AQA Approved

AQA GCSE Biology

Third edition

Ann Fullick

Andrea Coates

Editor: Lawrie Ryan

OXFORD

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Biology
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Message from AQA

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A wide range of other useful resources can be found on the relevant subject pages of our website: www.aqa.org.uk.

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Contents

This book has been written for the *AQA GCSE Biology* and *AQA GCSE Combined Science: Trilogy* courses, making them completely co-teachable. Biology only lessons are easily identifiable with their own black-bordered design, and are also formatted in italics in the below contents list for quick access.

Required Practicals

Practical work is a vital part of biology, helping to support and apply your scientific knowledge, and develop your investigative and practical skills. As part of your GCSE Biology course, there are 10 required practicals you must carry out. Questions in your exams could draw on any of the knowledge and skills you have developed in carrying out these practicals.

A Required practical feature box has been included in this student book for each of your required practicals. Further support is available on Kerboodle.

Required practical		Topic
1	**Using a light microscope.** Use a light microscope to observe, draw, and label a selection of plant and animal cells and include a scale magnification.	B1.2
2	**Investigating the effect of antiseptics or antibiotics on bacterial growth.** Use agar plates and measure the zones of inhibition produced around colonies.	B5.4
3	**Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.** Investigate osmosis by measuring how the mass of plant tissue changes in a range of concentrations of salt or sugar solutions.	B1.8
4	**Use standard food tests to identify food groups.** Detect sugars, starch, and proteins in food using Benedict's test, the iodine test, and Biuret reagent.	B3.3
5	**Investigate the effect of pH on the rate of reaction of amylase enzyme.** Students should use a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values.	B3.6
6	**Investigate the effect of light intensity on the rate of photosynthesis** Use an aquatic plant to observe the effect light intensity has on the rate of photosynthesis.	B8.2
7	**Investigate the effect of a factor on human reaction time.** Plan and carry out an investigation, choosing appropriate ways to measure reaction time and considering the risks and ethics of the investigation.	B10.2
8	**Investigate the effect of light or gravity on the growth of newly germinated seedlings.** Record results both as length measurements and as accurate, labelled biological drawings to show the effects.	B11.9
9	**Measure the population size of a common species in a habitat.** Use sampling techniques to investigate the effect of a factor on the distribution of this species.	B16.3
10	**Investigate the effect of temperature on the rate of decay of fresh milk.** Measure the pH change of milk to investigate how temperature affects its rate of decay.	B17.4

How to use this book

Learning objectives

- Learning objectives at the start of each spread tell you the content that you will cover.
- Any outcomes marked with the higher tier icon **H** are only relevant to those who are sitting the higher tier exams.

This book has been written by subject experts to match the new 2016 specifications. It is packed full of features to help you prepare for your course and achieve the very best you can.

Key words are highlighted in the text. You can look them up in the glossary at the back of the book if you are not sure what they mean.

Many diagrams are as important for your understanding as the text, so make sure you revise them carefully.

Synoptic link

Synoptic links show how the content of a topic links to other parts of the course. This will support you with the synoptic element of your assessment.

There are also links to the Maths skills for biology chapter, so you can develop your maths skills whilst you study.

Practical

Practicals are a great way for you to see science in action for yourself. These boxes may be a simple introduction or reminder, or they may be the basis for a practical in the classroom. They will help your understanding of the course.

Required practical

These practicals have important skills that you will need to be confident with for part of your assessment. Your teacher will give you additional information about tackling these practicals.

Study tip

Hints giving you advice on things you need to know and remember, and what to watch out for.

Anything in the Higher Tier spreads and boxes must be learnt by those sitting the higher tier exam. If you will be sitting foundation tier, you will not be assessed on this content.

Higher

Go further

Go further feature boxes encourage you to think about science you have learnt in a different context and introduce you to science beyond the specification. You do not need to learn any of the content in a Go further box.

Using maths

This feature highlights and explains the key maths skills you need. There are also clear step-by-step worked examples.

