn more about balanced diets in B2 1.3 Unhealthy diet

Key Words

nutrient, carbohydrate, lipids, protein, vitamin, mineral, fibre, balanced diet

Summary Questions

1 Match the nutrient to its role in the body.

carbohydrates	growth and repair
lipids	remain healthy
protein	provide energy
vitamins and minerals	provide bulk to food
water	energy store and insulation
fibre	needed in cells and bodily fluids

(6 marks)

2 Describe the role of lipids in the body.

(3 marks)

3 Explain in detail what is meant by a balanced diet. Provide examples of what a balanced diet should contain.

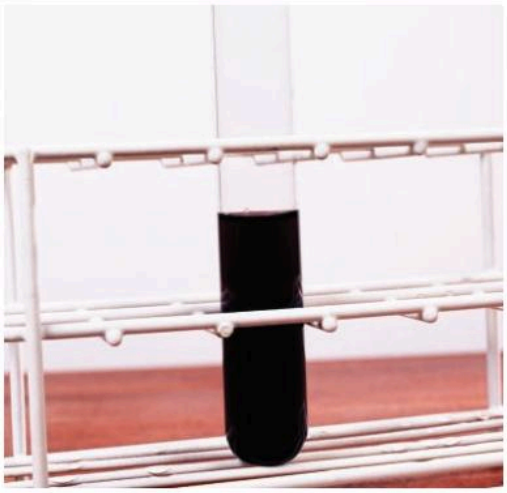
(6 marks QWC)

1.2 Food tests

Learning objectives

After this topic you will be able to:

- describe how to test foods for starch, lipids, sugar, and protein
- describe the positive result for each food test.



▲ This food solution contains starch.

Key Words

food test, hypothesis

Hypothesis

Scientists observe the world and come up with a **hypothesis** to explain what they observe. A hypothesis is an idea about things that always happen. A hypothesis can be tested in an investigation. You can use hypotheses to make a prediction.

You may be able to guess by looking at some foods which nutrients they contain. For example, you may know that oily foods contain lipids. Scientists use food tests to find out which nutrients are in a food product.

How can you test foods?

A different chemical test exists for each type of nutrient. For most **food tests**, you will need a solution of the food. To prepare a food solution:

1 crush the food using a pestle and mortar

2 add a few drops of water, and mix well.

You should use a special type of water called distilled water – this is pure water that contains no other chemical substances.

How do you test for starch?

To test for starch you use iodine solution. Iodine solution is an orange-yellow liquid.

1 Add a few drops of iodine solution to the food solution.

2 If the solution turns a dark blue-black colour, the food contains starch.

A State the colour change in iodine if a food contains starch.

How do you test for lipids?

To test for lipids in a solid piece of food you use a piece of filter paper.

1 Rub some of the food onto a piece of filter paper.

2 Hold the paper up to the light. If the paper has gone translucent, the food contains lipids.

B State how you would test a solid piece of food for lipids.

To test for lipids in a food solution you use ethanol. Ethanol is a colourless liquid.

1 Add a few drops of ethanol to the food solution.
2 Shake the test tube and leave for one minute.
3 Pour the ethanol into a test tube of water.
4 If the solution turns cloudy, the food contains lipids.

How do you test for sugar?

To test for simple sugars such as glucose you use Benedict's solution. Benedict's solution is a blue liquid.

1 Add a few drops of Benedict's solution to the food solution.
2 Heat the test tube in a water bath.
3 If the solution turns orange-red, the food contains sugar.

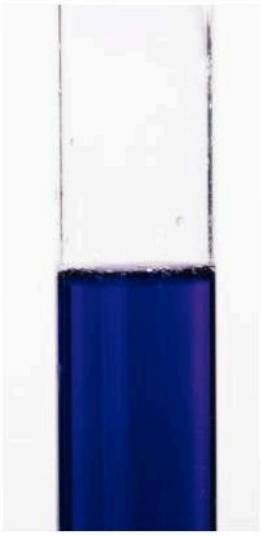
C State the colour change in Benedict's solution if a food contains sugar.

How do you test for protein?

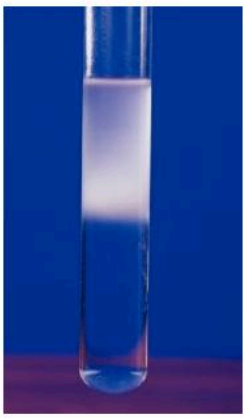
To test for protein you use copper sulfate solution and sodium hydroxide solution. Copper sulfate solution is a pale-blue liquid. Sodium hydroxide solution is a colourless liquid.

1 Add a few drops of copper sulfate solution to your food solution.
2 Add a few drops of sodium hydroxide solution.
3 If the solution turns purple, the food contains protein.

D State the colour change in a solution of copper sulfate and sodium hydroxide if a food contains protein.



▲ This food solution contains protein.



▲ This food solution contains lipids.

▲ This food solution contains sugar.

Summary Questions

1 Complete the table using the words below.

turns blue-black
turns orange-red
makes paper translucent
turns purple

Nutrient	Colour change if nutrient present
starch	
lipids	
sugar	
protein	

(4 marks)

2 Describe how to prepare a food solution of a breakfast cereal.

(3 marks)

3 Explain in detail how you would test a gingerbread-biscuit solution for the presence of starch, sugar, and protein.

(6 marks QWC)

1.3 Unhealthy diet

Learning objectives

After this topic you will be able to:

- describe some health issues caused by an unhealthy diet
- calculate the energy requirements of different people.

▲ This food pyramid shows a healthy balanced diet. The largest part of your diet should be carbohydrate based. Lipids, oils, and sweets should only be eaten in very small quantities.

Link

You can learn more about energy in food in P2 2.1 Food and fuels

Key Words

malnourishment, starvation, obese, deficiency

You may have seen pictures of people who are either extremely overweight or underweight. Both of these conditions are caused by malnourishment. This means the people have eaten the wrong amount or the wrong types of food.

Where does your energy come from?

You need energy for everything you do, even to sleep. This energy comes from your food. The energy in food is measured in joules (J) or kilojoules (kJ). 1 kilojoule is the same as 1000 joules.

If you look on a food label it will tell you how much energy is stored in that food.

A State the unit that energy in food is measured in.

Why is it unhealthy to be underweight?

Some people do not eat enough food. In extreme cases this is known as **starvation**. If the energy in the food you eat is less than the energy you use, you will lose body mass. This leads to you being underweight. Underweight people:

- often suffer from health problems, such as a poor immune system
- lack energy to do things, and are often tired
- are likely to suffer from a lack of vitamins or minerals.

B State three problems caused by being underweight.

Why is it unhealthy to be overweight?

Some people eat too much, or eat too many fatty foods. If the energy content in the food you eat is more than the energy you use, you gain body mass. This is stored as fat under the skin. If a person becomes extremely overweight, they are said to be **obese.**

Overweight people have an increased risk of:

- heart disease
- stroke
- diabetes
- some cancers.

C State three diseases that obese people are more likely to suffer from.

What are vitamin and mineral deficiencies?

If a person does not have enough of a certain vitamin or mineral they are said to have a **deficiency**. This can damage a person's health. For example, a vitamin A deficiency can lead to 'night blindness'. This makes it difficult for you to see clearly in dim light. A vitamin D deficiency can lead to a condition called rickets, where your bones become weak.

D Name the condition caused by a vitamin A deficiency.

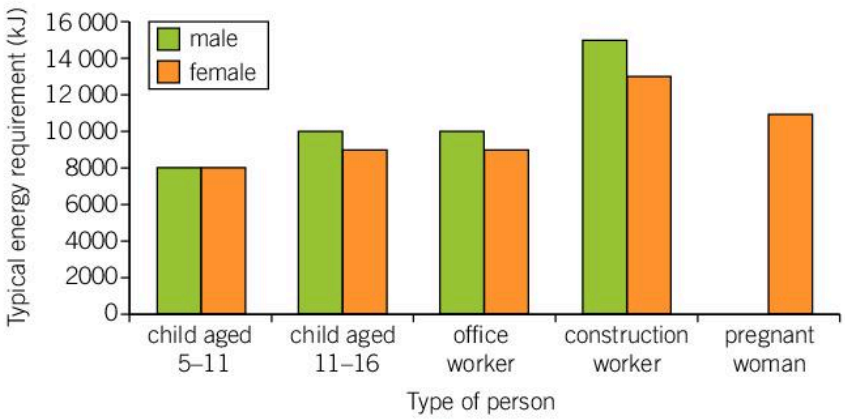
▲ This person is suffering from rickets.

How much energy do you need?

Your body needs energy to function properly. The amount of energy you need depends on your age (as this affects your growth rate), your body size, and how active you are. The more exercise you do, the more energy your body requires.

Energy requirements

Use the graph below to estimate the energy that a female computer programmer needs each day. How did you arrive at your answer?



▲ Daily energy requirements for different types of people.

Summary Questions

1 Copy and complete the sentences below.

You gain the _____ you need to survive from food. Energy is measured in _____.

If you take in more energy than you use you _____ body mass. If you become _____ your risk of _____ disease increases. An underweight person is often _____.

(6 marks)

2 Use the graph on this page to answer the following questions.

a Calculate the extra energy a female office worker would need each day if she became pregnant. *(2 marks)*

b A male office worker starts a new job as a construction worker. Calculate the percentage increase in his daily energy needs. *(4 marks)*

3 Compare the health problems of being underweight and the health problems of being overweight.

(6 marks QWC)

1.4 Digestive system

Learning objectives

After this topic you will be able to:

- describe the structure and function of the main parts of the digestive system
- describe the process of digestion.

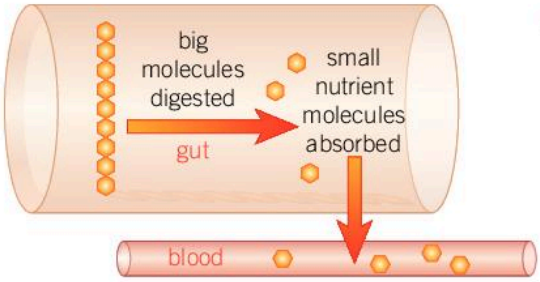
You may sometimes notice your stomach rumbling. This is a hint that you need to eat. You know that the food contains nutrients. But how does your body get nutrients out of food?

What is the digestive system?

The **digestive system** is a group of organs that work together to break down food. The nutrients in most of the food you eat are large molecules, like lipids and proteins. During **digestion** these large molecules are broken down into small molecules of nutrients. These nutrients can then pass into the blood where they are used by the body.

Link

You can learn more about molecules in C1 2.3 Compounds



◀ During digestion large molecules are broken down into small molecules and pass into the bloodstream.

A State what happens during digestion.

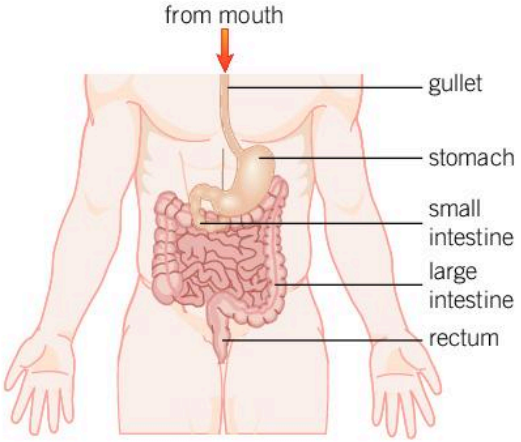
Fantastic fact

If you unravelled your small intestine it would be roughly four times taller than you – it is not very small!

Structures in the digestive system

The diagram opposite shows the main structures in your digestive system. It is often referred to as your gut.

Mouth	Food is chewed and mixed with saliva. Teeth help to break the food into smaller chunks.
Gullet	Food passes down this tube.
Stomach	Food is mixed with digestive juices and acids.
Small intestine	Digestive juices from the liver and pancreas are added and digestion is completed. Small molecules of nutrients pass through the intestine wall into the bloodstream.
Large intestine	Only food that cannot be digested gets this far. Water passes back into the body, leaving a solid waste of undigested food called feces.
Rectum	Feces are stored here until they leave the body.
Anus	This is a muscular ring through which feces pass out of the body.

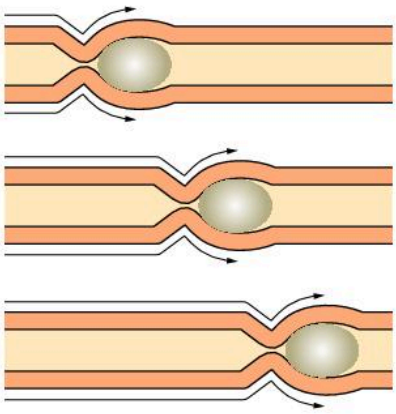


▲ Movement of food out of the digestive system.

B Name the structure that food passes along to reach the stomach.

Moving through the digestive system

Fibre in your food isn't digested but adds bulk to the food. Muscles push against this, forcing food along the gut. Eating lots of fibre-rich foods such as vegetables and wholemeal bread helps prevent constipation.



◀ Muscles in the wall of the gut squeeze food along – a bit like squeezing a tube of toothpaste.

C Describe how food moves along the gut.

Passing into the blood

The small molecules of nutrients produced during digestion pass into the bloodstream through the wall of the small intestine. They are then transported around the body.

The small intestine needs to absorb the nutrients quickly, before the undigested food passes out of the body. The small intestine is specially adapted to this function. The wall of the small intestine is thin. It is also covered with tiny structures called **villi**. These stick out of the wall and give it a big surface area. They also contain blood capillaries to carry away the absorbed food molecules.

▲ Villi in the small intestine increase the surface area so more nutrients can be absorbed.

Key Words

digestive system, digestion, gullet, stomach, small intestine, large intestine, rectum, anus, villi

Wordbank

Make a wordbank by listing all the scientific terms about digestion. You can refer to your wordbank as you progress through this topic.

Summary Questions

1 Match each organ below to its role in digestion.

stomach	food is chewed and mixed with saliva
small intestine	water is absorbed back into the body
large intestine	food is mixed with acid and digestive juices
rectum	feces are stored here until they pass out of the body
mouth	small molecules of nutrients are absorbed into the blood stream

(5 marks)

2 Describe the adaptations of the small intestine to its function.

(3 marks)

3 Explain why it is important to eat a fibre-rich diet.

(3 marks)

4 Describe in detail the passage of food through the digestive system.

(6 marks QWC)

1.5 Bacteria and enzymes in digestion

Learning objectives

After this topic you will be able to:

- describe the role of enzymes in digestion
- describe the role of bacteria in digestion.

▲ Probiotic foods.

Have you seen the TV adverts that say that yoghurts and yoghurt drinks are good for your digestive system? They contain bacteria, which is important for digestion.

Bacteria in digestion

Your large intestine contains bacteria. They live on the fibre in your diet. They make important vitamins such as vitamin K. These vitamins are then absorbed into your body and help to keep you healthy.

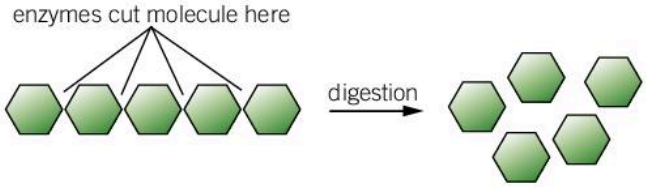
Some foods, called probiotic foods, like live yoghurt, contain these useful bacteria.

A State why bacteria are important in your digestive system.

What's in digestive juices?

Your teeth begin digestion by breaking down food into smaller pieces. The digestive juices in your gut contain **enzymes**. These are special proteins that can break large molecules of nutrients into small molecules.

Large molecules in your food like starch, a type of carbohydrate, are made of lots of smaller molecules joined together. Enzymes chop these large molecules into the smaller molecules they are made from.



◀ Enzymes chop large molecules into smaller molecules.

Enzymes are known as biological **catalysts** – they speed up digestion without being used up.

B State the role of enzymes in digestion.

What's in a name?

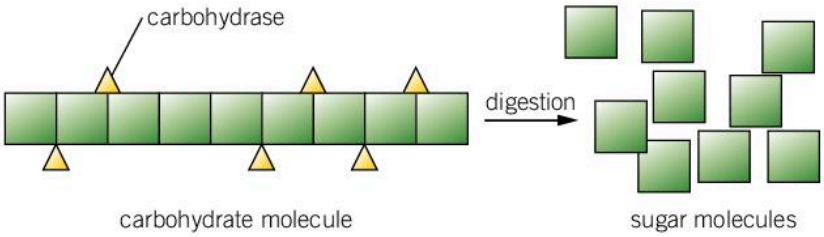
The enzymes carbohydrase, protease, and lipase are named after the type of nutrient they break down.

Different types of enzyme

Different types of enzyme break down different nutrients. There are three main types of enzymes involved in digestion – **carbohydrase**, **protease**, and **lipase**.

Carbohydrase

Carbohydrase is an enzyme that breaks down carbohydrates into sugar molecules.

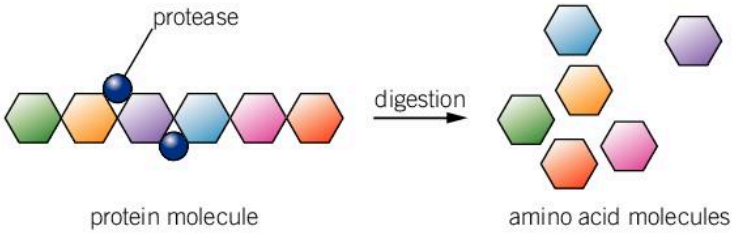


▲ Starch is broken down into sugar molecules.

Carbohydrates are digested in the mouth, stomach, and small intestine. Carbohydrase present in your saliva breaks down the starch in bread into sugar.

Protease

Protease is an enzyme that breaks down proteins into amino acids.



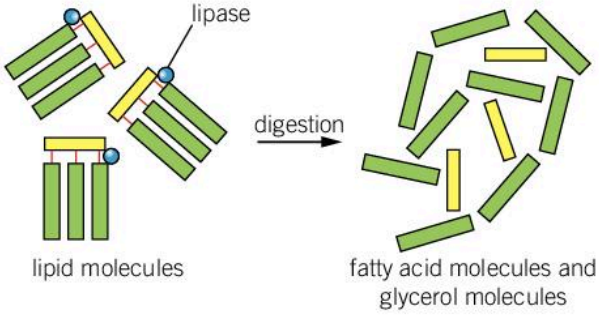
▲ Protein is broken down into amino acids.

Proteins are digested in the stomach and small intestine. Acid in the stomach helps digestion and kills harmful microorganisms in food.

Lipase

Lipase is an enzyme that breaks down lipids into fatty acids and glycerol.

Digestion of lipids takes place in the small intestine. It is helped by **bile**, a substance made in the liver. Bile breaks the lipids into small droplets that are easier for the lipase enzymes to work on.



◀ Lipids are broken down into fatty acids and glycerol.

C State the function of bile.

What happens to the bread you eat?

Describe the journey bread takes through your body and how it is digested. Present its journey as a flow diagram. Hint – bread contains a lot of starch.

Key Words

enzyme, catalyst, carbohydrase, protease, lipase, bile

Summary Questions

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

Carbohydrates/proteins are broken down into sugar by the enzyme **lipase/carbohydrase**. Proteins are broken down into **amino acids/lipase** by the enzyme **carbohydrase/protease**. Lipids are broken down into **lipase/fatty acids and glycerol** by the enzyme **lipase/carbohydrase**.

(6 marks)

2 Explain why live yoghurt should be part of your diet.

(3 marks)

3 Make a visual summary of the ideas on this page to compare the roles of enzymes and bacteria in digestion.

(6 marks)

1.6 Drugs

Learning objectives

After this topic you will be able to:

- describe the difference between recreational and medicinal drugs
- describe the effects of drugs on health and behaviour.

▲ Antibiotic pills are used to treat bacterial infections.

Some drugs can seriously damage your health, or even be deadly. Some can save your life, and are used widely in medicine. So what's the difference?

What are drugs?

Drugs are chemical substances that affect the way your body works. They alter the chemical reactions that take place inside your body. Sometimes these changes are helpful but in many cases they are harmful.

There are two types of drugs – **medicinal drugs** and **recreational drugs**.

A State what is meant by a drug.

What are medicinal drugs?

Medicinal drugs are used in medicine. They benefit your health in some way. They may be used to treat the symptoms of a condition; for example, paracetamol is taken to relieve pain. Other drugs can cure an illness. For example, antibiotics are often used to treat chest infections.

However, even medicinal drugs can cause harm if you do not take them in the right way. Some medicinal drugs also have unwanted side effects. When prescribing drugs, doctors have to weigh up the benefits of a person taking a drug over any possible risks.

B State what is meant by a medicinal drug.

What are recreational drugs?

Recreational drugs are drugs that people take for enjoyment, to help them relax, or to help them to stay awake. Recreational drugs normally have no health benefits and in many cases are harmful.

C State what is meant by a recreational drug.

Recreational drugs are not prescribed by a doctor. Many are illegal – this means that you are breaking the law if you take them. Even very small amounts of these drugs can damage your body. Examples of these drugs include heroin, cocaine, cannabis, and ecstasy.

Key Words

drug, medicinal drug, recreational drug, addiction, withdrawal symptoms

▲ Many recreational drugs are illegal.

▲ Caffeine is a recreational drug that speeds up your nervous system.

D Name three illegal drugs.

Some recreational drugs are legal to use. They can still be harmful. These include:

- alcohol – drinking alcohol affects your nervous system and damages your liver.
- tobacco – smoking significantly increases your risk of cancer, as well as lung and heart disease.

Drug addiction

If your body gets used to the changes caused by a drug, it may become dependent on the drug. This means that you need to keep taking the drug to feel normal. If this happens you have an **addiction**. If a person with an addiction tries to stop taking the drug, they may suffer **withdrawal symptoms**. These can be very unpleasant and make it even harder to give up the drug. Withdrawal symptoms include headaches, anxiety, and sweating.

E State what is meant by an addiction.

Drug factsheet

Produce a factsheet about one of the following drugs to share with other members of your class:
cannabis, cocaine, ecstasy, heroin

Summary Questions

1 Copy and complete the sentences below.

Drugs are _____ that affect the way your body works.

_____ drugs are taken for enjoyment. _____ drugs benefit health.

If you take drugs too often you may develop an _____. When addicted people stop taking drugs, they suffer _____ _____, which can make it harder to give up.

(5 marks)

2 Describe three differences between medicinal drugs and recreational drugs.

(3 marks)

3 Compare the effects of different types of drug on health and behaviour.

(6 marks QWC)

1.7 Alcohol

Learning objectives

After this topic you will be able to:

- describe the effect of alcohol on health and behaviour
- describe the effect alcohol has on conception and pregnancy.

Many adults drink alcohol but it can be harmful. Drinking even small amounts of alcohol can change your behaviour. It can make some people feel relaxed and happy but others can feel aggressive and depressed.

What is alcohol?

Alcohol contains the drug **ethanol**. When you drink alcohol, ethanol is absorbed into your bloodstream. It then travels to your brain, where it affects your nervous system. This chemical is called a **depressant** because it slows down your body's reactions.

A Name the drug found in alcoholic drinks.

If people drink a lot of alcohol regularly, they may need to drink greater and greater amounts to cause the same effect on their body. They may become addicted. People who have an addiction to alcohol are called **alcoholics**.

B State what is meant by the word alcoholic.

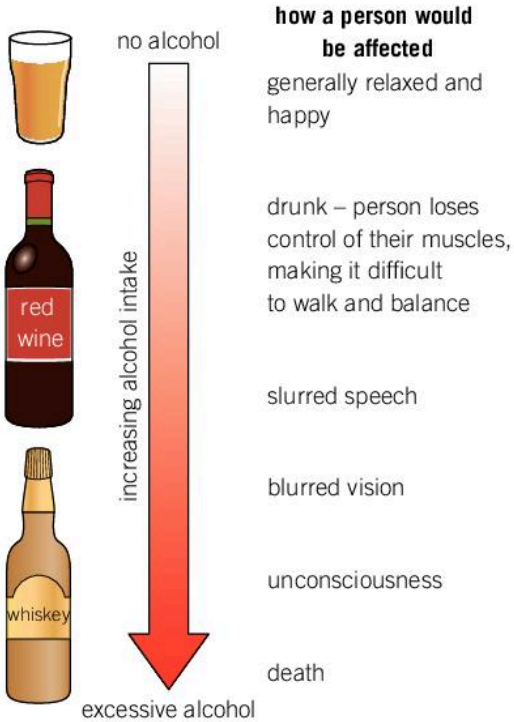
How much alcohol can you drink safely?

Different alcoholic drinks contain different amounts of alcohol. For example, spirits such as vodka and whisky contain more alcohol than beer.

To lower the risk of damage to your body from drinking alcohol, the government recommends that adult women drink a maximum of two **units of alcohol** per day (14 units per week) and adult men a maximum of three units per day (21 units per week). One unit of alcohol is 10 ml of pure alcohol.

However, these are only guidelines because height, weight, and gender affect the way people react to alcohol.

C State the recommended maximum number of alcohol units per week for adult women and for adult men.



▲ This diagram shows what happens to a person as they increase their alcohol intake.

▲ What is one unit of alcohol?

Dangers of alcohol

Drinking large amounts of alcohol over a long time can cause stomach ulcers, heart disease, and brain and liver damage.

Your liver breaks down harmful chemicals (including ethanol) into harmless waste products, which are then excreted from your body. As a result of having to break down large amounts of ethanol the livers of heavy drinkers become scarred. This means their liver works less efficiently, taking longer to break down alcohol and other chemicals. This condition is called cirrhosis of the liver, and can result in death.

D Name three conditions that are more likely to occur if a person drinks a lot of alcohol for a long time.

Should pregnant women drink?

The Department of Health recommends that pregnant women do not drink any alcohol. Drinking alcohol increases the risk of miscarriage, stillbirth, premature birth, and low-birth-weight babies.

When a pregnant woman drinks alcohol, it diffuses into the baby's bloodstream. It can then damage the developing organs and nervous system. Fetal Alcohol Syndrome (FAS) affects the way a baby's brain develops. It can result in children with learning difficulties, facial problems, and poor immune systems.

Alcohol can also reduce fertility in both men and women. This means they are less likely to conceive (get pregnant). For example, alcohol reduces the amount of sperm that a man produces.

Units of alcohol

On drinks labels the alcohol content is given as a percentage of the whole drink. Wine that says "10%" on its label contains 10% pure alcohol. Calculate the number of units of alcohol in a 200 ml glass of wine. One unit = 10 ml of pure alcohol.

Key Words

ethanol, depressant, alcoholic, unit of alcohol

▲ Look at the difference in appearance of a diseased liver (left) and a healthy liver (right).

Summary Questions

1 Copy and complete the sentences below.

Alcoholic drinks contain the drug _____. This is a _____, because it affects the_____ system, slowing down your body's reactions. Drinking alcohol can lead to brain and _____ damage.

(4 marks)

2 Explain why it is important that pregnant women avoid alcohol.

(3 marks)

3 Make a visual summary to show the effects of alcohol on behaviour, health, and life processes such as conception, growth, and development.

(6 marks)

1.8 Smoking

Learning objectives

After this topic you will be able to:

- describe the effects of tobacco smoke on health
- describe the effects of tobacco smoke on pregnancy.

Key Words

passive smoking, stimulant

▲ The chemicals in tobacco smoke can be deadly.

Most people know that smoking harms your health, yet many people still smoke. Even breathing in the smoke of someone else's cigarette can affect your health.

Why is smoking dangerous?

Smoking increases your chances of developing conditions such as breathing problems, cancer, heart attacks, and strokes. Smokers are much more likely to die prematurely than non-smokers. For example, male smokers are over 20% more likely to die from lung cancer than non-smokers.

A Name three conditions that a smoker is more likely to suffer from.

As well as affecting their own health, smokers endanger the health of others. By breathing in other people's smoke, your risk of developing circulatory and respiratory conditions increases. This is known as **passive smoking**.

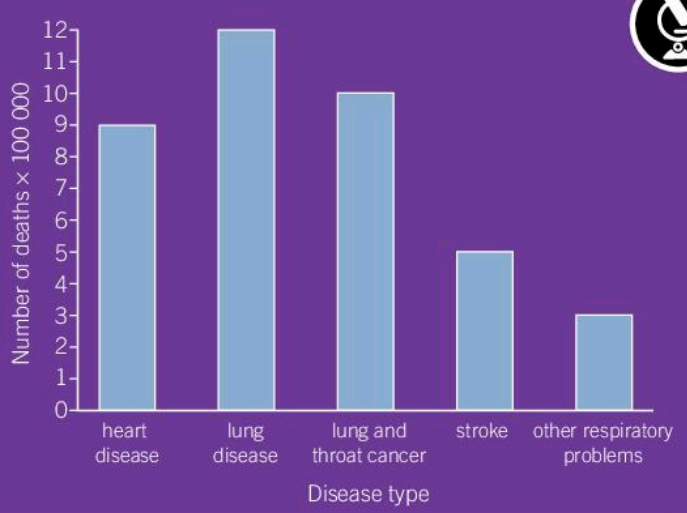
Smoking in pregnancy greatly increases the risk of miscarriage. It can also increase the risk of low-birth-weight babies and affects the fetus's development. Parents who smoke after a baby is born increase the risk of sudden-infant-death syndrome ('cot death') and respiratory illness, such as bronchitis and pneumonia.

B State what is meant by passive smoking.

Deadly smoke

Use the graph to answer the following questions:

1. Which smoking-related diseases cause the greatest number of deaths?
2. How many more deaths occurred due to lung disease than heart disease?
3. How many times more likely is a smoker to die from lung and throat cancer, compared to a stroke?



What's in tobacco smoke?

Cigarettes contain tobacco. Tobacco smoke contains over 4000 chemicals, many of which are harmful. These include:

- tar – a sticky black material that collects in the lungs. It irritates and narrows the airways. Some of the chemicals it contains cause cancer.
- nicotine – an addictive drug that speeds up the nervous system. It is a **stimulant**, which makes the heart beat faster and narrows blood vessels.
- carbon monoxide – a poisonous gas that stops the blood from carrying as much oxygen as it should. It binds to the red blood cells in the place of oxygen.

C Name the addictive drug in tobacco smoke.

How does smoking cause disease?

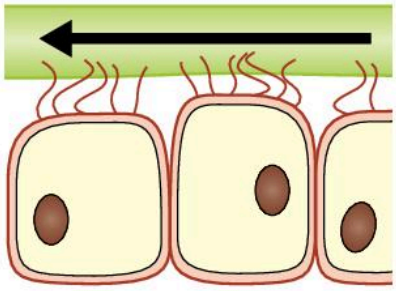
◀ This diseased lung is full of tar. Healthy lungs should be pink.

Some examples of the way smoking causes disease are listed below:

- Heart disease – smoking causes a person's arteries to become blocked. This prevents blood flowing properly, and can cause a heart attack or stroke.
- Emphysema (a lung disease) – chemicals in tobacco smoke affect the alveoli in your lungs. Their walls become weakened so they do not inflate properly when you inhale. They may also burst during coughing. This reduces the amount of oxygen that can pass into the blood, making the person breathless.
- Respiratory infections – the cells lining your windpipe produce mucus, which traps dirt and microorganisms. They also have cilia that sweep the mucus into your stomach, keeping your airways clean. Chemicals in tobacco smoke stop the cilia from moving. This allows mucus to flow into your lungs, making it harder to breathe and often causing infection. Smokers cough this mucus up, which can damage the lungs further.

