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PEARSON EDEXCEL 9-1 GCSE

COMBINED SCIENCE

REVISION GUIDE

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Bitesize Pearson Edexcel GCSE (9-1) COMBINED SCIENCE

REVISION GUIDE

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- Make every minute count with timed, bite-sized chunks of revision.
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Contents

Tick off each topic as you go.

How to use this book

Use the features in this book to focus your revision, track your progress through the topics and practise your exam skills.

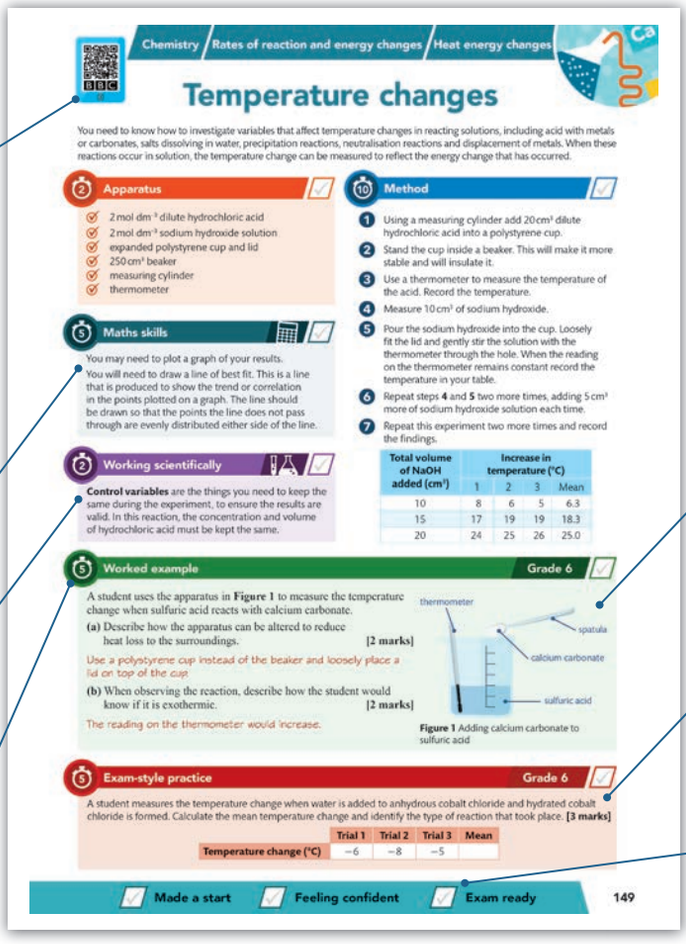
Features to help you revise

Scan the **QR codes** to visit the BBC Bitesize website. It will link straight through to more revision resources on that subject.

Questions that test **maths skills** are explained in callouts and in the *Exam skills* section at the back of the book.

Topics that are related to **working scientifically** are explained in callouts throughout the book.

Each bite-sized chunk has a **timer** to indicate how long it will take. Use them to plan your revision sessions.



Chemistry / Rates of reaction and energy changes / Heat energy changes

Temperature changes

You need to know how to investigate variables that affect temperature changes in reacting solutions, including acid with metals or carbonates, salts dissolving in water, precipitation reactions, neutralisation reactions and displacement of metals. When these reactions occur in solution, the temperature change can be measured to reflect the energy change that has occurred.

Apparatus

- 2 mol dm^{-3} dilute hydrochloric acid
- 2 mol dm^{-3} sodium hydroxide solution
- expanded polystyrene cup and lid
- 250 cm^3 beaker
- measuring cylinder
- thermometer

Method

1. Using a measuring cylinder add 20 cm^3 dilute hydrochloric acid into a polystyrene cup.
2. Stand the cup inside a beaker. This will make it more stable and will insulate it.
3. Use a thermometer to measure the temperature of the acid. Record the temperature.
4. Measure 10 cm^3 of sodium hydroxide.
5. Pour the sodium hydroxide into the cup. Loosely fit the lid and gently stir the solution with the thermometer through the hole. When the reading on the thermometer remains constant record the temperature in your table.
6. Repeat steps **4** and **5** two more times, adding 5 cm^3 more of sodium hydroxide solution each time.
7. Repeat this experiment two more times and record the findings.

Maths skills

You may need to plot a graph of your results. You will need to draw a line of best fit. This is a line that is produced to show the trend or correlation in the points plotted on a graph. The line should be drawn so that the points the line does not pass through are evenly distributed either side of the line.

Working scientifically

Control variables are the things you need to keep the same during the experiment, to ensure the results are valid. In this reaction, the concentration and volume of hydrochloric acid must be kept the same.

Total volume of NaOH added (cm^3)	Increase in temperature (°C)			
	1	2	3	Mean
10	8	6	5	6.3
15	17	19	19	18.3
20	24	25	26	25.0

Worked example Grade 6

A student uses the apparatus in **Figure 1** to measure the temperature change when sulfuric acid reacts with calcium carbonate.

(a) Describe how the apparatus can be altered to reduce heat loss to the surroundings. **[2 marks]**

Use a polystyrene cup instead of the beaker and loosely place a lid on top of the cup.

(b) When observing the reaction, describe how the student would know if it is exothermic. **[2 marks]**

The reading on the thermometer would increase.

thermometer, spatula, calcium carbonate, sulfuric acid

Figure 1 Adding calcium carbonate to sulfuric acid

Exam-style practice Grade 6

A student measures the temperature change when water is added to anhydrous cobalt chloride and hydrated cobalt chloride is formed. Calculate the mean temperature change and identify the type of reaction that took place. **[3 marks]**

	Trial 1	Trial 2	Trial 3	Mean
Temperature change (°C)	−6	−8	−5	

Made a start / Feeling confident / Exam ready

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Completed **worked examples** demonstrate how to approach exam-style questions.

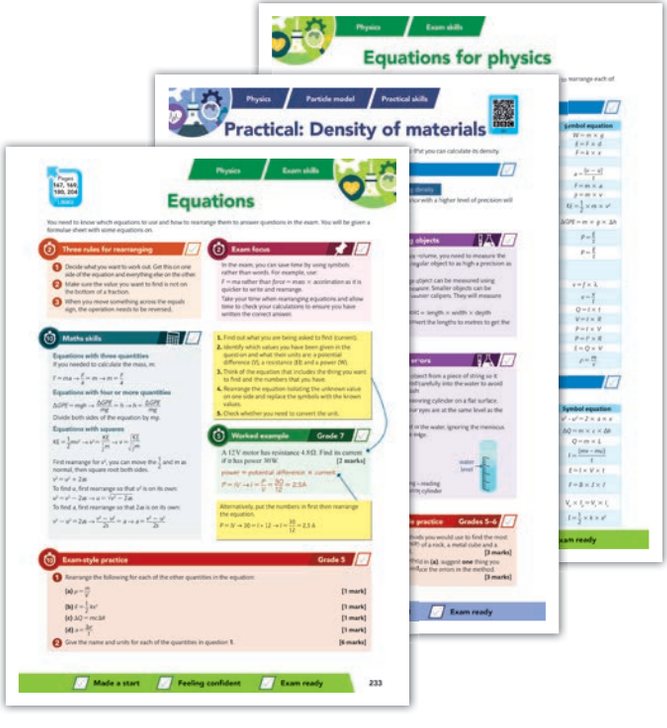
Test yourself with **exam-style practice** at the end of each page and check your answers at the back of the book.

Tick boxes allow you to track the sections you've revised. Revisit each page to embed your knowledge.

Exam focus features

The *About your exam* section at the start of the book gives you all the key information about your exams, as well as showing you how to identify the different questions.

You will also find green *Exam skills* pages and purple *Practical* pages. These work through an extended exam-style question and provide further opportunities to practise your skills.



Physics / Exam skills

Equations for physics

Physics / Particle model / Practical skills

Practical: Density of materials

Physics / Exam skills

Equations

Made a start / Feeling confident / Exam ready

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ActiveBook and app

This Revision Guide comes with a **free online edition**. Follow the instructions from inside the front cover to access your ActiveBook.

You can also download the **free BBC Bitesize app** to access revision flashcards and quizzes.

If you do not have a QR code scanner, you can access all the links in this book from your ActiveBook or visit **www.pearsonschools.co.uk/BBCBitesizeLinks**.

Your Science GCSE

This page will tell you everything you need to know about the structure of your upcoming Pearson Edexcel GCSE (9–1) in Combined Science (Higher Tier) exams.

5 About the exam papers

You will have to take **six** papers as part of your Pearson Edexcel GCSE (9–1) in Combined Science (Higher Tier) qualification: **two biology, two chemistry** and **two physics**. The papers will test your knowledge and understanding of different topic areas and your ability to work scientifically.

Paper 1	Paper 2	Paper 3	Paper 4	Paper 5	Paper 6
Biology 1	**Biology 2**	**Chemistry 1**	**Chemistry 2**	**Physics 1**	**Physics 2**
1 hour 10 minutes	1 hour 10 minutes	1 hour 10 minutes	1 hour 10 minutes	1 hour 10 minutes	1 hour 10 minutes
60 marks in total	60 marks in total	60 marks in total	60 marks in total	60 marks in total	60 marks in total



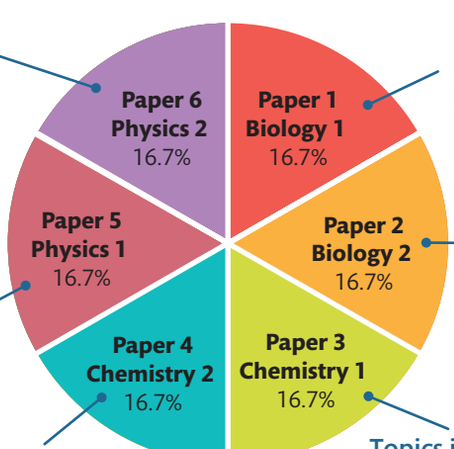



5 Exam topics

Topics include: key concepts of physics; energy – forces doing work; forces and their effects; electricity and circuits; magnetism and the motor effect; electromagnetic induction; particle model; forces and matter

Topics include: key concepts of physics; motion and forces; conservation of energy; waves; light and the electromagnetic spectrum; radioactivity

Topics include: key concepts in chemistry; groups in the periodic table; rates of reaction and energy changes; fuels and Earth science



Topics include: key concepts in biology; cells and control; genetics; natural selection and genetic modification; health, disease and the development of medicines

Topics include: key concepts in biology; plant structures and their functions; animal coordination, control and homeostasis; exchange and transport in animals; ecosystems and material cycles

Topics include: key concepts in chemistry; states of matter and mixtures; chemical changes; extracting metals and equilibria

2 Maths skills

You will be required to demonstrate the following mathematical skills in your GCSE Science exams:

- rearranging equations
- interpreting data from graphs and tables, including finding a gradient
- converting units
- using standard form
- using ratios, fractions and percentages
- calculating mean, mode and median
- using geometry (volumes, areas, angles, working out sides of triangles).

2 Working scientifically

There are 21 required practical activities you will carry out during your GCSE Science course.

Practical activities are an opportunity for you to apply your knowledge and understanding, while developing relevant practical skills and techniques.

You need to know how to:

- plan and carry out an investigation
- use apparatus correctly and safely
- take accurate measurements and record data appropriately
- analyse your findings
- evaluate your investigation.

Multiple-choice questions

Multiple-choice questions give you several options to choose from. You must indicate the correct answer by marking your choice clearly.