Key points

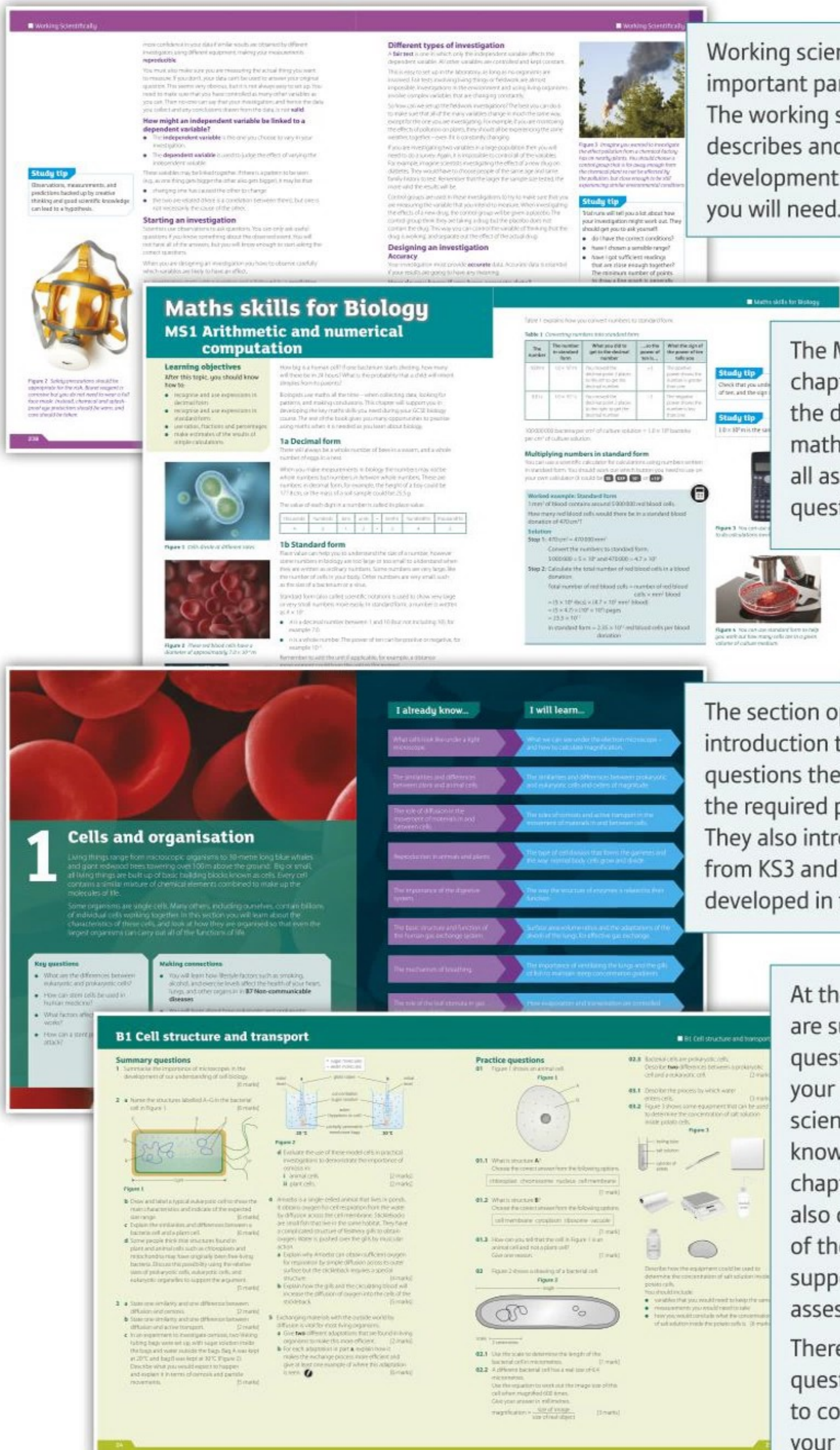
Linking to the Learning objectives, the Key points boxes summarise what you should be able to do at the end of the topic. They can be used to help you with revision.

Summary questions

Each topic has summary questions. These questions give you the chance to test whether you have learnt and understood everything in the topic. The questions start off easier and get harder, so that you can stretch yourself.

The Literacy pen shows activities or questions that help you develop literacy skills.

Any questions marked with the higher tier icon **H** are for students sitting the higher tier exams.



Working scientifically skills are an important part of your course. The working scientifically section describes and supports the development of some of the key skills you will need.

The Maths skills for biology chapter describes and supports the development of the important mathematical skills you will need for all aspects of your course. It also has questions so you can test your skills.

The section openers include an introduction to the section, some key questions the section will answer, and the required practicals in that section. They also introduce the key concepts from KS3 and tell you how they will be developed in that section.

At the end of every chapter there are summary questions and practice questions. The questions test your literacy, maths, and working scientifically skills, as well as your knowledge of the concepts in that chapter. The practice questions can also call on knowledge from any of the previous chapters to help support the synoptic element of your assessment.

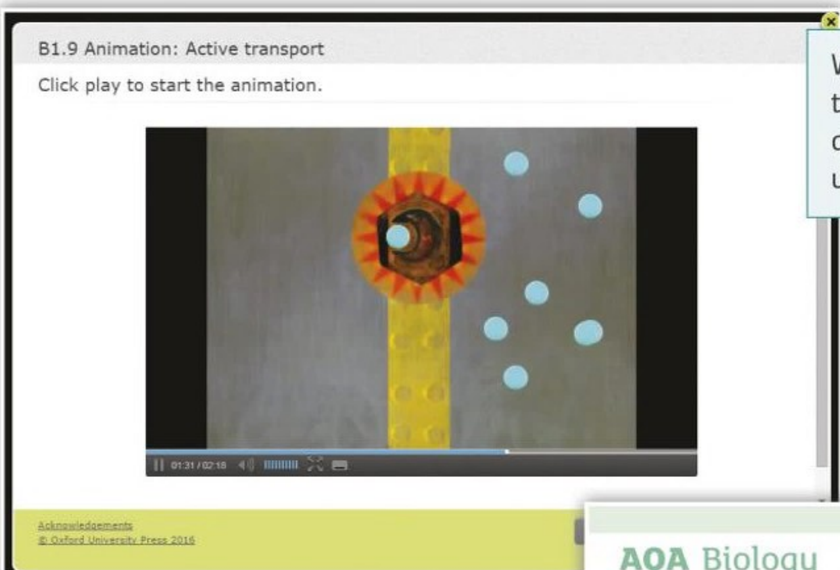
There are also further practice questions at the end of the book to cover all of the content from your course.