Foul Fact

According to the World Health Organisation, approximately one person dies every six seconds due to tobacco. Deaths caused by tobacco accounts for 10% of adult deaths.



▲ Smoking makes it harder for ciliated cells to sweep mucus from your airways.

Summary Questions

1 Match the chemicals in tobacco smoke to their harmful effect.

tar	addictive and makes the heart beat faster
nicotine	reduces the amount of oxygen the blood can carry
carbon monoxide	contains chemicals that cause cancer

(3 marks)

2 Suggest why smokers often cough a lot when they first wake in the morning.

(2 marks)

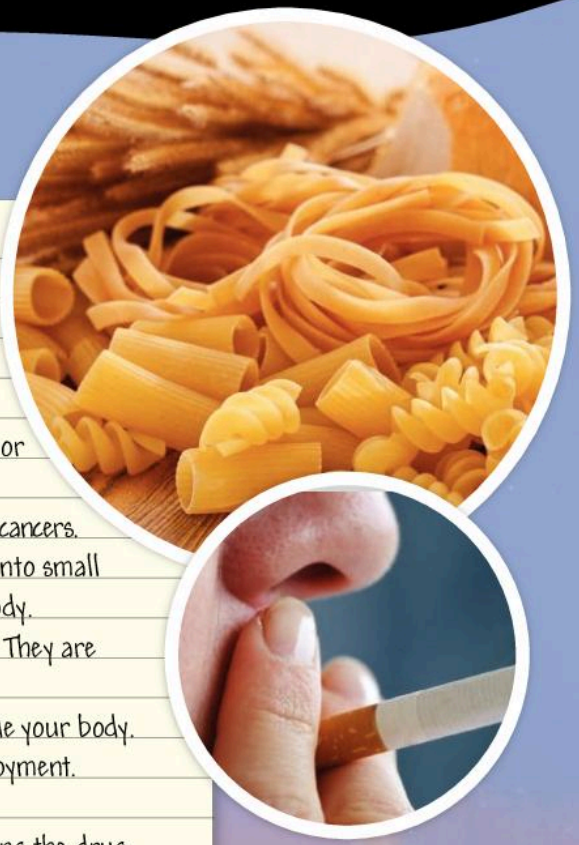
3 Describe how tobacco smoke can cause problems during pregnancy.

(2 marks)

4 Explain in detail three ways that smoking can damage your health.

(6 marks QWC)

B2 Chapter 1 Summary



Key Points

- Nutrients are essential substances that your body needs to survive. They are carbohydrates, lipids, proteins, vitamins, mineral, water, and fibre.
- Food tests are used to find out which nutrients a food contains.
- To remain healthy you must eat a balanced diet. This means eating food containing the right nutrients in the correct amounts.
- Underweight people often lack energy. They may also suffer from a vitamin or mineral deficiency, which can cause problems like a poor immune system.
- Overweight people have an increased risk of heart disease, stroke, diabetes, and some cancers.
- During digestion large molecules like lipids and proteins are broken down into small molecules. They can then pass into the blood where they are used by the body.
- Enzymes are proteins that can break large molecules into small molecules. They are biological catalysts – they speed up digestion without being used up.
- Drugs are substances that alter the chemical reactions that take place inside your body. Medicinal drugs have health benefits. Recreational drugs are taken for enjoyment.
- If a person becomes dependent on a drug, they have an addiction.
- A person with an addiction can suffer withdrawal symptoms if they stop taking the drug.
- Alcoholic drinks contain the drug ethanol. This is a depressant, which slows down the nervous system.
- Drinking large amounts of alcohol over a long time can cause stomach ulcers, heart disease, and brain and liver damage. A person with an alcohol addiction is called an alcoholic.
- Smoking tobacco causes breathing problems, cancer, heart attacks, and strokes.
- Tobacco smoke contains nicotine. This is a stimulant, which speeds up the nervous system. It is also addictive.

Key Words

nutrients, carbohydrate, lipids, protein, vitamin, mineral, fibre, balanced diet, food test, hypothesis, malnourishment, starvation, deficiency, obese, digestive system, digestion, gullet, stomach, small intestine, large intestine, rectum, anus, villi, feces, enzyme, catalyst, carbohydrase, protease, lipase, bile, drug, medicinal drug, recreational drug, addiction, withdrawal symptom, ethanol, alcoholic, depressant, unit of alcohol, stimulant, passive smoking, hypothesis

BIG Write

Say no to drugs

You work for the NHS as a communications officer. You have been asked to produce an antidrugs leaflet. It will be given to all teenagers as part of an antidrugs campaign.

Task

Write the text that will appear in the leaflet. It should contain information on smoking, alcohol, and illegal recreational drugs.

Tips

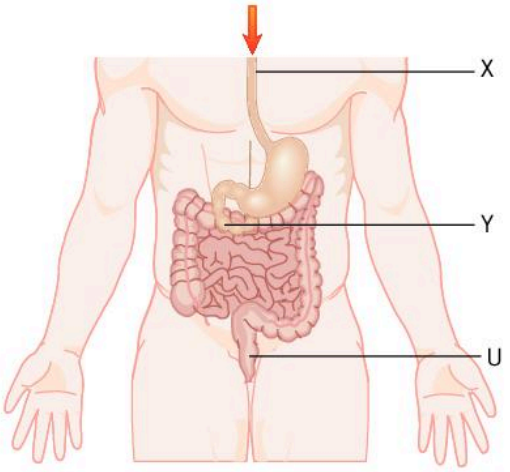
- Make sure your points are clear, concise, and convincing – back up your arguments with scientific facts.
- Keep your audience in mind – your leaflet needs to appeal to teenagers and all scientific concepts must be explained clearly.

End-of-chapter questions

1 To remain healthy you must eat a balanced diet. Draw a line to match the nutrient to its function in the body.

carbohydrates	used for growth and repair
lipids	needed in small amounts to keep you healthy
proteins	provide energy
vitamins and minerals	provide a store of energy and are used to insulate the body

(4 marks)



2 The diagram above shows your digestive system.

a Name structure X. *(1 mark)*

b State what happens in structure Y. *(1 mark)*

c Which letter represents the structure that stores feces until it leaves the body? *(1 mark)*

d Describe the role of the stomach in digestion. *(2 marks)*

(5 marks)

3 A student wants to do a food test to find out which nutrients are in crisps. She starts by making a solution of the crisps.

a Name the piece of equipment she should use to break the crisps into small pieces. *(1 mark)*

b Suggest **two** safety precautions the student should take before beginning the test. *(2 marks)*

c Describe how the student should test the food solution for protein. *(3 marks)*

(6 marks)

4 People take drugs for a number of reasons.

a Describe the difference between medicinal drugs and recreational drugs. *(2 marks)*

b State how a drug causes an effect on the body. *(1 mark)*

c State the difference between a stimulant and a depressant. Give an example of each type of drug. *(4 marks)*

(7 marks)

5 Enzymes are special proteins that play a crucial rule in digestion.

a Describe the role of enzymes in digestion. *(1 mark)*

b Explain why enzymes are called catalysts. *(2 marks)*

c Compare how and where carbohydrates and proteins are digested. *(4 marks)*

d Explain how lipids are broken down and digested. *(3 marks)*

(10 marks)

6 Alcohol contains the drug ethanol and can have damaging effects on health.

Explain why a couple should avoid alcohol when trying to conceive, and why a pregnant woman should not drink any alcohol during pregnancy.

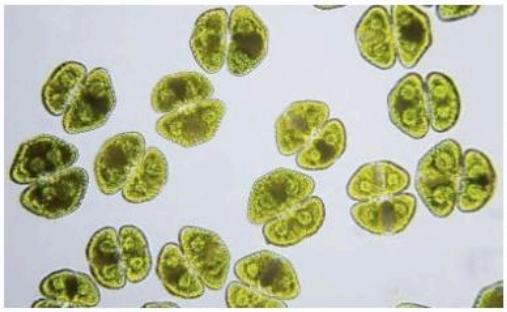
(6 marks QWC)

2.1 Photosynthesis

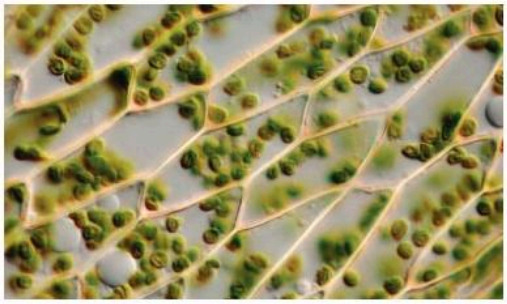
Learning objectives

After this topic you will be able to:

- describe the process of photosynthesis
- state the word equation for photosynthesis.



▲ Algae live in water.



▲ Photosynthesis takes place inside chloroplasts in leaf cells.

Hypothesis

A hypothesis is an idea about why something happens.
Look at the word equation for photosynthesis. Write a hypothesis for what would happen to the plant if you put it in a dark cupboard for a week. Write a plan for how you could test this hypothesis by carrying out an investigation.

Unlike animals, plants do not have to eat other organisms to survive. Instead they make their own food using sunlight. How do they do this?

What is a producer?

Plants and **algae** are called **producers** because they make their own food. They convert materials found in their environment into glucose, a carbohydrate, using sunlight.

Algae are like plants because they are green organisms that make their own food. However, they differ from plants in the following ways:

- They can be unicellular or multicellular organisms.
- They live underwater while most plants live on land.
- Algae do not have leaves, stems, or roots.

Animals are called **consumers** as they have to eat other organisms to survive. These can be plants or other animals. They break down the organism during digestion. This releases nutrients, which are then used by the body.

A State what is meant by a producer.

What is photosynthesis?

Plants make food through the process of **photosynthesis**. Photosynthesis is a chemical reaction in which plants take in carbon dioxide and water and change them into glucose. This provides the plant with food. Oxygen is also made. Oxygen is a waste product of the reaction. Oxygen is released back into the atmosphere. Plants need to use light from the Sun in this chemical reaction.

The word equation below shows the process of photosynthesis.

$$\underset{\text{(reactants)}}{\text{carbon dioxide} + \text{water}} \xrightarrow{\text{light}} \underset{\text{(products)}}{\text{glucose} + \text{oxygen}}$$

B State the word equation for photosynthesis.

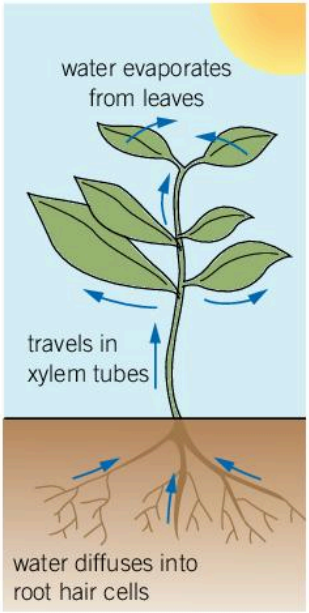
Where does photosynthesis occur?

Photosynthesis mainly takes place in chloroplasts in the leaf cells, though a small amount happens in the stem. Leaves and stems are green because they contain the green pigment **chlorophyll**. Chlorophyll uses light from the Sun. The energy transferred from the Sun is needed for the plant to change carbon dioxide and water into glucose and oxygen.

C Name the part of the cell where photosynthesis occurs.

How does water get into a plant?

Water diffuses into the root hair cells. It is then transported around the plant in tubes, called xylem tubes. As the water evaporates from the leaves, more water is drawn up through the plant. It is a bit like sucking on a straw!

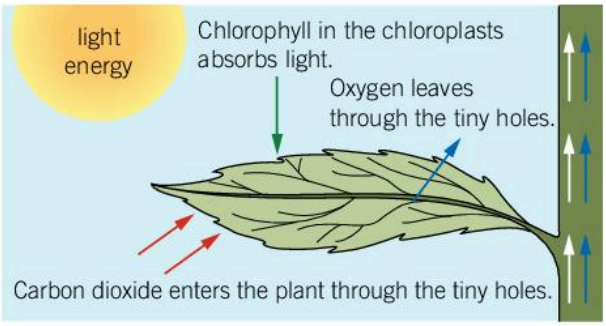


▲ Water enters the plant through the roots, then travels through the plant in the xylem tubes.

How do gases get into and out of a plant?

On the underside of the leaf there are tiny holes. These allow gases to diffuse into the leaf. Carbon dioxide diffuses into the leaf, and oxygen diffuses out.

The diagram below represents what happens during photosynthesis.



Glucose is transported to all the parts of the plant. Water is transported from the roots to the stem and leaves.

Definitions

Using the information in the text to write a definition of the following words – producer, consumer, photosynthesis.

Key Words

algae, producer, consumer, photosynthesis, chlorophyll

Link

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

Summary Questions

1 Copy and complete the sentences below.

Plants and _____ are _____. They use _____ to make their own food. They use _____ and water to make _____ and oxygen using _____ energy.

(6 marks)

2 Explain why photosynthesis is important for all life.

(3 marks)

3 State and explain whether photosynthesis would occur in the following situations:

a a bright sunny day *(1 mark)*

b at night *(1 mark)*

c in the root hair cells *(2 mark)*

4 Explain how the reactants of photosynthesis get into the leaf cells and what happens to the products of photosynthesis.

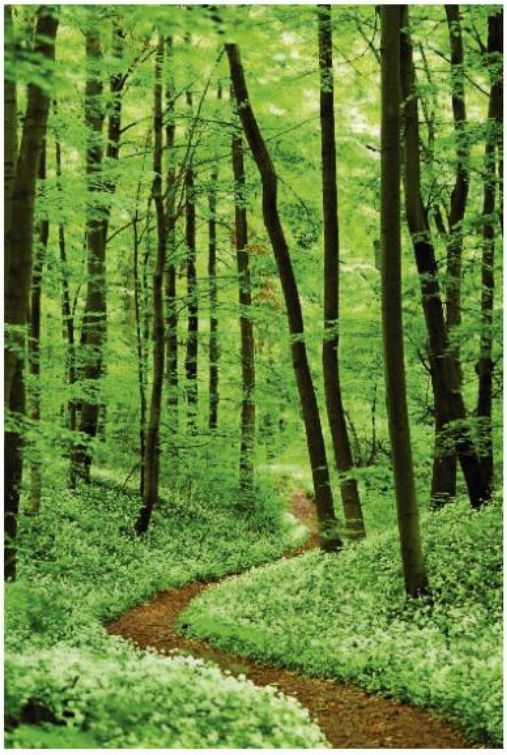
(6 marks QWC)

2.2 Leaves

Learning objectives

After this topic you will be able to:

- describe the structure and function of the main components of a leaf
- explain the distribution of chloroplasts in a leaf.



▲ Leaves come in all shapes and sizes.

Leaves come in all shapes and sizes. Most are green because they contain lots of chlorophyll but have you ever looked closely at a leaf? Some, like stinging nettles, are covered in tiny hairs.

Structure of a leaf

Leaves are specially adapted for photosynthesis. Each component of a leaf has a special function that helps it to carry out photosynthesis. Most leaves:

- are green – they contain chlorophyll, which absorbs sunlight
- are thin – this allows gases to diffuse in and out of the leaf easily
- have a large surface area – to absorb as much light as possible
- have veins – these contain xylem tubes, which transport water, and phloem tubes, which transport glucose.

A State why most leaves are green.

The underneath of a green leaf is lighter than the top. This is because the cells in the bottom of the leaf contain fewer chloroplasts, which means there is less chlorophyll. Most sunlight hits the top of the leaf so this is where the chloroplasts need to be to absorb as much sunlight as possible.

B State which part of the leaf contains the most chloroplasts.

The top of the leaf feels waxy, whereas the bottom is normally much drier. This waxy layer reduces the amount of water evaporating out of the leaf. The Sun will heat up the top of the leaf, which means more water will try to escape from the leaf's top surface.

C State why the top surface of the leaf is covered in a waxy layer.

Link

You can learn more about evaporation in C1 1.5 More changes of state

Observing stomata

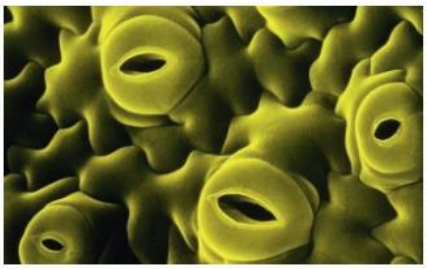
Draw a detailed diagram of the underside of a leaf, labelling the key structures.

How do gases get into and out of the leaf?

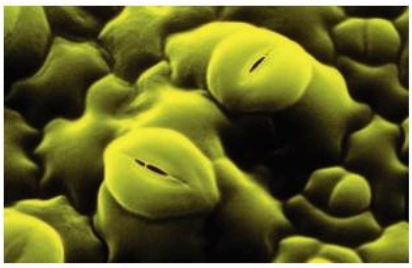
The tiny holes found on the bottom surface of the leaf are called **stomata** (singular: stoma). Their function is to allow gases to diffuse into and out of the leaf:

- Carbon dioxide diffuses in. Carbon dioxide is a reactant in photosynthesis.
- Oxygen and water vapour diffuse out. Oxygen and water are products of photosynthesis.

Stomata are opened and closed by guard cells. These cells open the stomata during the day, and close them at night.

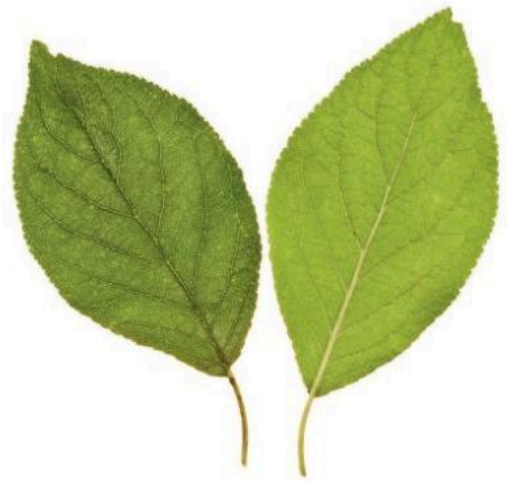


▲ Open stomata.



▲ Closed stomata.

D State the function of stomata.

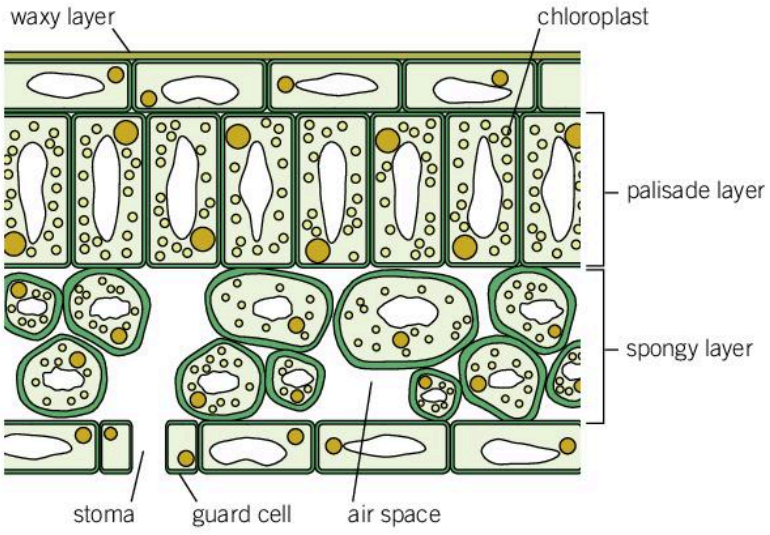


▲ The top and bottom surfaces of the leaf are normally quite different.

Key Words

stomata

What does the inside of a leaf look like?



▲ Cross section of a leaf.

The leaf is divided into two main layers:

- palisade layer – contains cells packed with chloroplasts. This is where most of a plant's photosynthesis occurs.
- spongy layer – contains air spaces, allowing carbon dioxide to diffuse throughout the leaf. Oxygen diffuses out of the leaf.

Summary Questions

1 Match the part of a leaf to its function.

stomata	reduces amount of water evaporating
waxy layer	main site of photosynthesis
guard cells	transport water to cells in leaf
veins	open and close stomata
cells in palisade layer	allow gases to diffuse into and out of the leaf

(5 marks)

2 Suggest why stomata may close during hot weather.

(1 mark)

3 Explain in detail how leaves are adapted for photosynthesis.

(6 marks QWC)

2.3 Plant minerals

Learning objectives

After this topic you will be able to:

- describe how a plant uses minerals for healthy growth
- explain the role of nitrates in plant growth.

Link

You can learn more about the importance of minerals in B2 1.1 Nutrients

Farmers and gardeners regularly check their plants for signs of poor health. If your plants start to wilt they need watering. What does it mean if the leaves turn yellow? Just like people, plants need minerals for healthy growth.

What minerals do plants need?

For healthy growth, plants need four important minerals:

- **nitrates** (contain nitrogen) – for healthy growth
- **phosphates** (contain phosphorus) – for healthy roots
- **potassium** – for healthy leaves and flowers
- **magnesium** – for making chlorophyll.

A Name four minerals that plants need for healthy growth.

Where do plants get minerals from?

Plants get the minerals they need from the soil. The minerals are dissolved in soil water. They are absorbed into the root hair cells, and are then transported around the plant in the xylem tubes.

B State how minerals enter plants.

Mineral deficiency

If a plant does not get enough minerals, its growth will be poor. This is called a mineral **deficiency**. Different mineral deficiencies have different symptoms:

- nitrate deficiency – plant will have poor growth and older leaves are yellowed
- magnesium deficiency – plant leaves will turn yellow
- phosphorus deficiency – plant will have poor root growth, and younger leaves look purple
- potassium deficiency – has yellow leaves, with dead patches.

C State what is meant by a mineral deficiency.

▲ A nitrate deficiency results in poor growth.

Mineral deficiency

Produce a leaflet for farmers that could help them to decide which mineral their plant is missing. You should include an image of a healthy plant that farmers can compare to their own.

The chlorophyll molecule, which makes plants green, contains magnesium. If a plant does not get enough magnesium it can't make as much chlorophyll as it needs. This results in yellow leaves.

Nitrates are involved in making amino acids. The amino acids join together to form proteins. These proteins are needed for cell growth, to grow leaves and shoots.

Why do farmers use fertilisers?

When crops are harvested, minerals are removed from the ground. These would normally be replaced when the plant dies, or when leaves are shed. To prevent future crops suffering from a mineral deficiency, farmers add chemicals to the soil to replace missing minerals – these chemicals are called **fertilisers.**

D State what is meant by a fertiliser.

NPK is a common fertiliser. It contains three of the important minerals needed for healthy plant growth: nitrogen (N), phosphorus (P), and potassium (K).

▲ Farmers use fertilisers to add minerals to their crops.

▲ Magnesium deficiency results in yellow leaves.

Key Words

nitrates, phosphates, potassium, magnesium, deficiency, fertiliser

Summary Questions

1 Copy and complete the sentences below.

To remain healthy, plants need to absorb _____ from the soil. They are absorbed through the root _____ cells and then travel around the plant in the _____ tubes.

The mineral _____ is needed to make chlorophyll, and _____ are needed to make amino acids.

(5 marks)

2 Explain the role of nitrates in plant growth.

(3 marks)

3 Explain in detail why farmers have to add to fertiliser to soil to ensure good crop yields year after year.

(6 marks QWC)

2.4 Chemosynthesis

Learning objectives

After this topic you will be able to:

- describe where chemosynthesis takes place
- describe the process of chemosynthesis.

Key Words

chemosynthesis

All living organisms need food to survive. Animals are consumers but plants and some microorganisms have to produce their own food. Plants use light to photosynthesise. How do microorganisms that live in the dark make their own food?

What is chemosynthesis?

Some species of bacteria use a variety of chemical reactions to make glucose. Glucose is a carbohydrate. This process is known as **chemosynthesis**.

A State what is meant by chemosynthesis.

You know the word equation for photosynthesis. There is no general word equation for chemosynthesis, as the chemical reaction depends on the chemical involved. Chemosynthesis reactions:

- use chemicals as their source of energy
- often use carbon dioxide as a reactant
- have glucose as a product.

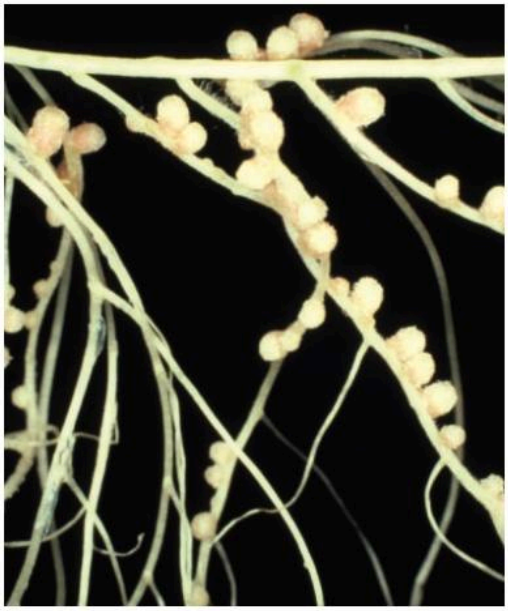
B Name the gas that is often used in chemosynthesis.

Where do bacteria live?

Bacteria that perform chemosynthesis are called chemosynthetic. They live in places without light.

- Sulfur bacteria are found at the bottom of the sea near volcanic vents. Hydrogen sulfide pours out of the vents. The sulfur bacteria turn the hydrogen sulfide into sulfur by chemosynthesis. This produces organic molecules, which they use as nutrients.
- Nitrogen bacteria perform chemosynthesis using nitrogen compounds. They live in the soil and roots of some plants.

C Name two types of bacteria that perform chemosynthesis.

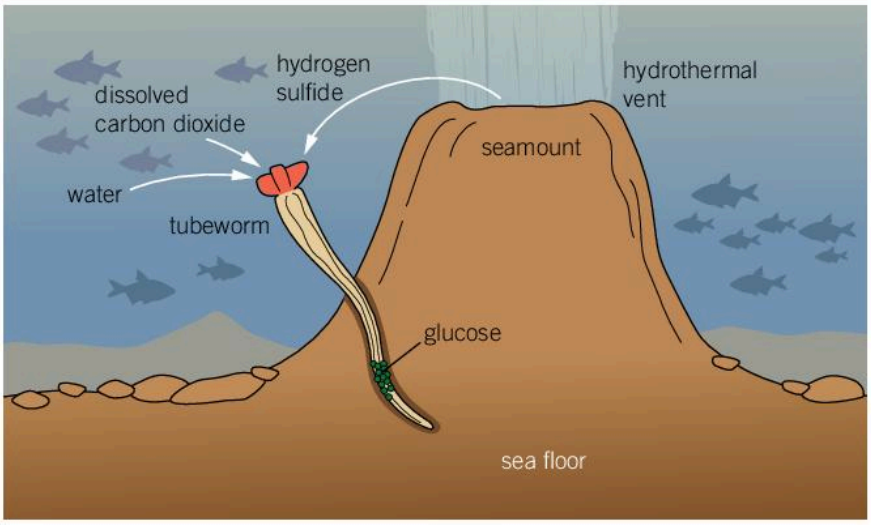


▲ Nitrogen bacteria live on plant roots.

Chemosynthesis in other organisms

Some chemosynthetic bacteria live within animals. For example, tubeworms, which live close to deep sea vents, have no stomach. Instead, chemosynthetic bacteria live within the tubeworm. The bacteria use chemicals from the tubeworms to make food. In return, the tubeworms feed off the substances made by the bacteria.

This type of biological relationship between organisms, where each organism benefits the other, is known as a symbiotic or mutualistic relationship.



▲ Chemosynthetic bacteria live within tubeworms, close to volcanic vents on the ocean floor. They produce sulfur, which is used to make nutrients needed by the tubeworms.

▲ Tubeworms on a deep sea vent.

Interesting organisms

Find out about one organism that performs chemosynthesis. Share your findings with your partner.

Photosynthesis and chemosynthesis

The table below shows the similarities and differences between photosynthesis and chemosynthesis.

	Photosynthesis	Chemosynthesis
Energy required	yes	yes
Energy source	light	chemical
Water required?	yes	not always
Carbon dioxide required?	yes	usually
Glucose produced?	yes	yes

Summary Questions

1 Copy and complete the sentences below.

Some species of _____ use energy released by chemical _____ to make _____ .

This process is known as _____ .

(4 marks)

2

a Name one organism that produces glucose through the process of chemosynthesis. *(1 mark)*

b For the example you have chosen, explain why it cannot produce glucose using photosynthesis. *(1 mark)*

3 Seaweed is a plant. Tubeworms contain bacteria that perform chemosynthesis. Compare the way in which glucose is produced in seaweed and tubeworms.

(6 marks QWC)

2.5 Aerobic respiration

Learning objectives

After this topic you will be able to:

- state the word equation for aerobic respiration
- describe the process of aerobic respiration.

Key Words

aerobic respiration, plasma, haemoglobin

You now know how organisms consume or produce glucose, but what happens next? Glucose is the key chemical that your body needs.

How do cells transfer energy?

Your body needs energy for everything it does. You need energy to move, to grow, and to keep warm. Energy is being used constantly (even when you are asleep!) to keep your body functioning.

You get your energy from organic molecules in the food you eat. To transfer the energy stored in food, glucose reacts with oxygen in a chemical reaction called **aerobic respiration**. This reaction transfers energy to your cells. The waste products carbon dioxide and water are also produced.

A Name the chemical reaction that transfers energy from glucose.

The word equation for aerobic respiration is:

glucose + oxygen ⟶ carbon dioxide + water (+ energy)

(reactants) (products)

B State the word equation for aerobic respiration.

Defining respiration

Read through the information about respiration on these pages for three minutes. Close the book, and produce a definition and description of aerobic respiration. Swap your ideas with a partner. Together can you improve your definition?

▲ Physically active people like athletes need to eat lots of high-energy foods, as their bodies require energy to be transferred quickly.

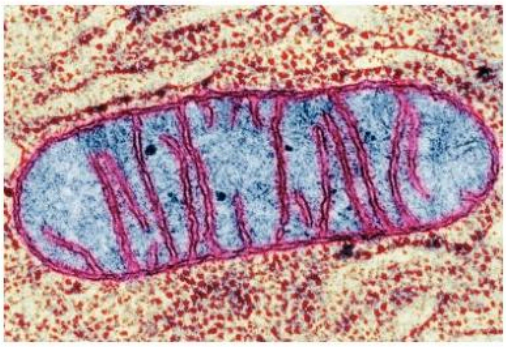
Link

You can learn more about mitochondria in B1 2.2 Plant and animal cells

Where does respiration happen?

Respiration happens inside tiny structures inside your cells called mitochondria. All cells contain mitochondria but different cells contain different amounts. Muscle cells carry out lots of respiration, so they contain large amounts of mitochondria.

C State where in a cell respiration occurs.



▲ A mitochondrion.

How does glucose get into cells?

Glucose is a carbohydrate found in food. Digestion breaks down food into small molecules, releasing glucose molecules. These molecules are absorbed by the wall of the small intestine, into the bloodstream.