Types of multiple-choice question

- tick box
- linking boxes
- sentence completion

Exam focus

Bold words usually give important instructions. Read them carefully.

e.g. Give **one** way in which a second allele for eye colour might be different.

Exam explainer

Clearly mark the answer you think is correct with a tick in the box. If you change your mind, draw a line through the incorrect answer and tick the correct answer.

A cricket ball is hit by a bat. The bat and ball exert a force on each other. Which of the following statements about the two forces is true? **[1 mark]**

- ☐ **A** The force on the bat and the force on the ball are in the same direction
- ☐ **B** The bat has a larger mass so it exerts a larger force on the ball
- ☑ **C** The two forces are equal
- ☐ **D** The two forces give the bat and ball equal accelerations

If you are unsure of the answer, use what you know to rule out the incorrect options.

Use a pencil to draw lines, so you can change your answer easily, if necessary.

Draw **one** line from each diagram to the name of the cell. **[3 marks]**

Diagram	Name of cell
	red blood cell
	sperm cell
	root hair cell

Read the question carefully. Here, you are instructed to only use words from the box provided. You would not be awarded marks for using similar words.

The pH scale is a measure of the acidity or alkalinity of a solution.

Use words from the box to complete the sentences. **[3 marks]**

neutral	acidic	alkaline

A solution with a pH value of 5 is _____.

A solution with a pH value of 7 is _____.

A solution with a pH value of 13 is _____.

Short-answer questions

Short-answer questions come in a variety of forms and are the most common type of questions.

5 Exam explainer

Underline key information, such as numbers and units. Make sure you include the correct units in your answer.

A power station has an efficiency of 0.45. Its energy comes from burning coal, which it uses at a rate of 300 MW.

(a) Calculate the useful output of electrical power. **[2 marks]**

(b) Describe the advantages and disadvantages of this type of power station compared to a wind turbine. **[3 marks]**

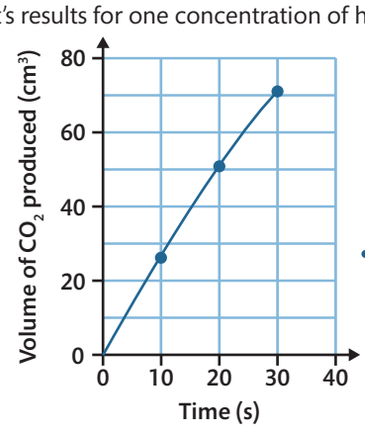
It is important to show your working when answering a calculation question. If done correctly, you will get method marks even if the final answer is wrong.

For a sketch question, you only need to draw approximately. You should only use a ruler if it helps you to make your answer clear.

Sketch a reaction profile for an endothermic reaction. **[3 marks]**

A student investigated the rate of reaction between calcium carbonate and hydrochloric acid.

Figure 1 The student's results for one concentration of hydrochloric acid.



You will need to be able to interpret information from a graph, photo, table or image in any of your exam papers.

The table shows the student's results when the concentration was two times greater than the results shown in **Figure 1**.

Time (s)	Volume of CO_2 (cm^3)
0	0
10	41
20	62
30	71

(a) Plot the results shown in the table on the grid in **Figure 1**. Draw a line of best fit. **[3 marks]**

(b) Give **one** conclusion about how the rate of reaction changed when the concentration of hydrochloric acid was changed. **[1 mark]**

Extended-response questions

Some questions require a longer written response or a multi-step calculation. They are typically worth 4, 5 or 6 marks. You will need to give a coherent and sustained line of reasoning in your answer.

Command words

- explain – set out purposes or reasons
- evaluate – consider evidence for and against and conclude
- calculate – use numbers provided to work out the answer
- compare – identify similarities and/or differences
- describe – recall some facts, events or processes

Structure your answers

1. Make a **point** – for example: *Embryo screening is an expensive procedure.*
2. **Develop** your point – for example: *This means that the procedure is available only to people who can afford it.*
3. **Link** your point back to the question – for example: *This is a socio-economic issue because the procedure is not accessible to everyone.*

Exam explainer

4 mark questions have **two** levels:

1. basic
2. clear.

A clear answer interprets, evaluates or analyses scientific information or resources.

Aluminium can be extracted from its ore by electrolysis.

Explain how aluminium is extracted from aluminium oxide by electrolysis. **[4 marks]**

For this question, you are expected to use your knowledge of electrolysis to explain how the process can be used to extract aluminium from aluminium oxide. You need to include reference to ions, electrodes and reduction in your answer.

For this type of question, you should provide specific examples for each of the issues mentioned, interpreting them in an objective way, and finishing with a reasoned conclusion.

Evaluate the use of embryo screening for cystic fibrosis. In your answer discuss the economic, social and ethical issues. **[6 marks]**

6–9 mark questions have **three** levels:

1. basic
2. clear
3. detailed.

A detailed answer shows understanding of scientific topics and knowledge of specific information. It is presented in a clear and balanced way.

When asked to calculate something, always show your working. There are often some marks available for method and it also helps you to check your answer.

Calculate the mass of calcium carbonate needed to produce 56 g of calcium oxide during thermal decomposition. **[5 marks]**

Levels of organisation

You need to understand the principles of organisation within living organisms.

10 Organisation

Cells are the fundamental building blocks of all living things. Simple organisms, such as bacteria, consist of just one single cell (**unicellular**). **Multicellular** organisms have various levels of organisation within them, ranging from the individual cell to the entire organism. The levels of organisation range in complexity, from simplest to most complex, and in size, from very small to large.

Cells contain **organelles**, also known as sub-cellular structures, which perform specific functions within the cell. Individual cells can perform specific functions (page 4). Groups of specialised cells which all have a similar structure and function are called **tissues**. Groups of tissues that perform specific jobs are known as **organs**. Groups of organs form **organ systems**.

Cells are very small. You need a microscope to be able to examine them. Go to pages 5 and 6 for more about microscopy.

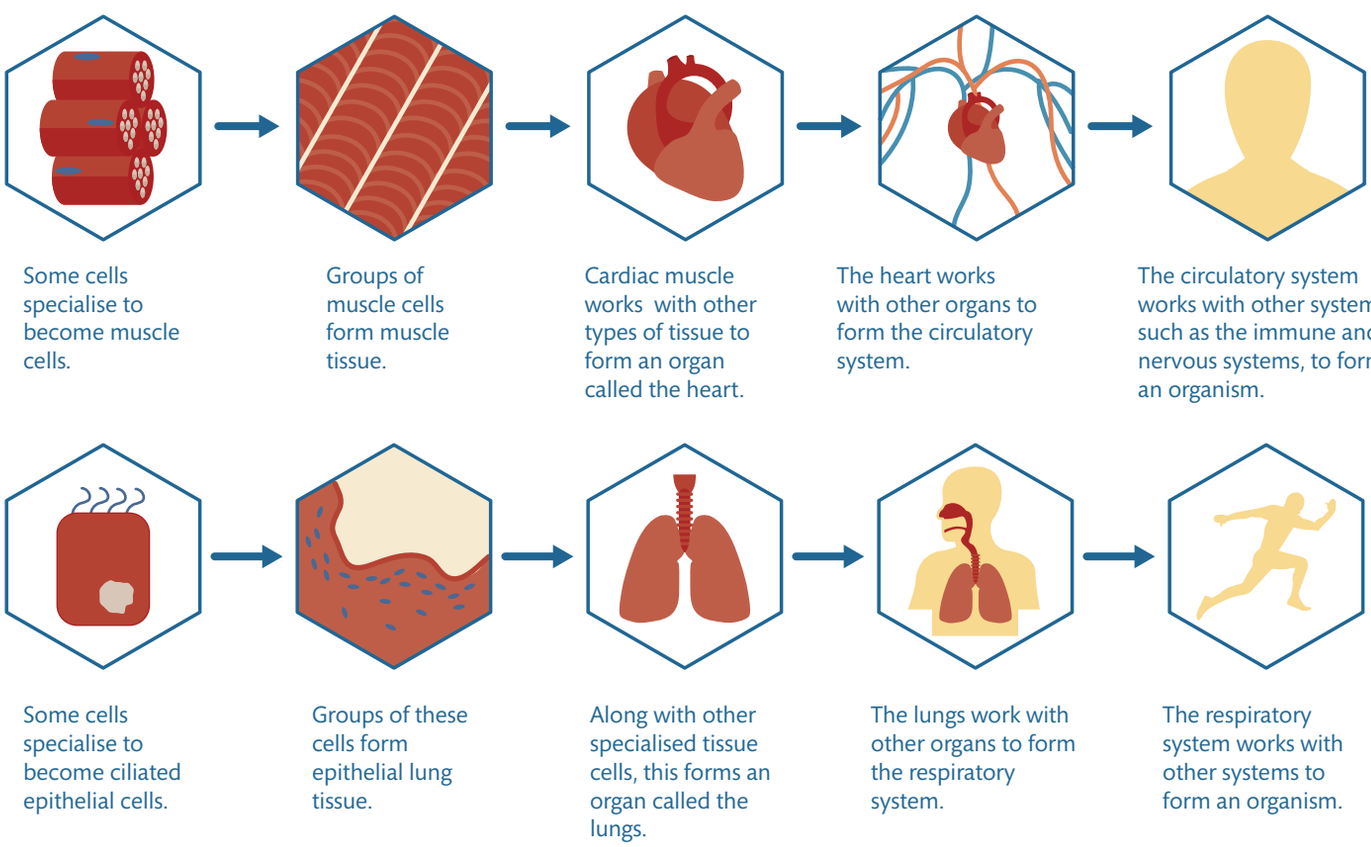


Figure 1 The levels of organisation within the circulatory and respiratory systems

5 Worked example — Grade 4

Describe the levels of organisation within the human nervous system. **[4 marks]**

The nervous system is an organ system made up of several organs, including the brain and spinal cord, working together. The organs consist of different types of nervous tissue, made up of different types of nerve cell (neurones).

Go to page 18 for more about the human nervous system.

5 Exam-style practice — Grade 4

1. Describe what is meant by an organ system. **[2 marks]**
2. Describe the levels of organisation within the human circulatory system. **[4 marks]**

Eukaryotic and prokaryotic cells

You need to know the differences in structure and function of eukaryotic and prokaryotic cells.

10 Eukaryotes and prokaryotes

Cells can be classified as either **eukaryotic cells** (eukaryotes) or **prokaryotic cells** (prokaryotes). Animals and plants consist of eukaryotic cells. Bacteria consist of prokaryotic cells. Eukaryotic cells are larger and more complex than prokaryotic cells. Eukaryotic cells contain membrane-bound **organelles** (sub-cellular structures) which are not found in prokaryotic cells. Animal cells contain the organelles nuclei and mitochondria; plant cells contain these, as well as chloroplasts.

There is more about the different structures of plant and animal cells on page 3.

