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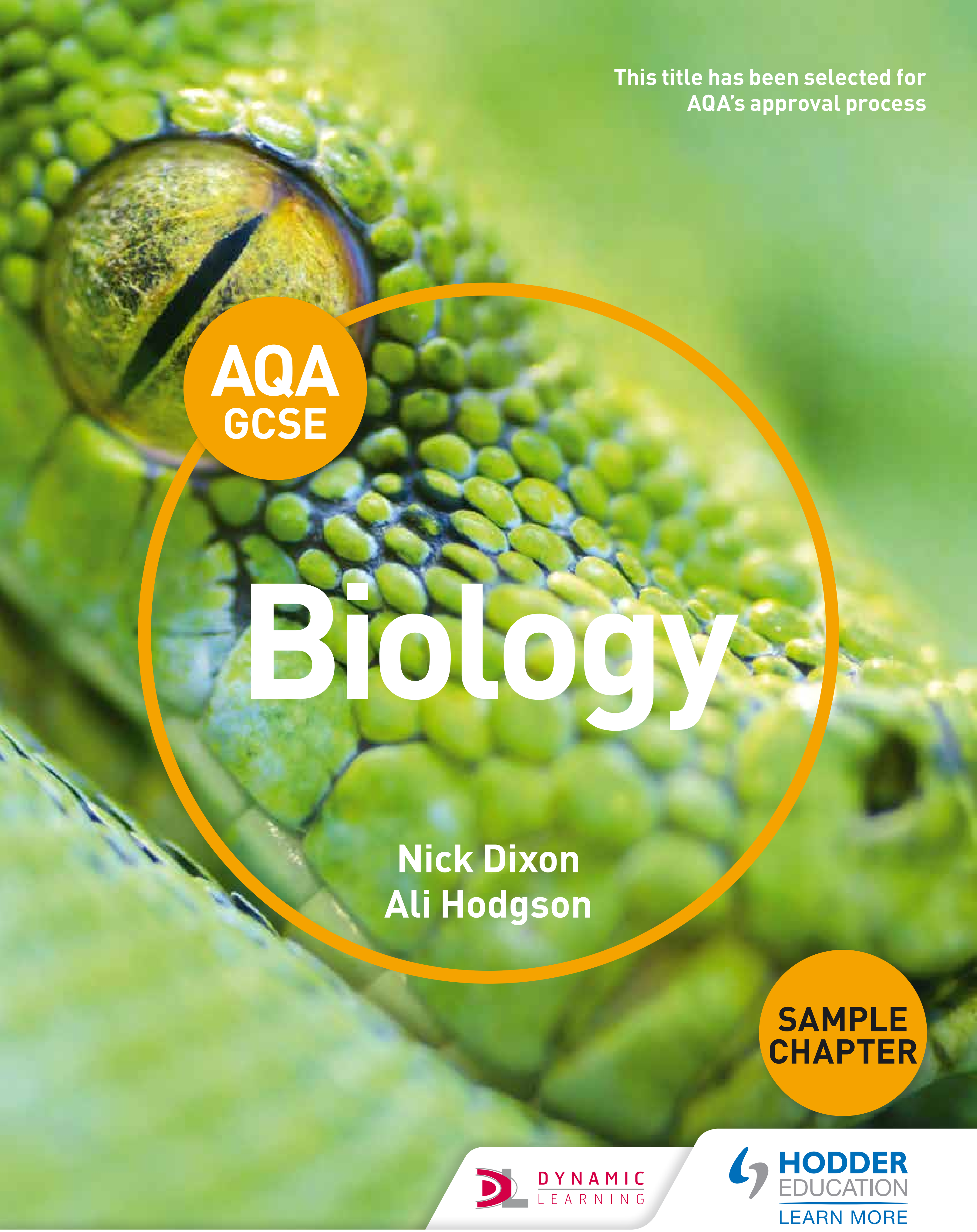

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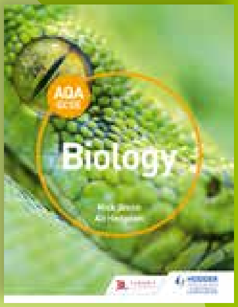