Glucose is transported around your body in your blood. It dissolves in the liquid part of your blood called **plasma**. The dissolved glucose can diffuse into the cells that need it for respiration.

How does oxygen get into cells?

When you breathe in, oxygen fills the alveoli in your lungs. The oxygen then diffuses into your bloodstream.

Oxygen is carried by the red blood cells in your body. Red blood cells contain **haemoglobin** (the substance that makes them red). Oxygen joins to the haemoglobin, and gets carried around the body in the blood vessels. When it reaches a cell requiring oxygen, the oxygen diffuses into the cell.

▲ Red blood cells carry oxygen to cells.

D Name the component of blood that carries oxygen around the body.

How does carbon dioxide leave the body?

If carbon dioxide remained in your body it would build up to a harmful level. You get rid of carbon dioxide when you exhale. Carbon dioxide produced during respiration diffuses out of your cells and into the blood plasma. The blood transports it to the lungs, where it diffuses into the air sacs, and is then exhaled.

E Name the component of blood that transports carbon dioxide.

Summary Questions

1 Copy and complete the sentences below.

Energy is released in _____ inside your cells by the process of _____. _____ and oxygen react together to release _____. Carbon dioxide and _____ are produced as waste products.

(5 marks)

2 Describe where and how respiration takes place.

(4 marks)

3 Explain in detail how the reactants of respiration get into the cells and what happens to the products of respiration.

(6 marks QWC)

2.6 Anaerobic respiration

Learning objectives

After this topic you will be able to:

- state the word equation for anaerobic respiration
- describe the differences between aerobic and anaerobic respiration.

▲ After heavy exercise you will breathe heavily, to break down lactic acid in your muscles.

Key Words

anaerobic respiration, oxygen debt, fermentation

Useful microorganisms

Using the information on this page, write a paragraph explaining how anaerobic respiration is used to produce a useful product.

During a sprint race athletes have very little time to breathe. Respiration must constantly supply your body with energy, even when you are unable to breathe.

How do you respire without oxygen?

Anaerobic respiration is a type of respiration that does not use oxygen. Your body uses this type of respiration to transfer energy from glucose when there is not enough oxygen for aerobic respiration to take place.

Anaerobic respiration often happens during strenuous exercise, as the body requires extra energy to be produced quickly. The body can transfer this extra energy for short periods of time without oxygen.

The word equation for anaerobic respiration is:

glucose ⟶ lactic acid (+ energy)

(reactant) (products)

A State the word equation for anaerobic respiration.

There are two reasons why the body normally respires aerobically:

1. Aerobic respiration transfers more energy per glucose molecule than anaerobic respiration.
2. The lactic acid produced from anaerobic respiration can cause painful cramps in your muscles.

When you have finished exercising you keep on breathing heavily. The extra oxygen you inhale breaks down the lactic acid. The oxygen needed for this process is called the **oxygen debt**.

B State two reasons why the body normally respires aerobically.

Do other organisms perform anaerobic respiration?

Other animals also use anaerobic respiration when they require a lot of energy quickly. For example, when a fox chases a rabbit, both organisms are likely to respire anaerobically.

Anaerobic respiration also takes place in plants and some microorganisms when there is no oxygen available. For example, the roots of plants in waterlogged soils respire anaerobically.

Fermentation

Anaerobic respiration in some microorganisms produces ethanol and carbon dioxide instead of lactic acid. This process is called **fermentation**. Fermentation is a type of anaerobic respiration, as the microorganism respires without oxygen.

The word equation for fermentation is:

glucose ⟶ ethanol + carbon dioxide (+ energy)

(reactant) (products)

C State the word equation for fermentation.

Yeast is an important microorganism in food production. It is needed to make bread, beer, and wine. These products are made using fermentation.

D State three products that are made using fermentation.

How do you make bread?

To make bread, bakers mix together flour, water, and yeast to make dough. The yeast ferments the carbohydrates in the flour into ethanol and carbon dioxide. The gas is trapped inside the dough and makes it rise. When the dough is baked the ethanol evaporates, and the dough becomes bread.

How do you make beer and wine?

Beer is made by fermenting barley grains; wine is made by fermenting grapes. In both cases, yeast ferments sugar into alcohol.

▲ Yeast ferments the sugar in barley to make beer.

▲ Yeast is a type of fungus.

Fantastic Fact

The world record for the longest loaf of bread is 1211.6 m. It was baked in Portugal in 2005 during the Bread and Bakers' Party.

Summary Questions

1 Copy and complete the sentences below.

_____ respiration is a type of respiration that does not use _____.

Anaerobic respiration in humans causes _____ to be released from glucose. _____ is produced as a waste product, which can build up in muscles and cause _____.

Some microorganisms carry out a type of anaerobic respiration called _____. In this reaction carbon dioxide and _____ are produced.

(7 marks)

2 Describe the main differences between anaerobic and aerobic respiration.

(3 marks)

3 Imagine you are an athletics coach. Explain to a sprinter why they use anaerobic respiration during a race but marathon runners use aerobic respiration.

(6 marks)

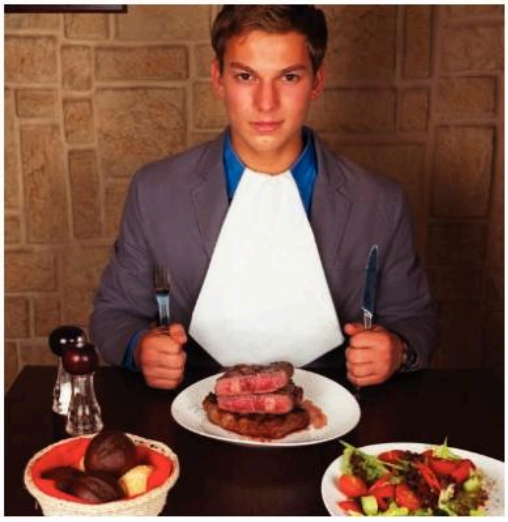
2.7 Food chains and webs

Learning objectives

After this topic you will be able to:

- describe what food chains show
- describe what food webs show.

To survive you need to transfer energy from food to your cells. You need to eat plants or other animals. Some of the animals you eat may have to eat other animals to survive. We can represent this information in diagrams called food chains and food webs.



▲ A human is an omnivore. This means we eat both plants and other animals.

What is a food chain?

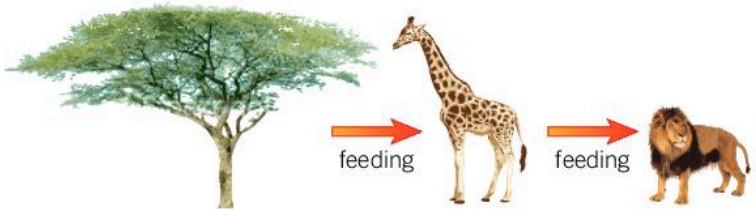
A **food chain** is a diagram that shows what an organism eats. It shows the transfer of energy between organisms.

A State what a food chain is.

Food chains have the following features:

- The first organism is a producer. Energy is transferred from the Sun to the organism and is changed into glucose by photosynthesis.
- The second organism is a herbivore. This is an animal that only eats plants.
- The third organism is a carnivore. This is an animal that eats other animals.
- Arrows show the transfer of energy (stored in food) from one organism to the next.

B State the difference between a herbivore and a carnivore.



An example of a food chain from Africa is shown opposite.

In this example the acacia tree is a producer, the giraffe is a herbivore, and the lion is a carnivore.

A giraffe is also a **prey** organism. This means that it is eaten by another animal. The lion is a **predator**. This means it eats other animals.

C State the difference between a predator and a prey organism.

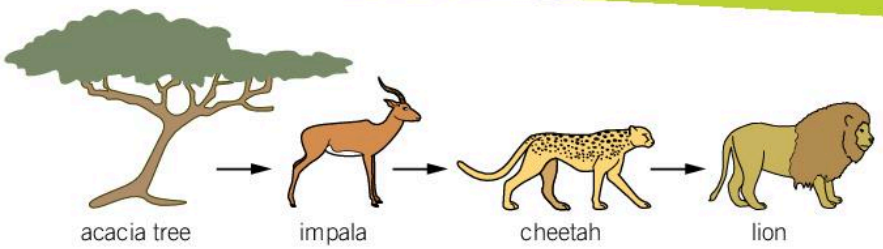
Key Words

food chain, predator, prey, food web

Do all food chains have three links?

Most food chains have only four or five links. If there were more, too little energy would be transferred to organisms at the top of the chain. As energy is transferred along the food chain some is

transferred to the surroundings by heating and as waste products. This means that at each level of the food chain less energy is transferred to the organism in the level above.



The food chain opposite has four links:

The lion can is called the top predator – this means it is not eaten by any other animals. The top predator is always the last link in the food chain.

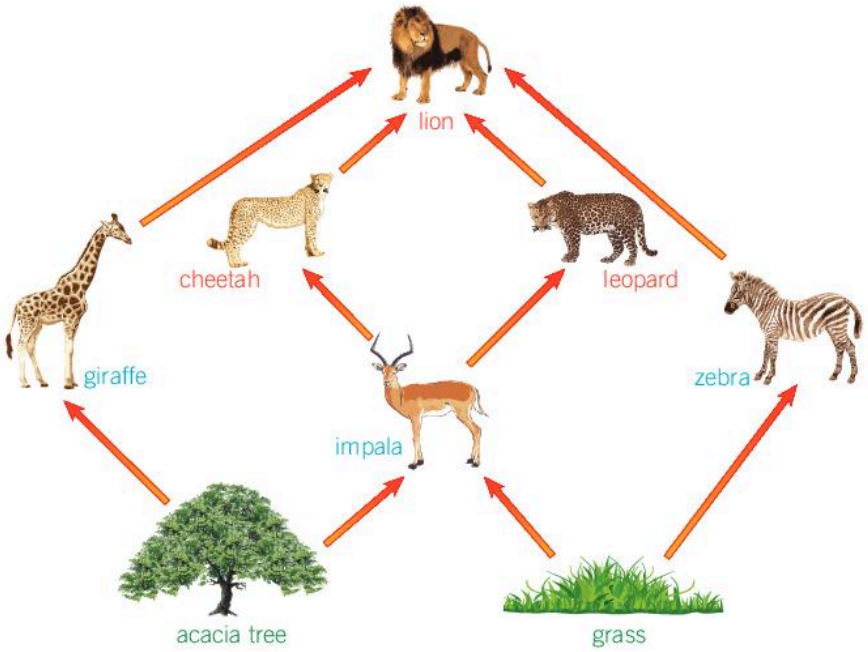
How much energy?

Around 10% of the energy available at one level of a food chain is transferred to the next level. If 1000 kJ of energy enters a food chain that has three links, how much energy would be transferred to the top predator?

What is a food web?

Most animals eat more than one type of organism. For example, lions eat giraffes, cheetahs, leopards, and zebras. Scientists show this in **food webs**. A food web is a set of linked food chains. Food webs show the feeding relationships of organisms more realistically than food chains.

D State what a food web is.



▲ A food web showing feeding relationships in Africa.

Summary Questions

1 Match the following definitions to their meanings.

food chain	diagram showing linked food chains
food web	animal that is eaten
predator	animal that eats another animal
prey	diagram showing the transfer of energy between organisms

(4 marks)

2 Use the food web on this page to answer the questions below.

a Name a herbivore. *(1 mark)*

b Name a producer. *(1 mark)*

c State what the giraffe eats. *(1 mark)*

d Draw a food chain that has four links. *(2 marks)*

3 Using scientific terms, describe the feeding relationships between the organisms in the following food chain.

grass → grasshopper → field mouse → owl

5000 kJ of energy is available in the grass.

(6 marks)

2.8 Disruption to food chains and webs

Learning objectives

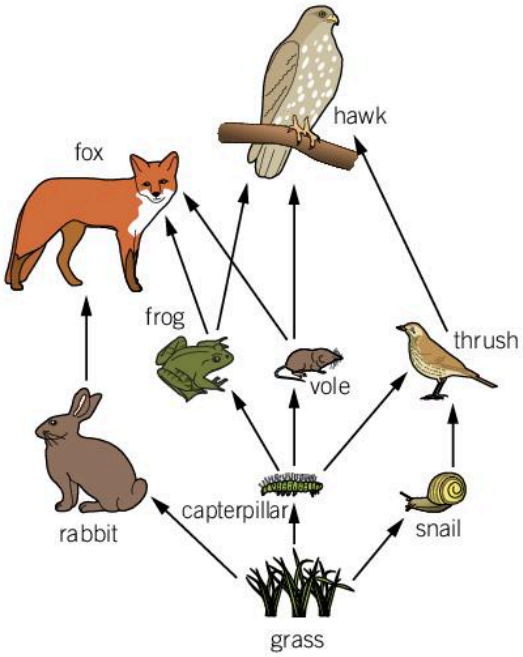
After this topic you will be able to:

- describe the interdependence of organisms
- describe how toxic materials can accumulate in a food web.

Some crops, including many fruits and vegetables, depend on bees to pollinate their flowers in reproduction. Bees depend on flowers as they feed on their nectar to survive. Bees and flowers are said to be interdependent – they each depend on the other for survival.

Interdependence is the way in which living organisms depend on each other to survive, grow, and reproduce.

A State what is meant by interdependence.



▲ The organisms in this food web are interdependent.

Interdependence in food webs

The organisms in a food web depend on each other for survival. They are interdependent.

The number of animals or plants of the same type that live in the same area is called a **population**. In a food web, the populations of organisms are constantly changing. The population size of one type of organism has a direct effect on the size of another type of population.

The food web opposite shows the feeding relationships of organisms living in a field.

There are many food chains within this web. Some organisms, like the rabbit, have just one predator. Its predator is a fox. If the number of rabbits decreased due to a disease, the number of foxes would also decrease as they would have less to eat.

B Write down the meaning of the word population.

Producer population

Grass is the producer. If there was no grass there would be no food for the snails, caterpillars, or rabbits. These organisms would die (unless they travelled to another area). All the other animals in the food web would also die as their food source has gone. If the population of the producer falls then the populations of the consumers also fall.

C State what happens to the population of consumers if the population of the producer decreases.

Interpreting food webs

In small groups discuss what would happen to the other organisms in the food web above if disease reduced the population of voles.

Consumer population

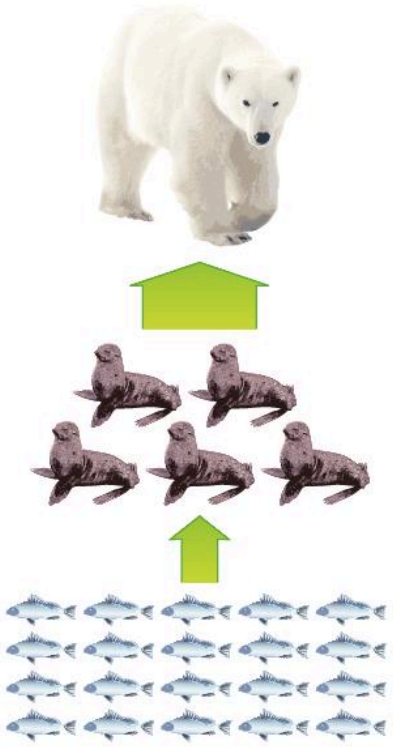
If the snail population decreased, the thrush population would also decrease. This may reduce the population of hawks. However, the hawk population would not decrease if they could gain enough energy from eating more frogs and voles. If this happened the population of frogs and voles would decrease.

Bioaccumulation

It is not only energy that transfers along a food chain. Some chemicals can also be passed on. One example is insecticides. These are chemicals that some farmers use to kill insects that eat their crops.

Some insecticides are washed into rivers and end up in the sea. Fish absorb small amounts of these chemicals and store them in their body. Seals eat the fish, and the insecticide passes into their body. The levels of the chemical accumulate (build up) in the seals because one seal eats lots of fish. This process is called **bioaccumulation**.

Polar bears eat seals. One polar bear eats a lot of seals and so the insecticide accumulates into dangerous levels in the polar bear's body. This makes the bear ill and can cause death.



◀ This food chain shows the bioaccumulation of insecticides.

D State what is meant by bioaccumulation

Key Words

interdependence, population, bioaccumulation

Summary Questions

1 Copy and complete the sentences below.

If two organisms both depend on each other for something, this is called _____.

In a food web if the producer population decreases the consumer population will _____.

Toxic chemicals can build up in organisms through a food chain. This is known as _____.

(3 marks)

2 Using the food web on this page:

a Explain what would happen to the population of rabbits if all the foxes died. *(2 marks)*

b Explain what would happen to the populations in the food web if all the frogs died. *(4 marks)*

3 DDT is an insecticide that was once used to kill insects. It is no longer used, as it killed many fish-eating birds. The fish fed on plankton, which absorbed the insecticide from rivers. Draw a food chain to show this and explain how the insecticide killed the birds but not the fish.

(6 marks)

2.9 Ecosystems

Learning objectives

After this topic you will be able to:

- describe how different organisms co-exist within an ecosystem
- identify niches within an ecosystem.

In a coral reef, there are many types of fish that live together. They can do this because they all require slightly different things from the reef and they each perform different roles.

▲ Many species of fish live together in the coral reef.

What is an ecosystem?

An **ecosystem** is the name given to the plants and animals that are found in a particular location, and the area in which they live. These plants and animals depend on each other to survive.

A State what is meant by an ecosystem.

The organisms in an ecosystem are known as a **community**. The area they live in is called a **habitat**.

For example, in a pond ecosystem:

- habitat – pond
- community – water plants, microorganisms, insects, fish, and fish-eating birds.

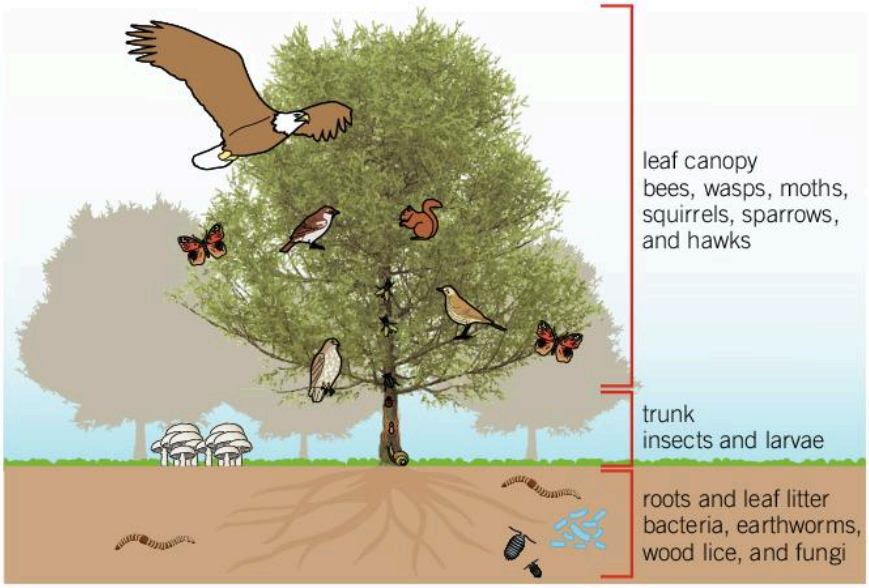
The plants and animals in a community and a habitat **co-exist**. This means they live in the same place at the same time.

B State what is meant by a habitat.

Link

You can learn more about the relationships between different organisms in B2 3.1 Competition and adaptation

Co-existing in an ecosystem



▲ An oak-tree ecosystem.

The diagram above shows an oak-tree ecosystem. There are lots of living organisms that live in or close to the tree but not every organism lives in the same part of the tree:

- Roots and leaf litter – microorganisms, woodlice, and earthworms live at the base of the tree. They break down the old leaves, releasing nutrients that the tree can then absorb and use for new growth.
- Trunk – the tree trunk provides food or shelter for a number of insects and caterpillars.
- Tree canopy – many organisms live amongst the branches and leaves of the tree. For example, bees gather pollen and nectar when the tree is in blossom. Fungi may grow on the leaves. Squirrels gather acorns and moths lay their eggs. Small birds such as sparrows eat the moth larvae. Sparrow hawks feed on the sparrows.

What is a niche?

Each of the organisms living in the oak-tree ecosystem has its own **niche**. A niche is a particular place or role that an organism has within an ecosystem. For example, they may live in a particular part of the tree or have a particular food source.

C State what is meant by a niche.

Sparrows and squirrels both live in the tree canopy but they do not compete for food. Squirrels feed on acorns, while sparrows feed on moth larvae and caterpillars. The sparrows and squirrels have similar but slightly different niches.

Scientific glossary

There have been lots of new words introduced in this chapter. Produce a scientific glossary of all the key terms covered in this chapter. Where possible, use examples to illustrate your answer.

Key Words

ecosystem, community, habitat, co-exist, niche

Summary Questions

1 Match the words below to their definitions.

ecosystem	plants and animals found in a particular habitat
community	particular place or role that an organism has in an ecosystem
habitat	living organisms in a particular area, and the habitat they live in
niche	place where a plant or animal lives

(4 marks)

2 Explain how bees and birds can both live within the canopy of a tree.

(2 marks)

3 Describe in detail how the different niches occupied by three organisms in a habitat mean that organisms can co-exist.

(6 marks QWC)

B2 Chapter 2 Summary

Key Points

- Plants and algae are producers – they make their own food by photosynthesis.
- Photosynthesis: carbon dioxide + water → glucose + oxygen
- Photosynthesis takes place in chloroplasts. Chloroplasts contain chlorophyll, which traps the light needed for photosynthesis.
- Stomata allow gases to enter and leave a leaf. Guard cells open the stomata during the day and close them at night.
- Plants need minerals for healthy growth. For example, nitrates are needed to make amino acids. Amino acids join together to form proteins, which are used for growth.
- To transfer energy from glucose, aerobic respiration takes place inside mitochondria.
- Aerobic respiration: glucose + oxygen → carbon dioxide + water (+ energy)
- If no oxygen is present, energy can be transferred from glucose using anaerobic respiration.
- Anaerobic respiration: glucose → lactic acid (+ energy)
- Fermentation is a type of anaerobic respiration performed by microorganisms. It is used in bread- and beer-making.
- Fermentation: glucose → ethanol + carbon dioxide (+ energy)
- Food chains show the transfer of energy between organisms. A food web is a set of linked food chains.
- Toxic chemicals can build up in organisms in a food chain until they reach harmful levels. This is called bioaccumulation.
- Interdependence is the way in which organisms depend on each other to survive, grow, and reproduce.
- Organisms can co-exist within a habitat as they each have a different niche.

Key Words

algae, producer, consumer, photosynthesis, chlorophyll, stomata, mineral, nitrates, phosphates, potassium, magnesium, deficiency, fertiliser, chemoynthesis, aerobic respiration, plasma, haemoglobin, anaerobic respiration, oxygen debt, fermentation, food chain, predator, prey, food web, interdependence, population, bioaccumulation, ecosystem, community, habitat, co-exist, niche

BIG Write

Banana power

Many tennis players eat a banana during a match to give them a boost of energy. The energy transferred to them from the banana has started off in the Sun. Almost all life on Earth depends on the transfer of the Sun's energy to plants and algae in photosynthesis.

Task

Write a short essay explaining how the energy was transferred into the banana from the Sun, and what happens inside the tennis player's body to transfer this energy to his muscles.

Tips

- Make sure you use as many scientific terms as possible.
- Use word equations to represent reactions that take place.

End-of-chapter questions

1

a Name the reaction that your body uses to transfer energy from glucose. *(1 mark)*

b State where in a cell this reaction happens. *(1 mark)*

c Complete the word equation below to represent this process:

glucose + _____ → _____ water (+ energy) *(2 marks)*

(4 marks)

2

a Re-arrange the following organisms into a food chain:

owl mouse corn *(1 mark)*

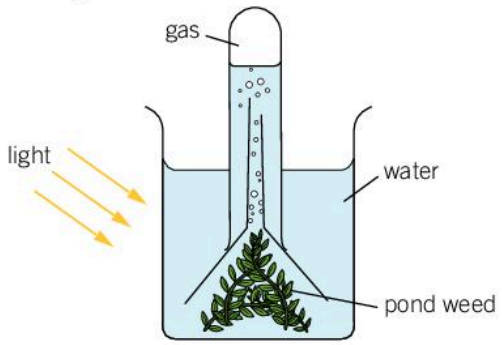
b Name the producer. *(1 mark)*

c Describe the difference in how energy is transferred to producers and consumers. *(2 marks)*

d Describe what would happen to the number of mice if a disease killed all of the owls. *(2 marks)*

(6 marks)

3 This equipment can be used to study photosynthesis.



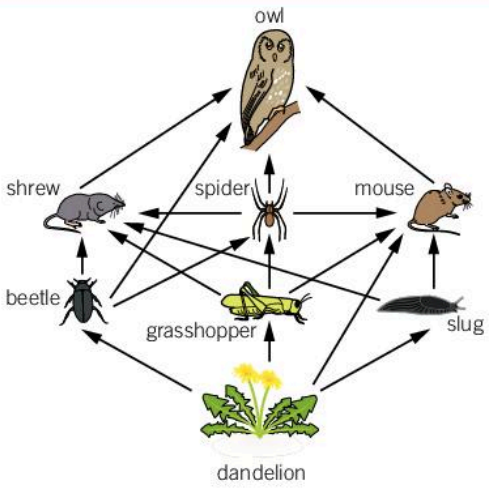
a Name the gas given off by the plant. *(1 mark)*

b State the **two** reactants needed for photosynthesis. *(2 marks)*

c Explain what would happen to the number of bubbles if the plant was placed in the dark. *(3 marks)*

d Describe the role of stomata in photosynthesis. *(2 marks)*

(8 marks)



4 This food web shows the feeding relationships between organisms in a garden.

a State and explain what would happen to the spider population if all the owls were removed from the area. *(2 marks)*

b State and explain what would happen to the grasshopper population if all the beetles died. *(2 marks)*

c Mice and shrews are very similar organisms. Explain why they can both successfully survive in the same habitat. *(2 marks)*

d A toxic chemical was used to kill all the dandelions. Explain how this could eventually result in the death of the owls. *(3 marks)*

(9 marks)

5 To remain healthy plants need minerals.

a Explain how a plant absorbs minerals and transports them to different parts of the plant. *(3 marks)*

b Plants lacking in magnesium have yellow leaves. Explain why this means they carry out less photosynthesis. *(2 marks)*

c Explain how the structure of a leaf is adapted to maximise sunlight absorption. *(3 marks)*

(8 marks)

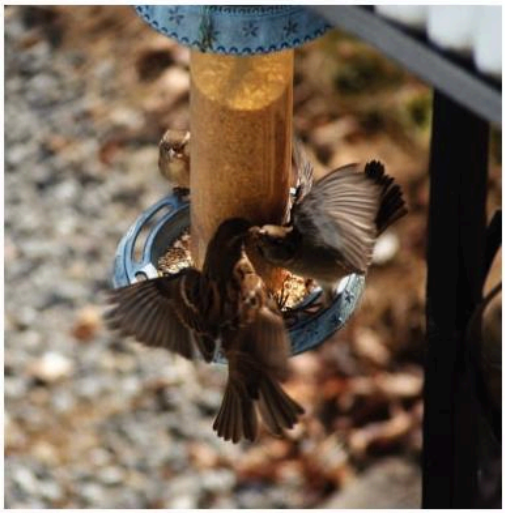
6 Explain how fermentation is used in food production. ***(6 marks QWC)***

3.1 Competition and adaptation

Learning objectives

After this topic you will be able to:

- describe some resources that plants and animals compete for
- describe how organisms are adapted to their environments.



▲ Birds competing for food.

If you have ever put food out for birds, you might see the birds 'fighting' over the food. Often, smaller species are scared off by larger birds. In the wild, all animals have to compete for resources.

What do animals compete for?

In a habitat there is a limited supply of resources, such as food, water, and space. To survive, animals compete with each other to get enough of these resources. This is known as **competition**.

Animals compete for:

1. food
2. water
3. space – to hunt and for shelter
4. mates – to reproduce.

A State four resources that animals compete for.

What do plants compete for?

Plants also compete for resources in their environment. Plants compete for:

1. light
2. water
3. space
4. minerals – plants do not compete for food, as they produce their own through photosynthesis.

B State four resources that plants compete for.

Who are the best competitors?

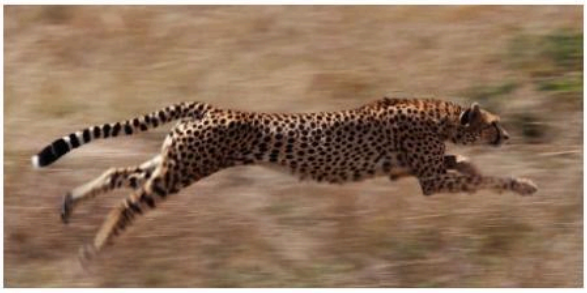
When competing with other animals for food the best predators will be fast, strong, and quick to spot their prey. These abilities allow them to sense their prey quickly and react before others, making sure that they get the food. Spotting their prey may require good eyesight or hearing. These features are known as **adaptations** – they are characteristics that enable an organism to be successful, and so survive.

Link

You can learn more about how organisms are adapted in B2 3.2 Adapting to change

Fantastic Fact

The Scimitar-horned oryx can survive for up to 10 months without drinking water. They get the moisture they need to survive from their food.

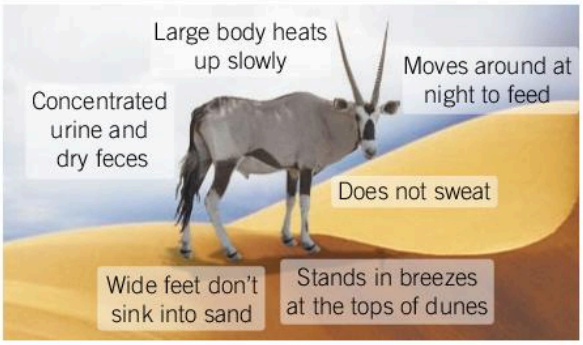


A cheetah is the fastest land animal – this adaptation of speed makes it a very successful predator.

C State what is meant by the term adaptation.

How can animals live in a desert?

The desert is one of the harshest habitats to live in as food and water are scarce. Temperatures are also extremely hot during the day. Most desert animals are small and hide away in burrows to avoid the daytime heat. Only a few large mammals, such as camels and oryx, can survive. They travel long distances to find food, and can survive for long periods of time without drinking.



Adaptations of an oryx.

How can plants live in a desert?

Plants in the desert have a number of adaptations to enable them to survive with very little water. These include:

- a waxy layer that covers the plant – this reduces water escaping from the plant
- stems that can store water
- widespread roots – to collect water from a large area
- spines instead of leaves – this gives a smaller surface area to reduce water loss. Spines also prevent the plant being eaten.

Nocturnal animals

Find out about the adaptations of a nocturnal animal. These animals reduce competition with other animals by being active at night. Produce an information poster about your chosen animal, labelling its features with as many scientific terms as possible.

Cacti are very well adapted to surviving in a desert.

Key Words

competition, adaptation

Summary Questions

1 Copy and complete the sentences below.

Plants and animals _____ for a number of _____. These include water and space.

Animals also compete for food and for _____ to reproduce. Plants make their own food by photosynthesis so they compete for _____.

Organisms have a number of _____ that enable them to survive in their habitat.