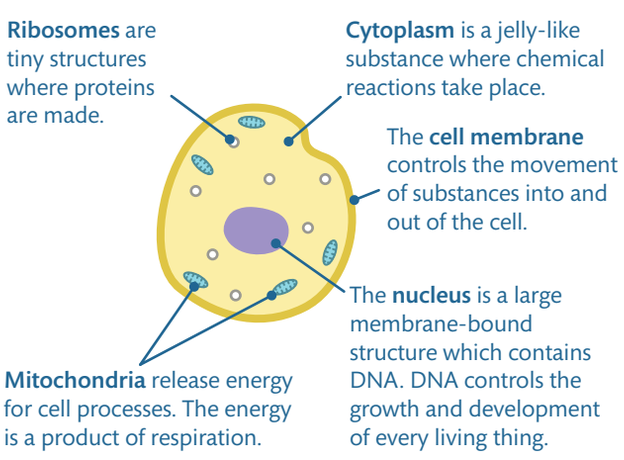


Figure 1 An animal cell – an example of a eukaryotic cell

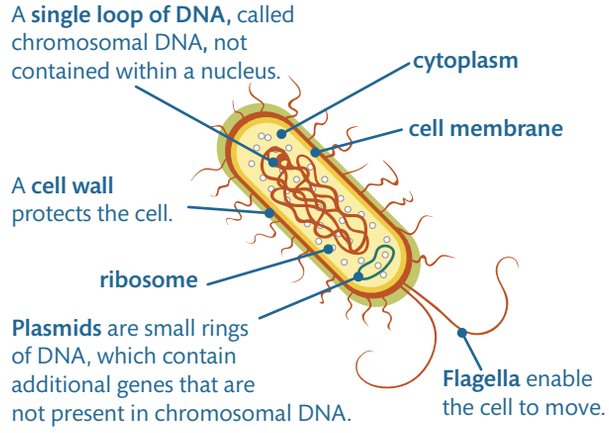


Figure 2 A bacterial cell – a prokaryotic cell

2 Working scientifically

Most cells are microscopic. You need to understand the scale and size of cells and use the correct prefixes.

The following are compared to one metre.

centimetre (cm) = one hundredth or 10^{-2}

millimetre (mm) = one thousandth or 10^{-3}

micrometre (μm) = one millionth or 10^{-6}

nanometre (nm) = one billionth or 10^{-9}

picometre (pm) = one trillionth or 10^{-12}

Remember, prokaryotic means 'before nucleus'. Prokaryotic cells do not have a nucleus. They contain a single DNA loop (chromosomal DNA) and small rings of DNA called plasmids.

5 Worked example — Grades 5–6

1 State where DNA is found in prokaryotic cells. **[1 mark]**

Chromosomal DNA and plasmid DNA are found in the cytoplasm. They are not enclosed in a nucleus.

2 Compare the structure of eukaryotic and prokaryotic cells. **[2 marks]**

Eukaryotic cells are larger and have more complex structures than prokaryotic cells. One important difference is that the genetic material in eukaryotes is enclosed in a nucleus.

Eukaryotic cells and prokaryotic cells are similar in that they both have:

- a cell membrane
- cytoplasm
- ribosomes.

Prokaryotic cell structures differ from eukaryotic cells because:

- they do not have a nucleus
- they do not have mitochondria.

5 Exam-style practice — Grades 5–6

1 Compare and contrast eukaryotic and prokaryotic cells. **[3 marks]**

2 Look at **Figure 1**, a diagram of a eukaryotic cell. Give the organelles in size order, starting with the smallest first. **[2 marks]**

Animal and plant cells

You need to be able to describe and explain the differences in structure of animal and plant cells.

10 Animal and plant cell structures

Although both animal and plant cells are eukaryotic, there are important structural differences between them. Plants stay in the same place and produce their own food. Animals move around in search of an external supply of food. These differences are the main reasons why animal and plant cell structures differ.

Algal cells have a similar structure to plant cells. They also have a cellulose cell wall that strengthens the cell.

Go to page 2 to revise the functions of organelles.

Organelle	Plant cell	Animal cell
nucleus	✓	✓
cytoplasm	✓	✓
cell membrane	✓	✓
cell wall	✓	×
mitochondria	✓	✓
ribosomes	✓	✓
chloroplasts	✓	×
permanent vacuole	✓	×

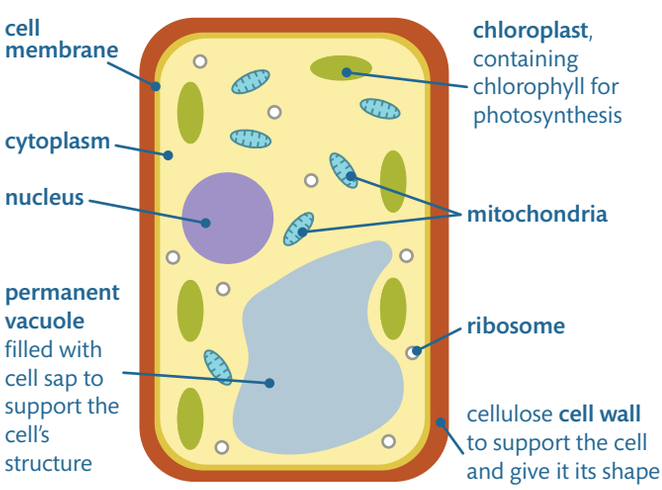


Figure 1 A plant cell

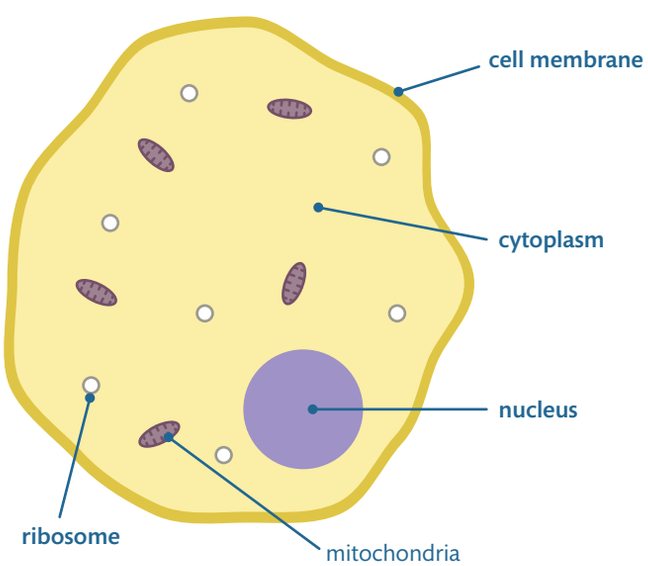


Figure 2 An animal cell

Structure is often related to function. Think of how animals and plants function differently from one another.

5 Worked example — Grade 5

Explain how the structures of plant cells are adapted to carry out their function. **[4 marks]**

Plants must produce their own food as they cannot move. Plant cells contain chloroplasts, which use sunlight to convert water and carbon dioxide into glucose and oxygen (photosynthesis).

Unlike many animals, plants do not have a skeleton, so they need another form of support and protection. Each cell has a cellulose cell wall and a sap-filled vacuole which makes the cell much firmer and helps support the plant.

'Estimate' means you don't have to make exact measurements or calculations. Only an approximation is required.

5 Exam-style practice — Grades 5–6

1 Look at **Figure 3**.

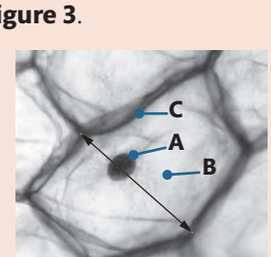


Figure 3 A plant cell as seen under a light microscope

(a) Identify which letter shows the nucleus. **[1 mark]**

(b) Estimate how many times wider the cell is than its nucleus. **[1 mark]**

2 Describe **three** differences between animal and plant cell structures. **[3 marks]**

Specialised animal cells

Multicellular organisms are large organisms, like animals, made up of more than one type of cell. You need to know about the structural adaptations of specialised cells that enable them to perform specific functions. Go to page 47 to read about specialised plant cells.

5 Specialised animal cells

You need to know how the following animal cells are specialised to carry out a particular function.

Sperm cells swim and fertilise egg cells.

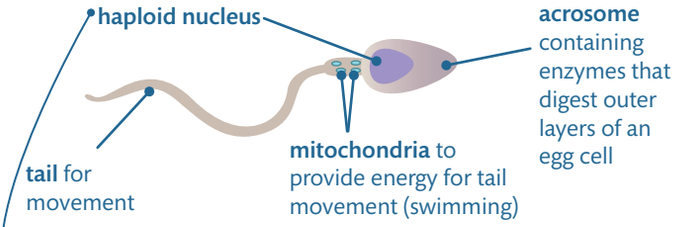


Figure 1 Sperm cell

A haploid nucleus contains half the normal number of chromosomes found in body cells. See page 19 for more about haploid cells.

Egg cells are fertilised by single sperm cells and then develop into an embryo.

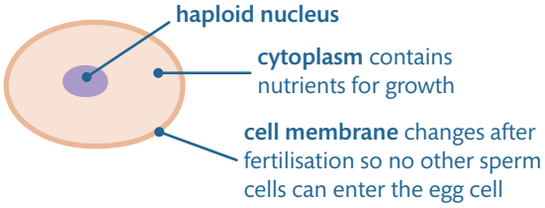


Figure 2 Egg cell

Ciliated epithelial cells, such as those in the trachea, move substances in a particular direction.

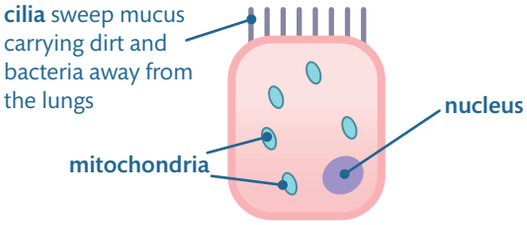


Figure 3 Ciliated epithelial cell

Red blood cells and white blood cells are other types of specialised cell.

Go to page 59 for more about the functions and adaptations of red blood cells and white blood cells.

5 Worked example — Grade 5

1 **Figure 4** shows a nerve cell (neurone). Describe **two** ways nerve cells are adapted for their function. **[2 marks]**

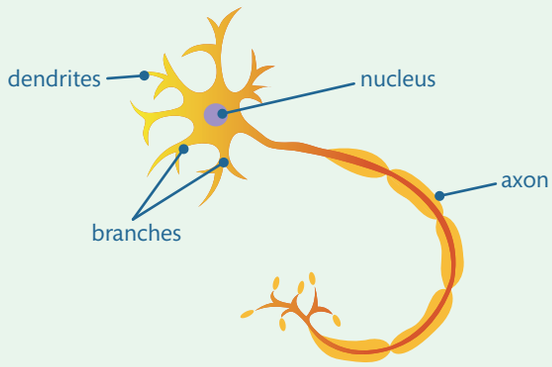


Figure 4 A nerve cell

Nerve cells have long axons so they are able to transmit nerve impulses between distant parts of the body. They also have branched endings called dendrites that connect with other nerve cells.

2 **Figure 5** shows a muscle cell. Suggest a reason why muscle cells contain many mitochondria. **[1 mark]**

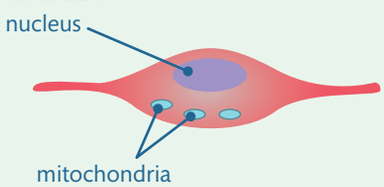


Figure 5 A muscle cell

Mitochondria are where respiration happens, so they release the energy needed for muscles to contract.

10 Exam-style practice — Grade 5

Describe **two** ways that each of the following are specialised to perform their functions:

(a) egg cells

(b) sperm cells

(c) ciliated epithelial cells. **[6 marks]**

Microscopy

You need to know how microscopes have developed, allowing scientists to examine increasingly smaller cellular structures.

5 Types of microscope

Microscopes are used to study cells. Over time, different kinds of microscope have been developed. The first light microscope, which could be used to observe simple cell structures, was invented about 350 years ago. This was gradually improved upon and refined to give the compound light microscopes that we use today. Very small cell structures can be studied with electron microscopes which were first developed in the 1930s.