Kerboodle

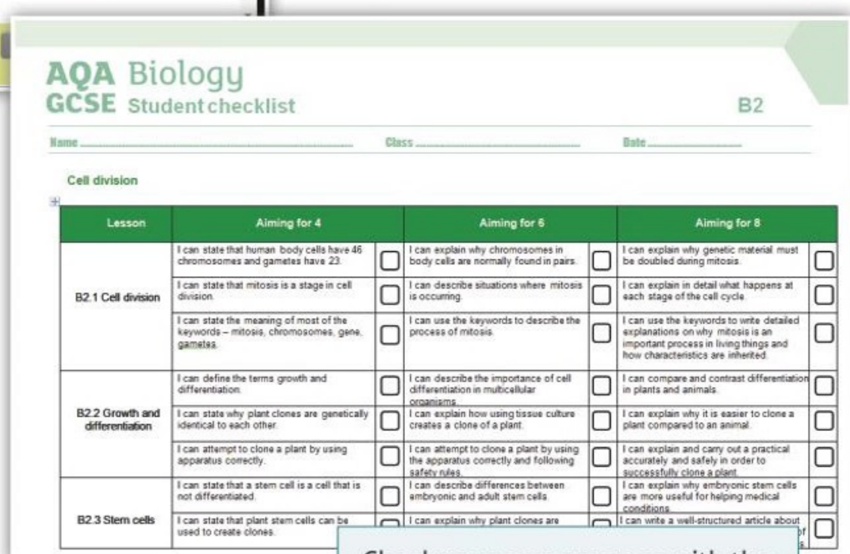
This book is also supported by Kerboodle, offering unrivalled digital support for building your practical, maths and literacy skills.

If your schools subscribes to Kerboodle, you will find a wealth of additional resources to help you with your studies and revision:

- animations, videos, and revision podcasts
- webquests
- maths and literacy skills activities and worksheets
- on your marks activities to help you achieve your best
- practicals and follow-up activities
- interactive quizzes that give question-by-question feedback
- self-assessment checklists



Watch interesting animations on the trickiest topics, and answer questions afterward to check your understanding.


AQA GCSE Biology Student checklist B2

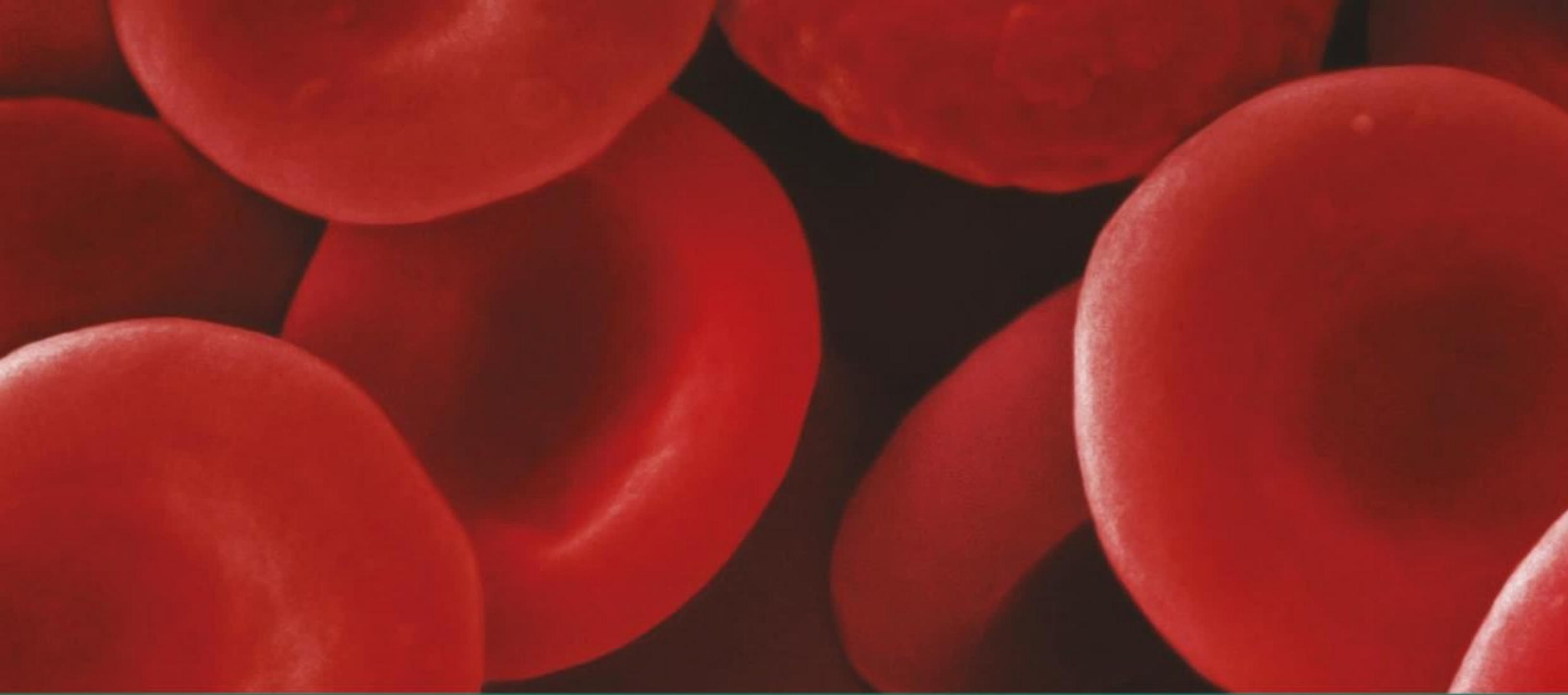
Name .... Class .... Date ....