(5 marks)

2 Describe three ways that a cactus is adapted to prevent water loss.

(3 marks)

3 Explain in detail how the adaptations and behaviour of an oryx allow it to survive in the desert.

(6 marks QWC)

3.2 Adapting to change

Learning objectives

After this topic you will be able to:

- describe how organisms adapt to environmental changes
- describe how competition can lead to adaptation.

▲ Deciduous trees lose their leaves in winter.

▲ The snowshoe hare. Its predator is the Canadian lynx.

You can usually tell what season it is by observing leaves on trees. If the leaves are in bud it is spring, green leaves mean it is summer, shades of orange and brown mean autumn, and when the tree is bare it is winter. Losing leaves is one way that trees change with their environment.

How do trees cope with the seasons?

Plants and animals have to cope with changes in their environment. For example, deciduous trees look different in each season. They grow rapidly during the spring when the weather is wet and warm but lose their leaves in winter. This saves energy. The fallen leaves provide a layer of warmth and protection around the base of the tree. The tree can reuse the nutrients from these leaves too.

A State two advantages of trees losing their leaves in winter.

How do animals cope with the seasons?

Animals have a number of ways of coping with cold winter temperatures, such as:

- hibernation – animals like bears find somewhere warm to sleep through the winter
- migration – animals like birds move somewhere warmer, or somewhere with more food
- grow thicker fur – animals like sheep are kept warm by their thick coat.

B Name three ways that different animals adapt to the winter.

The snowshoe hare

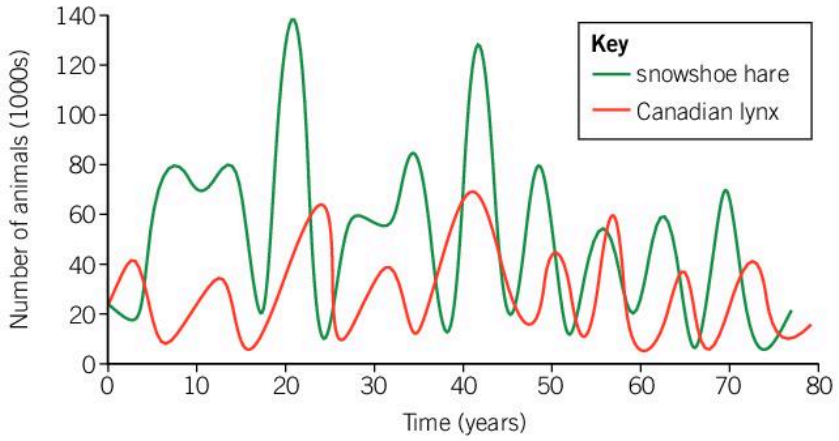
During the winter, snowshoe hares have white fur, which helps them blend in with the snow. When the seasons change to spring and summer, the snowshoe hare's fur turns a reddish-brown. This helps them to blend in with rocks and earth in mountain forests. When they are blended in with their environment it is harder for a predator to see them. This increases their chances of survival.

Predator–prey relationships

Animals have to adapt to changes in their food supply. Only the best competitors will survive to reproduce.

When a predator feeds on just one type of prey, there is an **interdependence** between the predator population and the prey population. This means that changes in the population of one animal directly affects the population of the other. When plotted on a graph this relationship shows a clear pattern.

C State what is meant by interdependence.



▲ Predator–prey graph showing the interdependence of the lynx and the hare.

- When the prey population (hare) increases, the predators (lynx) have more to eat. The lynx survive longer and reproduce more.
- This increases the number of predators.
- The growing predator population eats more prey. The prey numbers fall.
- Eventually there is not enough food for all the predators so their numbers decrease.
- There are now fewer lynx feeding on the hares. The hare population increases, and the cycle starts again.

How do organisms cope with change?

Plants and animals can lose their habitat through fire or climate change. Food supplies may also be reduced by disease. Sudden changes result in increased competition for survival. The organisms best adapted to the change will survive and reproduce, increasing the population of that species. Organisms that are not very well adapted will have to move to another habitat, or die.

Predator–prey graphs

Foxes are predators that eat rabbits. Sketch a graph showing how the fox and rabbit populations change over time.

Key Words

interdependence

Summary Questions

1 Copy and complete the sentences below.

A predator–prey relationship shows how the _____ of a predator and its prey are linked. When there are lots of prey, the population of _____ increases. However, a large predator population will cause the _____ population to _____. There is not enough food for all the predators so its population decreases. As a result, the prey population will _____, and the cycle starts again.

(5 marks)

2 Describe how competition can lead to adaptation.

(3 marks)

3 Ladybirds with seven spots have spread to the UK from Europe. They are more successful than native UK ladybird, as they eat more aphids and reproduce faster. They also eat other ladybird species. Explain in detail how the population of seven-spotted ladybirds will vary over time. Draw a predator–prey graph as part of your answer.

(6 marks)

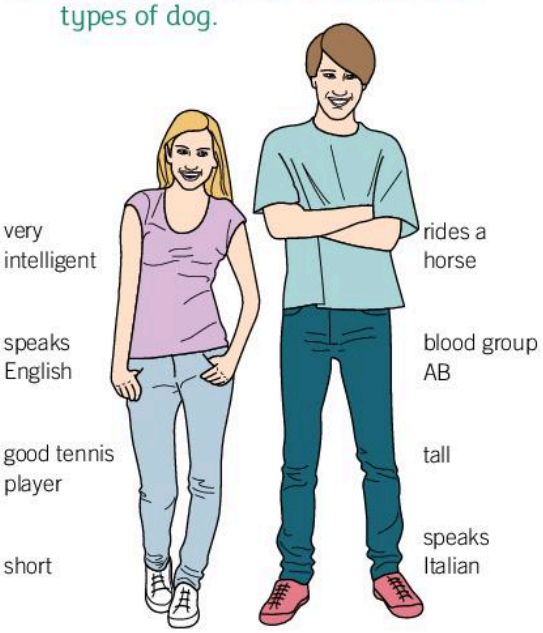
3.3 Variation

Learning objectives

After this topic you will be able to:

- describe how variation in species occurs
- describe the difference between environmental and inherited variation.

▲ There is a lot of variation between types of dog.



Link

You can learn more about how characteristics are inherited in B2 3.5 Inheritance

If you imagine your friends and family, you will picture people who look quite different to each other. For example, people may vary in height and have different colour hair. They have different characteristics.

How do organisms vary?

Differences in characteristics are known as **variation**.

A State what is meant by variation.

It is easy to tell the difference between a dog and a fish. For example, a fish has fins and gills; a dog has four legs and is covered in fur. This is because these organisms belong to different **species**. They have lots of different characteristics.

B State what is meant by a species.

However, it is more difficult to tell the difference between two fish. This is because organisms of the same species have lots of similar characteristics. They can mate to produce fertile offspring.

Sometimes a species can be further grouped into types or breeds. These may look quite different but the individuals still belong to the same species. For example, different breeds of dog show great variation but they are all dogs.

How do humans vary?

Every human in the world is different – even identical twins differ in some ways. The image opposite shows some of the ways people may vary.

What causes variation?

Some variation is from characteristics the people have inherited from their parents, such as their eye colour. This is known as **inherited variation**.

Children usually share some characteristics with their mother and some with their father. They are not identical to either of their parents, as they get a mixture of their parents' features. An example of inherited variation is lobed or lobeless ears.

lobed ear

lobeless ear

◀ Whether you have lobed or lobeless ears depends on your parents.

C State what is meant by inherited variation.

Environmental variation

Variation caused by your surroundings and what happens to you is called **environmental variation**. For example, your characteristics can be affected by factors such as your diet, education, and lifestyle. A person with dyed hair, for example, has environmental variation.

D State what is meant by environmental variation.

Many characteristics are affected by both inherited and environmental variation. For example, you might inherit the characteristic to be tall from your father. However, if you eat a poor diet your rate of growth may be reduced.

Inherited characteristics that are not affected by environmental variation include:

- eye colour
- blood group
- genetic diseases.

Spelling key terms

There are a lot of long scientific words in this chapter. Can you spell them all correctly? Look carefully at the spelling of the following words for two minutes: species, variation, adaptation, inherited, environmental. Cover the words and ask a partner to test your spelling.

Key Words

variation, species, inherited variation, environmental variation

▲ These people have environmental variation.

Summary Questions

1 Copy and complete the sentences below.

The organisms in a _____ share many of the same _____. They can reproduce to produce fertile _____.

Differences in characteristics within a species are known as _____.

Variation can be a result of _____ factors or through _____ factors.

(6 marks)

2 Copy and complete the table using the words below.

body mass **intelligence** **tattoo** **blood group** **eye colour** **scar**

Environmental variation	Inherited variation	Both

(6 marks)

3 Explain why identical twins are the best people to study if you want to find out how the environment influences characteristics.

(2 marks)

4 Explain in detail the difference between inherited and environmental variation.

(6 marks QWC)

3.4 Continuous and discontinuous

Learning objectives

After this topic you will be able to:

- describe the difference between continuous and discontinuous variation
- represent variation within a species using graphs.

Fantastic Fact

The tallest ever person was Robert Wadlow. He grew to a height of 2.72 m. He could not fit into many houses without ducking!

Key Words

discontinuous variation, continuous variation.

If you look around your classroom at the other students, you will see that some students share the same eye colour but very few are exactly the same height. This is because there are different types of variation.

What is discontinuous variation?

Characteristics that can only result in certain values show **discontinuous variation**. For example, gender shows discontinuous variation. There are only two possible values: you are either male or female.

Other characteristics that show discontinuous variation are your blood group and eye colour.

A State what is meant by discontinuous variation.

What is continuous variation?

A characteristic that can take any value within a range is said to show **continuous variation**. For example, the height of the population ranges from the shortest person in the world to the tallest person. Everyone else's height can be any value in between. This is an example of continuous variation.

Other characteristics that show continuous variation are your body mass, hair length, and arm span.

B State what is meant by continuous variation.

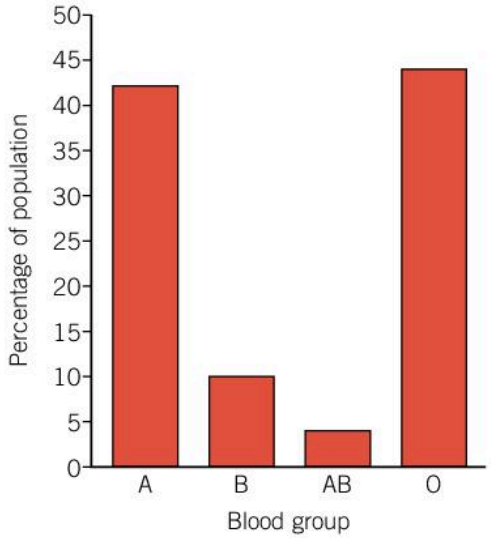
Patterns of variation

To study variation, scientists take measurements of different characteristics within the species. To come up with conclusions, they need to collect measurements from large numbers of the population. This data is then plotted on a graph so that patterns in the data can be easily spotted.

Plotting discontinuous variation

Characteristics that show discontinuous variation should be plotted on a bar chart.

For example, a person can only have one of four blood groups – A, B, AB, or O. These are the only values that a blood group can be, so you should plot a graph with four bars.



▲ Discontinuous data is always plotted on a bar chart.

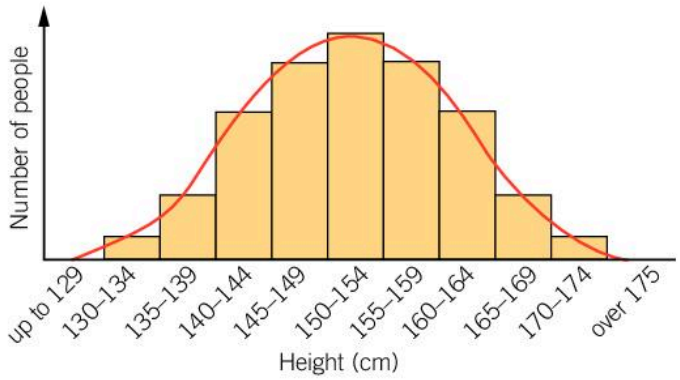
Characteristics that occur only as result of inherited variation normally show discontinuous variation.

C State the type of graph that should be used to plot discontinuous data.

Plotting continuous variation

Characteristics that show continuous variation should be plotted on a histogram. A line is then often added to the chart to make it easier to see the shape of the graph.

Within a population, characteristics that show continuous variation will display a range of measurements from one extreme to another.



▲ Continuous data is always plotted on a histogram.

This type of variation usually produces a curve, which is known as a normal distribution.

Characteristics that occur as a result of both environmental and inherited variation usually show continuous variation.

D State the type of graph that should be used to plot continuous data.

Which graph?

Which type of graph – a bar chart or histogram – would you use for the sets of data below?

a members of your class who have lobed, or lobeless ears

b the length of feet of each of your teachers

c the height of a group of seedlings, planted for a germination experiment

d the number of strawberries per plant, from a sample of 25 plants.

Summary Questions

1 Copy and complete the sentences below.

Characteristics that can only result in certain values show _____ variation. Characteristics that can have any value within a range show _____ variation.

The range of values of a characteristic from a sample can be displayed using a _____.
A characteristic such as eye colour should be displayed using a _____.
Characteristics showing continuous variation, such as body mass, should be shown using a _____.

(5 marks)

2 Classify each of these characteristics into continuous variation and discontinuous variation.

length of arm, hair colour, maximum sprinting speed, shoe size, average leaf size

(5 marks)

3

a Look at the graph of the variation in heights on this page. Describe the pattern that this variation shows. *(3 marks)*

b Explain whether this variation is a result of environmental factors, inherited factors, or both. *(3 marks)*

4 Explain in detail the difference between continuous and discontinuous variation, using examples of features from the human body.

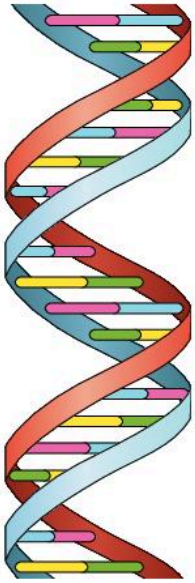
(6 marks QWC)

3.5 Inheritance

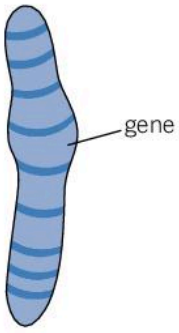
Learning objectives

After this topic you will be able to:

- describe how characteristics are inherited
- describe how scientists worked together to develop the DNA model.



▲ The shape of DNA is a double helix – a bit like a twisted ladder.



▼ A chromosome.

DNA timeline

Carry out some research to produce a timeline, showing the key steps in scientists' understanding of DNA.

Link

You can learn more about DNA in B3 2.5 DNA

You can often tell if people are members of the same family, as they look alike. The children have inherited some characteristics from each of their parents. Brothers and sisters do not look completely the same, as they each inherit a different mixture of characteristics.

How do you inherit characteristics?

You inherit characteristics from your parents through genetic material stored in the nucleus of your cells. This material is a chemical called **DNA** (deoxyribonucleic acid). DNA contains all the information needed to make an organism.

A State what DNA is.

Chromosomes

Inside the nucleus, your DNA is arranged into long strands called **chromosomes**. Different species have a different number of chromosomes in their nucleus. Humans have 46 chromosomes; cats have 38 chromosomes.

You inherit half of your chromosomes from your mother and half from your father. This is why you share some of your characteristics with your mother and some with your father.

B State what a chromosome is.

Genes

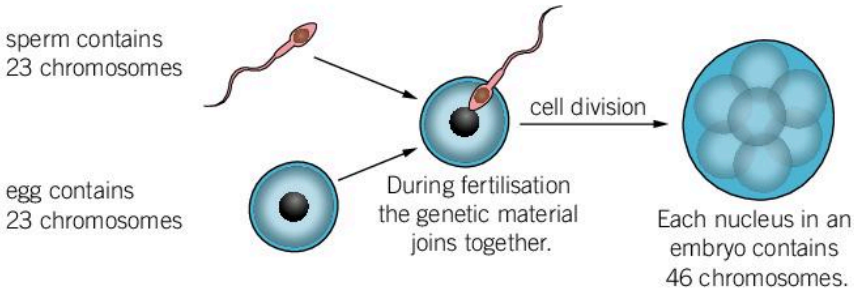
Each chromosome is divided into sections of DNA. The sections that hold the information to produce a characteristic are called **genes**. For example, one gene contains the information that sets your eye colour, while a different gene sets your hair colour. Each chromosome contains thousands of genes.

C State what a gene is.

How is genetic material inherited?

Inside the nucleus of your cells, the 46 chromosomes are arranged into 23 pairs. One copy of the chromosome of each pair comes from your mother, and the other comes from your father.

Egg and sperm cells are the only cells to contain 23 chromosomes. They only have one copy of each chromosome. During fertilisation, the egg and sperm cells join together. When their nuclei join, their chromosomes pair up, producing an embryo with 46 chromosomes.



▲ You get half of your genetic material from your mother, and half from your father.

D State the number of chromosomes present in a normal human body cell.

Discovering DNA

Four scientists worked together to produce a model of the structure of DNA.

In the early 1950s two scientists, Rosalind Franklin and Maurice Wilkins, used X-rays to investigate the structure of DNA. The image they produced is shown above.

James Watson and Francis Crick, scientists working at another university, were also studying DNA. When they saw this image it told them that DNA had a helical shape. Through further investigations, Watson and Crick worked out that the structure of DNA is like a twisted ladder. This is known as a double helix.

In 1962 Crick and Watson, along with Wilkins, won the Nobel Prize for Medicine for their discovery. Franklin died in 1958; some people say that at the time her role in this famous discovery wasn't recognised.

Team work

The scientists who discovered the structure of DNA did so by working together. Communication is very important so that scientists can share their ideas and carry out investigations. Watson and Crick were able to work out the structure of DNA by building on the work if Franklin and Wilkins.

◀ The first image of DNA, produced using X-rays.

Key Words

DNA, chromosome, gene

Summary Questions

1 Copy and complete the sentences below.

Genetic material in the body is stored in the _____ of a cell.

_____ is the name of the chemical that contains the instructions needed to make an organism.

_____ are made of long strands of DNA.

The sections of DNA that hold the information for a _____ are called _____.

(5 marks)

2 Arrange these objects in order of size, starting with the smallest.

cell chromosome gene DNA nucleus

(2 marks)

3 Describe how scientists worked together to discover the structure of DNA.

(2 marks)

4 Explain in detail why you share some characteristics with your mother and some with your father.

(6 marks QWC)

3.6 Natural selection

Learning objectives

After this topic you will be able to:

- describe the process of natural selection
- describe how organisms evolve over time.

Fantastic Fact

More proof for evolution comes from your DNA. You share about 97% of your DNA with a gorilla and 50% with a banana! This is evidence that all living things evolved from the same ancestor.

Key Words

evolution, fossil, natural selection

Evolution cartoon

Produce a cartoon strip showing the evolution of an organism of your choice – this could be a real organism or a made-up one.

Have you heard the phrase 'survival of the fittest'? It means that organisms that are best adapted to a situation will survive, and those that are not will die. This is how scientists think that all organisms on Earth have developed.

What is evolution?

Scientists have shown that the species we see on Earth today have gradually developed over millions of years. This process is called **evolution**.

Evolution started with unicellular organisms. These organisms, similar to bacteria, lived in water more than three billion years ago. Over time they evolved to become multicellular organisms. Eventually, this process resulted in organisms that could live on land and in the air.

A State what is meant by evolution.

▲ A dinosaur fossil.

The **fossil** record provides most of the evidence for evolution. Fossils are the remains, or traces, of plants or animals that lived many years ago. They have been preserved by natural processes. The fossil record provides evidence of species that no longer exist, such as dinosaurs.

B Describe what a fossil is.

How do organisms evolve?

Organisms evolve through the process of **natural selection**. They change slowly over time, to become better adapted to their environment. The process takes many years, sometimes millions, as it happens over a number of generations.

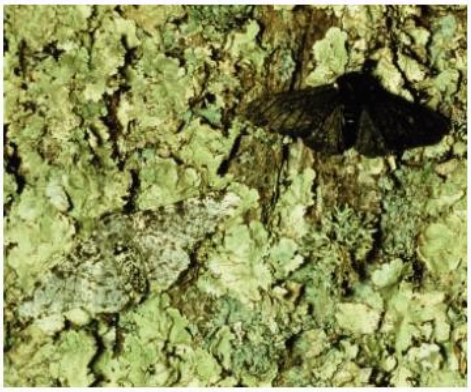
C Describe the process of natural selection.

Peppered moths

Living organisms are continually evolving to adapt to their environment. Evolution usually happens slowly over many years. However, dramatic changes in an organism's environment can result in evolution happening quickly. Peppered moths evolved in this way during the 19th century.

Before the Industrial Revolution, most peppered moths in Britain were pale coloured. This was helpful to the moths, as they blended in with tree bark. A few peppered moths were dark coloured. This was a disadvantage, as they were easily seen by birds, and eaten. The pale moths were more likely to survive and reproduce, so most of the peppered-moth population was pale coloured.

After the Industrial Revolution many trees were covered in soot, turning the bark black. This meant that the dark moths were camouflaged. More dark peppered moths survived and reproduced than pale moths. After several years, the population of dark peppered moths in towns and cities became much higher than the population of pale peppered moths.



▲ Before the Industrial Revolution, pale peppered moths were highly camouflaged against tree bark. Dark moths were easily seen.

▲ After the Industrial Revolution, dark peppered moths were more camouflaged against soot-blackened trees and pale moths were easily seen.

Natural selection

Organisms in a species show variation – this is caused by differences in their genes.

↓

The organisms with the characteristics that are best adapted to the environment survive and reproduce. Less well adapted organisms die. This process is known as 'survival of the fittest'.

↓

Genes from successful organisms are passed to the offspring in the next generation. This means the offspring are likely to possess the characteristics that made their parents successful.

↓

This process is then repeated many times. Over a period of time this can lead to the development of a new species.

Summary Questions

1 Copy and complete the sentences below.

All living organisms have _____ from a common ancestor. This process has taken _____ of years.

_____ provide evidence for evolution. These are the _____ of plants or animals that died long ago, which have turned to _____.

(5 marks)

2 Describe the process of natural selection.

(3 marks)

3 Explain in detail how peppered moths evolved as a result of the Industrial Revolution.

(6 marks QWC)

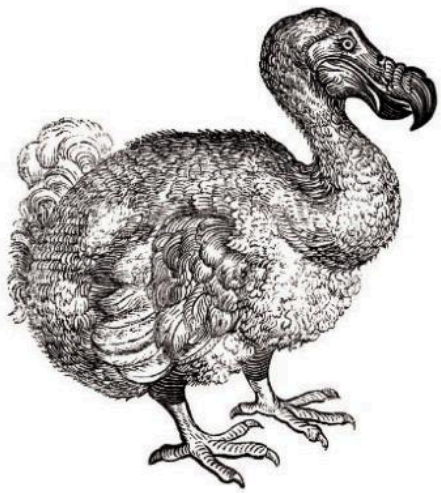
3.7 Extinction

Learning objectives

After this topic you will be able to:

- describe some factors that may lead to extinction
- describe the purpose of gene banks.

▲ An ammonite fossil. These animals lived in the sea and could grow up to 2 m wide.



▲ The dodo was a large, flightless bird.

Key Words

extinct, biodiversity, endangered, gene bank

Can you think of any species that no longer live on the Earth? You might think of dinosaurs; millions of years ago these organisms were found all over the Earth. There are many other animal and plant species that have completely died out.

What does extinction mean?

If a species is not adapted to its environment, it will not survive. Organisms will die before reproducing. Eventually the species becomes **extinct**. A species becomes extinct when there are no more individuals of that species left anywhere in the world. An extinct species has gone forever; no new organisms can be created.

A State what is meant by the word extinct.

How do we know other species existed?

The fossil record shows that many species have become extinct. For example, you may have seen the fossils of ammonites. These animals existed at around the same time as the dinosaurs. They had spiral shells and could be up to 2 m wide.

How do organisms become extinct?

There are a number of factors that can cause a species to become extinct, including:

- changes to the organism's environment
- destruction of habitat
- outbreak of a new disease
- introduction of new predators and competitors.

B State three causes of extinction.

Extinction occurs naturally. For example, most scientists believe that dinosaurs became extinct due to a dramatic change in the Earth's climate, after a meteor hit the Earth. Dinosaurs could not adapt to these changes in their environment and died out.

Humans can make extinction more likely. For example, the dodo lived on island of Mauritius, which was an uninhabited island. It had no natural predators. In the 17th century people arrived on the island,

and dodos were hunted for food. Rats that came on the ships ate the dodos' eggs. In less than a century, the dodo became extinct.

Climate change has resulted in many organisms losing their habitat. For example, the size of the polar ice caps is shrinking. If a species that lives in these habitats cannot adapt successfully, or find somewhere else to live, it could become extinct.

When a species becomes extinct, **biodiversity** is reduced. Biodiversity is the range of organisms living in an area.

C Name two organisms that have become extinct.

How can we prevent extinction?

Species of plants and animals that have only a small population in the world are said to be **endangered**.

Scientists are trying to help prevent these species becoming extinct, and therefore maintain biodiversity. One way is by using **gene banks**. Gene banks store genetic samples from different species. In the future they can be used for research, or to produce new individuals.

There are a number of different types of gene bank. These include:

- seed banks – dried seeds of plants are stored at low temperatures
- tissue banks – buds and other cells from plants are stored
- cryobanks – a seed or embryo is preserved at very low temperatures, normally in liquid nitrogen; sperm and egg cells from animals can also be stored in this way
- pollen banks – pollen grains are stored.

▲ A seed bank.

D State what is meant by a gene bank.

▲ The black rhino has become endangered due to poachers killing them for their horns.

Extinction

Find out about an organism that has become extinct. Write a newspaper article that describes how and why the organism became extinct.

Summary Questions

1 Copy and complete the sentences below.

A species becomes _____ when there are no more individuals of that species left _____ in the world.

Changes in a species' _____ or the introduction of new _____ can cause a species to become extinct.

Gene banks store genetic samples from organisms, which can be used for _____ and to create new individuals.

(5 marks)

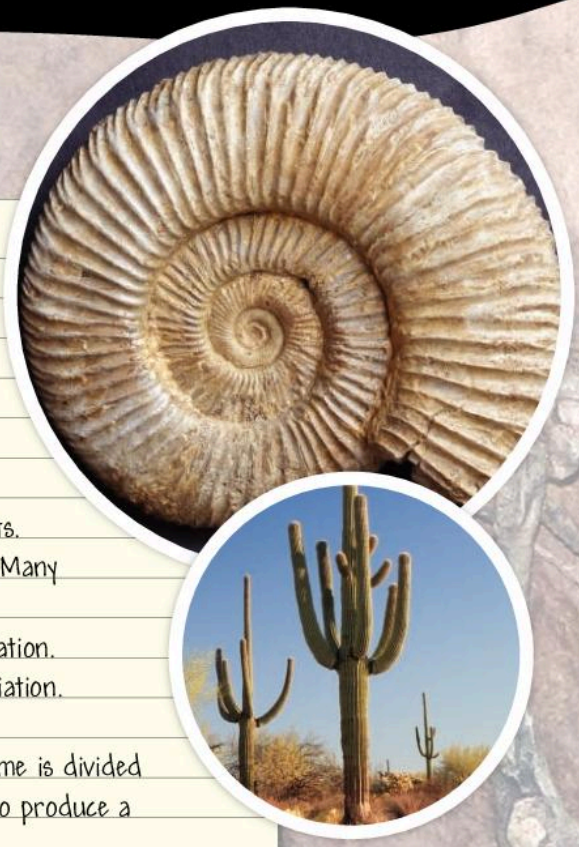
2 Describe the role of gene banks in preventing extinction.

(3 marks)

3 Explain in detail how a species could become extinct.

(6 marks QWC)

B2 Chapter 3 Summary



Key Points

- Animals compete for food, water, mates, and space. Plants compete for light, water, space, and minerals.
- Adaptations are characteristics that help an organism to survive and reproduce.
- Predator and prey species are interdependent – a change in the population of one animal directly affects the population of the other.
- Differences in characteristics within a species are known as variation. Inherited variation comes from characteristics inherited from your parents. Variation caused by your surroundings is called environmental variation. Many characteristics are affected by both.
- Characteristics that can only have certain values show discontinuous variation.
- Characteristics that can be any value within a range show continuous variation.
- You inherit characteristics from your parents in your DNA.
- DNA is arranged into long strands called chromosomes. Each chromosome is divided into sections of DNA. The sections of DNA that contain the information to produce a characteristic are called genes.
- Watson, Crick, Franklin, and Wilkins worked together to produce a model of the structure of DNA.
- All living organisms have evolved from a common ancestor, through the process of natural selection.
- Fossils provide evidence for evolution.
- If a species is not adapted to its environment, it will not survive. Eventually a species can become extinct.
- Gene banks store genetic samples from organisms. This may help to prevent extinction.

BIG Write

Explaining natural selection

Imagine that you have to teach the process of natural selection to other members of your year group.

Task

Produce a presentation that explains how peppered moths evolved as a response to the Industrial Revolution. You need to explain what genes are, and how they are passed on.

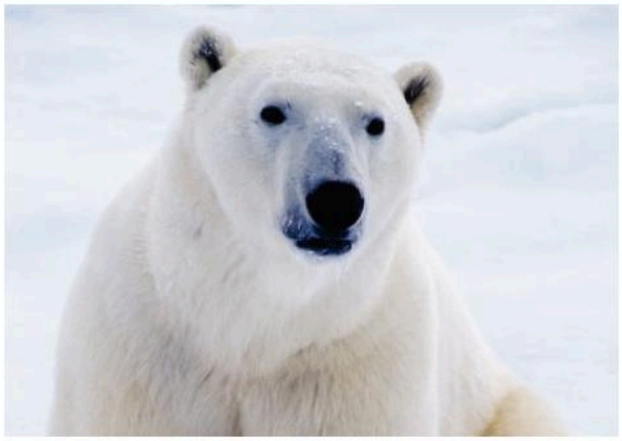
Tips

- Make sure your slides are clear and cover topics in a logical order.
- Remember to explain all scientific terms clearly.

Key Words

competition, adaptation, interdependence, variation, species, continuous variation, discontinuous variation, DNA, chromosome, gene, evolution, fossils, natural selection, extinct, biodiversity, endangered, gene bank

End-of-chapter questions



1 This is a polar bear. It has lots of adaptations to survive in its habitat.

a Name the habitat in which the polar bear lives. *(1 mark)*

b Match the adaptation to how it helps the polar bear to survive. *(4 marks)*

white fur	insulation
thick fur	camouflage
large feet	to stop the bear sinking into snow
sharp claws and teeth	to catch and eat prey

(5 marks)

2 A student studied the small insects living in a log pile.

a State the resource that the insects use the logs for. *(1 mark)*

b Apart from your answer to part a, state **one** other resource that all animals need for survival. *(1 mark)*

c Explain why plants don't compete for food. *(2 marks)*

d State **one** resource that plants compete for that animals don't compete for. *(1 mark)*

(5 marks)

3 Characteristics are passed on from parents to their children through genetic material.

a Name the cell component that stores genetic material. *(1 mark)*

b Name the chemical that contains all the information needed to make an organism. *(1 mark)*

c Describe the difference between a gene and a chromosome. *(2 marks)*

d Describe how genetic material is passed from parents to their children. *(4 marks)*

(8 marks)

4 Dinosaurs were animals that lived on Earth millions of years ago.

a State **one** piece of evidence that proves dinosaurs existed. *(1 mark)*

b State what is meant by the word extinction. *(1 mark)*

c State and explain **two** reasons that could cause an organism to become extinct. *(4 marks)*

d Describe the role of gene banks in helping to prevent extinction. *(3 marks)*

(9 marks)

5 Charlie was investigating variation within his class. He decided to investigate the differences in body mass between students.