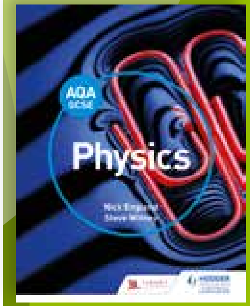

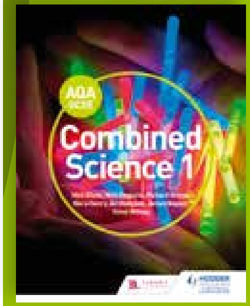

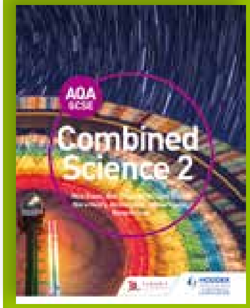

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AQA GCSE

Biology

Nick Dixon
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DYNAMIC LEARNING

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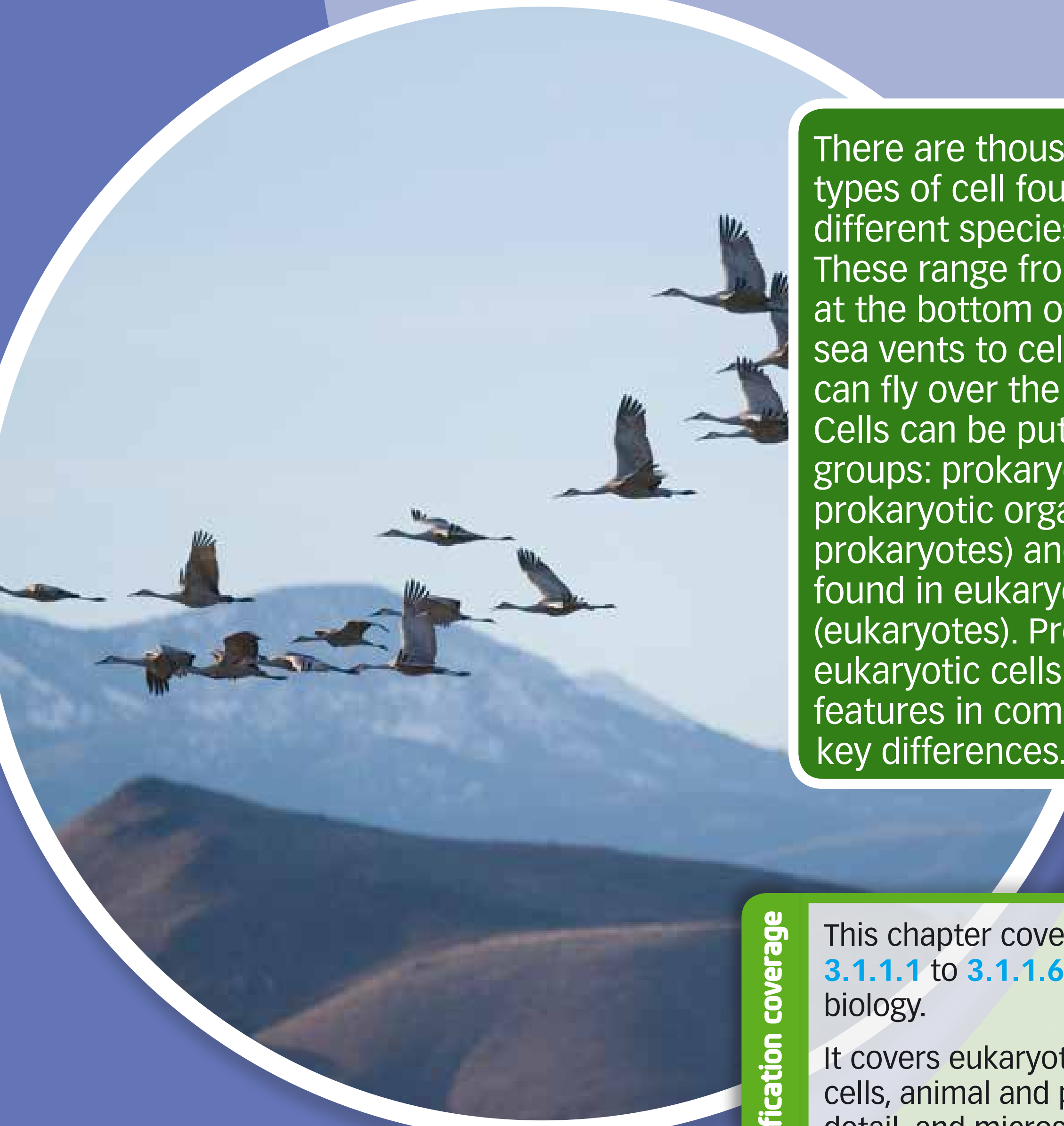
1 Cell biology