Cell division

Lesson	Aiming for 4	Aiming for 6	Aiming for 8
B2.1 Cell division	I can state that human body cells have 46 chromosomes and gametes have 23.	I can explain why chromosomes in body cells are normally found in pairs.	I can explain why genetic material must be doubled during mitosis.
	I can state that mitosis is a stage in cell division.	I can describe situations where mitosis is occurring.	I can explain in detail what happens at each stage of the cell cycle.
	I can state the meaning of most of the keywords – mitosis, chromosomes, gene, gametes.	I can use the keywords to describe the process of mitosis.	I can use the keywords to write detailed explanations on why mitosis is an important process in living things and how characteristics are inherited.
B2.2 Growth and differentiation	I can define the terms growth and differentiation.	I can describe the importance of cell differentiation in multicellular organisms.	I can compare and contrast differentiation in plants and animals.
	I can state why plant clones are genetically identical to each other.	I can explain how using tissue culture creates a clone of a plant.	I can explain why it is easier to clone a plant compared to an animal.
	I can attempt to clone a plant by using apparatus correctly.	I can attempt to clone a plant by using the apparatus correctly and following safety rules.	I can explain and carry out a practical accurately and safely in order to successfully clone a plant.
B2.3 Stem cells	I can state that a stem cell is a cell that is not differentiated.	I can describe differences between embryonic and adult stem cells.	I can explain why embryonic stem cells are more useful for helping medical conditions.
	I can state that plant stem cells can be used to create clones.	I can explain why plant clones are	I can write a well-structured article about

Check your own progress with the self-assessment checklists.

If you are a teacher reading this, Kerboodle also has plenty of practical support, assessment resources, answers to the questions in the book, and a digital markbook along with full teacher support for practicals and the worksheets, which include suggestions on how to support and stretch your students. All of the resources that you need are pulled together into ready-to-use lesson presentations.



1 Cells and organisation

Living things range from microscopic organisms, to blue whales that can be 30 metres long, and to giant redwood trees that tower over 100 metres. Big or small, all living things are built up of basic building blocks known as cells. Every cell contains a similar mixture of chemical elements combined to make up the molecules of life.

Some organisms are single cells. Many others, including ourselves, contain billions of individual cells working together. In this section you will learn about the characteristics of these cells, and look at how they are organised so that even the largest organisms can carry out all of the functions of life.

Key questions

- What are the differences between eukaryotic and prokaryotic cells?
- How can stem cells be used in human medicine?
- What factors affect how an enzyme works?
- How can a stent prevent a heart attack?

Making connections

- You will learn how lifestyle factors such as smoking, alcohol, and exercise levels affect the health of your heart, lungs, and other organs in in **B7 Non-communicable diseases**
- You will learn about how eukaryotic and prokaryotic organisms have evolved over time, how they are classified, and how they are still evolving in **B15 Genetics and evolution**.
- You will find out much more about the role of bacteria in animal and plant diseases in **B5 Communicable diseases**, about their importance in genetic engineering and evolution in **B14 Variation and evolution**, and about their importance in decomposition in **B17 Organising an ecosystem**.

I already know...	I will learn...
What cells look like under a light microscope.	What we can see under the electron microscope – and how to calculate magnification.
The similarities and differences between plant and animal cells.	The similarities and differences between prokaryotic and eukaryotic cells and orders of magnitude.
The role of diffusion in the movement of materials in and between cells.	The roles of osmosis and active transport in the movement of materials in and between cells.
Reproduction in animals and plants.	The type of cell division that forms the gametes and the way normal body cells grow and divide
The importance of the digestive system.	The way the structure of enzymes is related to their function.
The basic structure and function of the human gas exchange system.	Surface area: volume ratios and the adaptations of the alveoli of the lungs for effective gas exchange.
The mechanism of breathing.	The importance of ventilating the lungs and the gills of fish to maintain steep concentration gradients.
The role of the leaf stomata in gas exchange in plants.	How evaporation and transpiration are controlled in plants.

Required Practicals

Practical		Topic
1	Looking at cells	B1.2
3	Investigating osmosis in plant cells	B1.8
4	Food tests	B3.3
5	The effect of pH on the rate of reaction of amylase	B3.6

B 1 Cell structure and transport

1.1 The world of the microscope

Learning objectives

After this topic, you should know:

- how microscopy techniques have developed over time
- the differences in magnification and resolution between a light microscope and an electron microscope
- how to calculate the magnification, real size, and image size of a specimen.

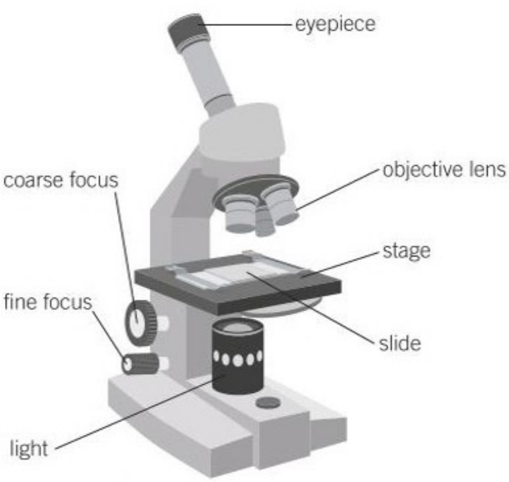


Figure 1 *A light microscope*

Living things are all made up of cells, but most cells are so small you can only see them using a microscope. It is important to grasp the units used for such tiny specimens before you start to look at them.

Using units

1 kilometre (km) = 1000 metres (m)

1 m = 100 centimetres (cm)

1 cm = 10 millimetres (mm)

1 mm = 1000 micrometres (μm)

1 μm = 1000 nanometres (nm) – so a nanometre is 0.000 000 001 metres (or written in standard form as 1×10^{-9} m).