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

b Name the piece of equipment Charlie should use to measure body mass. *(1 mark)*

Charlie found that everybody in the class had a different body mass.

c Name the type of graph Charlie should use to display his results. *(1 mark)*

d Sketch and label the axes he should use to plot his results. *(2 marks)*

e Explain why body mass is an example of continuous variation. *(1 mark)*

f Explain how the variation in students' body mass is caused. *(4 marks)*

(10 marks)

6 Explain the process of natural selection and the role it plays in the evolution of species.

(6 marks QWC)

Biology 3

In this unit, you will begin by looking at genetics. This includes genetically inherited disorders and how plant and animal genes can be changed to alter an organism's characteristics. You will also study how you can protect yourself from disease through immunisation and treat conditions using antibiotics. Finally, you will find out how forensic scientists help to solve crimes through the analysis of evidence found at the scene of a crime.

You already know

- Plants and animals, including humans, resemble their parents and share many features.
- Genetic information is passed from one generation to the next.
- Living organisms produce offspring of the same kind but normally offspring vary and are not identical to their parents. They exhibit variation.
- Animals and plants are suited to and adapt to their environment in different ways.
- Variation and adaptation lead to evolution.
- Living organisms have changed over time and fossils provide evidence and information about living things that inhabited the Earth millions of years ago.

Q

What is meant by the term habitat?

BIG Questions

- How can we create new food products?
- How can we protect ourselves against disease?
- How do forensic scientists help to solve crimes?

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**: This natural plant fibre was found at a crime scene.*

Making connections

In **B1** you learnt about reproduction in humans and plants.

In **B2** you learnt how characteristics are inherited.

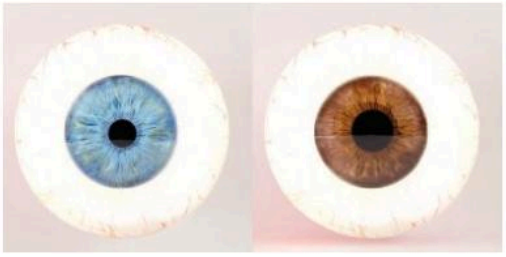
In **B3** you will learn about the role of genes in the inheritance of characteristics in offspring.

1.1 Genetics

Learning objectives

After this topic you will be able to:

- describe the difference between dominant and recessive alleles
- use a Punnett square to show what happens during a genetic cross.



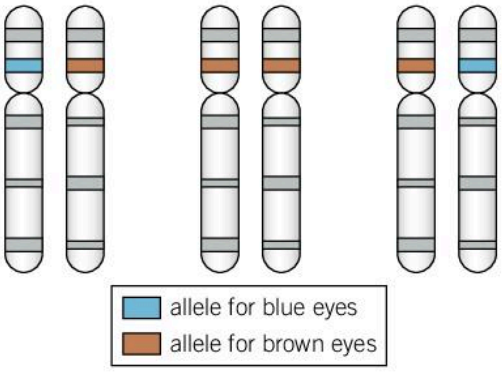
▲ The gene for eye colour has an allele for blue eye colour and an allele for brown eye colour.

Link

You can learn more about genes in B2 3.5 Inheritance

Key Words

allele , dominant, recessive, Punnett square



▲ These genes belong to people who all have brown eyes.

Have you ever wondered why brothers and sisters often have a similar appearance? It's all down to the genes they inherit from their parents.

Which characteristics will you inherit?

For each characteristic, you have two genes. One gene is inherited from your mother, and one from your father. These two genes may be the same, or different. Different forms of the same gene are called **alleles**.

A State what is meant by an allele.

How is eye colour inherited?

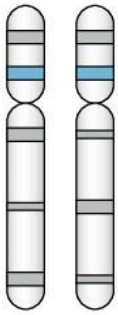
Some alleles will always produce a characteristic in an organism. These are called **dominant** alleles. You only need one copy of a dominant allele for the characteristic to appear in the organism. This allele is said to be 'expressed' in the organism.

B Name the type of allele that will always produce a characteristic in an organism.

For example, the allele for brown eyes is a dominant allele. If you inherit this allele from your mother, your father, or both parents, you will have brown eyes.

The allele for blue eye colour is a **recessive** allele. You need two copies of a recessive allele for the characteristic to be expressed in the organism.

For example, you will only have blue eyes if you inherit this allele from both your mother and your father.



▲ To have blue eyes, you need two copies of the allele for blue eyes.

C State how many copies of a recessive allele are needed for it to be expressed.

Can characteristics be predicted?

When a sperm fertilises an egg, genes from the mother join with genes from the father. This results in the combination of alleles present in the offspring. Scientists are able to predict what an organism's offspring will look like by carrying out a genetic cross.

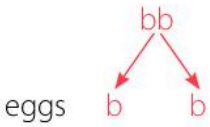
How do you perform a genetic cross?

In a genetic cross, alleles are represented by letters. The dominant allele is represented by a capital letter, and the recessive allele by the same, lowercase letter.

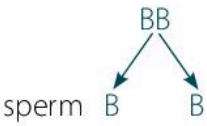
When studying eye colour, 'B' is used to represent the dominant allele for brown eyes, and 'b' represents the recessive allele for blue eyes.

Scientists use a **Punnett square** to show what happens to the alleles in the genetic cross. In this example, a mother with blue eyes (bb) is crossed with a father with brown eyes (BB).

Mother: blue eyes



Father: brown eyes



A sperm and egg cell only contain one copy of each gene.

A Punnett square is actually a simple table. To produce a Punnett square, put the possible alleles from one parent across the top of the square, and the alleles from the other parent down the side.

Mother \ Father	B	B
b		
b		

Use the square to work out the possible combinations of alleles in the offspring.

Mother \ Father	B	B
b	Bb	Bb
b	Bb	Bb

In this example, all offspring produced will have brown eyes. This is because the dominant allele is present in all possible combination of the parents' alleles.

If the father's alleles are Bb, he will still have brown eyes but now it is possible that the offspring will have blue eyes.

Mother \ Father	B	b
b	Bb	bb
b	Bb	bb

In this example, two of the four combinations are bb, which means there is a 2 in 4 chance that the offspring will have blue eyes, and a 2 in 4 chance it will have brown eyes.

Genetic-cross outcomes

Scientists often display the possible outcomes from a genetic cross as the probability of a characteristic being expressed. This could be in the form of a ratio, a percentage, or a fraction. For example, a 1 in 5 probability is 1/5 = 0.2 = 20%.

Write each of the following as a fraction and a percentage:

0 in 4 **1 in 4** **2 in 4**
3 in 4 **4 in 4**

Summary Questions

1 Copy and complete the sentences below.

Different forms of the same gene are known as _____. _____ will always be expressed if they are present. _____ alleles will only be expressed if two copies are present.

(3 marks)

2 In mice, black fur is dominant and white fur is recessive. State the fur colour a mouse would have with the following allele combinations:

a BB **b** bb **c** Bb

(3 marks)

3 Use a Punnett square to calculate and explain the chance of a person inheriting freckles if their mother has the alleles Ff and their father has the alleles Ff. Freckles are a dominant characteristic.

(6 marks)

1.2 Inherited disorders

Learning objectives

After this topic you will be able to:

- describe what is meant by a genetically inherited disorder
- calculate the probability of a person suffering from an inherited disease.

▲ Genetic counsellors work out the chance of a couple's child being born with an inherited disorder.

You can become ill by catching diseases such as coughs and cold from other people. Other medical conditions can be inherited in a person's genes.

What is a genetically inherited disorder?

Genetically inherited disorders are conditions passed from parents to their offspring in their genes. Examples include cystic fibrosis, haemophilia, and polydactyly.

A Write down a definition of the term genetically inherited disorder.

What is cystic fibrosis?

Cystic fibrosis sufferers produce lots of thick sticky mucus. This blocks their air passages, making it difficult to breathe, and can lead to chest infections. The excess mucus also causes difficulty in food being absorbed. Physiotherapy and antibiotics help to manage the symptoms but there is no cure.

Cystic fibrosis is caused by a recessive allele, so you need two copies of the allele to have the disorder. If either of your genes contains a copy of the healthy dominant allele, you will not suffer from cystic fibrosis.

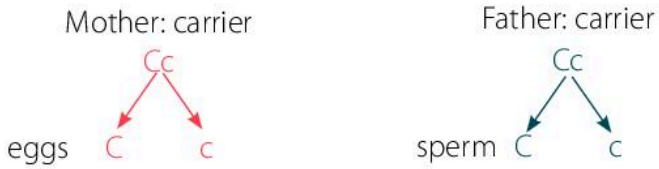
If a person has one copy of the dominant allele and one copy of the recessive allele, they are called a **carrier**. This means that they carry a copy of the allele, but do not have the disorder.

B State what is meant by a carrier.

What is the chance of inheriting cystic fibrosis?

Genetic counsellors can use a Punnett square to determine the chance of a child inheriting a condition from their parents. If the chance is high, couples may decide against having a child.

In this example, c is used to represent the allele for cystic fibrosis. The healthy (dominant) allele is represented with the letter C.



Genetically inherited disorders

Produce a presentation to show the main symptoms, possible treatments, and likelihood of suffering from cystic fibrosis.

The Punnett square shows the possible combinations of alleles in the offspring:

		Father	
		C	c
Mother	C	CC	Cc
	c	Cc	cc

The outcomes are:

- CC – one healthy
- Cc – two carriers
- cc – one cystic fibrosis sufferer

Out of the four possible outcomes, there is a 1 in 4, or 25%, chance of a child from this couple suffering from cystic fibrosis.

What is polydactyly?

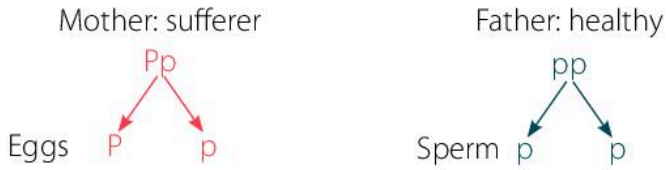
Polydactyly is a disorder that results in a child being born with extra digits on their hands or feet. These can be small stumps of soft tissue, or extra fingers or toes.

Polydactyly is caused by a dominant allele. Therefore, if one of your genes contains this allele, you will have the disorder. You cannot be a carrier of this disorder.

C State why it is not possible to be a carrier of polydactyly.

What is the chance of inheriting polydactyly?

The genetic cross below shows the likelihood of a person suffering from polydactyly if the mother has the disorder but the father does not. In this example, P is used to represent the allele for polydactyly.



The Punnett square shows the possible combinations of alleles in the offspring:

		Father	
		p	p
Mother	P	Pp	Pp
	p	pp	pp

The outcomes are:

pp – two healthy

Pp – two polydactyly sufferers

Out of the four possible outcomes, there is a 2 in 4, or 50%, chance of a child from this couple suffering from polydactyly.

▲ This suffer of polydactyly has an extra finger.

Key Words

genetically inherited disorder, carrier

Summary Questions

1 Copy and complete the sentences below.

Genetically _____ disorders are passed on from _____ to their _____ through their genes. The disorders can be caused by dominant or recessive alleles. If a disorder is _____ you need two copies of the allele to suffer from the disorder. If a person has only one copy of the allele, they are called a _____.

(5 marks)

2 Explain why most people would not know that they are a carrier of a genetically inherited disorder.

(3 marks)

3 Use a Punnett square to explain why a child could not suffer from cystic fibrosis if his mother's alleles were CC and his father's were Cc.

(6 marks)

1.3 Selective breeding

Learning objectives

After this topic you will be able to:

- describe the process of selective breeding
- describe some advantages and disadvantages of selective breeding.

You can often guess what product a farmer is rearing their livestock for. Large herds of dairy cows are used for milk production whereas sheep with long, thick coats are reared for wool. Farmers can increase their production levels by using a technique known as selective breeding.

A State what is meant by the term selective breeding.

Link

You can learn more about breeding in B2 3.6 Natural selection

Key Words

selective breeding

What is selective breeding?

Most farmers choose the animals or plants they raise for their characteristics. For example, a farmer may select dairy cattle that produce lots of milk, or strawberry plants that produce lots of large berries.

When producing offspring, the farmer will choose their best plants or animals to breed. This is **selective breeding**. The offspring produced are likely to share their parents' desirable characteristics.

B State an advantage of selective breeding.

How does a farmer selectively breed organisms?

There are five main steps in selectively breeding an organism. These are the same for both plants and animals.

1. Decide which characteristic(s) of the species is most important.
2. Select parents that show high levels of this characteristic.
3. Breed these individuals.
4. Select the best offspring and breed again.
5. Repeat for many generations.

Disadvantages of selective breeding

When you selectively breed an organism, you are choosing which versions of a gene are passed on. By making organisms look more and more similar over each generation, you are reducing the number of genes (the gene pool) from which a species is created. Selective breeding therefore reduces variation within a species.

C State the effect of selective breeding on variation.

Milk production

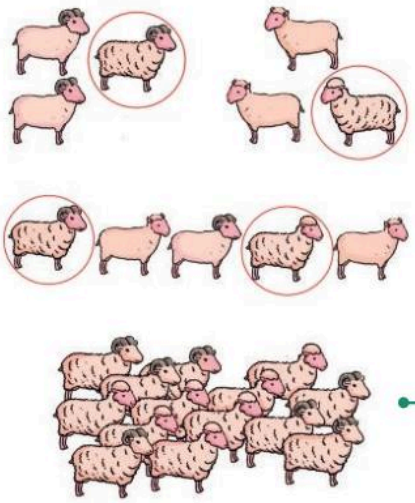
Produce an information leaflet to show farmers the steps involved in selectively breeding cows for milk production.

Selectively breeding sheep

Step 1
Decide which characteristic is most important. In this example, the farmer wishes to select sheep that produce large, good-quality fleeces.

Step 2
Select parents that show high levels of this characteristic.

Step 3
Breed these individuals.



◀ Selectively breeding sheep for wool production.

Step 4
Select the best offspring. Breed again from this generation.

Step 5
Repeat the process over many generations. Eventually, all sheep will have large, good-quality fleeces.

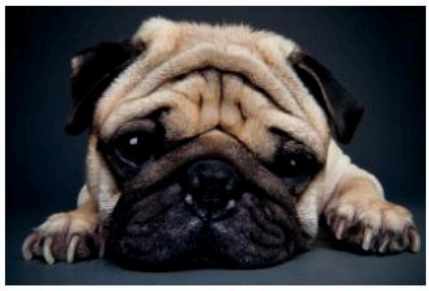
'Useful' genes, which may be needed in the future, could be lost. For example, if a new disease occurs, an organism may not exist that contains the gene for resistance to this disease. This could result in a species becoming extinct.

D State a disadvantage of selective breeding.

Selectively breeding dogs

Pedigree dogs are selectively bred so that they display the best characteristics of their breed. This could be for speed and strength, or appearance. However, many suffer from health problems as a result of this breeding. They are at higher risk of genetically inherited disorders.

▲ Pedigree dogs.



▲ Pugs are selectively bred to have short, stubby noses. This can cause breathing problems.

For example, many Labradors suffer from hip problems and pugs suffer from breathing problems.

The chance of inheriting a genetic defect is increased when animals are in-bred, for example, when closely related dogs, such as brother and sister, are bred. One result of in-breeding is that pedigree dogs have a much lower life expectancy than crossbreeds.

Summary Questions

1 Re-arrange the steps below into the correct order to show how organisms are selectively bred.

Repeat the process for many generations.

Select parents that show high levels of the desirable characteristic.

Select the best offspring and breed again.

Breed these individuals.

Choose a desirable characteristic.

(5 marks)

2 Describe an advantage and disadvantage of selectively breeding dogs.

(2 marks)

3 A farmer wants to produce large sweet tomatoes. He currently grows two species of tomato:

- One species produces very sweet tomatoes.
- The other species produces large tomatoes but they are not very sweet.

Explain in detail how the farmer can selectively breed the two species to produce large sweet tomatoes.

(6 marks QWC)

1.4 Genetic engineering

Learning objectives

After this topic you will be able to:

- state how a product is produced using genetic engineering
- describe some advantages of producing products through genetic engineering.

▲ GloFish.

Have you ever seen fish that glow in the dark? Scientists have altered the genes of one type of fish to make them fluoresce (glow) by genetic engineering. The aim was to produce a fish that would glow in the presence of polluted water.

What is genetic engineering?

When farmers selectively breed plants and animals, they are choosing organisms' genes. However, this is a slow process that takes place over many generations. It is also not very precise.

Scientists are now able to alter an organism's genes to produce an organism with desired characteristics. For example, crops can be produced that are resistant to disease. This is called **genetic engineering** (or genetic modification).

A State what is meant by genetic engineering.

This is a very precise process, as single genes can be targeted. It can also happen in one generation so is a much quicker process than selective breeding.

B State an advantage of genetic engineering.

Examples of genetic engineering

Many organisms have been genetically engineered. For example:

- cotton – to produce high yields
- corn – to produce toxins (poison) that kill insects
- bacteria – to produce medicinal drugs.

How can you alter an organism's genes?

To create an organism with a desired characteristic, scientists take genes from another organism that shows this characteristic. These are known as foreign genes. The foreign genes are put into plant or animal cells at a very early stage of the organism's development. As the organism develops, it will display the characteristics of the foreign genes.

Genetic engineering cartoon strip

Select one example of genetic engineering. Produce a cartoon strip that explains simply how an organism can be genetically engineered to produce a desired characteristic. Write a short caption for each step of the cartoon strip.

Frost-resistant tomatoes

The flounder is a fish that lives in very cold waters, and contains a gene to prevent it freezing. Scientists have created frost-resistant tomatoes by inserting the flounder's antifreeze gene into the cells of a tomato plant. This type of genetically engineered tomato plant is no longer destroyed by frost, which is very beneficial for farmers.

▲ Flounders produce antifreeze chemicals that allow them to live in very cold water.

▲ Tomatoes can be made frost resistant by adding the flounder's antifreeze gene.

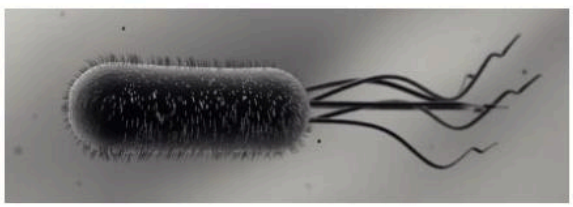
Genetically engineered bacteria

Bacteria can be genetically engineered to produce many useful chemicals, including vaccines and antibiotics. As bacteria reproduce very quickly, they can be used to produce large amounts of the chemical in a very short period.

C Name two useful chemicals produced by genetically engineered bacteria.

Your body needs a chemical called insulin to control your blood–sugar level. Some people do not produce enough insulin, and must inject it daily. The insulin they need can be made using genetically engineered bacteria:

1. Genes that code for the production of insulin are inserted into the bacteria.
2. The bacteria now produce insulin.
3. The bacteria multiply many times, and produce large quantities of insulin.
4. The bacteria are then removed, leaving behind the useful insulin.



◀ *E.coli* is genetically engineered to produce insulin.

Key Words

genetic engineering

Summary Questions

1 Copy and complete the sentences below.

Scientists can insert _____ genes into organisms to produce desired _____. This is called _____ engineering. For example, bacteria can be engineered to produce _____.

(4 marks)

2 Describe the advantages of genetic engineering over selective breeding.

(3 marks)

3 Haemophilia is a disease that prevents blood from clotting. Sufferers of this disease are unable to produce Factor VIII, a chemical that clots blood. Describe how bacteria can be genetically engineered to produce large quantities of Factor VIII for the treatment of haemophilia.

(6 marks QWC)

1.5 Cloning

Learning objectives

After this topic you will be able to:

- describe what is meant by a clone
- describe some advantages and disadvantages of cloning.

Link

You can learn more about the way plants reproduce in B1 3.6 Flowers and pollination

▲ Spider plants reproduce asexually by producing plantlets on side branches.

Key Words

clone, asexual reproduction

Can you tell the difference between two blackbirds? Perhaps you could if you looked carefully. Can you tell the difference between two bacteria? Probably not. This is because bacteria produce identical copies of themselves.

What is a clone?

A **clone** is an organism that is genetically identical to its parent. This means that it has the same genes as its parent, and will therefore look identical.

When bacteria reproduce, they divide in half. Each half contains identical genes, resulting in two identical organisms, called clones. The production of clones is useful when bacteria are used to make chemicals such as insulin.

A State what is meant by a clone.

Asexual reproduction

Bacteria do not reproduce using a partner. Only one parent is needed; this is known as **asexual reproduction**. New organisms are created by cell division. There is no mixing of genetic material so the offspring produced are clones.

Many plants can also reproduce asexually. For example:

- potato plants – produce many tubers, each of which can grow into a new plant
- strawberry plants – produce long stems with tiny plants (plantlets) on the end
- daffodils – at the end of each growing season a new bulb is formed from which next year's flower grows.

B State what is meant by asexual reproduction.

How can you make clones?

When you take a plant cutting, you are making a clone. Most plants can be grown from cuttings. A cutting is a small section of a plant. It is planted and allowed to grow into a new plant. Often the

cutting is dipped in a special chemical called rooting powder to encourage the cutting to grow roots.

Advantages of this technique are:

- new plants are produced quickly
- the technique is cheap
- all plants are genetically identical so they will all have the desired characteristics.

The main disadvantage is that cloning plants reduces the variety of genes available (the gene pool). This can increase the risk of disease, or a change in the plant's environment, destroying a species.

C State a disadvantage of cloning plants.

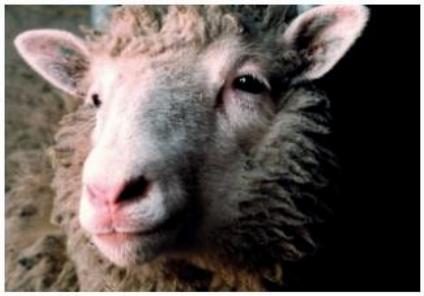
How can you make animal clones?

Most people are happy about cloning plants but there are very mixed views on cloning animals. Some people think that cloning animals is unethical.

Two animal cloning techniques that scientists regularly use are:

- cell cloning – scientists clone human cells in the laboratory, and use them for research into diseases
- tissue culture – new skin and cartilage can be grown in a sterile environment; this technique is used to grow new skin for burns victims.

Scientists believe that there may be many beneficial uses of cloning. For example, endangered species could be cloned, preventing their extinction.



▲ Dolly was the first mammal to be cloned using cells from an adult sheep.

▲ This is not actually an ear, it is just cartilage growing around a mould. Scientists hope they will be able to regrow noses and ears in the future.

▲ Rooting powder encourages roots to grow.

Plant cuttings

A new plant can be grown by taking a cutting from another plant. This is an example of cloning.

Try taking your own cuttings to see if you can clone a plant.

Summary Questions

1 Copy and complete the sentences below.

Organisms that are genetically _____ to their parents are known as _____. This is an example of _____ reproduction.

(3 marks)

2 Describe the main differences between asexual and sexual reproduction.

(3 marks)

3 Using examples to illustrate your answer, compare the main advantages and disadvantages of cloning.

(6 marks QWC)

1.6 Biotechnology 1

Learning objectives

After this topic you will be able to:

- write the word equation for fermentation
- describe how bread, beer, and wine are made.

▲ *Saccharomyces cerevisiae* is the yeast used to make bread.

▲ Before baking, the bread is left to rise.

Link

You can learn more about fermentation in B2 2.6 Anaerobic respiration

Many of the food and drinks we consume have been made using microorganisms. For example, yeast is added to bread to make it rise. This is an example of biotechnology.

What is biotechnology?

Biotechnology is the use of biological processes or organisms to create useful products. Many of these products are foods and drinks.

A State what is meant by the term biotechnology.

What is yeast?

Yeast is a microorganism. It is used in the production of bread and many alcoholic drinks. These products are made using the chemical reaction **fermentation**. Fermentation is a type of anaerobic respiration – the yeast respires without needing oxygen.

Fermentation can be represented by the following word equation:

glucose → ethanol + carbon dioxide (+ energy)

B Write down the word equation for fermentation.

Enzymes present in the yeast speed up fermentation, making the reaction occur faster. The enzymes work best in a warm environment.

How do you make bread?

Flour, water, and yeast are mixed to make dough. The dough is then left in a warm place to rise. This is caused by the yeast respiring, changing the sugars in the flour into ethanol and carbon dioxide. The carbon dioxide gas is trapped as bubbles inside the dough, making it rise.

The dough is then baked. In the oven, the ethanol evaporates. The bubbles of gas expand, making the bread rise further.

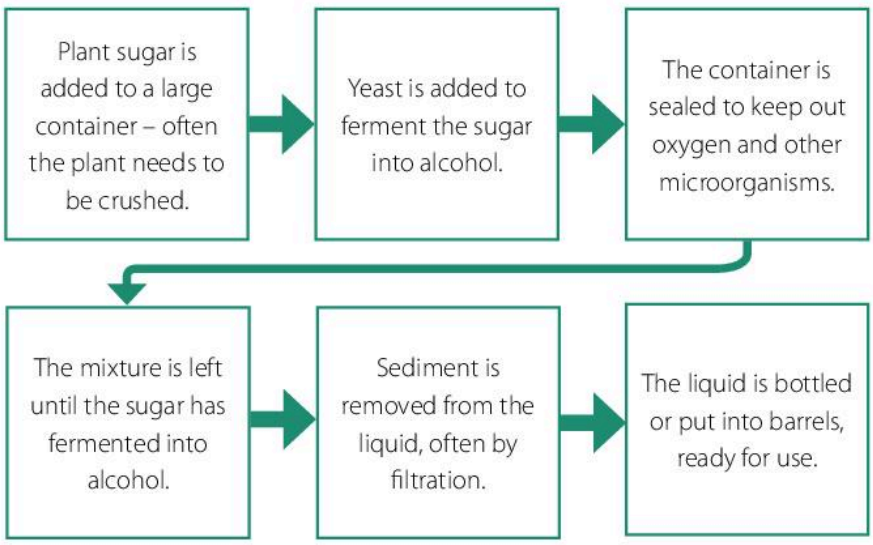
C Name the gas that makes dough rise.

How do you make beer and wine?

▲ Alcoholic drinks are made by fermenting plant sugars.

Beer and wine are made in very similar ways. The type of alcoholic drink produced depends on the source of sugar. This determines the type of ethanol produced.

Wine is made when yeast is used to ferment grape sugar. Beer or lager is made when yeast is used to ferment sugar in malted barley.



◀ Wine fermenters are kept warm to speed up the process of fermentation.

Fermenting sugar

When yeast ferments sugar, carbon dioxide is produced. Design an investigation to determine the ideal temperature for yeast to ferment sugar.

Key Words

biotechnology, fermentation

Summary Questions

1 Copy and complete the sentences below.

Yeast is a _____. It is used to make bread and _____ drinks.

During _____, the _____ in yeast convert glucose into ethanol and _____ _____.

(5 marks)

2 Some types of bread are made without using yeast. Suggest and explain how these breads would differ in appearance from bread made with yeast.

(3 marks)

3 Cider is an alcoholic drink made from apples. Explain how cider could be produced.

(6 marks QWC)

1.7 Biotechnology 2

Learning objectives

After this topic you will be able to:

- describe the role of bacteria in fermentation
- describe how cheese and yoghurt are made.

▲ Stilton cheese has mould (a type of fungus) growing throughout it.

▲ You can see the curds (milk solids) in the man's hand. The watery liquid is known as whey.

▲ Yoghurt production.

There are many different types of cheese. You may know that cheese is made from milk but did you know that bacteria are also used in cheese-making? Some types of cheese also need mould to be produced.

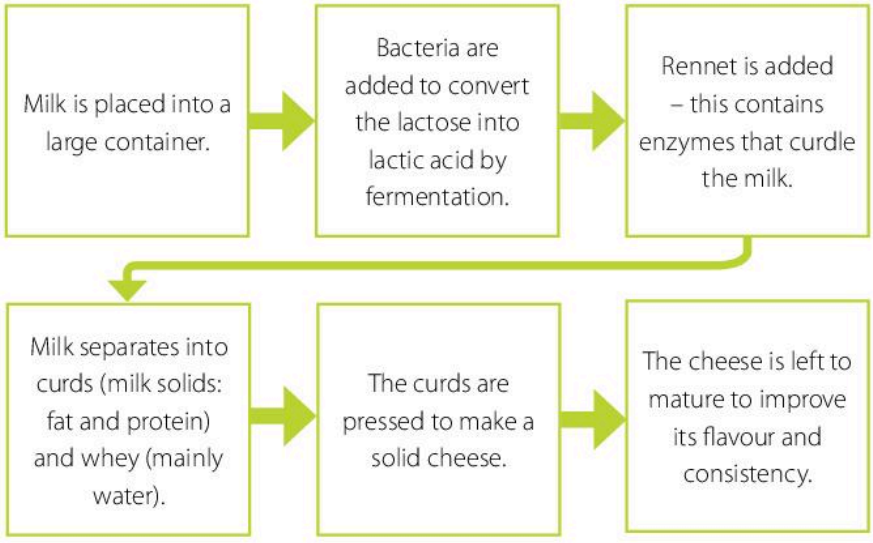
How do you make cheese?

Cheese is made from the milk of animals, including cows, goats, and sheep. Different types and flavours of cheese can be made using different species of bacteria and moulds.

To make cheese, bacteria are added to milk. The bacteria then ferment lactose, a type of sugar found in milk. During fermentation, the lactose is converted into lactic acid. This acid gives cheese its tangy taste.

A Name the product made when lactose is fermented.

The flow chart below shows how cheese is made:

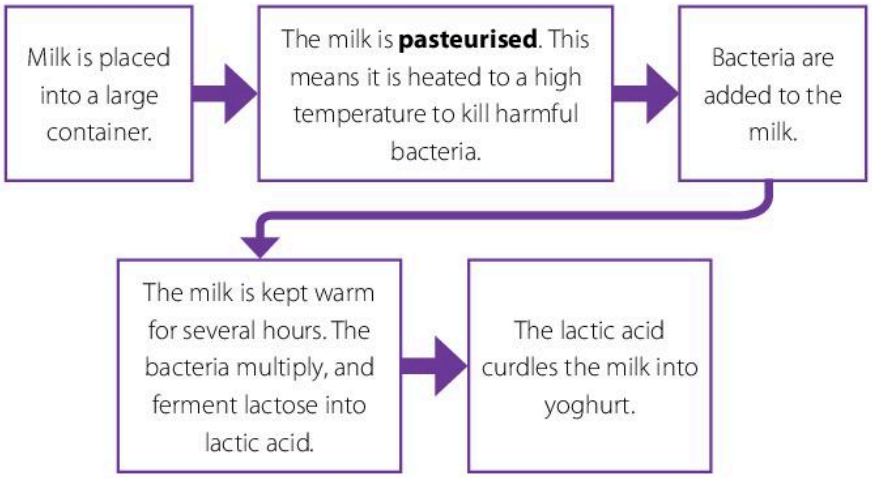


B State the purpose of rennet in cheese-making.