There are thousands of different types of cell found in millions of different species of life on Earth. These range from tiny bacteria at the bottom of hydrothermal sea vents to cells in birds that can fly over the Himalayas. Cells can be put into two broad groups: prokaryotic cells found in prokaryotic organisms (also called prokaryotes) and eukaryotic cells found in eukaryotic organisms (eukaryotes). Prokaryotic and eukaryotic cells have many features in common but also some key differences.

Specification coverage

This chapter covers specification points 3.1.1.1 to 3.1.1.6 and is called Cell biology.

It covers eukaryotic and prokaryotic cells, animal and plant cells in more detail, and microscopy.

Prior knowledge

Previously you could have learned:

- that cells are the fundamental unit of living organisms
- about the functions of some cell components
- about the similarities and differences between plant and animal cells
- about the structural adaptations of some unicellular organisms
- about the organisation of multicellular organisms: from cells to tissues, organs, systems and organisms.

Test yourself on prior knowledge

1. State the purpose of plant cell walls.
2. Describe a difference between plant and animal cells.
3. Explain the importance of plant leaves being green.
4. Put the following into size order starting with the largest:
   - tissues
   - cells
   - organ systems
   - organs.

Eukaryotes and prokaryotes

Eukaryotes

KEY TERMS

Eukaryotic cells Cells that contain a nucleus.

Eukaryote An organism that is made of eukaryotic cells (those that contain a nucleus).

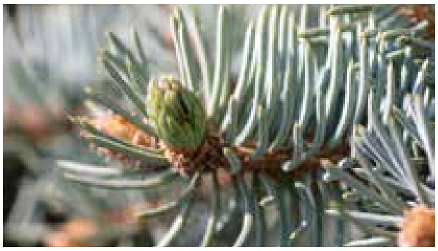
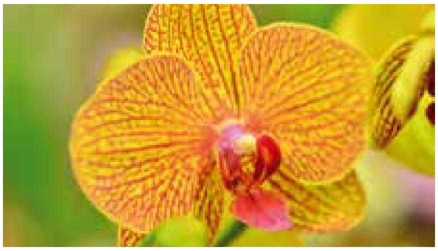
All animal and plant cells are **eukaryotic**, which makes all plants and animals **eukaryotes**. Figure 1.1 shows examples of the huge diversity we can see in eukaryotic life on Earth.

You can see from Figure 1.1 that many eukaryotic cells belong to more complex organisms. Often such organisms are made from more than one cell and so we call them multicellular. It is difficult to determine when eukaryotic cells first appeared on Earth, but many scientists think that it happened about two billion years ago. We are still not sure how exactly eukaryotic cells first appeared on Earth.

▼ **Figure 1.1** A range of different eukaryotic organisms.





KEY TERMS

Prokaryotic cells Cells that do not contain a nucleus (bacterial cells).

Prokaryote A prokaryotic organism (a bacterial cell).

TIP

It is important that you develop a sense of scale and know which type of cell is largest.

▲ **Figure 1.2** Colonies of different prokaryotic cells. There are thousands of individual bacteria in each colony.