The first light microscopes were developed in the mid-17th century. Their development has continued ever since and they are still widely used to look at cells. Light microscopes use a beam of light to form an image of an object and the best can magnify around 2000 times (×2000), although school microscopes usually only magnify several hundred times. They are relatively cheap, can be used almost anywhere, and can magnify live specimens (Figures 1 and 2).

The invention of the electron microscope in the 1930s allowed biologists to see and understand more about the subcellular structures inside cells. These instruments use a beam of electrons to form an image and can magnify objects up to around 2 000 000 times. Transmission electron microscopes give 2D images with very high magnification and resolution. Scanning electron microscopes give dramatic 3D images but lower magnifications (Figure 3). Electron microscopes are large, very expensive, and have to be kept in special temperature, pressure, and humidity-controlled rooms.

Calculating magnification

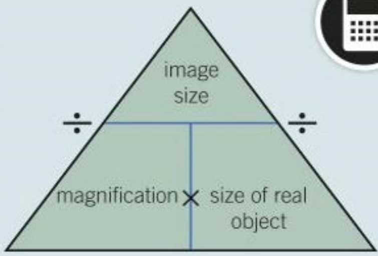
You can calculate the magnification you are using with a light microscope very simply. You multiply the magnification of the eyepiece lens by the magnification of the objective lens. So if your eyepiece lens is ×4 and your objective lens is ×10, your overall magnification is:

$$4 \times 10 = \times 40$$

When you label drawings made using a microscope, make it clear that the magnification you give is the magnification at which you looked at the specimen (eg., as viewed at ×40).

Calculating the size of an object

You will want to calculate the size of objects under the microscope. There is a simple formula for this, based on the magnification triangle.



As long as you know or can measure two of the factors, you can find the third.

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

For example, if you know you are working at magnification ×40, and the image of the cell you are looking at measures 1 mm, you can work out the actual diameter of the cell:

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

so

$$= \frac{1}{40}\,\text{mm} = 0.025\,\text{mm or } 25\,\mu\text{m}$$

Your cell has a diameter of **25 μm**.

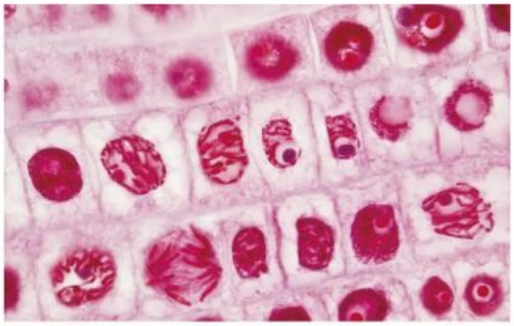


Figure 2 *Onion cells dividing as seen through a light microscope – magnification ×570*

Figure 3 *Chromosomes during cell division seen with a scanning electron microscope – magnification ×4500*

Magnifying and resolving power

Microscopes are useful because they magnify things, making them look bigger. The height of an average person magnified by one of the best light microscopes would look about 3.5 km, and by an electron microscope about 3500 km. There is, however, a minimum distance between two objects when you can see them clearly as two separate things. If they are closer together than this, they appear as one object. Resolution is the ability to distinguish between two separate points and it is the **resolving power** of a microscope that affects how much detail it can show. A light microscope has a resolving power of about 200 nm, a scanning electron microscope of about 10 nm and a transmission electron microscope of about 0.2 nm – that is approximately the distance apart of two atoms in a solid substance!

Synoptic links

You can learn more about writing very small or very large numbers in standard form in the Maths skills section in Topic M1b.

For more information on cell division look at Chapter B2.

Study tip

Make sure you can work out the magnification, the size of a cell, or the size of the image depending on the information you are given.

1 Name one advantage and one disadvantage of using:
a a light microscope [2 marks] **b** an electron microscope. [2 marks]

2 **a** A student measured the diameter of a human capillary on a micrograph. The image measures 5 mm and the student knows the magnification is ×1000. How many micrometres is the diameter of the capillary? [3 marks]
b A student is told the image of the cell has a diameter of 800 μm. The actual cell has a diameter of 20 μm. At what magnification has the cell been observed? [2 marks]

3 Evaluate the use of an electron microscope and a light microscope, giving one example where each type of microscope might be used. [6 marks]

Key points

- Light microscopes magnify up to about ×2000, and have a resolving power of about 200 nm.
- Electron microscopes magnify up to about ×2 000 000, and have a resolving power of around 0.2 nm.
- $\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$

B1.2 Animal and plant cells

Learning objectives

After this topic, you should know:

- the main parts of animal cells
- the similarities and differences between plant and animal cells.

Synoptic link

You will find out more about classifying the living world in Chapter B16.

Go further

The ultrastructure of a cell – the details you can see under an electron microscope – includes structures such as the cytoskeleton, the Golgi apparatus, and the rough and smooth endoplasmic reticulum. They support and move the cell, modify and package proteins and lipids, and produce the chemicals that control the way your body works.

Study tip

Learn the parts of the cells shown on these diagrams, and their functions.

Synoptic link

For more information on photosynthesis, look at Topic B8.1.

The cells that make up your body are typical animal cells. All cells have some features in common. You can see these features clearly in animal cells.

Animal cells – structure and function

The structure and functions of the parts that make up a cell have been made clear by the electron microscope (Figure 1). You will learn more about how their structure relates to their functions as you study more about specific organ systems during your GCSE Biology course. An average animal cell is around 10–30 μm long (so it would take 100 000–300 000 cells to line up along the length of a metre ruler). Human beings are animals so human cells are just like most other animal cells, and you will see exactly the same structures inside them.