How is yoghurt made?

Yoghurt is also made using bacteria. Normally cow's milk is used but any milk can be turned into yoghurt.

The flow chart on the next page shows how yoghurt is made:



The lactic acid produced by the bacteria has another useful property. It prevents the growth of harmful bacteria. This increases the time that yoghurt can be kept and eaten safely.

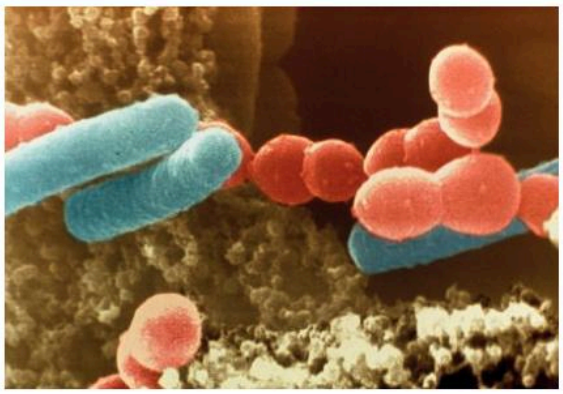
C State what is meant by milk that is pasteurised.

What is 'live' yoghurt'?

After production, some yoghurts are pasteurised to kill the bacteria used to make them. Yoghurts that have not been pasteurised are known as 'live' or 'probiotic' yoghurts – they contain actively growing bacterial cultures.

Pharmacists often recommend that people taking antibiotics (medicines that kill bacteria) eat 'live' yoghurt. This is to replace the useful bacteria that are present in your intestine. These are essential for digestion but are killed by any antibiotics you may take.

Some people eat probiotic yoghurts to help digestion. Normal yoghurt usually contains two types of bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophiles*. Probiotic yogurt contains additional types of bacteria that are thought to help a person's digestion, making you feel healthier.



◀ *Streptococcus thermophilus* (red) and *Lactobacillus bulgaricus* (blue) are the most common types of bacteria used in yoghurt production.

Link

You can learn more about probiotic foods in B2 1.5 Bacteria and enzymes in digestion

Fermentation products

Produce an infographic explaining clearly how one food or drink product is made using the process of fermentation.

Key Words

pasteurised

Summary Questions

1 Copy and complete the sentences below.

_____ are used to _____ the sugars in milk in the production of cheese and _____. The bacteria convert _____ into lactic acid.

(4 marks)

2 Describe two useful effects of lactic acid in yoghurt production.

(2 marks)

3 Compare the processes of cheese and yoghurt production.

(6 marks QWC)

1.8 Enzymes in industry

Learning objectives

After this topic you will be able to:

- describe some commercial uses of enzymes
- describe what happens when an enzyme is denatured.

▲ Proteases are added to baby food to break down proteins, making it easier for babies to absorb the nutrients.

▲ Biological washing powders are used to remove stains.

Have you ever looked closely at a washing-powder label? Many say they are biological powders. This means they contain enzymes that help to clean your clothes.

Why use enzymes?

Enzymes are a type of catalyst – they speed up reactions without being used up. Their use in industry often saves energy, for example, by allowing reactions to be carried out at lower temperatures.

Enzymes catalyse lots of reactions so they have lots of uses. These include:

- making baby food
- extracting juice from fruit
- removing stains from clothes.

Making baby food

It is hard for newborn babies to digest high-protein foods. Many baby foods are treated with proteases to break down protein into amino acids. The newborns can then absorb the amino acids, and they get the nutrients they need out of their food.

A State the purpose of protease in baby food.

Making fruit juice

Fruits such as apples and oranges contain pectin. Pectin makes it harder to break down the cell walls when you squeeze the fruit to release the juice. Pectinase is added to digest pectin. This makes it much easier to squeeze the fruit, releasing more juice.

Removing stains

The enzymes in biological washing powders help remove stains by breaking down the stain into water-soluble substances. These then dissolve and are washed away.

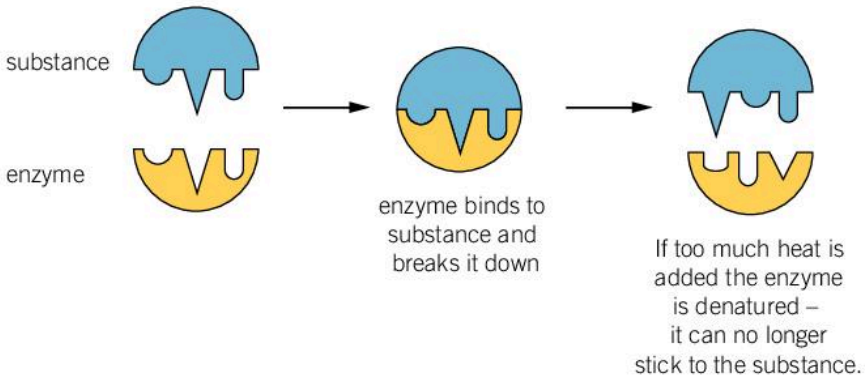
Enzyme	Function	Example of stains removed
proteases	digest protein, removing protein stains	egg, blood
lipases	digest fat, removing greasy stains	butter, oil

B State the enzyme that could be used to remove a blood stain.

Temperature and enzymes

The speed at which enzymes catalyse a reaction depends on the temperature. Generally, the higher the temperature, the faster the reaction. This is true up to a certain temperature; after that the enzyme is **denatured** and can no longer catalyse a reaction.

Enzymes are proteins. They have a specific shape that matches the shape of the substance they are acting on. If they are heated too much, they lose their shape and can no longer stick to the substance. The enzyme has been denatured, which means it has been permanently changed. Different enzymes are denatured at different temperatures.

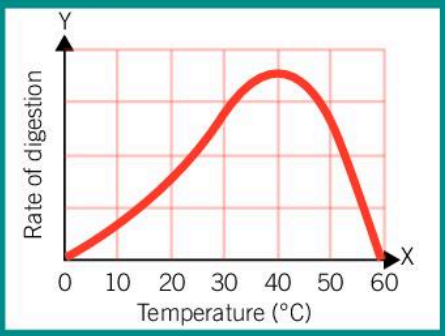


▲ Enzymes have to be the correct shape to bind to the substance they are acting on.

C State what happens to an enzyme when it is denatured.

Enzyme graphs

This graph shows what happens at different temperatures to an enzyme involved in human digestion.



a Describe what happens as the temperature increases from 10 °C to 20 °C.

b What is the optimum (best) temperature for the enzyme to work at?

c Explain why the rate of digestion falls at temperatures higher than the optimum.

The clue is in the name

You can often work out an enzyme's function from its name. Enzymes are named according to the job they do, and end in the letters 'ase'. For example:

lipases – break down lipids (fats) into fatty acids and glycerol

proteases – break down proteins into amino acids

carbohydrases – break down carbohydrates into sugar molecules

Key Words

denatured

Summary Questions

1 Copy and complete the sentences below.

_____ are a type of _____. They are used in reactions in industry. For example, _____ are used in washing powder to digest fat stains. If an enzyme is heated too much it will be _____.

(4 marks)

2 Describe the use of enzymes in the production of fruit juice.

(3 marks)

3 Explain how enzyme reactions are affected by temperature. Explain how this might affect your use of biological washing powders.

(6 marks QWC)

B3 Chapter 1 Summary

Key Points

- Different forms of the same gene are known as alleles.
- Dominant alleles will always be expressed if they are present. Recessive alleles will only be expressed if two copies are present.
- Punnett squares show the possible combinations of alleles inherited from the parents. This helps scientists to predict an offspring's characteristics.
- Genetically inherited disorders are conditions passed from parents to their offspring in their genes. Examples include cystic fibrosis and polydactyly.
- A carrier has one copy of the dominant allele and one copy of the recessive allele. Carriers do not have the disorder themselves.
- Farmers selectively breed their crops and plants to produce organisms with the desired characteristics.
- Selective breeding reduces variation within a species.
- Scientists can insert foreign genes into organisms to change their characteristics. This is called genetic engineering. For example, bacteria can be engineered to produce insulin.
- Clones are organisms that are genetically identical to their parents. This is an example of asexual reproduction.
- Biotechnology is the use of biological processes or organisms to create useful products.
- Yeast is used to make bread and alcoholic drinks. During fermentation, the enzymes in yeast convert glucose into ethanol and carbon dioxide.
- Bacteria ferment milk sugars in the production of cheese and yoghurt. The bacteria convert lactose into lactic acid. This curdles the milk.
- Enzymes catalyse reactions in industrial processes. For example, enzymes are used in washing powder to digest food stains.
- If an enzyme is heated too much it will be denatured, changing its shape. It can no longer catalyse the reaction.

Key Words

allele, dominant, recessive, Punnett square, genetically inherited disorder, carrier, selective breeding, genetic engineering, clone, asexual reproduction, biotechnology, fermentation, pasteurised, denatured

Big write

Biological techniques are used in a range of different situations, including food manufacture, improving a species' characteristics, and the production of medicines.

Task

Select one example that illustrates one of the above biological techniques. Write a magazine article to explain the science used in your example, and discuss the risks and benefits.

Tips

- Use diagrams where appropriate, and explain any scientific terms you use.
- Ensure that your article is written in a 'magazine' style. For example, include images and different text styles to enhance the presentation of the work.

End-of-chapter questions

1 The following sentences describe the production of cheese. Re-arrange them into the correct order.

Bacteria are added to convert the lactose into lactic acid by fermentation.

The cheese is left to mature.

Rennet is added. Enzymes curdle the milk.

The curds are pressed to make a solid cheese.

Milk is placed into a large container.

Milk separates into curds.

(6 marks)

2 Bread is made using fermentation.

a Circle the microorganism used in making bread.

bacteria yeast virus

(1 mark)

b Complete the word equation for fermentation.

glucose → _____ + carbon dioxide (+ energy)

(1 mark)

c State which of the products produced during fermentation causes bread to rise. *(1 mark)*

d Explain why bread does not contain ethanol. *(1 mark)*

(4 marks)

3 A student wanted to make their own yoghurt in the laboratory.

a Suggest **two** safety precautions the student should take before beginning. *(2 marks)*

b The student's first step was to pasteurise milk. State what pasteurised means. *(1 mark)*

c The student then added bacteria to the milk. To encourage the bacteria to multiply, the mixture must be kept warm. Suggest how the mixture can be kept at a constant warm temperature. *(1 mark)*

d State the product produced when bacteria ferment milk sugars. *(1 mark)*

e Give two useful properties of yoghurt that contains live bacteria. *(2 marks)*

(7 marks)

4 Enzymes are used in industry in many chemical reactions.

a Give **two** reasons that enzymes are used in reactions in industry. *(2 marks)*

b Draw and label a graph to illustrate how enzymes are affected by temperature. *(4 marks)*

c Describe the use of enzymes in making fruit juice. *(3 marks)*

(9 marks)

5 Some types of tomato have been genetically engineered to stay firm for longer.

a Suggest why this is this an advantage for tomato sellers. *(1 mark)*

b Suggest **one** other characteristic that a tomato grower may choose to improve using genetic engineering. *(1 marks)*

c Describe how a tomato plant may be genetically engineered. *(3 marks)*

d Explain how genetic engineering produces plants with the desired characteristics more quickly than selective breeding. *(2 marks)*

(7 marks)

6 Sickle cell anaemia is a genetically inherited disorder. It causes misshapen red blood cells, which can block blood vessels. The allele for this disorder is recessive. Calculate and explain the chance of a person inheriting the genetically inherited disorder if both of their parents are carriers.

(6 marks QWC)

2.1 Vaccines 1

Learning objectives

After this topic you will be able to:

- describe the role of vaccines in fighting disease
- describe how Jenner developed the smallpox vaccine.

▲ This teenager is being immunised against tuberculosis. The injection contains the vaccine.

▲ The polio vaccine can be given orally.

Have you had an injection recently? This was probably to prevent you from getting a disease like measles. These injections are known as immunisations (or vaccinations).

What is an immunisation?

To prevent you catching certain diseases you may be given an **immunisation**. This is a way of inserting a **vaccine** into your body. Most commonly this is in the form of an injection but sometimes this can be in the form of drops into the mouth.

A State what is meant by an immunisation.

What is a vaccine?

A vaccine contains dead or inactive forms of a disease-causing microorganism. This means that the microorganism can not make you ill. However, the vaccine tricks your body into thinking that the harmful, active form of the microorganism has entered your body. This triggers your **immune system** to start working. The immune system is the body's system for fighting disease. As a result of taking the vaccine, your body is protected from the disease.

B State what is meant by a vaccine.

Which immunisations should you have?

Doctors encourage parents to have their children immunised at an early age. Immunisations are the most cost-effective means of preventing life-threatening infections in a population.

The table below shows the immunisations offered to every child in the UK.

Child's age	Disease immunised against
2, 3, and 4 months	polio, diphtheria, tetanus, whooping cough, Hib meningitis, meningitis C
about 13 months	measles, mumps, rubella (MMR)
3–5 years	MMR, polio, diphtheria, tetanus, whooping cough
10–14 years	tuberculosis
12-13 years	cervical cancer (girls only)
13–18 years	polio, diphtheria, tetanus

How were vaccines discovered?

The first vaccine was developed in1796 by Edward Jenner, an English doctor. It was used to treat smallpox. Smallpox was a disease that killed one in three people who caught it, and badly disfigured those who survived.

C Name the person who developed the first vaccine.

Jenner was fascinated by news that milkmaids did not get smallpox. Most milkmaids instead suffered from a weak version of smallpox, known as cowpox. This disease caused blisters on their skin but did not cause death.

Jenner hypothesised that there must be a link between the cowpox and smallpox. He thought that the pus in the cowpox blisters somehow protected the milkmaids from smallpox. To test out his theory he took some pus from a milkmaid's blisters. He inserted the pus into a cut on the arm of an eight-year-old boy called James Phipps.

A few days later, Jenner then deliberately injected Phipps with smallpox. Phipps became ill but after a few days he made a full recovery. The cowpox vaccine had prevented James from getting smallpox.

In the 1970s smallpox was wiped out from the world as a result of immunisations. No cases have occurred since.

▲ Those who survived smallpox were left badly scarred and often blind.

▲ Edward Jenner, the English doctor who discovered the smallpox vaccine.

Key Words

immunisation, vaccine, immune system

Summary Questions

1 Copy and complete the sentences below.

The spread of infectious _____ can be prevented by _____. They work by introducing _____ that contain dead or inactive _____ into the body.

(4 marks)

2 Explain why dead or inactive microorganisms are used in vaccines.

(2 marks)

3 Suggest three reasons why it is important for scientists like Jenner to study the spread of a disease.

(3 marks)

4 Explain in detail how Jenner discovered the smallpox vaccine.

(6 marks QWC)

Human experiments

Was Edward Jenner right to test his hypothesis on James Phipps? Discuss the risks and benefits of the immunisation experiment.

Smallpox vaccine

Produce a cartoon strip showing how Jenner developed the smallpox vaccine.

2.2 Vaccines 2

Learning objectives

After this topic you will be able to:

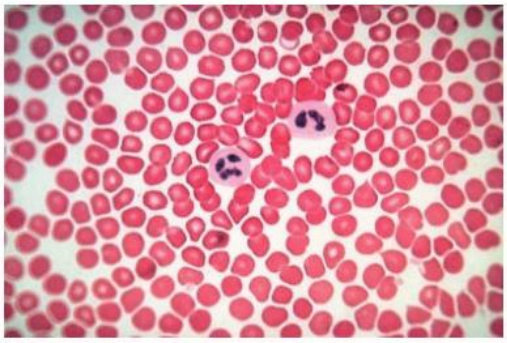
- describe how a person develops immunity
- compare the advantages and disadvantages of receiving a vaccine.

Have you ever heard the word 'immunity'? Doctors and nurses talk about you being immune to a disease. This means that you will never get that disease.

What is immunity?

The body has defences to prevent microorganisms entering your body. These include your skin, and the hairs in your nose. Sometimes though, a harmful microorganism, a **pathogen**, does get in. This is detected by your immune system. It will trigger your white blood cells to make **antibodies**. Antibodies are special chemicals that attack and destroy the microorganism. A different type of antibody has to be produced for each type of microorganism.

A Describe what an antibody does.



▲ The large white blood cells are responsible for fighting disease. The small cells are red blood cells.

It takes time for the body to make enough antibodies to destroy pathogens. During this time the microorganisms reproduce rapidly, damaging cells and making poisons that make you ill.

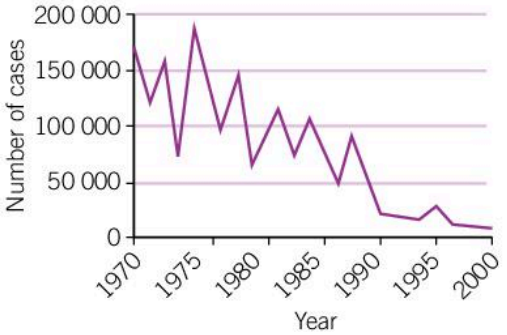
If the same type of pathogen enters your body again, your white blood cells remember it. Antibodies are produced more quickly. The pathogen is then destroyed before it has a chance to make you ill. You then have immunity to the disease.

B Name the cells that make you immune to a disease.

How do immunisations work?

When a vaccine is inserted into the body, white blood cells make antibodies to fight against the dead or inactive microorganism contained in the vaccine. The antibodies will be remembered by your body. If a live version of the pathogen later enters your body, the antibodies will destroy it before it causes disease.

Between 1970 and 2000, the population of the UK increased. During this time, measles immunisations were given to large numbers of the population. Despite a rise in population, the number of measles cases decreased.



▲ Number of cases of measles in the UK between 1970 and 2000.

Immunisations protect you against many life-threatening conditions. However, not everyone chooses to be immunised. This is because they may have concerns about:

- the safety of some vaccines
- possible side effects.

C Suggest one reason why people may choose not to be immunised.

Side effects

Immunisations sometimes have side effects. These can include:

- a temperature
- sickness
- swollen glands
- a small lump at the site of the injection

Side effects can usually be easily treated with a painkiller. Severe reactions are very rare. Before they are widely used vaccines are thoroughly tested to ensure they are safe.

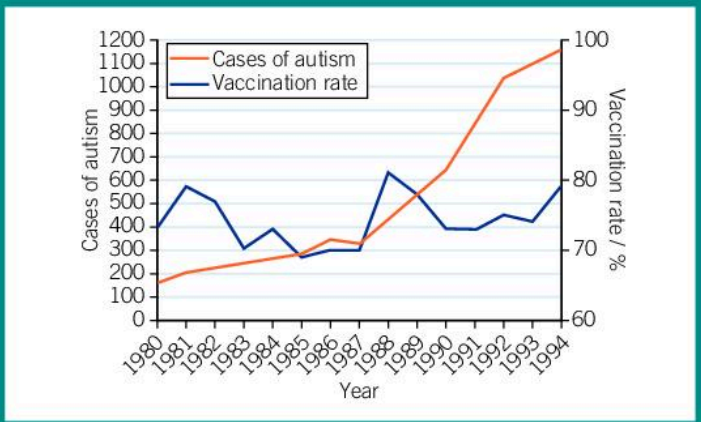
D State two common side effects of immunisation.

MMR and autism

MMR is a vaccine given to young children, which protects against measles, mumps, and rubella. Some people are concerned that the vaccination is linked to autism in children.

The graph shows the number of UK cases of autism across a 15-year period, and the MMR vaccination rate across the same period of time.

Using evidence from the graph, explain why scientists do not believe that autism is linked to the MMR vaccine.



Foul Fact

Bacteria can reproduce very quickly. In ideal conditions they divide into two every 20 minutes. Within a few hours, a few bacteria will have become several million!

Key Words

immune, pathogen, antibody

Summary Questions

1 Copy and complete the sentences below.

When a harmful _____ enters the body, white blood cells make _____ to destroy it. If the same microorganism enters your body again, your _____ _____ _____ remember it. They make the antibodies much more quickly, destroying the microorganism before it causes disease. You have _____ to the disease.

(4 marks)

2 Describe how a vaccine causes immunity.

(4 marks)

3 Compare the advantages and disadvantages of being immunised.

(6 marks QWC)

2.3 Antibiotics 1

Learning objectives

After this topic you will be able to:

- describe the use of antibiotics
- describe how Fleming discovered penicillin.

Have you ever had a very sore throat? Some sore throats are caused by bacteria. Doctors use antibiotics to treat this type of infection.

What are antibiotics?

When you are ill, doctors can prescribe a range of drugs to make you feel better. These medicinal drugs work by preventing, treating, or curing the symptoms of a disease.

A Name three ways that a medicinal drug can work.

Antibiotics work by killing the bacteria that has made you ill. They do not damage the cells in your body, and have no effect on viruses or fungi.

B State what antibiotics do.

There are many different types of antibiotics. One of the most common types is penicillin.

How was penicillin discovered?

During World War 1, Alexander Fleming worked in the battlefield hospitals. He saw large numbers of soldiers dying from wounds infected with bacteria. After the war he carried out research to try and discover chemicals that could be used to kill the bacteria.

▲ A sore throat caused by a bacterial infection.

▲ Antibiotics can be taken in tablet or liquid form. For severe infections, antibiotics can be given directly into the blood through a drip.

▲ Alexander Fleming discovered penicillin accidentally.

Fleming carried out his research by growing bacteria on agar plates. In September 1928, he returned to work after a holiday. He had left a number of agar plates with bacteria growing on them stacked up in his laboratory. When he returned he found mould (*Penicillium notatum*) growing on one of them.

He noticed that where the mould was growing, bacteria were killed. Fleming named the substance that killed the bacteria penicillin. Fleming discovered that penicillin killed many types of bacteria, such as those that cause meningitis and scarlet fever.

Fleming's discovery has saved millions of lives, and is recognised as one of the greatest medical developments of all time.

C Name the scientist who discovered the first antibiotic.

Which antibiotic?

There are now a number of different types of antibiotic a doctor can prescribe. Each type kills different species of bacteria.

To discover the correct antibiotic to use, samples of the bacteria can be spread over the surface of an agar plate. Antibiotic discs are then placed on the surface of the agar. These are tiny discs of paper that have been soaked in a particular antibiotic. The agar plates are then placed in an incubator and left for the bacteria to grow.

▲ The disc with the largest area free of bacteria is the most effective antibiotic.

This photo of an agar plate shows clear circles around the antibiotic discs. These are the areas where the bacteria have come into contact with the antibiotic, and have been prevented from growing. The larger this area, the more effective the antibiotic is on that type of bacteria.

▲ The mould growing on this orange is *Penicillium notatum*.

Key Words

antibiotic

Summary Questions

1 Copy and complete the sentences below.

_____ are a type of medicinal _____. They treat a disease by killing the _____ that caused it.

Alexander Fleming discovered the antibiotic _____. It is made from a type of _____.

(5 marks)

2 Colds are caused by viruses. Explain why doctors do not prescribe antibiotics to treat colds.

(2 marks)

3 Describe how Fleming discovered penicillin.

(4 marks)

4 Ear infections are caused by a number of different bacteria. Explain in detail how doctors can discover the most effective antibiotic to prescribe to treat the infection.

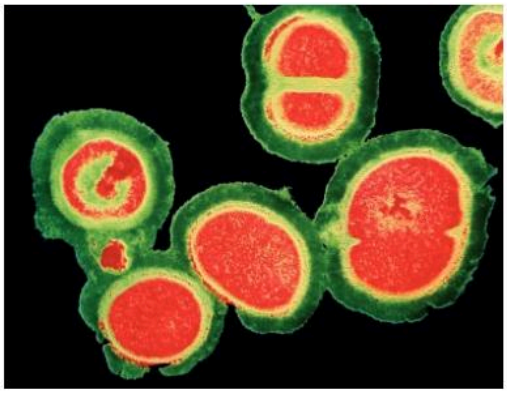
(6 marks QWC)

2.4 Antibiotics 2

Learning objectives

After this topic you will be able to:

- describe what is meant by antibiotic resistance
- describe some methods for preventing the spread of bacterial infection.



▲ MRSA bacteria are resistant to many antibiotics. They are an example of a superbug.

Have you heard of 'superbugs'? They are often the cause of infections in hospitals. These infections can be very difficult to treat.

Do antibiotics kill all bacteria?

Since penicillin was first discovered, millions of lives have been saved. Antibiotics have been widely used to treat a range of human and animal conditions. They can even be added to animal feed to prevent infections.

However, some types of bacteria are no longer killed by penicillin. They have become **antibiotic resistant**. New types of antibiotics have been developed but some bacteria are now resistant to these antibiotics too.

A State what it means when a bacterium is antibiotic resistant.

Some types of bacteria are resistant to most types of antibiotic. They are known as **superbugs**. Scientists are worried that these bacteria will become resistant to all antibiotics, leaving no way of treating the infections they cause. An example of a superbug is MRSA.

B State what is meant by a superbug.

Developing resistance

Bacteria reproduce very rapidly. When they multiply their DNA can be damaged or altered. This is known as a **mutation**. This normally results in the bacteria dying but sometimes the mutation can be beneficial to the bacterium. For example, a mutation may cause it to be resistant to an antibiotic.

C State what a mutation is.

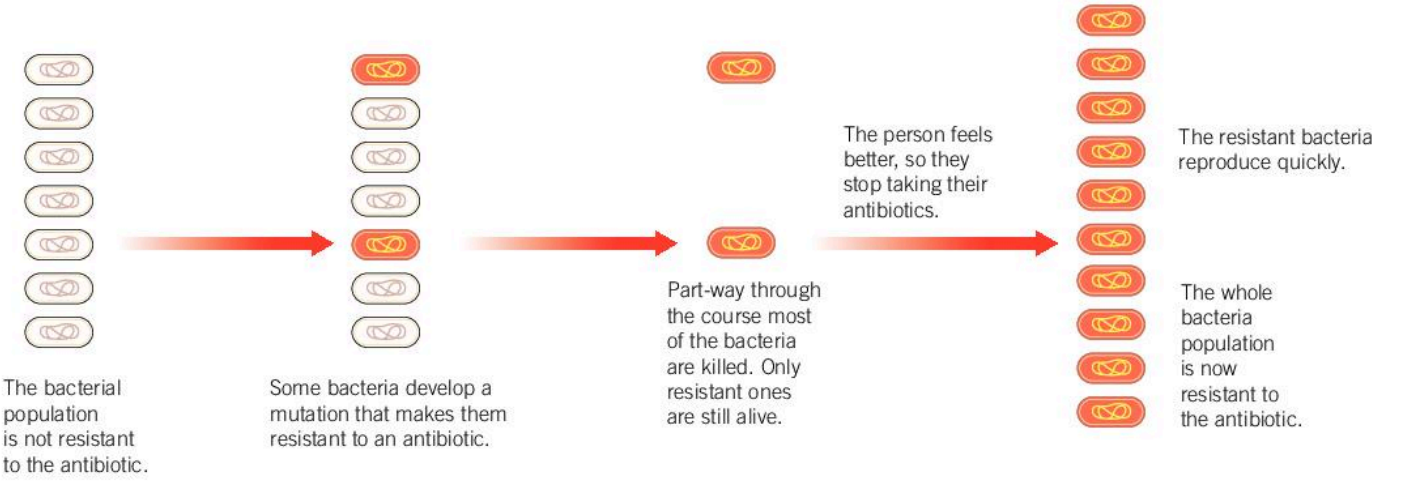
Antibiotics should be taken over a period of time to ensure that all the infecting bacteria are killed. Some people stop taking antibiotics too soon because they feel better. This increases the chance of an antibiotic-resistant strain of bacteria developing. The diagram on the next page shows how this happens.

Preventing MRSA

Design a poster to be placed in hospital waiting rooms that show how the risk of spread of MRSA can be reduced.

Link

You can learn more about how organisms evolve in B2 3.6 Natural selection



Doctors and nurses rub their hands with antiseptic gel between seeing patients. This helps to prevent the spread of bacteria around a hospital.

Key Words

antibiotic resistant, superbug, mutation

How can we stop superbugs developing?

Scientists cannot stop antibiotic-resistant bacteria developing. However, there are a number of things we can all do to reduce the risk of bacteria spreading:

- Thoroughly wash your hands before meals, before preparing food, and after going to the toilet. This removes bacteria from your hands.
- Use antiseptics to clean cuts and grazes. These are chemicals that kill microorganisms but do not damage your skin.
- Clean toilets and kitchens with disinfectants. These are very strong chemicals that kill microorganisms.
- Use sterile medical equipment. Only use plasters and dressings that are sealed. Sterile objects have no microorganisms on them.

D Write down what sterile means.

Surgical equipment is sterilised in an autoclave. This heats the equipment to 120 °C, killing all microorganisms. This reduces the risk of infection from surgery.

Summary Questions

1 Copy and complete the sentences below.

Bacteria that cannot be killed by an _____ are antibiotic _____. Bacteria that are resistant to most antibiotics are called a _____. The spread of bacteria can be prevented by good personal hygiene. Medical equipment should be _____. This means that there are no _____ present.

(5 marks)

2 Describe three ways in which the spread of bacteria can be reduced in hospitals.

(3 marks)

3 Explain how not completing a prescribed course of antibiotics increases the risk of antibiotic-resistant bacteria developing.

(6 marks QWC)

2.5 DNA

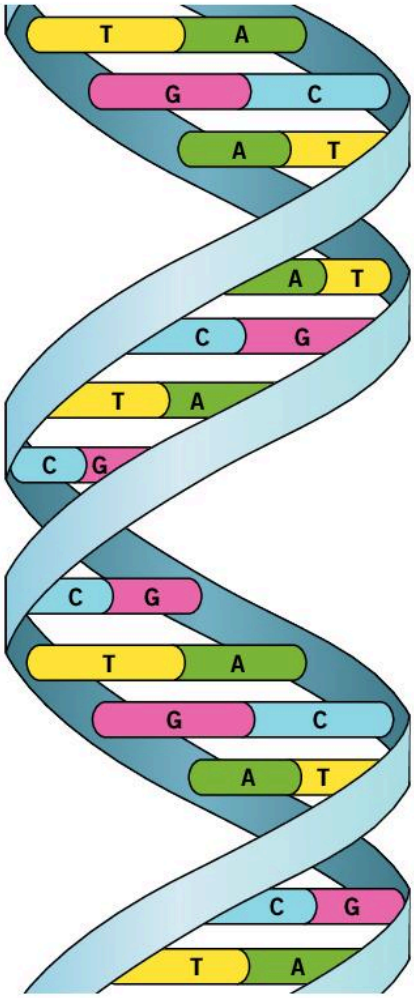
Learning objectives

After this topic you will be able to:

- describe the structure of DNA
- describe how scientists worked together to discover the structure of DNA.

Link

You can learn more about DNA and genes in B2 3.5 Inheritance



▲ DNA is a double helix.