Prokaryotes

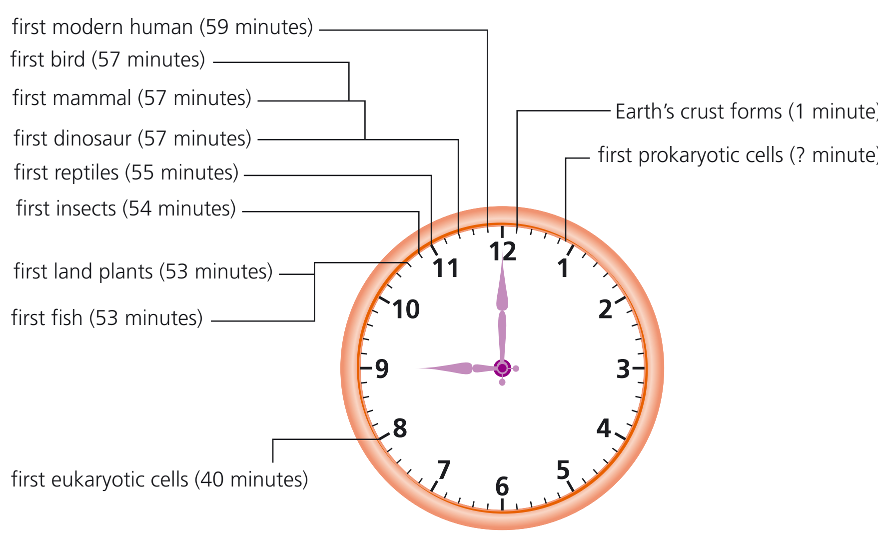
All bacterial cells are **prokaryotic**, which means that all bacteria are **prokaryotes**. Evolutionary evidence suggests that prokaryotes evolved much earlier than eukaryotic cells.

Prokaryotes:

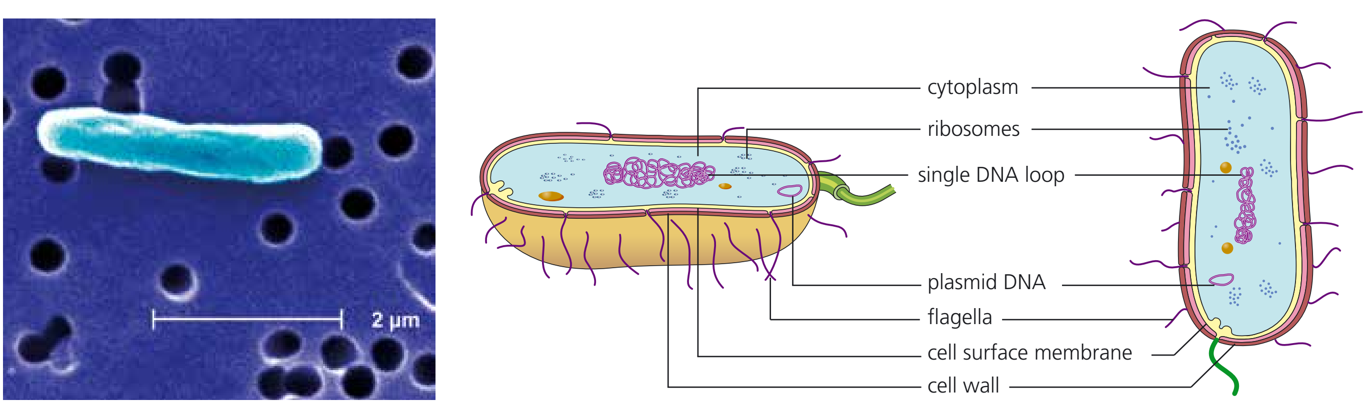
- are single celled
- do not have a nucleus containing their genetic material (DNA)
- are smaller than eukaryotic cells.

Individual bacterial cells are usually between 1 µm and 10 µm in length. One thousand micrometres (µm) make up one millimetre (mm). This means that between 100 and 1000 bacteria will fit in a straight line in 1 mm. Groups of bacterial cells, called colonies, are shown in Figure 1.2. Many, but not all, scientists think that prokaryotes evolved before eukaryotes and so are missing some cell components that eukaryotic cells possess. These scientists think that prokaryotes first appeared about 3.5 billion years ago, which is only one billion years after the Earth's crust formed.

If the last 4.6 billion years were scaled down into an hour, Figure 1.3 shows when the first prokaryotic and eukaryotic organisms are likely to have evolved. Humans have actually only been present for the last few seconds of the last minute, so not long at all!