- The **nucleus** – controls all the activities of the cell and is surrounded by the nuclear membrane. It contains the genes on the chromosomes that carry the instructions for making the proteins needed to build new cells or new organisms. The average diameter is around 10 μm.
- The **cytoplasm** – a liquid gel in which the organelles are suspended and where most of the chemical reactions needed for life take place.
- The **cell membrane** – controls the passage of substances such as glucose and mineral ions into the cell. It also controls the movement of substances such as urea or hormones out of the cell.
- The **mitochondria** – structures in the cytoplasm where aerobic respiration takes place, releasing energy for the cell. They are very small: 1–2 μm in length and only 0.2–0.7 μm in diameter.
- The **ribosomes** – where protein synthesis takes place, making all the proteins needed in the cell.

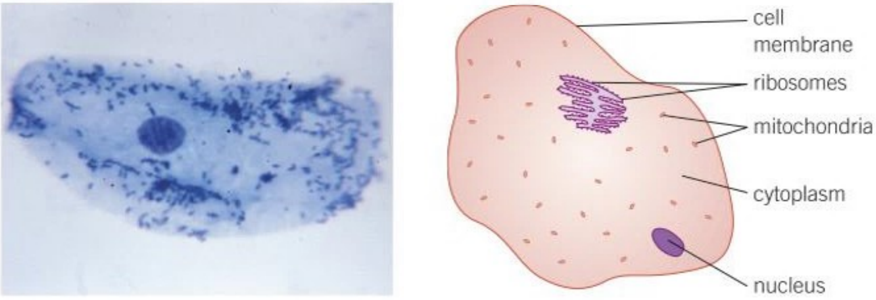


Figure 1 *Diagrams of cells are much easier to understand than the real thing seen under a microscope. This picture shows a simple animal cheek cell magnified ×1350 times under a light microscope. This is the way a model animal cell is drawn to show the main features common to most living cells*

Plant cells – structure and function

Plants are very different organisms from animals. They make their own food by photosynthesis. They do not move their whole bodies about from one place to another. Plant cells are often rather bigger than animal cells – they range from 10 to 100 μm in length.

Plant cells have all the features of a typical animal cell, but they also contain features that are needed for their very different functions (Figures 2 and 3). **Algae** are simple aquatic organisms. They also make their own food by photosynthesis and have many similar features to plant cells. For centuries they were classified as plants, but now they are classified as part of a different kingdom – the protista.

Figure 2 *Algal cells contain a nucleus and chloroplasts so that they can photosynthesise*

All plant and algal cells have a **cell wall** made of **cellulose** that strengthens the cell and gives it support.

Many (but not all) plant cells also have these other features:

- **Chloroplasts** are found in all the green parts of a plant. They are green because they contain the green substance **chlorophyll**. Chlorophyll absorbs light so the plant can make food by photosynthesis. Each chloroplast is around 3–5 μm long. Root cells do not have chloroplasts because they are underground and do not photosynthesise.
- A **permanent vacuole** is a space in the cytoplasm filled with cell sap. This is important for keeping the cells rigid to support the plant.

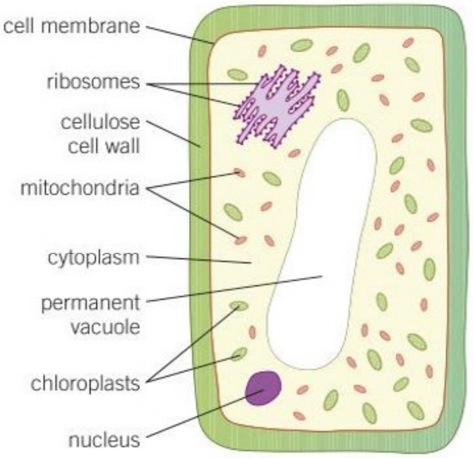


Figure 3 *A plant cell has many features in common with an animal cell, as well as other features that are unique to plants*

1 a Name the main structures you would expect to find in a human cell. [5 marks]

b Name the three extra features that may be found in plant cells but not animal cells. [3 marks]

c Describe the main functions of these three extra structures. [3 marks]

2 Suggest why the nucleus and the mitochondria are so important in all cells. [4 marks]

3 Chloroplasts are found in many plant cells but not all of them. Suggest two types of plant cells that are unlikely to have chloroplasts and in each case explain why they have none. [4 marks]

Looking at cells

Set up a microscope and observe, draw, and label examples of animal cells (e.g., cheek cells, Figure 1), algal cells (e.g., Figure 2) and plant cells (e.g., from onions or *Elodea*). In plant cells you should see the cell wall, the cytoplasm, and sometimes a vacuole. You will see chloroplasts in the *Elodea*, but not in the onion cells because they do not photosynthesise. Always show a scale magnification on your drawings.

Safety: if preparing your own cheek cells, please follow safety procedures.

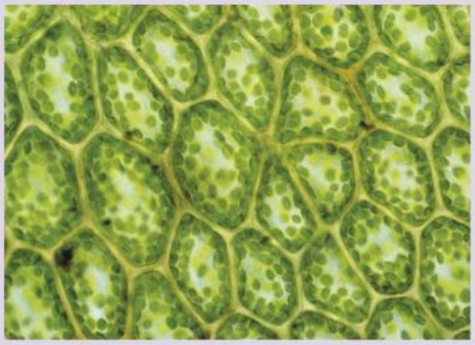


Figure 4 *Some of the common features of plant cells show up well under the light microscope. Here, the features are magnified ×40*

Study tip

Remember that not all plant cells have chloroplasts.