You know that the nucleus of your cells contains DNA. DNA contains all of the instructions that determine your characteristics.

What does DNA look like?

The chemical **DNA** (deoxyribonucleic acid) contains all the information needed to make an organism. Short sections of DNA are known as genes. Each gene contains the instruction (the code) for a characteristic.

A State what a gene is.

DNA has three main features:

1. It is made up of two strands.
2. The strands are joined together by chemicals called DNA bases.
3. The strands are twisted together to form a double-helix shape.

B Describe three features of a DNA molecule.

What are DNA bases?

DNA contains four different chemical bases. They are normally referred to by the letters A (adenine), T (thymine), C (cytosine), and G (guanine).

The order of the bases is a code for the order of the amino acids, which make a specific protein. The protein determines the function of a cell.

C Name the four DNA bases.

DNA model

Produce a scientific model to demonstrate the structure of DNA.

How did scientists discover DNA?

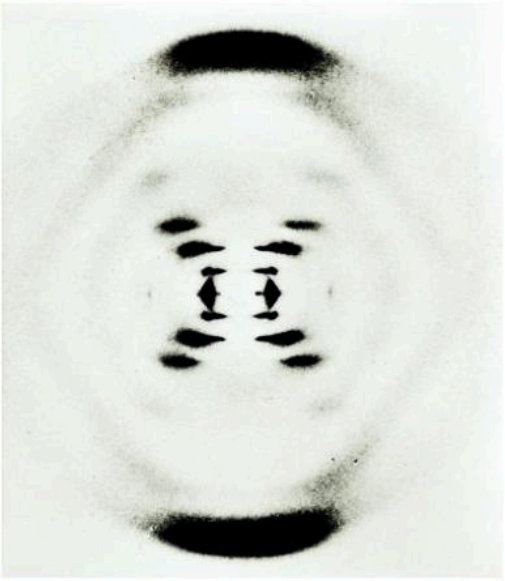
Many scientists have worked together to discover the structure and function of DNA. Although we have discovered lots of information about DNA, research is still continuing. It is hoped that this will lead to the prevention and cure of many diseases in the future.

The table below shows some of the main steps in the discovery of DNA.

1866	**Certain characteristics are inherited.** Gregor Mendel carries out experiments using peas. He notices that certain characteristics such as height and colour are passed on from parents to their offspring.
1869	**Nuclein is discovered.** Friedrich Miescher discovers an acidic substance in the nucleus of a cell. He calls this substance nuclein. This chemical is now called DNA.
1944	**Genes are passed from one generation to the next.** Oswald Avery transfers the ability to cause disease from one type of bacteria to another. He proves that genes are sections of the DNA molecule.
1950	**DNA base pairs are discovered.** Erwin Chargaff finds out that, even though different organisms have different amounts of DNA, all DNA contains equal quantities of bases, called A, T, C, and G.
1952	**DNA crystals are photographed.** Maurice Wilkins and Rosalind Franklin use X-rays to take an image of DNA crystals.
1953	**Double-helix structure of DNA is identified.** Building on these discoveries, James Watson and Francis Crick publish their description of DNA. They describe it as a double helix – two spirals held together by base pairs.
1953–2000	**Advances in genetics** Individual genes that code for genetically inherited disorders such as cystic fibrosis are discovered. The production of genetically engineered food and animal cloning also begin.
2003	**Human genome project completed** Scientists working across the globe identify around 24 000 genes – the complete set of genes in the human body.

Fantastic Fact

The police use a technique called DNA fingerprinting to prove the presence, or absence, of a suspect at a crime scene.



▲ Wilkins and Franklin's famous 'Photo 51' revealed the helical structure of DNA to Watson and Crick. The fuzzy X-shape suggests a helical structure.

Key Words

DNA

Summary Questions

1 Copy and complete the sentences below.

DNA is made up of two _____ that are twisted together to form a double _____. The strands are held together by four _____, called A, T, _____, and G.

(4 marks)

2 Describe how DNA leads to the production of different proteins.

(2 marks)

3 Explain how scientists worked together to discover the structure and function of DNA.

(6 marks QWC)

2.6 Charles Darwin

Learning objectives

After this topic you will be able to:

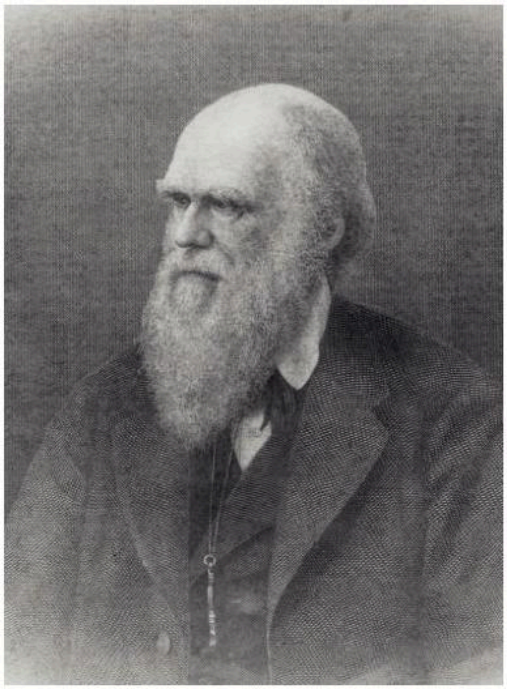
- describe the process of peer review
- describe the evidence that Darwin used to develop his theory of natural selection.

Have you heard of the scientist Charles Darwin? One of the most famous scientists of all time, Darwin developed the theory of evolution.

Darwin's theory

Darwin's theory states that organisms evolve as a result of natural selection. Darwin realised that organisms best suited to their environment are more likely to survive and reproduce, passing on their characteristics to their offspring. Gradually, a species changes over time. We now know that these characteristics are passed on through genes.

A Name the process by which organisms evolve.

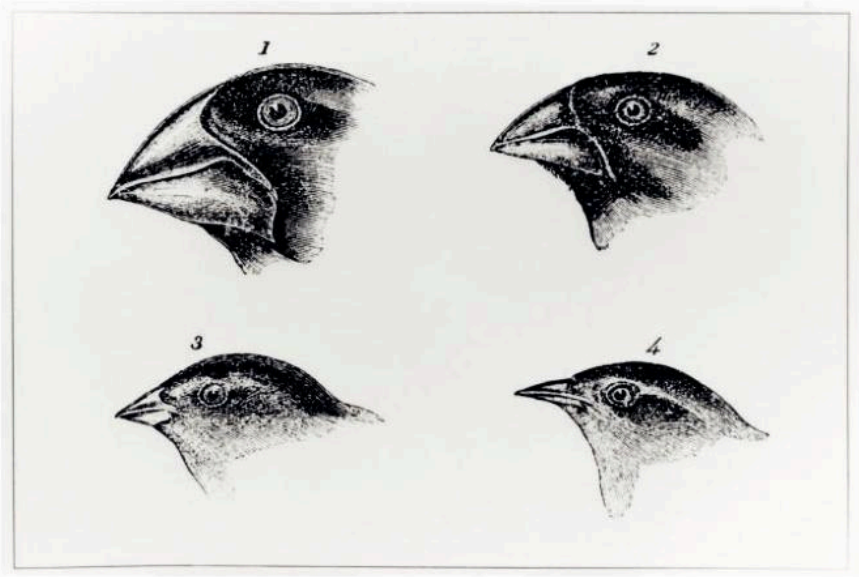


▲ Charles Darwin, author of 'On the Origin of Species'. Darwin's theory of evolution took over 20 years to develop.

How did Darwin come up with his theory?

Darwin was born in 1809. At that time, most people believed that the Earth and all the organisms on it were created by God.

In 1831, Darwin joined Captain Robert FitzRoy's scientific expedition to the Galapagos Islands. Whilst on HMS Beagle, Darwin read Lyell's 'Principles of Geology'. This suggested that fossils were actually evidence of animals that had lived millions of years ago. Modern scientists agree with this.



▲ Darwin noticed that finches on different islands had different beaks. The shape of the beak was adapted to the food the finch ate.

Link

You can learn more about evolution in B2 3.6 Natural selection

Darwin noticed that different islands had different types of finch. The birds' beaks and claws were different sizes and shapes. Darwin realised that the size and shape were linked to the type of food available on each island.

B Name the organism that Darwin studied on the Galapagos Islands.

Darwin concluded that if a bird was born with a beak suited to the food available on its island, it would survive for longer. Therefore, it would have more offspring. Over time the population of birds on that island would all have this characteristic. Darwin called this process natural selection.

Another scientist, Alfred Wallace, was working on his own theory of natural selection and evolution. Wallace and Darwin read each other's unpublished work. This is an early example of **peer review**, where a scientist's work is checked by another scientist who works in a similar area of science. Darwin's and Wallace's ideas were so similar that they jointly published the theory of evolution in a scientific paper.

C State what is meant by peer review.

A year later, in 1859, Darwin published his book 'On the Origin of Species'. The book was extremely controversial; the theory of evolution went against the view that God had created all of the life on Earth. As a result of Darwin's theory, people learned that humans were simply a type of animal, and had evolved from apes.

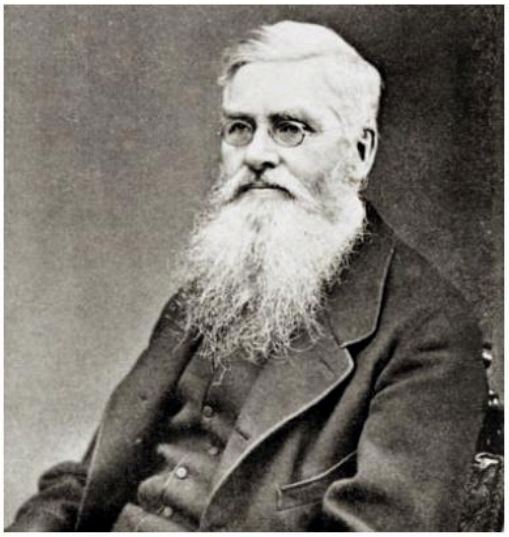
Do people still disagree with Darwin?

Darwin's theory of evolution is now widely accepted, though not by everyone. Evidence for his theory includes:

- the fossil record – which provides evidence that organisms have changed over time
- changes that have been observed in microorganism populations – for example, the development of antibiotic-resistant bacteria
- extinction – species that do not adapt to environmental changes die out.

Natural selection

Imagine you are a newspaper reporter at the time of the publication of Darwin's 'On the Origin of Species'. Write a front-page article about the theory of evolution.



▲ Alfred Wallace gathered his evidence for the theory of evolution from the wildlife of South America and Asia.

Key Words

peer review

Summary Questions

1 Copy and complete the sentences below.

Charles _____ came up with the theory of _____ by natural _____. Before they published their theory, Darwin and Wallace checked each other's work. This is called _____ _____.

(4 marks)

2 Describe three pieces of evidence in support of Darwin's theory of natural selection.

(3 marks)

3 Describe the process of peer review.

(2 marks)

4 Explain how Darwin's observations of finches in the Galapagos Islands contributed to his theory of natural selection.

(6 marks QWC)

2.7 Preventing extinction

Learning objectives

After this topic you will be able to:

- describe how animals become extinct
- describe some techniques used to prevent extinction.

▲ A woolly mammoth – this animal became extinct about 4000 years ago.

Link

You can learn more about why species die out in B2 3.7 Extinction

▲ It is estimated that there are fewer than 2000 giant pandas living in the wild.

Several million years ago, dinosaurs roamed the planet. These species are now extinct. Did you know that other species are becoming extinct today?

What does extinct mean?

Extinct means that no organisms of a particular species are alive anywhere in the world. The fossil record shows us that throughout history many species have become extinct. Extinction is still happening today, in many cases as a result of human activity. Humans compete with other organisms for space, food, and water, and are also very successful predators.

A Write down what extinct means.

Can we prevent extinction?

Species that are at risk of extinction are called **endangered species**. This means that there are very few of the species left. An example is the giant panda. Their numbers have been severely reduced by loss of habitat, and by being killed by poachers.

B State why the panda is an endangered species.

There are a number of ways that scientists are trying to prevent extinction. These include:

- **conservation**
- **captive breeding**
- **seed banks**

What is conservation?

Conservation means protecting a natural environment, to ensure that habitats are not lost. Protecting an organism's habitat increases their chance of survival, allowing them to reproduce.

As well as reducing the risk of a particular species becoming extinct, conservation also:

- reduces disruption to food chains and food webs
- makes it possible for medicinal plant species to be discovered.

The UK has over 4000 conservation areas where habitats are protected. These are known as Sites of Special Scientific Interest (SSSI) and cover around 8% of the nation's land.

C State what is meant by conservation.

What is captive breeding?

Captive breeding means breeding animals in human-controlled environments. Scientists working on captive-breeding programmes aim to:

- create a stable, healthy population of a species
- gradually re-introduce the species back into its natural habitat.

D List the aims of captive breeding.

Unfortunately there are also problems associated with captive breeding.

- Maintaining genetic diversity can be difficult. Only a small number of breeding partners are available.
- Organisms born in captivity may not be suitable for release in the wild. For example, predators bred in captivity may not know how to hunt for food.

What are seed banks?

Seed banks are a way of conserving plants. Seeds are carefully stored so that new plants may be grown in the future. A seed bank is an example of a gene bank – a store of genetic material.

The Millennium Seed Bank Project at Kew Gardens is an international project. Its purpose is to provide a back-up against the extinction of plants in the wild by storing seeds for future use. Its large underground frozen vaults preserve over a billion seeds; it is the world's largest collection of seeds.

◀ Seeds in the Millennium Seed Bank.

Captive-breeding debate

Hold a debate to discuss the advantages and disadvantages of captive-breeding programmes.

▲ Nearly half of the medicines used by doctors today are based on plant extracts that have come from the rainforests.

Key Words

endangered species, conservation, captive breeding, seed bank

Summary Questions

1 Copy and complete the sentences below.

Scientists are using a number of techniques to try to prevent _____ species becoming _____. These include storing seeds in seed _____, breeding animals in _____, and protecting habitats through _____.

(5 marks)

2 Describe how animals become extinct.

(3 marks)

3 Describe two advantages and two disadvantages of captive-breeding programmes.

(4 marks)

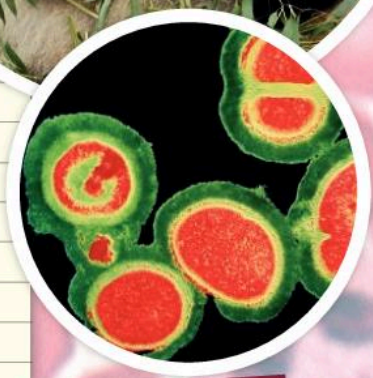
4 Discuss how humans can have a positive or a negative effect on the population of a species.

(6 marks QWC)

B3 Chapter 2 Summary

Key Points

- When a harmful microorganism enters the body, white blood cells make antibodies to destroy it.
- If the same microorganism enters your body again, your white blood cells make antibodies much more quickly, destroying the microorganism before it causes disease. This is known as immunity.
- The spread of infectious diseases can be prevented by immunisations. These work by introducing vaccines, which contain dead or inactive microorganisms, into the body. These trick your immune system into producing antibodies.
- Edward Jenner discovered the first vaccine. It was used to prevent smallpox.
- Antibiotics are medicinal drugs that work by killing bacteria.
- Alexander Fleming discovered the antibiotic penicillin.
- Bacteria that cannot be killed by an antibiotic are antibiotic resistant. This resistance is created by a mutation in their DNA.
- Bacteria that are resistant to many antibiotics are called superbugs. An example is MRSA.
- The spread of bacteria can be prevented by good personal hygiene and the use of disinfectants. Medical equipment should be sterilised before use, to remove all microorganisms.
- DNA (deoxyribonucleic acid) is made up of two strands twisted together to form a double helix. The strands are held together by bases. There are four bases: A, T, C, and G.
- Many scientists worked together to discover the structure and function of DNA.
- Charles Darwin and Alfred Wallace came up with the theory of evolution by natural selection.
- To prevent endangered species becoming extinct, scientists store seeds in seed banks, breed animals in captivity, and protect habitats through conservation.



Key Words

immunisation, vaccine, immune system, immune, pathogen, antibody, antibiotic, antibiotic resistant, superbug, mutation, peer review, endangered species, conservation, captive breeding, seed bank

Big Write

The scientists behind the science

Behind every scientific discovery is a scientist or a team of scientists who have worked together.

Task

Imagine you are working for a magazine. Write a feature article on at least two scientific discoveries from the following list:

- the first vaccine
- the development of the first antibiotic
- the discovery of the structure of DNA
- the development of the theory of evolution

Tips

- Your article should be written in a 'magazine' style. Think carefully about the language you will use, and the way you will present the article.
- Explain any scientific terms used. Your readers may not have much scientific understanding.

End-of-chapter questions

1 Match the scientist to their discovery.

Darwin	penicillin
Fleming	smallpox vaccine
Watson and Crick	theory of evolution by natural selection
Jenner	structure of DNA

(4 marks)

2

a Scientists are trying to prevent endangered species becoming extinct. Tick the cells in the table to show what type of organism the technique is used for. *(3 marks)*

Technique	Plants	Animals	Both
captive breeding			
seed bank			
conservation			

b Describe the difference between an endangered organism and an extinct organism. *(2 marks)*

(5 marks)

3 Re-arrange the following sentences to explain how an immunisation works.

Microorganisms are destroyed before you get ill.

White blood cells 'remember' the microorganism.

A vaccine is inserted into the body.

Antibodies destroy the microorganism.

White blood cells make antibodies against the dead or inactive microorganism.

If the live microorganism enters the body, antibodies are made very quickly.

(6 marks)

4 To work out the most effective antibiotic to prescribe to a patient, a sample containing microorganisms was sent for testing in a laboratory.

a Name the type of microorganism an antibiotic is used to kill. *(1 mark)*

b State **two** safety precautions that should be followed when working with microorganisms. *(2 marks)*

c Before the testing is started, name the process that should be used in the laboratory to ensure all equipment is free from microorganisms. *(1 mark)*

d These are the results achieved in the laboratory after using antibiotic discs and bacteria grown on an agar plate.

Antibiotic	Area free of bacteria (cm^2)
A	2
B	4
C	0

State and explain which antibiotic should be prescribed to the patient. *(3 marks)*

(7 marks)

5

a Explain how MRSA became a superbug. *(2 marks)*

b Explain how hospitals can help reduce the spread of MRSA. *(2 marks)*

c Explain how people can help stop antibiotic resistance. *(2 marks)*

(6 marks)

6 Discuss the importance of the discoveries of vaccines, antibiotics, DNA, and evolution.

(6 marks QWC)

3.1 Microscopy

Learning objectives

After this topic you will be able to:

- describe the main differences between a light microscope and an electron microscope
- describe how microscopic evidence is used by forensic scientists.

Have you ever seen police tape sealing off a crime scene? It is very important that people do not enter a crime scene until forensic scientists have collected any evidence to help them solve the crime.

What is forensic science?

Forensic science is the study of materials and situations that relate to a crime. Forensic scientists gather and study evidence so that it can be used in a court of law.

A Write down a definition of forensic science.

Key Words

forensic science, magnification, resolution

Link

You can learn more about using a light microscope in B1 1.1 Observing cells

What are microscopes used for?

Many types of evidence that forensic scientists collect are too small to see in detail with the naked eye. Some samples are looked at through light microscopes – this is the type of microscope you use at school.

Some samples are too small even for light microscopes. These are studied using a type of microscope called an electron microscope. These are very powerful microscopes that provide better magnification and resolution.

- **Magnification** is how many times bigger the image appears compared to the object.
- **Resolution** is how clearly the microscope can distinguish two separate points.

B Name two types of microscope that a forensic scientist might use.

▲ This scientist is looking into an electron microscope. It is much larger and more expensive than a light microscope.

Converting units

A typical cotton fibre is 10 micrometres wide. To understand what this means, you can use the following conversions:

1 cm = 10 mm

1 mm = 1000 micrometres

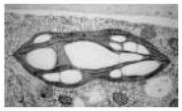
Convert the following units:

a 8 cm to millimetres

b 6 mm to micrometres

c 3500 micrometres to centimetres

The table below summarises the main differences between light microscopes and electron microscopes.

Microscope	Light	Electron
Radiation source	light	electrons
Typical magnification	up to 1000 ×	up to 1 000 000 ×
Resolution	0.2 μm (2×10^{-7} m)	50 pm (5×10^{-11} m)
Image	colour	black and white
Image of a chloroplast in moss cell		

Uses of microscopes

Microscopes are used to study a range of samples. These include hairs and fibres, paint flecks, pollen grains, and soil. Forensic scientists try to match samples found at a crime scene with those on a suspect's clothing or body.

C Name three types of sample that forensic scientists observe under a microscope.

Pollen

Pollen grains often attach to clothing. Pollen grains differ in size, shape, and surface texture. Pollen samples can provide evidence that a suspect was present at a crime scene.

Clothing fibres

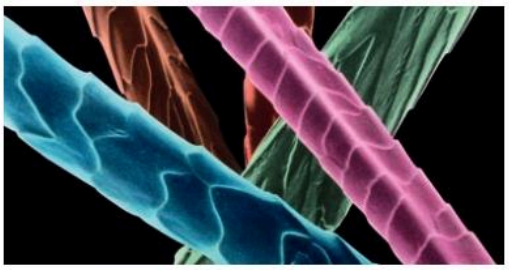
Fibres from clothing look very different under the microscope.

Fibres found at the scene of a crime can be matched to a suspect's clothing, showing that the suspect was present at a crime scene. Also, fibres taken from a suspect's clothing can be matched to a victim's clothes or hair, for example.

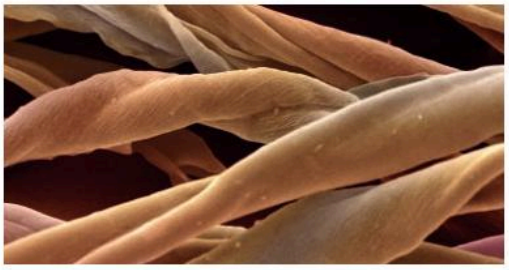
D State one difference in appearance between cotton and wool fibres.

Evidence from pollen and clothing fibres can place a suspect at the scene of a crime but this does not always mean that they were there when the crime was committed or that they committed the crime.

▲ Pollen grains can be useful evidence.



▲ Wool.



▲ Cotton.

Summary Questions

1 Copy and complete the sentences below.

_____ scientists study evidence so that it can be used in a court of _____. They use a _____ to study samples of fibres. They use two types of microscope – light microscopes and _____ microscopes.

(4 marks)

2 Describe three differences between a light microscope and an electron microscope.

(3 marks)

3 Explain how the use of microscopes can match a suspect to the scene of a crime.

(6 marks QWC)

3.2 Fingerprinting

Learning objectives

After this topic you will be able to:

- describe how fingerprints are formed
- describe how the police use fingerprints to solve crimes.

Fantastic Fact

There is a 1 in 64 billion chance that your fingerprint will match up exactly with someone else's.

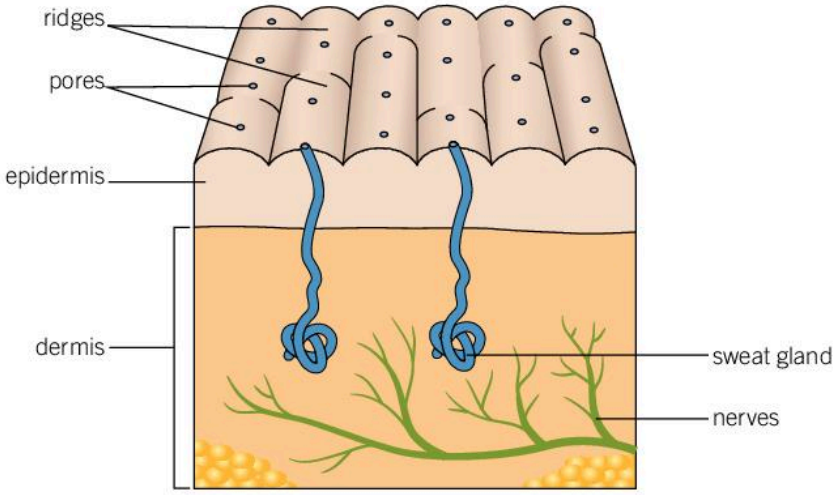
Key Words

fingerprint

Have you ever left sticky fingerprints on a table top or on a window? You could claim they were not yours but if you look closely enough you will see that each person's fingerprints are unique.

What is a fingerprint?

The surface of your fingers is covered in tiny ridges. These allow you to grip objects. They form when a baby stretches or bends their fingers in the uterus. The ridges form a pattern that is unique to each individual. **Fingerprints** are an impression of these ridges.



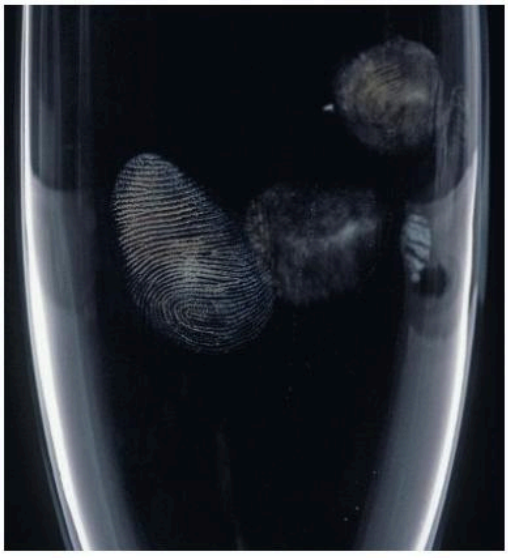
▲ A section of skin.

A State the purpose of ridges in the surface of your fingers.

How are fingerprints made?

Fingerprints can be left in materials such as soil and sand. This is a direct impression of the finger. It provides a mirror image of the ridges and troughs of the finger.

Each ridge contains pores, which are attached to sweat glands under the skin. This is where sweat is released. Oils are left behind after the sweat has evaporated, which forms an impression when you touch a surface. This makes the fingerprints you normally see on glass.



▲ The fingerprints on this glass are created by oils found on the surface of the fingers.

B Describe how a fingerprint can be left on a glass.

How can fingerprints help to solve crimes?

No two fingerprints are the same, not even identical twins' fingerprints. If a person's fingerprint matches one found at the scene of a crime, the person must have been at that location at some point.

Police officers take suspects' fingerprints by pressing each finger in turn on to an ink pad, and then rolling the finger on a piece of paper. The patterns in the fingerprints are then studied and compared to those found at the crime scene.

▲ Taking a fingerprint.

Finding fingerprints

The most common ways to recover a fingerprint at a crime scene are:

- powder dusting – powders are brushed over the surface of objects. These stick to oils in the fingerprints, making them show up.
- ultraviolet light – oils in the fingerprints glow when ultraviolet light is shone on them.

▲ Fingerprints being collected at the site of a break-in.

Matching fingerprints

Scientists look at the arrangement, shape, size, and number of lines in fingerprint patterns to distinguish one from another.

There are three main patterns that are used to identify fingerprints:

- arch – arches slope up and then down, like very narrow mountains
- whorl – whorls form a circular or spiral pattern
- loop – loops begin on one side of the finger, curve around or upward, and end on the other side.

◀ There are three types of pattern in a fingerprint.

C State the three types of pattern in a fingerprint.

Identifying your own fingerprint

Make your own fingerprint using an ink pad. Identify the patterns in your fingerprint. Does each of your fingers produce the same print?

Summary Questions

1 Copy and complete the sentences below.

Everybody's fingerprints are _____. They are an impression of the _____ present on the surface of your fingers. When _____ evaporates, oils are left behind. This leaves a _____ where a surface is touched.

(4 marks)

2 Describe two different methods that the police can use to collect fingerprints from a crime scene.

(3 marks)

3 Explain how scientists can use fingerprints to prove that a suspect was present at the scene of a crime.

(6 marks QWC)

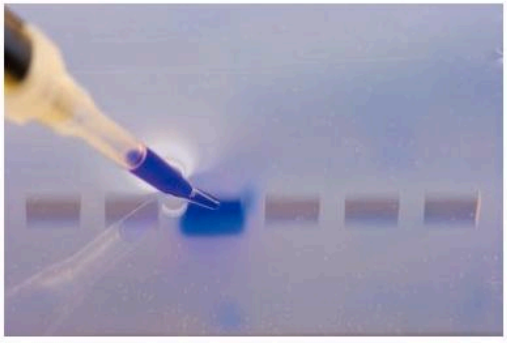
3.3 DNA fingerprinting

Learning objectives

After this topic you will be able to:

- state what is meant by DNA fingerprinting
- describe some uses of DNA fingerprinting.

▲ Mouth swabs are used to collect cells from the inside of your cheek.



▲ This DNA is being loaded into a well in the gel.

Presentation

Produce a short presentation for Year 7 students about what a DNA fingerprint is. Describe how this technique is used for solving crimes and in medicine.

Have you ever heard of a DNA fingerprint? Forensic scientists use evidence from DNA fingerprints to match a suspect to the scene of a crime.

What is a DNA fingerprint?

Everybody's DNA is different. The only exception is identical twins; they have the same DNA because they are formed when one fertilised egg splits into two embryos at an early stage of development.

DNA fingerprinting (or DNA profiling) is the analysis of DNA from body samples, to identify individuals. As your DNA is unique it is possible to work out if the DNA has come from you, or from someone else.

A State what is meant by DNA fingerprinting.

DNA is found in the nucleus of all body cells (except red blood cells, as they have no nucleus). Therefore, any cell can be used to collect a DNA sample. Most commonly the sample is taken from blood (white blood cells), hair, or cells from the inside of your cheek.

B Name two types of sample that can be used for DNA fingerprinting.

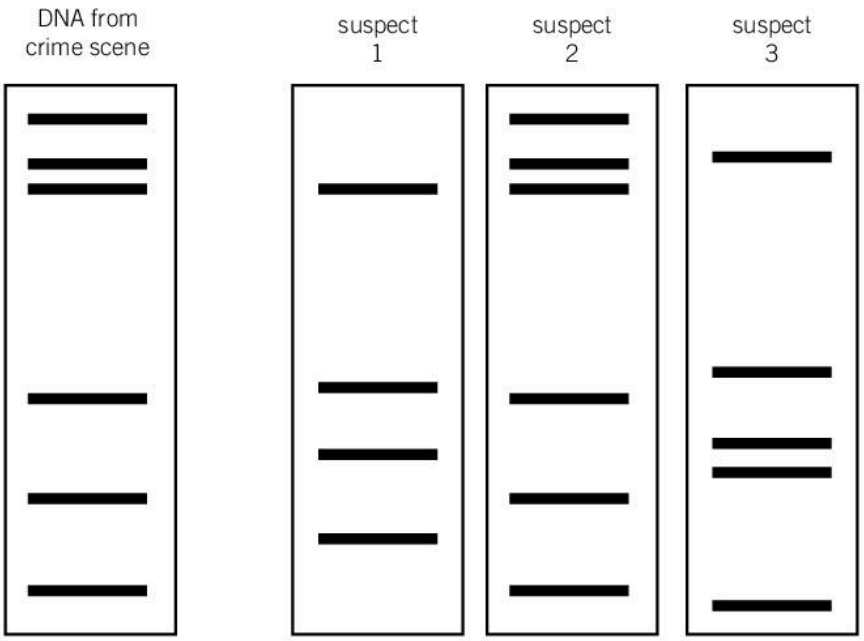
How do you make a DNA fingerprint?