► **Figure 1.3** The 4.6 billion years since the Earth was created shown as minutes in an hour.



▲ **Figure 1.4** A bacterial cell as seen with a microscope (magnified ×20 000) and as three- and two-dimensional diagrams.

TIP

Copy out the table headings in the first row and column and test yourself by filling in the rest of the table from memory. This will help you remember the processes.

KEY TERMS

Chromosome An arrangement of DNA into an 'X' shape, found in the nucleus of eukaryotic cells.

Mitochondrion A small cell organelle, in which respiration occurs, found in the cytoplasm of eukaryotic cells.

Respiration The release of energy from glucose.

TIP

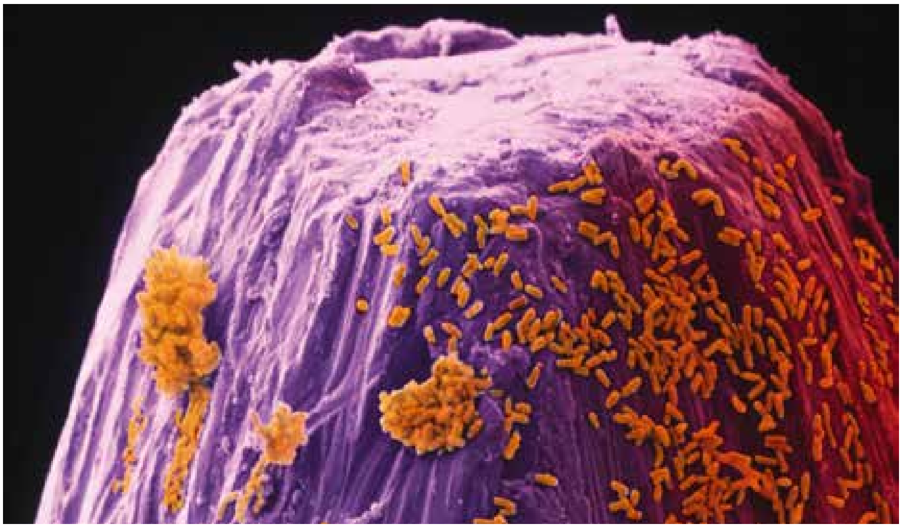
It is important that you can explain what a chromosome is.

A typical bacterial cell is shown in Figure 1.4. The functions of bacterial cell components are shown in Table 1.1.

Table 1.1 The components of bacterial cells and their functions.

Component	Structure and function
Cytoplasm	This fluid is found in all cells. It is mainly water and it holds other components such as ribosomes. Here most of the chemical reactions in the cell happen (such as the making of proteins in ribosomes).
Cell wall	Like those of plants and fungi, bacterial cells have a cell wall to provide support. However, unlike plant cell walls this is not made of cellulose. The cell membrane is found on the inside surface of the cell wall.
Single DNA loop (not in chromosomes)	DNA in prokaryotes is not arranged in complex **chromosomes** like in eukaryotic cells. It is not held within a nucleus.
Plasmid DNA	These are small, circular sections of DNA that can move from one cell to another. They provide genetic variation for bacteria.
Flagellum	This is a whip-like structure that helps many prokaryotes to move by rotating or flicking (like a whip).
Cell-surface membrane	This controls what substances go in and out of a cell. It also has internal extensions that have enzymes attached to them. **Respiration** occurs in these enzymes. Prokaryotic cells do not have **mitochondria**, which is where respiration occurs in eukaryotic cells.
Ribosome	Proteins are made from amino acids in ribosomes, which are present in the cytoplasm.

Figure 1.5 shows how small bacterial cells are. Typical eukaryotic cells are much larger than this. Almost all eukaryotic cells are microscopic, though. This means you can't see a single cell without using a microscope.



▲ **Figure 1.5** Prokaryotic bacterial cells seen on a pinhead.

Show you can...

Explain why some scientists think that prokaryotic cells evolved first.