Tiny cell organelles can be observed with an electron microscope. Ribosomes can be seen with an electron microscope but they are too small to be seen with a light microscope. The nucleus and mitochondria can be seen with a light microscope. The nucleus is larger so can be seen more clearly.

10 Magnification and resolution

Magnification is the measure of how many times bigger the image is than the object.

If a microscope has an eyepiece lens of ×10 and an objective lens of ×50, the image looks 10 × 50 times bigger, that is, 500 times bigger.

Light microscopes use light to see an image. They can only magnify up to about ×1200, due to problems with resolution.

Resolution is the measure of how well a microscope can distinguish between two very close objects.

Above ×1200, light microscopes cannot distinguish between two close objects. This is due to the wavelength of light.

Electron microscopes use electrons rather than light. Electrons have a much shorter wavelength than light. This means they can resolve two very close objects at a much higher magnification, some even reaching up to ×10 000 000.

5 Worked example — Grade 5

Figure 2 shows a scale drawing of a cell.

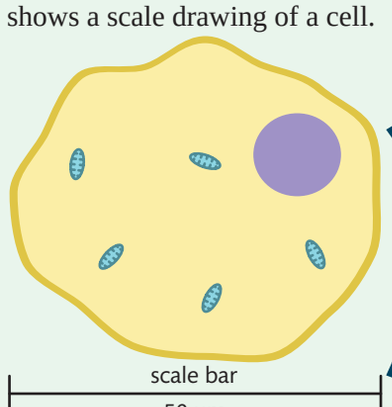


Figure 2

Calculate the magnification of the image in **Figure 2.** **[3 marks]**

size of image = 5 cm

5 cm = 50 000 µm

from scale bar

size of real object = 50 µm

$$\text{magnification} = \frac{50\,000}{50} = \times 1000$$

Maths skills

You need to know how to work out magnification using the equation:

$$\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

Use a ruler to measure the size of the image.

2 Maths skills

When calculating the size of microscopic cells, you may need to use standard form. Standard form is an efficient way of writing very big or very small numbers. For example:

35 000 000 can be written as:

3.5 × 10 × 10 × 10 × 10 × 10 × 10 × 10

or 3.5×10^7 in standard form.

10 Exam-style practice — Grades 5–6

1. A cell has a width of 100 µm. A scale drawing of the same cell has a width of 20 cm. Calculate the magnification of the drawing. Write your answer in standard form. **[2 marks]**

2. A microscope has an eyepiece lens of ×15 and an objective lens of ×50. Calculate how many times bigger the image is than the object. **[2 marks]**

Practical: Using microscopes

You need to know how to set up and use a microscope to look at cells. You also need to be able to draw and label cell images from a microscope.

5 Using a microscope

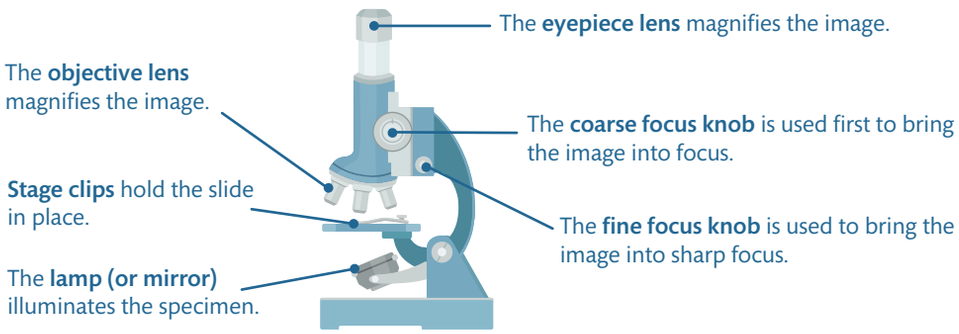
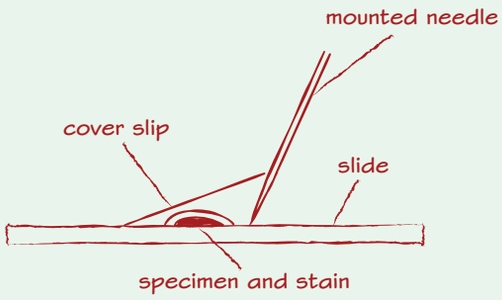


Figure 1 A light microscope

10 Worked example — Grade 5

1 Explain how you would prepare a slide of onion epidermal tissue. You may use a diagram to help you answer. **[3 marks]**

Peel off a one-cell-thick layer of cells and place it on a glass slide. Add one drop of stain, such as iodine, to the tissue. Use a mounted needle to lower the cover slip slowly and carefully to avoid trapping any air bubbles.



Tissue samples are stained to add contrast because most cells are colourless. Samples should be one cell thick so that cells can be seen clearly.

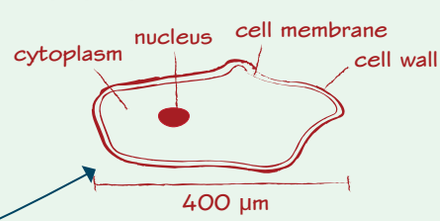
- You should only draw the things that you can see.
- Do not use shading.
- Keep the labels simple and clearly identified.
- Remember to include a scale bar on your drawing.

2 Explain how you would view the slide under a microscope. **[4 marks]**

Place the prepared slide under the stage clips of the microscope. Use the coarse focus knob to lower the low power objective lens to just above the slide. Look through the eyepiece lens and raise the lens until the image is nearly in focus. Use the fine focus knob to get a clear sharp image. To see parts of the specimen in more detail, move the slide so the parts you are interested in are in the middle of your field of view. Then use a higher power objective lens, and focus as before.

(c) Look at **Figure 2**. Draw and label an onion cell. **[2 marks]**

Figure 2 An onion cell



5 Exam-style practice — Grade 5

1. Explain why tissue samples must be very thin to be viewed with a microscope. **[2 marks]**
2. Explain why scientists often stain tissue samples before viewing them with a microscope. **[1 mark]**

Enzyme action

You need to know how enzymes work and the factors that affect their activity.

10 Enzymes

Enzymes are biological **catalysts**. This means they speed up reactions without themselves being changed. Most chemical reactions that occur in living organisms involve enzymes, because otherwise processes such as respiration or photosynthesis would happen far too slowly for organisms to survive.

The enzymes you will be most familiar with are those involved in digestion. See pages 8 and 9.

Enzyme molecules are **specific**, with each enzyme having a 3D shape that corresponds to the shape of the molecule (**substrate**) it works with. The part of the enzyme that binds to the substrate molecule is the **active site**.

High temperatures or extremes of pH affect an enzyme's molecular structure, irreversibly changing the shape of the active site. This means that the active site will not fit the substrate and the enzyme will no longer work. It has become **denatured**.

5 Lock and key model

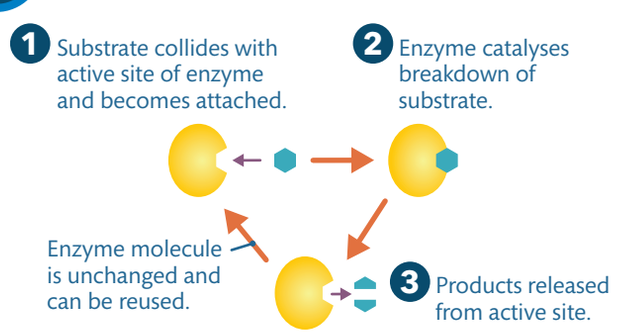


Figure 1 The lock and key model helps explain how enzymes work. Each type of enzyme has a differently shaped active site so can only work with a specific shape of molecule.

As substrate concentration increases, the rate of reaction increases due to more collisions between enzyme and substrate molecules. Eventually the rate of reaction levels off as each enzyme active site is fully occupied.

5 Worked example Grade 6

If you increase substrate concentration, eventually the rate of an enzyme-catalysed reaction becomes constant. Explain **one** way you could increase the rate further. **[2 marks]**

Increase the temperature so that the particles move and collide more quickly.

10 Factors affecting enzymes

The rate of an enzyme-catalysed reaction is affected by pH, temperature and substrate concentration.

Temperature

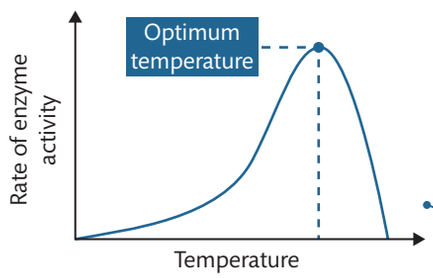


Figure 2 How enzyme activity is affected by temperature

As temperature increases, particles move and collide more quickly increasing the rate of reaction up to a maximum (its **optimum temperature**). Above this temperature, the enzyme molecules become denatured reducing the rate of reaction.

pH

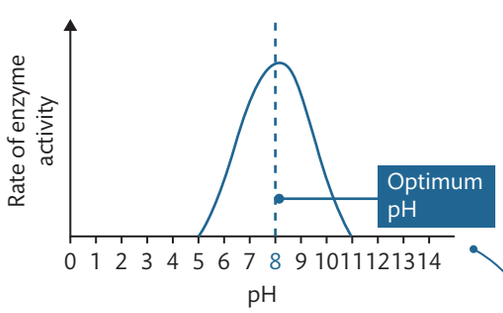


Figure 3 How enzyme activity is affected by pH

Each enzyme has its own **optimum pH**. Above or below this, the enzyme becomes denatured so the rate of reaction decreases.

Substrate concentration

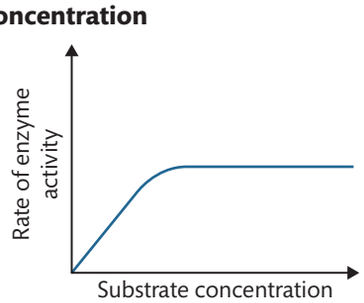


Figure 4 How enzyme activity is affected by substrate concentration

10 Exam-style practice Grade 5

Explain the mechanism of enzyme action. **[4 marks]**

Practical: Enzymes

You need to know how to investigate the effect of pH on the rate of reaction of an enzyme. Most enzymes will only work efficiently within a narrow pH range.

2 Apparatus

- three beakers containing the same amount of water
- three test tubes containing starch solution
- three test tubes containing amylase solution in a buffer solution
- water bath
- spotting tile with iodine solution
- thermometer
- pipettes

Working scientifically

You must control temperature during this investigation, as it affects the behaviour of enzymes.

Working scientifically

Interpreting these results is tricky. Iodine solution turns from yellow to black in the presence of starch. When the spots on the tile no longer turn black or brown, but remain yellow, all the starch has been broken down into maltose by the amylase.

You need to make a sensible judgement of when all the starch has been broken down.

10 Method

1. Add one drop of iodine solution to each well in the spotting tile.
2. Make up three beakers of water, each containing a test tube of starch solution and a test tube of amylase solution in a buffer solution. (Buffer solutions maintain constant pHs.) Each buffer solution should be at a different pH, for example: pH 7, pH 8 and pH 9.
3. Using a water bath, heat the three beakers to 25 °C.
4. Pour the test tube of amylase solution into the test tube of starch solution.
5. Starting at 0 seconds, take a drop from each test tube every 30 seconds and add it to the iodine using a pipette.

2 Maths skills

You need to know how to calculate the rate of a reaction. The rate of a reaction is inversely proportional to the time taken for it to complete.

$$\text{rate} \propto \frac{1}{\text{time}}$$

10 Worked example — Grades 5–6

1 Look at **Figure 1**. At which pH does the enzyme amylase break down starch the quickest? Justify your answer. **[2 marks]**

Figure 1 Results

pH 7 – at pH 7 the drops go from black to yellow the quickest, showing that the starch breaks down the quickest at pH 7.