1. DNA is extracted from cells.
2. Enzymes are used to cut the DNA into short fragments.
3. Samples of the DNA are inserted into a well (a small dent) in a gel.
4. An electric current is passed through the gel. This makes the fragments move.
5. The fragments move different distances, depending on their size.
6. The pattern produced is the person's DNA fingerprint. It looks a bit like a barcode.

Matching DNA fingerprints

To find out whether someone was at the scene of a crime their DNA fingerprint must be compared with samples collected from the crime scene.

The diagram below shows the DNA fingerprint collected at a crime scene. The DNA fingerprints of three suspects are also shown.



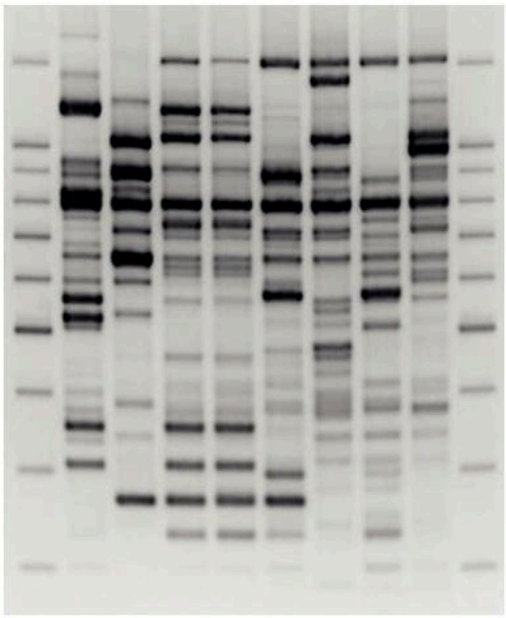
Can you identify who was at the scene of the crime?

Use your ruler to compare the position of the DNA fragments. You should see that the DNA found at the crime scene is an exact match with the DNA from suspect 2.

Other uses of DNA fingerprinting

DNA fingerprinting is widely used to solve crimes but there are other uses too.

- Maternity and paternity testing – by comparing fragments of DNA you can determine who a child's mother or father is. The child's DNA will be made of fragments of DNA that match the mother, and fragments that match the father.
- Genetic counselling – people wishing to have a child can find out if they are a carrier of a genetically inherited disease. This allows them to make an informed choice about whether or not to have a baby.
- Identification and treatment of genetic disorders – the treatment of some genetic disorders is more successful when they are identified earlier in life.



▲ DNA fingerprints of different people.

Key Words

DNA fingerprinting

Summary Questions

1 Copy and complete the sentences below.

DNA _____ is the analysis of _____ from body samples in order to identify individuals. The DNA is cut into _____ and compared with other samples. Except for _____ twins, each person's DNA is _____. This makes it is possible to work out who the DNA has come from.

(5 marks)

2 Describe how a DNA fingerprint is made.

(3 marks)

3 Explain in detail three uses of DNA fingerprinting.

(6 marks QWC)

3.4 Blood typing

Learning objectives

After this topic you will be able to:

- describe the structure and function of blood components
- describe what is meant by a blood group.

▲ Blood stains can provide useful evidence in solving crimes.

If a violent crime has been committed, blood stains are often left at the scene or on clothing. This forms useful evidence that can help with the identification of a suspect or victim.

What is blood analysis?

Blood analysis is used to help confirm the presence of a suspect at the scene of a crime. It can also be used to identify an unknown victim.

The blood sample is analysed to determine its **blood group**.

A State what is meant by blood analysis.

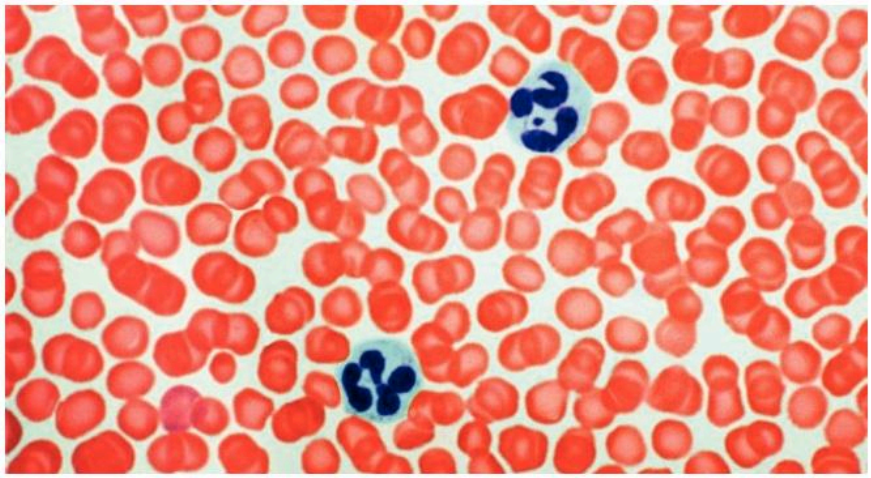
What is found in blood?

Blood is used to transport materials around your body, and to protect against disease. You have approximately five litres of blood in your body. The main components of blood are:

- red blood cells – to carry oxygen
- white blood cells – to fight disease
- **plasma** – to carry blood cells, digested food, waste (e.g., carbon dioxide), hormones, and antibodies
- **platelets** – fragments of cells that help the blood to clot.

B State the four main components of blood.

What do blood cells look like?



▲ Red blood cells are shown here in red and white blood cells are shown in blue.

Giving blood

When you give blood it is split into its main components. For example, red blood cells are used to 'top-up' blood after major surgery, childbirth, or accidents. Platelets are given to patients being treated for cancers with chemotherapy. Blood transfusions save thousands of lives each year. Write the script for a TV advert to try to persuade people to give blood.

Red blood cells:

- are small
- are a disclike shape and have no nucleus – this increases their surface area for carrying oxygen
- contain haemoglobin (red pigment), which binds to oxygen.

All white blood cells:

- are large
- have a nucleus.

Some white blood cells:

- change shape so they can destroy microorganisms
- produce antibodies.

Plasma:

- is a straw-coloured liquid
- is mainly composed of water (about 90%).

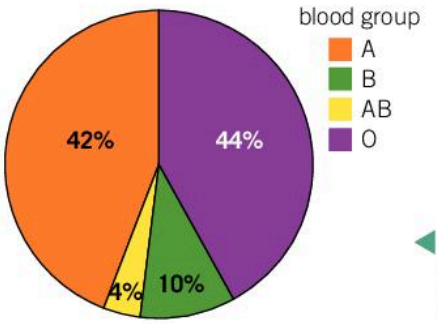
What is a blood group?

The type of blood you have is determined by your genes. There are four main blood groups: A, B, AB, and O.

C Name the four blood groups.

Blood types are determined by antigens (protein molecules) found on the surface of red blood cells:

- Blood group A contains A antigens.
- Blood group B contains B antigens.
- Blood group AB contains both A and B antigens.
- Blood group O contains no antigens.



This pie chart shows the approximate proportion of people in the UK with each blood group.

It is important to know your blood group if you need a transfusion. Receiving the wrong group could be life threatening because your immune system will identify the antigens as foreign to your system, and produce antibodies to destroy them.

Foul Fact

In 2012, intact samples of red blood cells were identified in the body of Otzi the Iceman, a frozen body discovered in the Italian alps. Otzi died around 3300 BC.

Key Words

blood group, plasma, platelets

Blood transfusions save many lives every day.

Summary Questions

1 Match the component of blood to its function.

red blood cells	fight disease
white blood cells	clot the blood
plasma	transport oxygen
platelets	transports blood cells

(4 marks)

2 Explain why it is important for a patient's blood type to be analysed before they receive a blood transfusion.

(3 marks)

3 Compare the structure and function of red blood cells and white blood cells.

(6 marks QWC)

3.5 Time of death

Learning objectives

After this topic you will be able to:

- describe how time of death can be determined
- describe some of the difficulties in determining time of death.

▲ Scientists use a number of factors to determine the time of death of an animal.

You may have seen flies buzzing around an animal that has been killed on the road. The number and type of insects found can provide evidence of when the animal died.

Finding out the time of death

Scientists use a number of factors to determine the time of death of an animal. These include:

- temperature of the body
- appearance of the body
- insects found on the body.

A State three factors that scientists use to determine the time of death of an animal.

Body temperature

An animal's core body temperature drops by around 1.5 °C per hour from the time of death. This continues until the temperature of the animal matches the temperature of its environment. After this point, scientists have to rely on other factors.

Body appearance

A few hours after death, the body gradually becomes rigid. This process is called **rigor mortis**. The muscles in the body stiffen from a lack of blood and oxygen.

Approximately 20–30 hours later, the rigor mortis disappears. The degree of rigor mortis can be used to estimate the time of death, up to around 48 hours after the animal has died.

B State what is meant by rigor mortis.

From 48 hours after death, the colour of the body can be used to find the time of death. At this point, bacteria begin to breed on the skin, giving the skin a greenish tone.

Approximately 4–7 days after death, skin takes on a marblelike appearance. This occurs as the veins in the body become closer to the surface, making them easier to see. The abdomen starts to inflate because of the gases produced as the body decays.

Foul Fact

The Body Farm in Tennessee, US is a research centre that studies how human bodies decay. Bodies are kept in a variety of ways to study the decay process. They have found out that flies and maggots can reduce a body to a skeleton in under two weeks in warm weather.

Insects on a body

The types of insect living on a body, and the stage in their lifecycle, can also be used to determine how long an animal has been dead.

The table below shows the types of insect that are found on a body after death.

Approximate time after death	Example of insects found	
0–3 days	blowflies	
4–7 days	fly larvae (maggots)	
1–2 weeks	cockroaches	
2–4 weeks	mites	

C State the type of insect found on a body after 10 days.

To estimate the time of death accurately, forensic scientists combine information gathered on body temperature, body appearance, and the presence of insects.

Insect identification key

Using the images from this page, produce a key that a forensic scientist could use to help estimate the time of an animal's death.

Key Words

rigor mortis

Summary Questions

1 Copy and complete the sentences below.

To estimate the time of an animal's death, scientists gather information on the _____ of the body, the appearance of the body, and the presence of any _____. A few hours after death the body becomes stiff; this is called _____ _____.

(3 marks)

2 Describe the condition a body is likely to be in after five days.

(3 marks)

3 Describe how hot and humid conditions can lead to an inaccurate time of death.

(3 marks)

4 Explain in detail the techniques that scientists use to determine the time of death of an animal.

(6 marks QWC)

3.6 Pathology

Learning objectives

After this topic you will be able to:

- describe the role of a pathologist
- describe how dental records can be used to help solve crimes.

▲ Pathologists carry out a post-mortem to determine how a person died.

Key Words

pathologist

Have you heard of a post-mortem? This is an examination of a body carried out by a pathologist (a specialist doctor) to determine the cause of death.

What is a pathologist?

A **pathologist** is a doctor who specialises in understanding the nature and cause of disease. As part of their job, pathologists carry out post-mortem examinations to determine the cause of death.

Forensic pathologists take part in criminal investigations. For example, the police would ask a forensic pathologist to determine whether a suspicious death was an accident or not.

A State what is meant by pathologist.

Pathologists also carry out tests on body samples of living people to determine the cause of disease and illness. For example, they check body tissues for the presence of cancerous cells. Routine tests also performed by pathologists include:

- blood – for example, to check blood–iron levels in detecting anaemia
- urine – for example, to test for sugar in detecting diabetes
- feces – for example, to test for the presence of bacteria in detecting food poisoning.

B State three body samples that pathologists test to identify disease and illness.

▲ Samples taken from fecal matter have been grown on agar plates to identify the bacteria present.

Protecting yourself

Working with body samples can be potentially dangerous. Make a list of the safety precautions a pathologist should take so that they do not become contaminated.

Identification

If a body cannot be identified by its appearance, dental records are examined. This is a particularly useful technique for a body that has been discovered many years after death. Tooth enamel (the outer layer of teeth) is harder than any other substance in the human body. This means that teeth remain intact long after all other body parts have decayed.

To identify a person from his or her teeth, the teeth are compared to their dental record. Even if only a few teeth are available, a positive identification can normally still be made. The best comparisons come from X-rays the person may have had as part of their dental treatment. If these are not available, dental notes can be used to check if the teeth are the same. For example, a person's dental history may note the presence of fillings or chipped teeth.

C State how a person can be identified by their teeth.

▲ This person has missing teeth, making dental identification straightforward.

Foul Fact

Victims of fires are often identified using their dental records. Teeth can withstand temperatures of more than 1000 °C.

Identifying bite marks

A person's dental records, and impressions of their teeth, can also be used to help solve crimes. Bite marks can be found at the scene of a violent crime. By comparing the features of a bite mark with dental records, it is possible to identify a suspect. This is known as bite-mark analysis.

If a bite mark includes a gap, the biter is probably missing a tooth. Crooked teeth leave crooked impressions, and chipped teeth leave jagged-looking impressions. The depth of a bite mark can also be used to determine how hard a person was bitten.

▲ Analysis of a bite mark can be used to solve crimes.

Summary Questions

1 Copy and complete the sentences below.

_____ are doctors who specialise in understanding the nature and cause of disease. They test a range of body _____ such as blood and urine. They also carry out _____ to identify the cause of death.

(3 marks)

2 Describe how dental records can be used to solve crimes.

(3 marks)

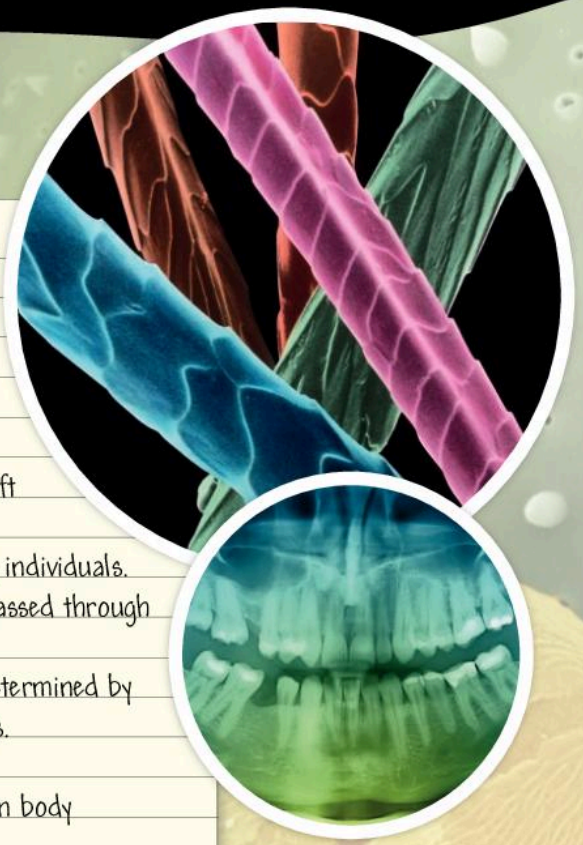
3 Explain in detail the role of a pathologist.

(6 marks QWC)

B3 Chapter 3 Summary

Key Points

- Forensic scientists gather and study evidence that can later be used in a court of law.
- Light microscopes and electron microscopes are used to examine objects that are too small to see in detail with the naked eye.
- Electron microscopes provide better magnification and resolution than light microscopes.
- A person's fingerprints are unique. They are an impression of the ridges present on the surface of your fingers. When sweat evaporates, oils are left behind, leaving a fingerprint where a surface was touched.
- DNA fingerprinting is the analysis of DNA from body samples to identify individuals. The DNA is cut into fragments and placed on a gel. When a current is passed through the gel the fragments move, creating a unique pattern.
- The four main blood groups are A, B, AB, and O. Your blood group is determined by antigens (protein molecules) found on the surface of your red blood cells.
- Blood contains plasma, platelets, red blood cells, and white blood cells.
- To estimate the time of an animal's death, scientists gather information on body temperature, body appearance, and the presence of any insects.
- Pathologists are doctors who specialise in understanding the nature and cause of disease. They test a range of body samples such as blood and urine. They also carry out post-mortems to identify the cause of death.
- Dental records can be used to identify bodies that are otherwise hard to identify.



Key Words

forensic science, magnification, resolution, fingerprint, DNA fingerprinting, blood group, platelets, plasma, rigor mortis, pathologist

Case study

To catch a thief

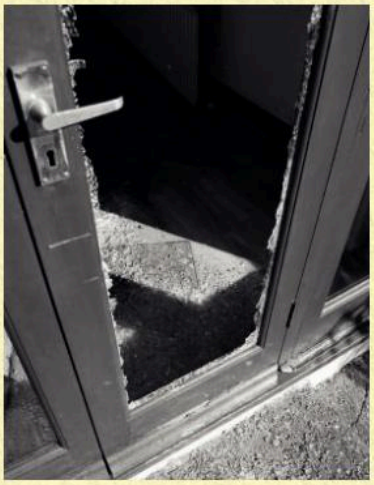
There has been a break-in. The thief cut himself when breaking the window.

Task

Identify different possible sources of evidence in the crime scene. Produce a factsheet to explain how each source can be used in solving the crime.

Tips

- Include an annotated image of the crime scene, showing where forensic scientists should gather samples.
- Explain how each sample should be analysed.
- Explain how the results can be used to solve the crime.



End-of-chapter questions

1 Complete the sentences below about blood.

_____ blood cells carry oxygen around the body.

_____ blood cells fight disease.

_____ are used to clot the blood.

A, AB, B, and O are the four main blood _____.

(4 marks)

2 Forensic scientists often use microscopes to look at evidence they have collected.

a State the purpose of a microscope. *(1 mark)*

b Name the two types of microscope a forensic scientist might use. *(2 marks)*

c Name **two** pieces of evidence a forensic scientist might look at using a microscope. *(2 marks)*

(5 marks)

3 Fingerprints are often left at the scene of a crime.

a Describe how forensic scientists identify fingerprints at a crime scene. *(2 marks)*

b Suggest **one** advantage of using fingerprints, rather than DNA fingerprints, to help solve crimes. *(1 mark)*

c Explain how police take fingerprints from suspects. *(3 marks)*

(6 marks)

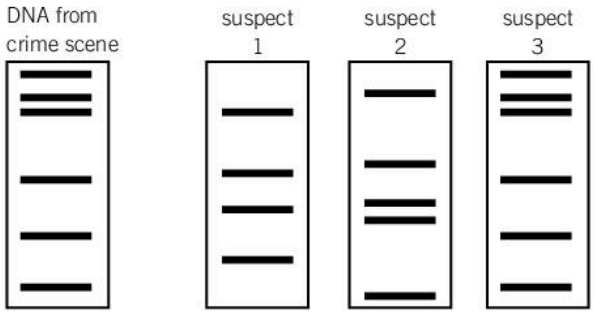
4 Forensic scientists collected the following pieces of evidence from a crime scene.

- a fingerprint on a window pane
- a sample of blood from a bloodstain
- a strand of hair

Explain how each of these pieces of evidence can be used to link a suspect to a crime.

(4 marks)

5 Below is a DNA fingerprint. There are three suspects.



a Suggest the source of DNA that may have been found at the crime scene. *(1 mark)*

b State and explain which suspect's DNA matches the DNA found at the crime scene. *(2 marks)*

c Describe how enzymes are used in the production of a DNA fingerprint. *(1 mark)*

d Explain the role of electricity in the production of a DNA fingerprint. *(2 marks)*

6 Explain how the processes of microscopy, fingerprinting, DNA fingerprinting, blood typing, and time-of-death estimates can be used to solve a violent crime.

(6 marks QWC)

Glossary

accurate Close to the true value of what you are measuring.

adaptation Characteristic that helps an organism to survive in its environment.

addiction A need to keep taking a drug in order to feel normal.

adolescence The period of time when a child changes into an adult.

aerobic respiration Chemical reaction where glucose reacts with oxygen to release energy, carbon dioxide, and water.

alcoholic A person who is addicted to alcohol.

algae Green unicellular or multicellular organisms that perform photosynthesis and live underwater.

allele Different forms of a gene.

alveolus (air sac) A structure inside the lungs where gas exchange takes place with the blood.

amoeba A unicellular organism.

analyse The process of looking at data and writing about what you have found out.

anaerobic respiration Chemical reaction that takes place without oxygen. Glucose is converted into lactic acid and energy is released.

antagonistic muscles A pair of muscles that work together to control movement at a joint – as one muscle contracts, the other relaxes.

antibiotic A medicinal drug that kills bacteria.

antibiotic resistant Bacteria that cannot be killed by an antibiotic.

antibody Chemicals produced by the body that destroy pathogens.

anther The part of a flower that produces pollen.

anus Muscular ring through which feces pass out of the body.

asexual reproduction Reproduction using only one parent.

balanced diet Eating food containing the right nutrients in the correct amounts.

bar chart A way of presenting data when one variable is discrete or categoric and the other is continuous.

bile Substance that breaks fat into small droplets.

bioaccumulation The build up of toxic chemicals inside organisms in a food chain.

biodiversity The range of organisms living in an area.

biotechnology The use of biological processes or organisms to create useful products.

blood group Category of blood, determined by antigens found on the surface of red blood cells.

bone A tissue that forms a hard structure, used to protect organs and for movement.

cancer A disease caused by mutations in cells.

captive breeding Breeding animals in human-controlled environments.

carbohydrase Enzyme that breaks down carbohydrates into sugar molecules.

carbohydrate Nutrient that provides energy.

carpel The female reproductive part of the flower.

carrier A person who has one copy of a dominant allele, and one copy of a recessive allele. A carrier only has the characterisitcs of the dominant allele.

cartilage The strong, smooth tissue that covers the end of bones to prevent them rubbing together.

catalyst Substance that speeds up a reaction without being used up.

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.

chemosynthesis Reaction performed by bacteria, using energy transferred from chemical reactions to produce glucose.

chlorophyll Green pigment that absorbs light for use in photosynthesis.

chloroplast The plant cell component where photosynthesis takes place.

chromosome Long strand of DNA, which contains many genes.

cilia Tiny hairs on the surface of cells.

clone An organism that is genetically identical to its parent.

co-exist Plants and animals living in the same habitat at the same time.

community The collection of the different types of organism present in an ecosystem.

competition Competing with other organisms for resources.

conclusion What you write down to say what you have found out during an investigation.

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 Protecting a natural environment, to ensure that habitats are not lost.

consumer Organisms that eat other organisms as food.

continuous A variable that has values that can be any number.

continuous variation Characteristic that can take any value within a range of values.

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.

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.

deficiency A lack of minerals, that causes poor growth.

denatured The shape of an enzyme is changed if the temperature of a reaction is too high.

dependent variable A variable that changes when you change the independent variable.

depressant A drug that slows down the body's reactions by slowing down the nervous system.

diaphragm (breathing) The sheet of muscle used in breathing.

digestion Process where large molecules are broken down into small molecules.

digestive system Group of organs that work together to break down food.

discontinuous variation Characteristic that can only be a certain value.

discrete A variable that can only have whole-number values.

DNA Chemical that contains all the information needed to make an organism.

DNA fingerprinting The analysis of DNA from body samples. The DNA fingerprint produced is unique to an individual.

dominant A dominant allele will always be expressed if it is present.

drug Chemical substance that affects the way your body works.

ecosystem The name given to the interaction between plants, animals, and their habitat in a particular location.

ejaculation When semen is released from the penis.

embryo A ball of cells that forms when the fertilised egg divides.

endangered Species of plants and animals that have only a small population in the world.

endangered species A species with only small numbers of organisms left in the world.

enzyme Special protein that can break large molecules into small molecules.

euglena Unicellular organism that performs photosynthesis.

evaluate To discuss the quality of data collected during an investigation and suggest improvements to the method.

evidence Observations and measurements that support or disprove a scientific theory.

evolution Development of a species over time.

exhale Breathing out, to remove carbon dioxide.

extinct When no more individuals of a species are left anywhere in the world.

fermentation A type of anaerobic respiration where glucose is converted into ethanol, carbon dioxide, and energy.

fertilisation The process where the nucleus of a sperm cell joins with the nucleus of an egg cell.

feces Undigested food that leaves the body as waste.

fetus The name given to an unborn baby from eight weeks of development.

fibre Provides bulk to food to keep it moving through the digestive system.

filament The part of a flower that holds up the anther.

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.

food chain A diagram that shows the transfer of energy between organisms.

food test Chemical test to detect the presence of particular nutrients in a food.

food web A diagram showing a set of linked food chains.

forensic science Study of evidence and objects that relate to a crime.

fruit The part of a plant that contains seeds.

gametes Reproductive cells. The male gamete is a sperm cell and the female gamete is an egg cell.

gas exchange The transfer of gases between an organism and its environment.

gene Section of DNA that contains the information for a characteristic.

gene bank A store of genetic samples, used for research and to try to prevent extinction.

genetically inherited disorder A condition passed from parents to their offspring in their genes.

genetic engineering A technique where scientists insert foreign genes into organisms to change their characteristics.

germination The period of time when a seed starts to grow.

gullet Tube that food travels down into the stomach.

habitat The area in which an organism lives.

haemoglobin The substance in blood that carries oxygen around the body.

hazard A possible source of danger.

hormones Chemical messengers that travel around the body in the blood.

hypothesis An idea that is a way of explaining scientists' observations.

immune Resistant to a disease.

immune system The body system responsible for fighting disease.
immunisation A method of inserting a vaccine into the body.
implantation The process where an embryo attaches to the lining of the uterus.
independent variable A variable you change that changes the dependent variable.
inhale Breathing in, to take in oxygen.
interdependence The way in which living organisms depend on each other to survive, grow, and reproduce.
investigation An experiment or set of experiments designed to produce data to answer a scientific question or test a theory.

joint A part of the skeleton where two bones join together.

large intestine Organ where water passes back into the body, leaving a solid waste of undigested food called feces.
leaf cell The plant cells that contain chloroplasts, where photosynthesis takes place.
ligament Joins two bones together.
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.
lipase Enzyme that breaks down lipids into fatty acids and glycerol.
lipids Nutrients that provide a store of energy and insulate the body.
lungs The organ in which gas exchange takes place.
magnesium A mineral needed by plants for making chlorophyll.
malnourishment Eating the wrong amount or the wrong types of food.
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.
medicinal drug Drug that has a medical benefit to your health.
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.
microscope An optical instrument used to magnify objects, so small details can be seen clearly.
mineral Essential nutrient needed in small amounts to keep you healthy.
mitochondria The cell component where respiration takes place.
multicellular Made of many cells.
multicellular organism An organism made up of many cells.
mutation Change to cells that can cause disease.

natural selection Process by which the organisms with the characteristics that are most suited to the environment survive and reproduce, passing on their genes.
nerve cell An animal cell that transmits electrical impulses around the body.
niche A particular place or role that an organism has in an ecosystem.
nitrates Minerals containing nitrogen for healthy growth.
nucleus The cell component that controls the cell and contains genetic material.
nutrient Essential substance that your body needs to survive, provided by food.

obese Extremely overweight.
observation Carefully looking at an object or process.
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.

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.

oxygen debt Extra oxygen required after anaerobic respiration to break down lactic acid.

passive smoking Breathing in other people's smoke.

pasteurised Heating a food or drink product to a high temperature to kill any microorganisms present.

pathogen A microorganism that causes a disease.

pathologist A doctor who specialises in understanding the nature and cause of disease.

peer review The evaluation of a scientist's work by another scientist.

penis The structure that carries sperm and semen out of the body.

period Loss of uterus lining through the vagina.

petal The brightly coloured part of a flower that attracts insects.

phosphate Mineral containing phosporus for healthy roots.

photosynthesis The process plants use to make their own food, glucose. In photosynthesis, carbon dioxide and water react together to make glucose and oxygen.

pie chart A way of presenting data when one variable is discrete or categoric and the other is continuous.

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.

plasma Liquid that transports blood cells and other materials around the body.

platelet Fragment of cells that helps the blood to clot.

plan A description of how you will use equipment to collect valid data to answer a scientific question.

pollen The male gamete of a plant.

pollination The transfer of pollen from the anther to the stigma.

population The number of plants or animals of the same type that live in the same area.

potassium A mineral needed by plants for healthy leaves and flowers.

precise This describes a set of repeat measurements that are close together.

predator An animal that eats other animals.

prediction A statement that says what you think will happen.

pregnant When a baby is growing inside a woman she is pregnant.

prey An animal that is eaten by another animal.

producer Organism that make its own food using photosynthesis.

protease Enzyme that breaks down proteins into amino acids.

protein Nutrient used for growth and repair.

puberty The physical changes that take place during adolescence.

Punnett square A diagram used to show the possible combinations of alleles inherited from the parents.

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.

recessive A recessive allele will only be expressed if two copies are present.

recreational drug Drug that is taken for enjoyment.

rectum Feces are stored here, before being passed out of the body.

red blood cell An animal cell that transports oxygen around the body.

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.

respiration A chemical reaction where food and oxygen are converted into energy, water, and carbon dioxide.

respiratory system The organs involved in gas exchange.

ribcage The bones that protect the lungs.

rigor mortis The stiffening of the body a few hours after death.

risk The probability of something happening that could cause damage or injury.

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.

safety Making sure that something is safe and that hazards and risks are minimal.

scientific journal A collection of articles written by scientists about their research.

scrotum The bag of skin that holds the testes.

seed The structure that develops into a new plant.

seed bank A store of genetic material from which new plants can be grown in the future.

seed dispersal The movement of seeds away from the parent plant.

selective breeding Breeding organisms to produce offspring with the desired characteristics.

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.

small intestine Organ where small digested molecules are absorbed into the bloodstream.

specialised cell A cell whose shape and structure enable it to perform a particular function.

species Organisms that have lots of characteristics in common, and can mate to produce fertile offspring.

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.

starvation Extreme case of not eating enough food.

sterilise To kill the bacteria or other microorganisms on an object.

stigma The part of a flower that is sticky to catch grains of pollen.

stimulant A drug that speeds up the body's reactions by speeding up the nervous system.

stomach Organ where food is churned with digestive juices and acids.

stomata Holes found on the bottom of the leaf that allow gases to diffuse in and out of the leaf.

style The part of a flower that holds up the stigma.

superbug Bacteria that are resistant to most types of antibiotic.

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.

testes The testes produce sperm and the male sex hormones.

tissue A group of similar cells working together to perform a function.

umbilical cord Connects the fetus to the placenta.

uncertainty The amount by which you cannot be sure of the value of your measurement because of your measuring instruments or methods.

unicellular Consisting of just one cell.

unit of alcohol 10 ml of pure alcohol.

urethra Tube that carries urine or sperm out of the body.

uterus Where a baby develops until its birth.

vaccine A substance containing dead or inactive microorganisms used to immunise against disease. variation Differences in characteristics within
a species.

vacuole The plant cell component that contains cell sap and helps to keep the cell firm.

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.

variation Differences in characteristics within a species.

villi Tiny projections in the small intestine wall that increase the area for absorption.

vitamin Essential nutrients needed in small amounts to keep you healthy.

windpipe (trachea) The structure through which air travels from the mouth to the lungs.

withdrawal symptom Unpleasant symptom a person with a drug addiction suffers from when they stop taking the drug.

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