Test yourself

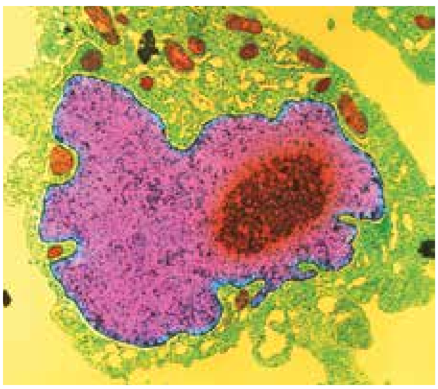
1 State the type of DNA structure only present in prokaryotes.
2 State which organisms have a single loop of DNA.
3 Describe the main difference between eukaryotic and prokaryotic cells.
4 Describe the function of ribosomes.

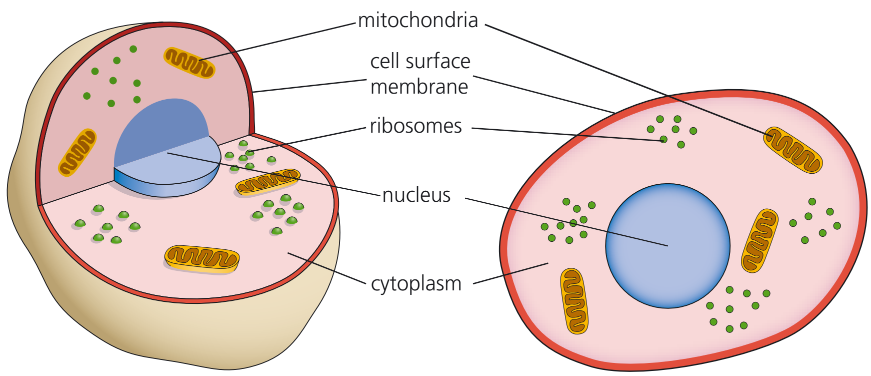
Animal and plant cells

Generalised animal cells

Plant and animal cells are eukaryotic. They can be unicellular or belong to multicellular organisms. Eukaryotic cells almost always have a nucleus and are generally larger than prokaryotic (bacterial) cells.

The structure of a generalised animal cell is shown in Figure 1.6. A generalised cell is one that has been simplified to make the key components easier to identify.





▲ **Figure 1.6** A generalised animal cell as seen with a microscope (magnified ×4800) and as three- and two-dimensional diagrams.

Components of animal cells

In the previous section we looked at bacterial cells. Animal cells have many components in common with these. The cytoplasm of animal cells is also mainly water and it holds other components such as ribosomes. In the cytoplasm most of the chemical reactions in the cell happen (such as the making of proteins in ribosomes).

The cell-surface membrane of animal cells also surrounds the cell. There are no cell walls in animal cells and so the membrane is on the outside of these cells. The membrane controls what substances go in and out of the cell. Many cells need glucose and oxygen for respiration, and these substances move by **diffusion** into the cell from the blood, where it is found at a higher concentration. Carbon dioxide moves back into the blood capillaries through the membrane.

KEY TERM

Diffusion The net movement of particles from an area of high concentration to an area of lower concentration.

Mitochondria are small organelles found in the cytoplasm and are only present in eukaryotic cells. They are the site of most of a cell's respiration. Here the energy stored in glucose is released for the cell to complete the seven life processes. Without this energy all cells die. More-active cells such as those in muscles or sperm cells usually have more mitochondria because these cells need more energy. Mitochondria have many folds inside them, which make their surface area very large to increase the rate at which energy is released.

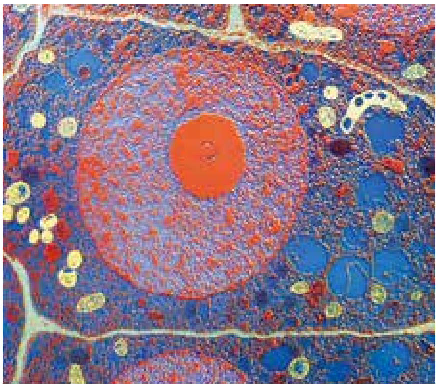
Ribosomes are the site of protein synthesis. These organelles are present in the cytoplasm of animal cells.