2 Explain why it is difficult to decide how long it takes for amylase to break down the starch at pH 8. **[2 marks]**

The drops change from black to brown gradually over a period of 2–4 minutes, and at the end of the experiment not all the starch has been broken down as the iodine still does not remain yellow.

3 A student investigated the time taken for amylase to break down starch at different pH values. Calculate the rate of reaction for each pH value. Give your answers to two significant figures. **[3 marks]**

pH	Time taken for starch to disappear (s)	Rate of reaction (per second)
4	480	0.0021
6	120	0.0083
8	270	0.0037

5 Exam-style practice — Grade 6

1 Explain why temperature must be controlled during this experiment. **[3 marks]**

2 Describe **one** way the experiment could be improved. **[1 mark]**

Digestion and enzymes

You will have already studied the digestive system in Key Stage 3 Science. For the GCSE exam, you need to know how the digestive enzymes, carbohydrase, protease and lipase, act.

10 Digestion and enzymes

Digestion is the process of enzymes breaking down large insoluble food molecules into small soluble molecules that can be absorbed into the bloodstream. Enzymes catalyse and speed up chemical reactions. They work best at specific temperatures and pH levels.

Protease enzymes

- Proteases, such as pepsin, break down proteins into amino acids in the stomach and small intestine.
- They are produced in the stomach, small intestine and pancreas.
- Protease enzymes in the stomach need acidic conditions to work.

Carbohydrase enzymes

- Carbohydrases, such as amylase and maltase, break down carbohydrates into simple sugars.
- Amylase is produced in the salivary glands, small intestine and pancreas. Maltase is produced in the small intestine. Amylase and maltase work together to break down starch into glucose, starting in the mouth and finishing in the small intestine.

Lipase enzymes

- Lipases break down lipids (fats and oils) into fatty acids and glycerol in the small intestine.
- They are produced in the pancreas and the small intestine.
- They need alkaline conditions.

The products of digestion are used by the body in many ways, for example, some of the glucose produced is used for respiration and the release of energy. Other products of digestion are used to build up new proteins, carbohydrates and lipids in our body.

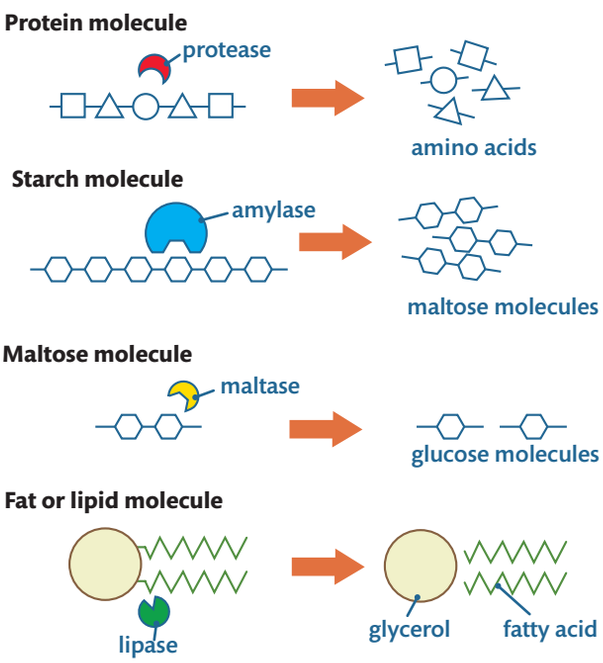


Figure 1 Enzymes in digestion

10 Worked example — Grade 5

Figure 2 shows the effect of pH on two different protease enzymes, **A** and **B**, found in the human digestive system.

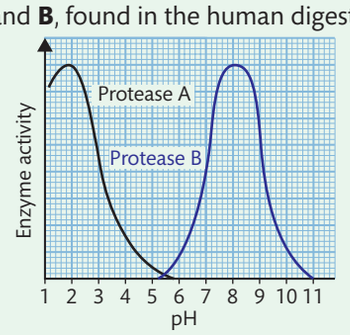


Figure 2 The effect of pH on protease enzymes

(a) Give the optimum pH of both protease **A** and protease **B**. **[2 marks]**

The optimum pH of protease A is pH 2 and the optimum pH of protease B is pH 8.

(b) The pH in the stomach is normally in the range of 1.5 to 3.5. Explain whether the two protease enzymes could be active in the stomach. **[2 marks]**

Protease A would be active because its optimum pH is in the pH range found in the stomach. Protease B would not be active in the stomach because it is completely denatured at the pH range found there.

2 Exam-style practice — Grade 7

Explain why acid from the stomach must be neutralised before it enters the small intestine. **[2 marks]**

Diffusion

You need to know how some substances move in and out of cells by diffusion and how multicellular organisms have adaptations to enable the effective exchange of substances.

Rate of diffusion

Diffusion is the **net movement** of particles of gas or in solution, down a **concentration gradient**, from an area of higher concentration to an area of lower concentration. Diffusion is an important process that occurs in both plants and animals. Useful substances such as oxygen and glucose diffuse into cells. Waste products diffuse out of cells. Carbon dioxide is a waste product of respiration, given out during gas exchange in fish gills, leaf cells and the lungs. Urea is a waste product made by the liver, which diffuses into the blood plasma and is then excreted in the kidney.

Certain factors affect the rate of diffusion:

- **difference in concentrations** – the greater the concentration gradient, the greater the rate of diffusion
- **temperature** – the higher the temperature, the higher the rate of diffusion because molecules have more kinetic energy so move faster
- **surface area** – the greater the surface area, the greater the rate of diffusion.

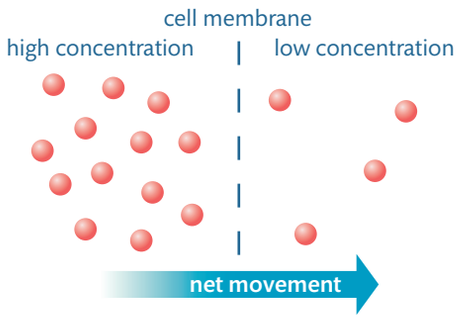


Figure 1 Diffusion occurs due to the random movement of particles. Particles move into and out of cells by diffusion until they are evenly distributed in space.

The surface area : volume ratio is even more important. Go to page 57 to read more about this.

Exchange surfaces

Substances diffuse in and out of small unicellular organisms by passing through their cell membrane. Multicellular organisms have evolved to have specialised exchange surfaces and organ systems that maximise diffusion by having:

- a large surface area
- a thin membrane for a short diffusion path
- a good transport system to maintain maximum concentration gradients.

In animals, an efficient blood supply and continuous ventilation maintain the concentration gradient required for efficient gaseous exchange of oxygen and carbon dioxide.

Examples of specialised exchange surfaces include:

- alveoli (air sacs) in the lungs, which provide a large surface area and thin membrane for gaseous exchange
- root hair cells in plants, which have a large surface area for absorbing water and mineral ions from the soil.

Find out more about adaptations on pages 58 (lungs) and 47 (plant roots).

Worked example — Grade 5

1 Give **three** factors that affect the rate of diffusion into and out of cells. **[3 marks]**

The difference in concentration (i.e. the concentration gradient), the temperature and the surface area of the membrane.

Another suitable answer is the thickness of the membrane.

2 **Figure 2** shows three cells, **A**, **B** and **C**, which contain different concentrations of oxygen. The darker the shading, the higher the oxygen concentration. Draw arrows on the diagram to show how oxygen will diffuse between the cells. Explain your answer. **[2 marks]**

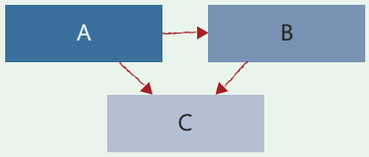


Figure 2

Oxygen will diffuse from areas of higher concentration to areas of lower concentration.

Exam-style practice — Grade 5

1 Explain why a good blood supply increases the rate of absorption of oxygen in the lungs. **[2 marks]**

2 Alveoli (air sacs) in the lungs have a large surface area. Explain the effect this has on the rate of gas exchange. **[2 marks]**

Osmosis

You need to understand the process of osmosis and be able to draw and interpret labelled diagrams that model the diffusion of water molecules.

10 Diffusion of water molecules

Osmosis is the diffusion of a solvent's molecules, from a **dilute solution** to a **concentrated solution**, through a **partially permeable membrane**.

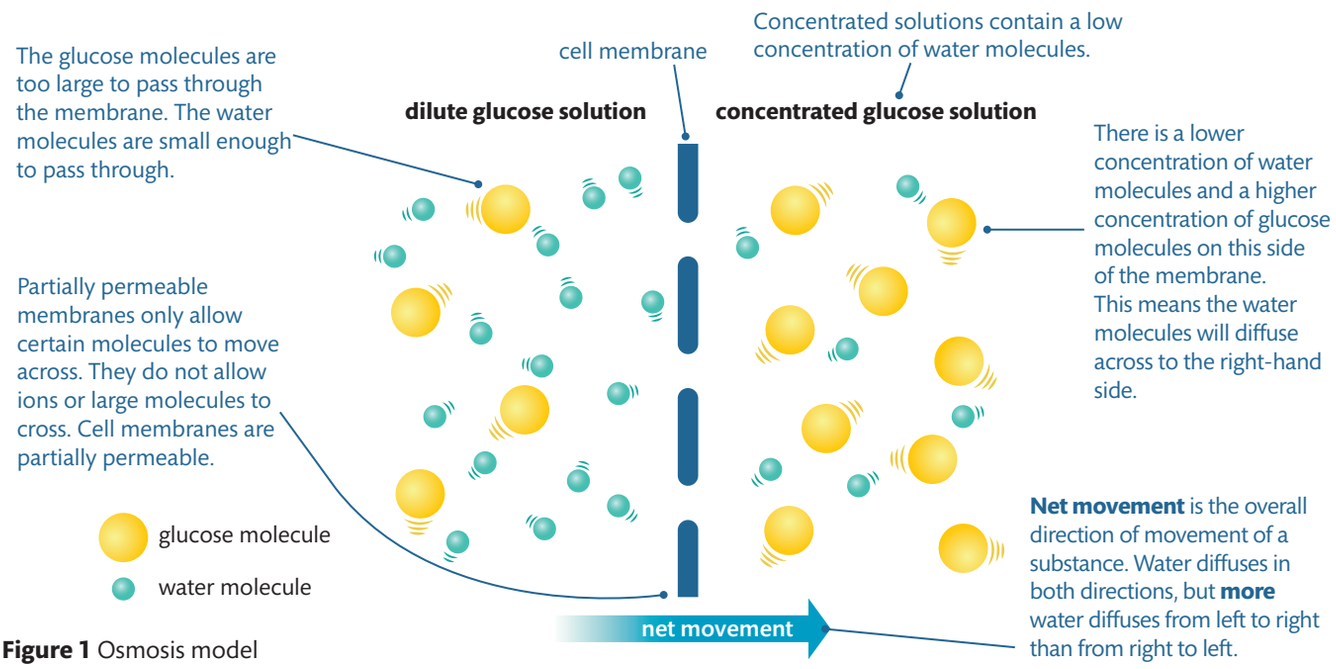


Figure 1 Osmosis model

5 Worked example — Grade 7

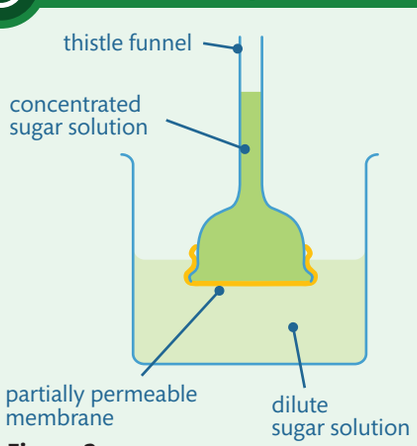


Figure 2

Figure 2 shows the apparatus a student uses in an osmosis experiment.