Do not confuse chloroplasts and chlorophyll.

Key points

- Animal cell features common to all cells – a nucleus, cytoplasm, cell membrane, mitochondria, and ribosomes.
- Plant and algal cells contain all the structures seen in animal cells as well as a cellulose cell wall.
- Many plant cells also contain chloroplasts and a permanent vacuole filled with sap.

B1.3 Eukaryotic and prokaryotic cells

Learning objectives

After this topic, you should know:

- the similarities and differences between eukaryotic cells and prokaryotic cells
- how bacteria compare to animal and plant cells
- the size and scale of cells including order of magnitude calculations.

Eukaryotic cells

Animal and plant cells are examples of **eukaryotic cells**. Eukaryotic cells all have a cell membrane, cytoplasm, and genetic material that is enclosed in a nucleus.

The genetic material is a chemical called DNA and this forms structures called chromosomes that are contained within the nucleus. All animals (including human beings), plants, fungi, and protista are eukaryotes.

Prokaryotes

Bacteria are single-celled living organisms. They are examples of prokaryotes. At 0.2–2.0 µm in length prokaryotes are 1–2 orders of magnitude smaller than eukaryotes. You could fit hundreds of thousands of bacteria on to the full stop at the end of this sentence, so you cannot see individual bacteria without a powerful microscope. When you culture bacteria on an agar plate, you grow many millions of bacteria. This enables you to see the bacterial colony with your naked eye.

Synoptic link

You will learn more about growing colonies of bacteria on agar plates in Topic B5.3. You will learn more about bacteria that cause disease in Topic B5.7, and about bacteria that are important in the environment in Topic B17.2 and Topic B17.3.

Bacteria have cytoplasm and a cell membrane surrounded by a cell wall, but the cell wall does not contain the cellulose you see in plant cells. In prokaryotic cells the genetic material is not enclosed in a nucleus. The bacterial chromosome is a single DNA loop found free in the cytoplasm.

Prokaryotic cells may also contain extra small rings of DNA called plasmids. Plasmids code for very specific features such as antibiotic resistance.

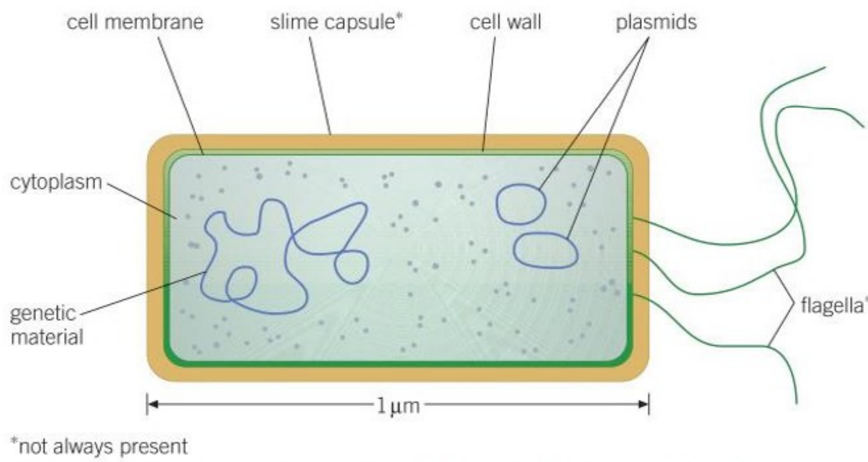


Figure 1 *Bacteria come in a variety of shapes, but they all have the same basic structure*

Go further

The plasmids found in bacteria are used extensively in genetic engineering to carry new genes into the genetic material of other organisms, ranging from bananas to sheep.

Some bacteria have a protective slime capsule around the outside of the cell wall. Some types of bacterium have at least one flagellum (plural: flagella), that is, a long protein strand that lashes about. These bacteria use their flagella to move themselves around.

Many bacteria have little or no effect on other organisms and many are very useful.

Some bacteria are harmful. Bacteria can cause diseases in humans and other animals and also in plants. They can also decompose and destroy stored food.

Relative sizes

In cell biology it is easy to forget just how small everything is – and how much bigger some cells are than others. It is also important to remember just how large the organisms built up from individual cells can be. Figure 2 shows you some relative sizes.

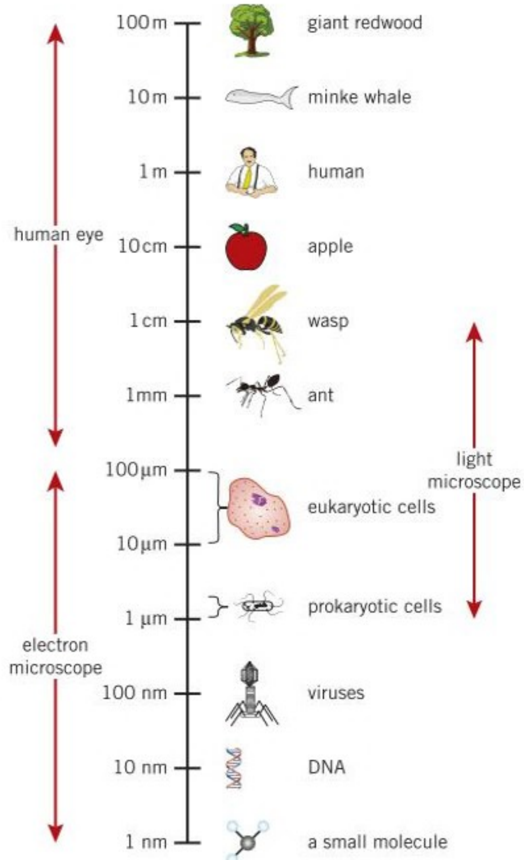


Figure 2 *The relative sizes of different cells and whole organisms and how they can be seen*

Orders of magnitude

Orders of magnitude are used to make approximate comparisons between numbers or objects. If one number is about 10 times bigger than another, it is an order of magnitude bigger. You show orders of magnitude using powers of 10. If one cell or organelle is 10 times bigger than another, it is an order of magnitude bigger or 10^1. If it is approximately 100 times bigger it is two orders of magnitude bigger or 10^2.