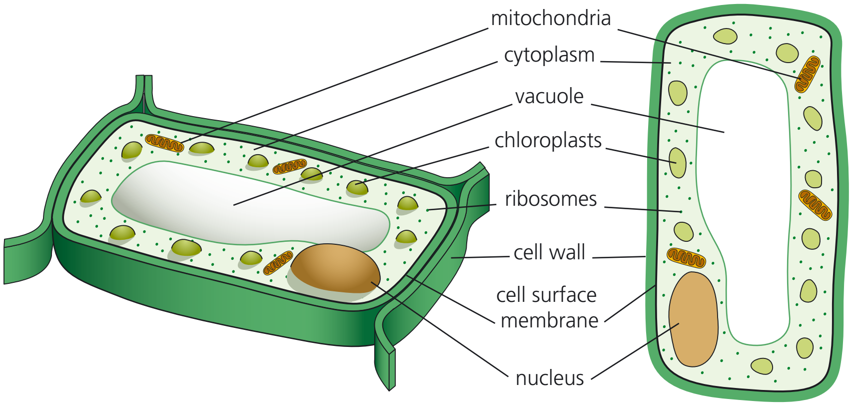
Animal cells are unlike bacterial cells in that they usually possess a nucleus. This component is present in almost all eukaryotic cells. It is found in the cytoplasm and is surrounded by its own membrane. The cell's genetic material (DNA) is enclosed within it, arranged into shapes called chromosomes. (Red blood cells do not have a nucleus, so they have more room to absorb and carry the maximum amount of oxygen, which is their main function.)

Humans are of course classified as animals. Many of our cells are like other animal cells.

Generalised plant cells

Like those belonging to animals, plant cells are eukaryotic. This means that they may belong to single-celled or multicellular organisms, they do have a nucleus and they are generally larger than prokaryotic (bacterial) cells.





▲ **Figure 1.7** A generalised plant cell as seen with a microscope (magnified ×2800) and as three- and two-dimensional diagrams.

Components of plant cells

Plant cells have many components in common with animal cells, including a nucleus in which the organism's genetic material (DNA) is found. Plant cells also possess ribosomes for protein synthesis and mitochondria for respiration in their cytoplasm.

KEY TERM

Photosynthesis An endothermic reaction that occurs in the chloroplasts of plants and algae and stores energy in glucose.

Plant cells possess some components not present in animal cells. Chloroplasts are small components, full of a green pigment called chlorophyll which is necessary for **photosynthesis** to occur. This reaction uses light energy from the Sun to convert carbon dioxide and water into glucose and oxygen and so provides an energy source for the plant. It is the green chlorophyll in plants that gives some of their parts their green colour. Most roots are hidden from the Sun and so cannot photosynthesise. They do not have chloroplasts and so are often white, not green.

There are huge numbers of chloroplasts in leaf cells. There are often well over half a million per square millimetre of leaf.

▲ **Figure 1.8** The structure of a chloroplast (magnification about ×15 000).

Plant cells also possess a cell wall, unlike animal cells. This is made from cellulose and provides structure for the cell. Plants would not be able to stand upright to catch light energy from the Sun without cell walls. The cell surface membrane is found inside the cell wall.

KEY TERM

Turgid Used to describe swollen cells.

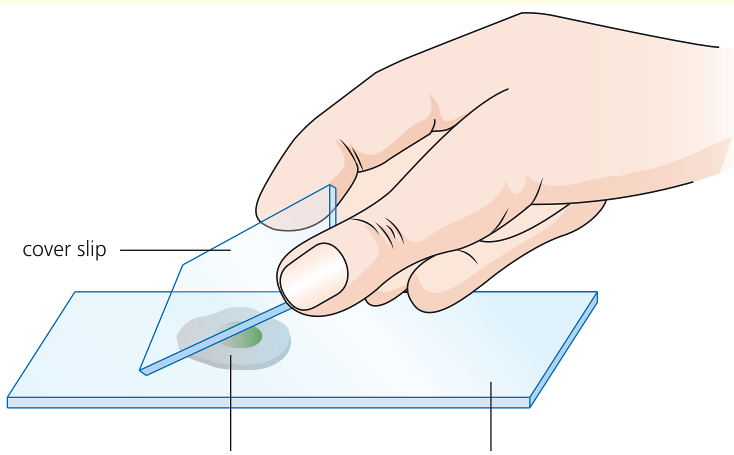
Many plant cells also possess a permanent vacuole. This is filled with water in which dissolved sugars and mineral ions are found. The vacuole helps by pressing the cytoplasm against the wall to keep the cell **turgid**.