(a) Describe the result that the student observes. **[1 mark]**

The level of the solution will rise up the tube.

(b) Use your knowledge of osmosis to explain this result. **[3 marks]**

In the dilute solution there is a higher concentration of water molecules than in the concentrated sugar solution. Sugar molecules are too large to pass through the partially permeable membrane. Water molecules are able to pass through the membrane and will move from the dilute solution to the concentrated solution. There will be a net movement of water molecules into the thistle funnel, so the volume of liquid inside the thistle funnel will increase.

You need to think about how the concentration gradient will change. Go to page 10 to revise this topic.

5 Exam-style practice — Grade 7

1. Explain what happens to the rate of osmosis in **Figure 1** if the concentration of glucose on the right-hand side of the partially permeable membrane is increased. **[3 marks]**
2. The higher the temperature, the faster molecules move. Explain what happens to the rate of osmosis as the temperature is increased. **[2 marks]**

Practical: Osmosis

You need to know how to investigate the effect of different concentrations of sugar solution on osmosis in potatoes.

10 Worked example — Grade 8

A student placed equal-sized raw potato chips in different concentrations of sugar solution for two hours. The table shows the change in mass of each of the potato chips.

Sugar solution concentration ($g\,dm^{-3}$)	Initial mass of chip (g)	Final mass of chip (g)	Percentage change in mass (%)
0	2.50	2.95	+18
80	2.50	2.45	−2
160	2.50	2.20	
240	2.50	2.05	−18
320	2.50	1.98	−21

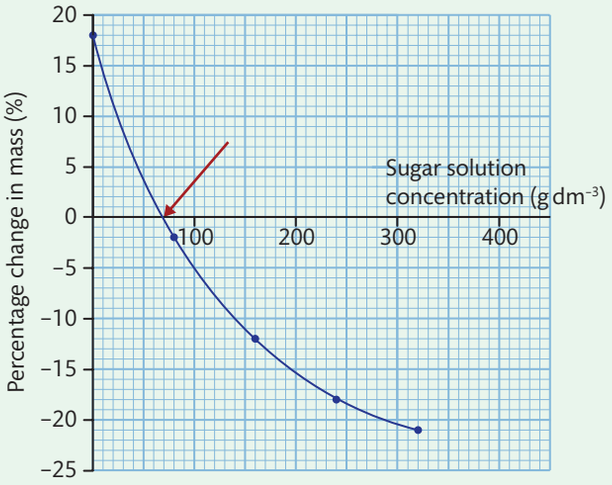


Figure 1 A graph showing the student's results

(a) One of the results is missing from the table. Determine the missing result. **[2 marks]**

$$100 \times \frac{(2.20 - 2.50)}{2.50} = -12\%$$

(b) Explain **one** way the student could improve the method. **[2 marks]**

The student could do the investigation several more times under the same conditions to see whether the results are repeatable.

(c) Use **Figure 1** to determine the concentration of sugar solution inside the potato cells. **[2 marks]**

The concentration of the cytoplasm will be the same as the sugar solution when there is no change in mass. From the arrow on the graph, this is about $68\,g\,dm^{-3}$.

2 Apparatus

- five equal-sized potato chips
- five different concentrations of sugar solution:
  - $0\,g\,dm^{-3}$
  - $80\,g\,dm^{-3}$
  - $160\,g\,dm^{-3}$
  - $240\,g\,dm^{-3}$
  - $320\,g\,dm^{-3}$
- ruler
- balance

Maths skills

You can calculate percentage change in mass by subtracting the initial mass from the final mass, then dividing by the initial mass and multiplying by 100.

$$\text{percentage change} = \frac{\text{change in mass} \times 100}{\text{original mass}}$$

5 Method

1. Using the balance, measure the masses of five **equal-sized** potato chips.
2. Place each potato chip in a different concentration of sugar solution.
3. Leave the chips for two hours.
4. Remove each of the chips, pat them dry and measure their masses.
5. Record the data in a table of results and calculate the percentage changes in mass.
6. Plot a line graph of the results.

1 Working scientifically

You should be able to produce a suitable hypothesis based on your understanding of osmosis. For example, a student's hypothesis for this investigation could be:

The higher the concentration of sugar solution, the greater the change in mass.

5 Exam-style practice — Grade 5

1. The potato chips were equal in size at the start of the investigation. Explain why this was important. **[2 marks]**
2. State and explain whether the hypothesis in the box above was supported or disproved. **[2 marks]**

Active transport

You need to understand how substances are transported by active transport and be able to describe how it differs from osmosis and diffusion.

10 Active transport

Active transport is the movement of a substance from an area of low concentration to a higher concentration against the **concentration gradient**. It requires energy from respiration.

Plants require mineral ions for healthy growth. The uptake of minerals in a plant requires active transport. Root hair cells absorb minerals from the soil, where the concentration is very low.

Go to page 47 for more about specialised root hair cells.

In humans, active transport allows glucose to be absorbed through the wall of the small intestine during digestion. The concentration of glucose is usually higher in the blood than in the gut so the glucose does not enter by diffusion. The glucose is then used for respiration.

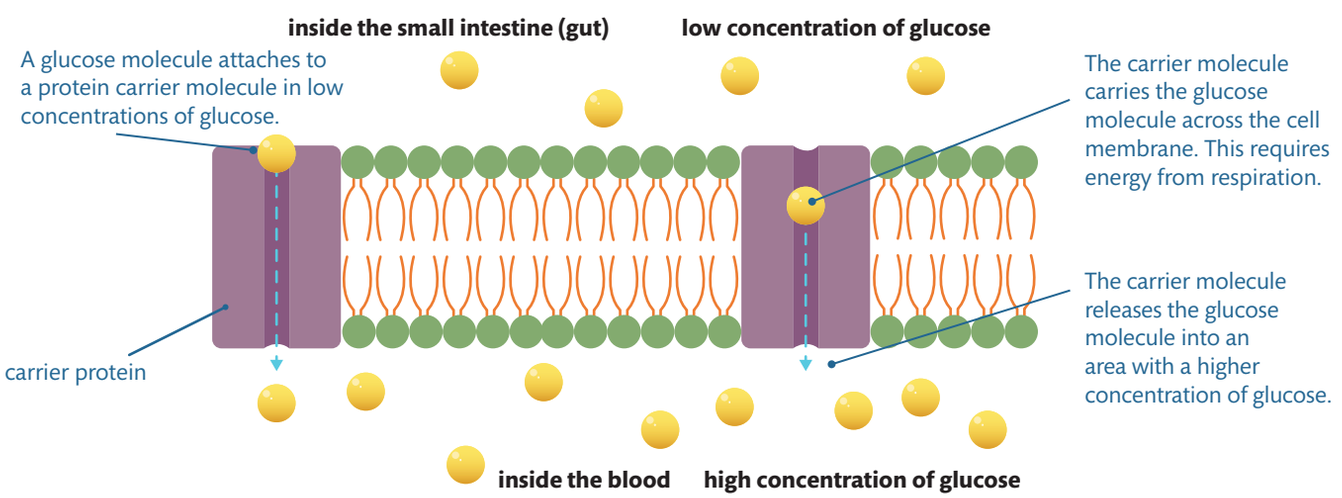


Figure 1 Membrane of cell lining small intestine showing active transport in the human gut

5 Worked example — Grade 6

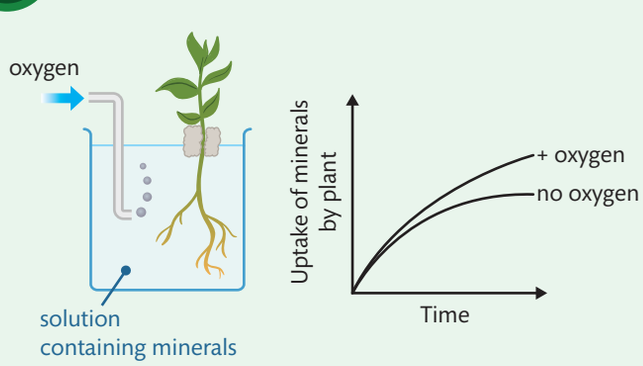


Figure 2 The apparatus shows a plant growing in a solution of mineral ions. Oxygen is bubbled through the solution.

1 Explain the shape of the graph in **Figure 2**. **[2 marks]**

The graph shows an increase in mineral uptake when extra oxygen is added by being bubbled through the solution. This is because oxygen is used for respiration and respiration provides energy for the active transport of mineral ions.

2 State **one** factor that slows down the rate of active transport. **[1 mark]**

A reduction in the availability of oxygen.

1 Exam focus

If you are ever asked to explain how one thing is different from another, make sure you use the names of the things you are comparing. Do not refer to either as just 'it' as it may not be obvious which one you mean.

5 Exam-style practice — Grade 6

1 Explain the differences between diffusion and active transport. **[3 marks]**

2 Describe **two** different examples of active transport in living organisms. **[2 marks]**

Mitosis and the cell cycle

Multicellular organisms grow and develop using a type of cell division called mitosis. You need to know how this occurs.

5 Chromosomes: key facts

- Chromosomes are found in the nucleus of nearly all types of cell.
- There are two copies of each chromosome in nearly all body cells. In humans, there are 23 pairs of chromosomes giving a total of 46 chromosomes in each cell (but not in the sex cells – see page 24).
- Chromosomes consist of long strands of DNA coiled up.
- The full number of chromosomes, found in nearly all body cells, is called the **diploid** number. For humans the diploid number is 46.
- Chromosomes carry many **genes**, sections of DNA which control our characteristics.

10 The cell cycle

The life-cycle of a cell is called the **cell cycle** and it is made up of different stages.

1 Interphase

The cell grows and the number of sub-cellular structures such as ribosomes and mitochondria increases. The DNA replicates (copies) itself in preparation for cell division. The chromosomes are not yet visible because the DNA is uncoiled.

2 Mitosis

There are four stages of mitosis (**prophase**, **metaphase**, **anaphase** and **telophase**) during which the genetic material is split up so each new cell will have a full diploid set of chromosomes.

3 Cytokinesis

The cell itself divides into two daughter cells – this is called **cytokinesis** – and the cells begin interphase again.

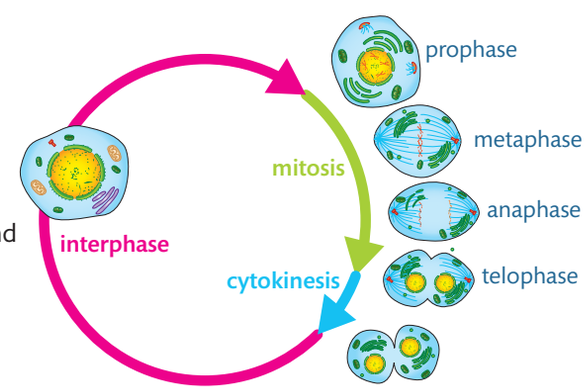


Figure 1 The cell cycle

10 Stages in mitosis

Mitosis leads to the production of two genetically identical diploid daughter cells from one parent cell.