If you have two numbers to compare, as a rule of thumb you can work out orders of magnitude as follows:

If the bigger number divided by the smaller number is less than 10, then they are the same order of magnitude.

If the bigger number divided by the smaller number is around 10, then it is 10^1 or an order of magnitude bigger.

If the bigger number divided by the smaller number is around 100, then it is two orders of magnitude or 10^2 bigger.

Example:

A small animal cell has a length of around 10 μm. A large plant cell has a length of around 100 μm.

$$\frac{100}{10} = 10$$

So, a large plant cell is an order of magnitude or 10^1 bigger than a small animal cell.

Study tip

Be clear about the similarities and differences between animal, plant, and bacterial cells and between eukaryotic cells and prokaryotic cells.

1 **a** Describe the difference between the genetic material in a prokaryotic cell and the genetic material in the eukaryotic cell. [2 marks]

b **i** Describe what flagella are. [1 mark]

ii Name one use of flagella in a prokaryote. [1 mark]

2 A cell nucleus has an average length of 6 μm. Calculate the order of magnitude comparison between the nucleus of a cell and:

a a small animal cell [2 marks] **b** a large plant cell. [2 marks]

3 Describe the similarities and differences between the features found in prokaryotic and eukaryotic plant and animal cells. [6 marks]

Key points

- Eukaryotic cells all have a cell membrane, cytoplasm, and genetic material enclosed in a nucleus.
- Prokaryotic cells consist of cytoplasm and a cell membrane surrounded by a cell wall. The genetic material is not in a distinct nucleus. It forms a single DNA loop. Prokaryotes may contain one or more extra small rings of DNA called plasmids.
- Bacteria are all prokaryotes.

B1.4 Specialisation in animal cells

Learning objectives

After this topic, you should know:

- how cells differentiate to form specialised cells
- animal cells may be specialised to carry out a particular function
- how the structure of different types of animal cells relates to their function.

Synoptic links

You can find out much more about the organisation of specialised cells into tissues, organs and organ systems in Topic B3.1 and Topic B3.2.

Synoptic link

You can find out more about specialised nerve cells in Chapter B10.

Observing specialised cells

Try looking at different specialised cells under a microscope.

When you look at a specialised cell, there are two useful questions you can ask yourself:

- How is this cell different in structure from a generalised cell?
- How does the difference in structure help the cell to carry out its function?

Although the smallest living organisms are only single cells, they can carry out all of the functions of life. Most organisms are bigger and are made up of lots of cells. Some of these cells become specialised to carry out particular jobs.

As an organism develops, cells differentiate to form different types of specialised cells. Most types of animal cells differentiate at an early stage of development, whereas many types of plant cells retain the ability to differentiate throughout life. As a cell differentiates, it gets different sub-cellular structures that enable it to carry out a particular function. It has become a specialised cell. Some specialised cells, such as egg and sperm cells, work individually. Others are adapted to work as part of a tissue, an organ, or a whole organism.

Nerve cells

Nerve cells are specialised to carry electrical impulses around the body of an animal (Figure 1). They provide a rapid communication system between the different parts of the body. They have several adaptations including:

- Lots of dendrites to make connections to other nerve cells.
- An axon that carries the nerve impulse from one place to another. They can be very long – the axon of a nerve cell in a blue whale can be up to 25 m long! The longest axon in your body runs from the base of your spine to your big toe.
- The nerve endings or synapses are adapted to pass the impulses to another cell or between a nerve cell and a muscle in the body using special transmitter chemicals. They contain lots of mitochondria to provide the energy needed to make the transmitter chemicals.

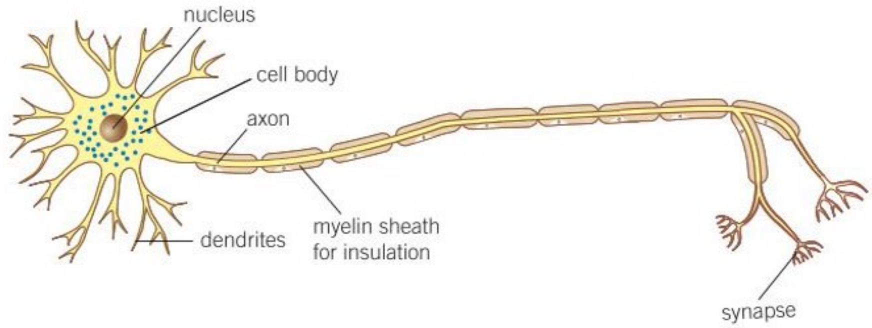


Figure 1 *A nerve cell is specialised to carry electrical impulses from one part of the body to another*

Muscle cells

Muscle cells are specialised cells that can contract and relax. Striated (striped) muscle cells work together in tissues called muscles (Figure 2). Muscles contract and relax in pairs to move the bones of the skeleton, so vertebrates can move on land and in water, and in some cases fly. Smooth muscle cells form one of the layers of tissue in your digestive system and they contract to squeeze the food through your gut.