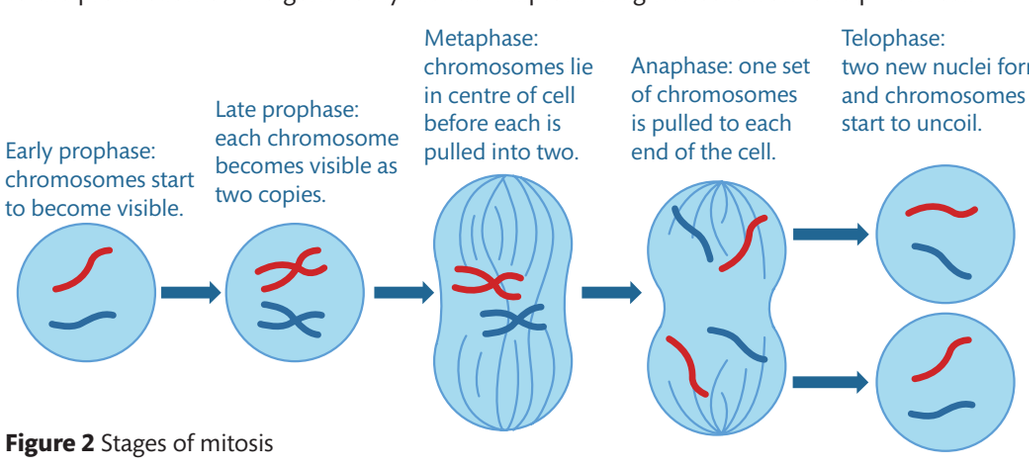


Figure 2 Stages of mitosis

5 Exam-style practice — Grade 6

1. Describe what must happen to a cell before it can divide. **[2 marks]**
2. Give the number of chromosomes in a body cell from a human baby. **[1 mark]**

Importance of mitosis

You need to know the importance of mitosis for growth, repair and asexual reproduction. Sometimes cells can divide uncontrollably. This is called cancer.

The importance of mitosis

Mitosis is the process of cell division involved in body growth, in repair (the replacement of damaged cells) and asexual reproduction. The new daughter cells produced by mitosis are genetically identical to each other and to the parent cell. They are all diploid cells.

Asexual reproduction

Asexual reproduction only involves one parent. There is no fusion of male and female gametes. (A **gamete** is a sex cell which contains genetic information.)

This means that there is no mixing of genetic information, so when the cells divide, all the offspring are genetically identical to the parent.

The only type of cell division involved in asexual reproduction is mitosis. These offspring are called clones. Organisms which can produce asexually include bacteria, fungi, potatoes and daffodils.

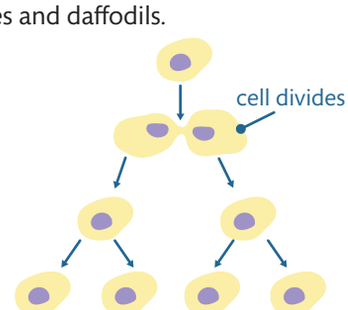


Figure 1 Asexual reproduction involves only mitosis.

Nuclei is the plural of nucleus.

Cancer

Cancer is caused by changes to genes in the DNA inside cells that lead to uncontrolled cell division and tissue growth. A change in the DNA of a cell is called a **mutation** (page 25).

Risk factors

Some people inherit alleles that are more likely to mutate (change) than other alleles. This means these people are born with certain genetic risk factors which make them more likely to develop cancer later in life.

Lifestyle factors linked to cancer include sunbathing, smoking, heavy drinking and working with carcinogenic (cancer-causing) materials such as asbestos.

Go to page 22 for more about alleles.

Sexual reproduction

Sexual reproduction involves the joining of male (pollen or sperm) and female (ova or egg) gametes. Gametes in reproductive organs are produced by a type of cell division called meiosis (see page 19).

During fertilisation, the nuclei of the male and female gametes fuse together to make a fertilised egg cell called a **zygote**.

The zygote divides many times by mitosis (page 14), eventually forming an embryo. The mixing of genetic information from the male and the female parent provides variation.

Go to page 25 for more about variation.

Worked example — Grade 5

Compare sexual and asexual reproduction. **[4 marks]**

Sexual reproduction involves gametes (sex cells) produced by meiosis, whereas asexual reproduction involves one parent cell dividing by mitosis. Sexual reproduction produces variety in offspring but asexual reproduction leads to genetically identical clones. This is because sexual reproduction involves the mixing of genetic information from male and female gametes.

Exam questions could refer to sexual or asexual reproduction. Make sure you know the differences between the two types of reproduction.

Exam-style practice — Grade 6

1. Explain **three** reasons why mitosis is important. **[3 marks]**
2. Explain what happens in cells to cause cancer. **[2 marks]**

Cell differentiation and growth

You need to understand the importance of cell **differentiation** in plants and animals. You also need to understand how percentile charts can be used to monitor human growth.

10 Cell differentiation

As an organism develops, cells differentiate to form different types of specialised cells. When a cell differentiates, it acquires different sub-cellular structures to enable it to perform specific functions. For example:

- muscle cells need to be able to contract to cause movement
- nerve cells need to be able to transmit electrical impulses to communicate with other parts of the organism
- plant root hair cells need to have a large surface area to absorb water and nutrients from the soil.

Stem cells are able to differentiate into different kinds of cell. Human stem cells can come from human embryos or from adult bone marrow. Go to page 17 for more about stem cells.

Go to page 4 to revise how cells have become specialised to perform their function.

Differentiation in animal cells

Most types of animal cell are formed by differentiation at an early stage in the life of an organism. In mature animals, cell division is restricted mainly to repair and replacement, such as generating new blood cells, healing skin cuts, hair and fingernail growth, and healing broken bones.

Differentiation in plant cells

Many types of plant cell retain the ability to differentiate throughout the life of an organism. Cells can differentiate to grow new leaves, flowers, branches, xylem and phloem. This is why plants can regrow branches that are cut off during pruning. Cells in meristems (page 17) in plants can divide, elongate and then differentiate into any type of plant cell, throughout the life of the plant.

5 Monitoring growth

The weight and height of babies and children are regularly measured to make sure they are growing properly and are healthy. Percentile charts show the normal range of variation. **Figure 1** shows a **percentile chart** for boys' heights. For example, if a child is on the 75th percentile line at a particular age, then they are the same height or taller than 75% of boys of the same age.

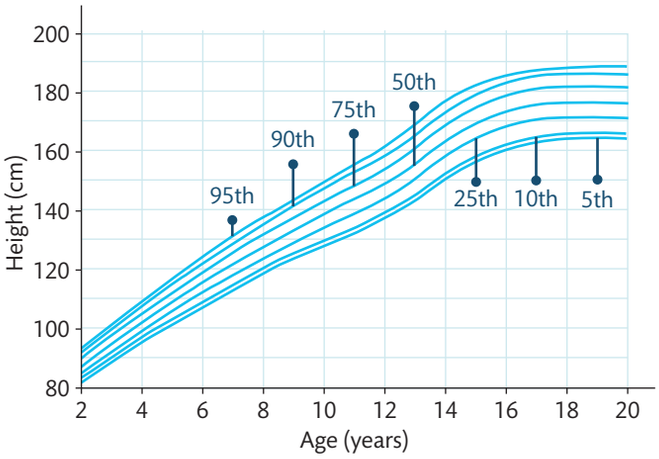


Figure 1 A percentile growth chart for height in boys

5 Worked example — Grade 6

Describe **two** examples of cell differentiation in mature animals. **[4 marks]**

In mature animals, cell division is mainly restricted to providing new cells to repair and replace damaged or lost tissue. For example, new red blood cells are constantly being generated to replace old and damaged red blood cells. Cell differentiation is also integral to the repair of skin and bone after injury.

10 Exam-style practice — Grades 5–6

1. Describe **two** examples of repair and replacement in humans, not including the creation of red blood cells or the healing of cut skin. **[2 marks]**
2. Explain the advantage of some cells retaining the ability to differentiate throughout the life of the organism. **[1 mark]**
3. Look at **Figure 1**. At age 12 years, what is the height of the 10th percentile? **[1 mark]**

Stem cells

Stem cells are undifferentiated cells. They can develop into different types of body cell. You need to know how stem cells are obtained and how they can be used.

10 Stem cell applications

Stem cells may one day be used to cure diseases by replacing faulty cells. They could cure diseases such as diabetes, paralysis, hearing and vision loss, and Parkinson's disease. If the stem cells are used to treat the donor, then there is no danger of the cells being rejected.

Embryonic stem cells

Stem cells from human embryos can be cloned and made to differentiate into most types of human cell when instructed. They have the potential to cure many genetic conditions by replacing damaged cells. However, embryos cannot choose to donate and they are destroyed in the process. Unwanted embryos from fertility clinics are often used.

Adult stem cells

Adult human stem cells can be taken from bone marrow. They can form many, but not all, types of cell, as they are used naturally in the body for repair and replacement of some tissues. Adult stem cells are useful in the treatment of people suffering from blood disorders as they can form new blood cells.

An advantage is that donation of adult stem cells is a choice and no life is destroyed, but it can be a painful procedure.

Meristem tissue in plants

In animals, growth can occur anywhere in the body. However, plants only grow in certain areas called **meristems**. Meristems consist of stem cells that can differentiate into any type of plant cell throughout the life of the plant. Growth occurs in meristems as they are the only points on the plant with actively dividing cells. Meristems are found, for example, at the tips of shoots and roots. They can be used to quickly and cheaply produce cloned plants (by taking cuttings) and are useful for growing rare species of plants to protect them from extinction. They can be used to grow lots of identical crops exhibiting desired traits such as disease resistance.

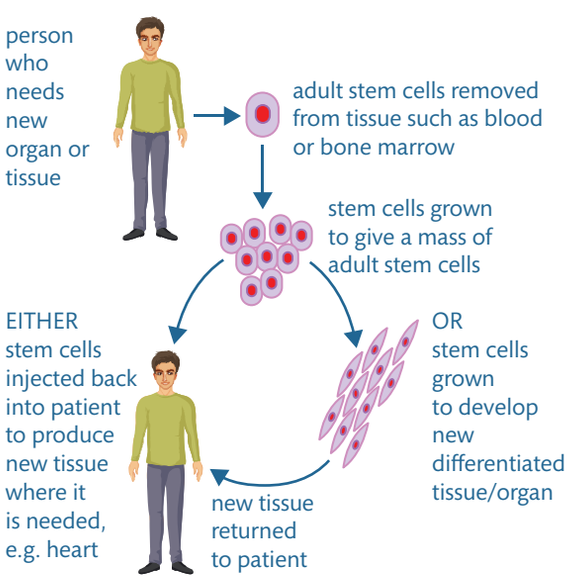


Figure 1 How adult stem cells can be used

1 Working scientifically

Stem cell research is controversial. Some people have ethical and religious objections to the process since human embryos are being destroyed in the process, but others believe the advantage of using stem cells to cure diseases or injured people outweighs the rights of an embryo.

5 Worked example Grade 7

Scientists are developing a treatment for paralysis using embryonic stem cells.

Why are stem cells used? **[2 marks]**

Stem cells are unspecialised, so they can differentiate into any type of cell. Therefore, they can differentiate and replace the damaged cells causing the paralysis.

1 Exam focus

You do not need to know details about stem cell techniques for the exam, but you are expected to be able to evaluate the risks and benefits. You also need to know about social and ethical issues in science.

5 Exam-style practice Grades 5–7

1. Give **one** advantage for commercial growers using cloned plants. **[1 mark]**
2. Describe the ethical considerations involved with embryonic stem cell therapy. **[2 marks]**

The human nervous system

The nervous system senses a stimulus (a change in the environment) and coordinates the body's response. You need to be able to explain the structure and function of the human nervous system.

5 Coordination

When **sensory receptors** are stimulated, for example when light stimulates receptors in the retina in the eye, **electrical impulses** are sent to the **central nervous system (CNS)**, which consists of the brain and spinal cord. The CNS coordinates suitable responses to stimuli by sending impulses to **effectors** (muscles or glands). This pathway is known as a **reflex arc**:

stimulus ➔ receptor ➔ coordinator ➔ effector ➔ response

Examples of stimuli include: touch, substances in food, temperature and light.

10 Types of neurone

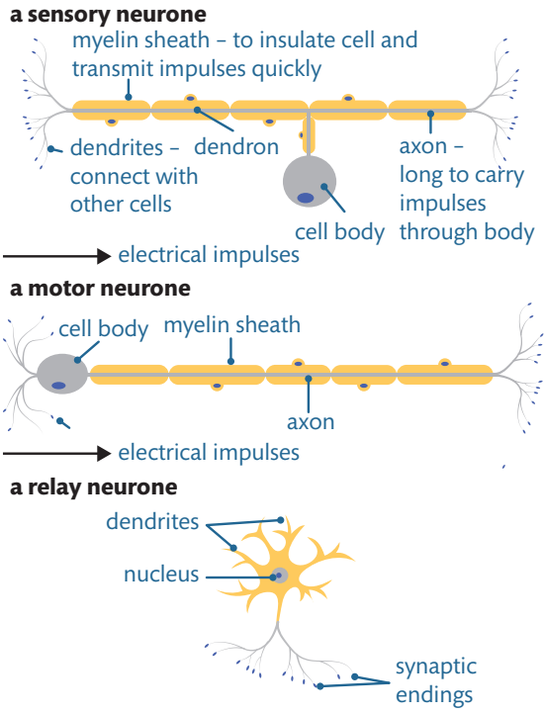


Figure 1 Neurones

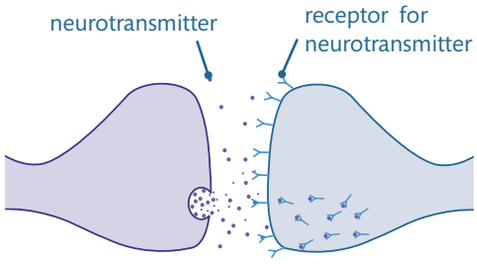


Figure 2 A synapse

Neurones are cells in the nervous system. Sensory neurones carry information from sensory receptors to the CNS. Motor neurones carry instructions from the CNS to effectors. Sensory and motor neurones are covered in an insulating **myelin sheath** which speeds up the transmission of the impulses. **Synapses** are gaps between neurones. When electrical impulses arrive at a synapse they cause the release of chemical messengers called **neurotransmitters** which diffuse across the gap and cause an electrical impulse in the next neurone.

5 Reflex arcs

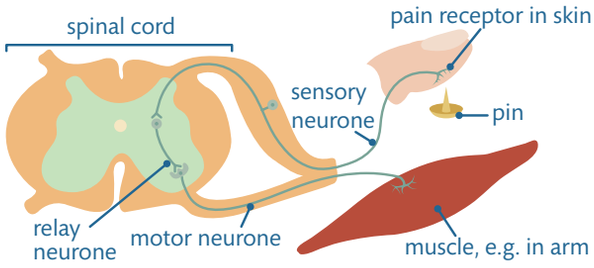


Figure 3 An example of a reflex arc

Reflex arcs are automatic and do not involve the conscious part of the brain. This is important to speed up reaction times.

Not all impulses go via the brain: some impulses just go to into the spinal cord and straight back out to an effector. Sensory and motor neurones are connected by **relay neurones**.

receptor ➔ sensory neurone ➔ relay neurone ➔ motor neurone ➔ effector

5 Exam-style practice — Grade 6

Describe and explain **two** ways that the structure of a motor neurone is adapted for its function. **[4 marks]**

Meiosis

Meiosis is the type of cell division that produces the cells called gametes, which are needed for sexual reproduction. You need to know how this occurs.

10 The stages of meiosis

Meiosis in humans and other animals results in sperm and egg cells (**gametes**).

Although similar to mitosis (see page 14), it is a two-stage cell division process, resulting in the production of four cells, each containing a single set of chromosomes.

The gametes produced by meiosis are genetically different from each other.

During fertilisation, one male gamete and one female gamete join up to form a cell with the typical number of chromosomes in a body cell (in humans, 46 chromosomes arranged in 23 pairs). This cell is called a **zygote**.

The zygote will then divide by mitosis forming a ball of cells called the **embryo**. As the embryo develops, cells differentiate.

The final stage of division during meiosis will always produce cells containing half the number of chromosomes (**haploid** number) as the parent cell (which has the full or **diploid** number). The chromosomes can be either chromosome from each pair of chromosomes contained in the parent cell.

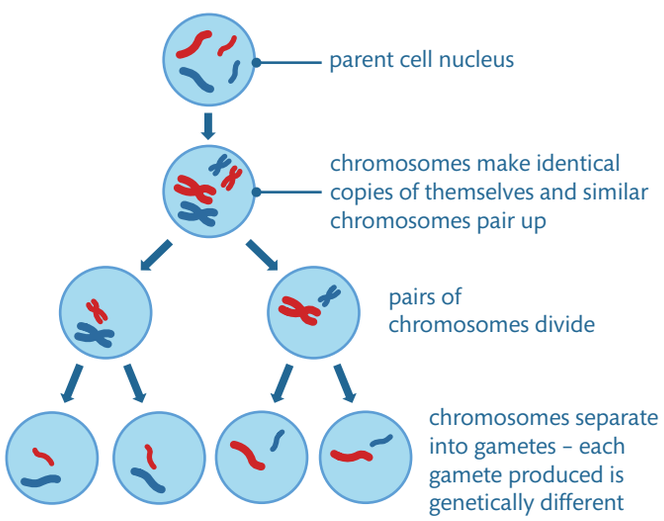


Figure 1 The stages of meiosis

5 Worked example — Grade 7

1 Describe what happens to the chromosomes when a cell divides by meiosis. **[4 marks]**

The chromosomes duplicate; the cell then divides twice to form four gametes, each with a single set of chromosomes.

2 Complete the diagram to show the nucleus of a parent cell. **[1 mark]**

3 Complete the diagram to show one of the four nuclei produced from the cell above during meiosis. **[1 mark]**

2 Key terms

- **gametes** – sex cells: sperm and egg cells
- **diploid** – a cell containing two sets of chromosomes
- **haploid** – a cell containing a single set of unpaired chromosomes

The first cell division occurs after chromosomes have made identical copies of themselves and paired up.

The second round of cell division splits the 46 chromosomes in one cell into two cells, each containing only half the number of chromosomes (23).

1 Exam focus

In your exam, be very careful with your spellings of 'mitosis' or 'meiosis', so it is clear which one you are writing about. If it is not clear, you may lose marks.

5 Exam-style practice — Grades 4–6

1 Describe how variation occurs due to meiosis and sexual reproduction. **[3 marks]**

2 **(a)** Describe how the number of chromosomes in a human sex cell differs from the number of chromosomes in a human body cell. **[1 mark]**

(b) Give the number of chromosomes found in a human egg cell. **[1 mark]**

The structure of DNA

You need to know about the substance that makes up genetic material: DNA or deoxyribonucleic acid.

10 DNA

DNA (deoxyribonucleic acid) is the genetic material – the substance that genes are made of. Understanding its structure has allowed advances such as genetic engineering (page 30) and 'DNA fingerprinting'.

DNA consists of two strands made of sugars and phosphates. The strands are coiled to form a **double helix**. The strands are linked by pairs of bases held together by weak intermolecular bonds called **hydrogen bonds**. There are four different bases: A, T, C and G. They always form the same pairs: A-T and C-G. These are known as **complementary base pairs**. Each gene has a different sequence of base pairs along its length.

DNA is a **polymer**, meaning that it is a very long molecule made up of repeating sub-units (see page 94). Each sub-unit is made of a sugar molecule attached to a phosphate group and a base, and is known as a **nucleotide**.

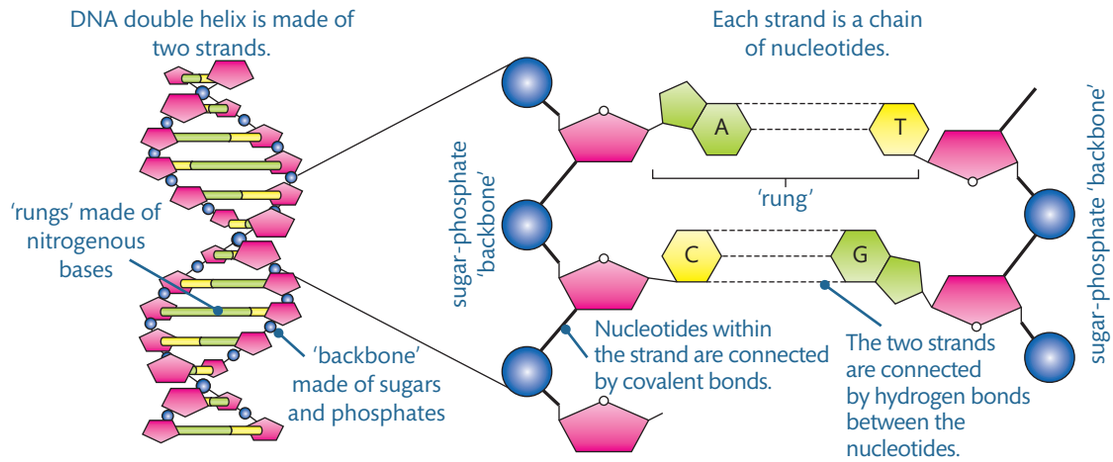


Figure 1 The structure of DNA

5 Worked example — Grade 5

1 State why DNA is described as a 'polymer'. **[1 mark]**

Each strand is a repeating series of nucleotides.

2 Everyone has a unique 'DNA fingerprint'. Suggest an explanation for what makes one person's DNA different from someone else's. **[2 marks]**

DNA contains a sequence of base pairs. Each person has a slightly different sequence.

2 Working scientifically

The structure of DNA was worked out in 1953 by James Watson and Francis Crick, using research from other scientists like Rosalind Franklin to help them. In 1962, together with Maurice Wilkins, Watson and Crick were awarded a Nobel prize, recognising the importance of their discovery.

10 Extracting DNA

DNA can be extracted from fruit and vegetables. The process works well with kiwi, bananas and strawberries.

Method

1. Remove any tough skin and mush up the fruit.
2. Add a prepared mixture made of water, salt and detergent to the mushed fruit and leave for about 20 minutes.
3. Filter the mixture to remove pips and pulp, collecting the liquid in a test tube.
4. Carefully pour some cold alcohol or methylated spirits down the side of the test tube so it collects on top of the fruit extract. The alcohol needs to have been kept in a freezer so that it is very cold.
5. After about 10 minutes, white 'stringy' material will appear in the alcohol. This is DNA.

10 Exam-style practice — Grade 6

Describe the structure of DNA. **[6 marks]**