Practical

Observing cells

Method

1 Use tweezers to remove the thin sheet of cells (epidermis tissue) from the inner part of an onion layer.
2 Place this flat on a microscope slide, being careful not to fold it.
3 Place a drop of iodine onto the onion tissue.
4 Carefully lower a cover slip on top of the tissue, ensuring no air bubbles form (Figure 1.9).
5 Place on a microscope stage and observe using the lowest power objective lens.
6 Focus in on the image, and then increase the magnification until you can clearly observe the onion cell's structure.
7 Draw a diagram of what you observe, labelling any structures you recognise. Ensure you record the magnification at which you have made your observation.
8 Repeat this process using a leaf from a piece of pond weed (*Elodea*), and add a drop of water rather than iodine.



▲ **Figure 1.9** How to make a light microscope slide.

Questions

1 Describe the similarities and differences between the onion cells and the pond weed cells you observed.
2 Explain why no chloroplasts were found in the onion cells.
3 Name two organelles that you would not have observed if you had examined animal cells instead.

TIP

It is important that you can explain how the main components of animal and plant cells are linked to their structure.

Test yourself

5 State two structures present only in plant cells.
6 State in which type of cell you would find mitochondria.
7 Describe the function of the cytoplasm.
8 Describe the function of mitochondria.

Show you can...

Explain why sperm cells contain a large number of mitochondria.

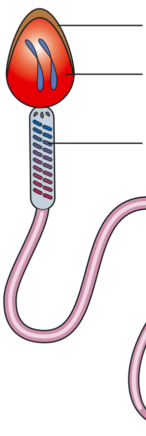
Cell specialisation

KEY TERM

Biconcave Used to describe a shape with a dip that curves inwards on both sides.

TIP

If you are asked to explain how a cell is adapted to its function, don't forget to use a connecting phrase like 'so that it can' or 'to allow it to'.



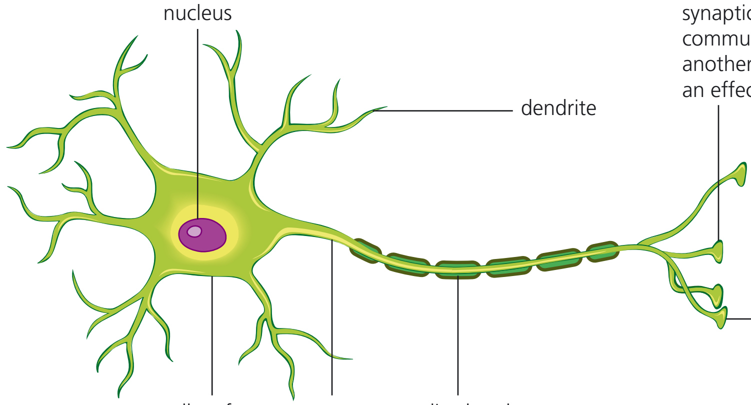
▲ **Figure 1.10** The parts of a sperm cell.

The previous section looked at generalised animal and plant cells. Eukaryotic organisms, like us, are not usually made of generalised cells. We have developed specialised cells that have adaptations to allow them to complete specific functions. Red blood cells, for example, have a **biconcave** shape (which dips in the middle on both sides) and no nucleus to maximise their surface area to absorb more oxygen. Key specialised cells for animals and plants, together with their adaptations, are listed below.

Sperm cell

In humans, during a male orgasm about a teaspoon of semen is ejaculated. Within this are tens of millions of sperm cells, which must swim through the cervix and uterus to the fallopian tubes. Here one cell may fertilise an egg cell (ovum). Sperm cells have a tail to propel them towards the ovum (Figure 1.10). They have a relatively large number of mitochondria to release the energy from glucose during respiration. This is needed to keep them swimming. The nucleus of a human sperm contains the genetic material (DNA) of the father. This will make up half of the DNA of the baby. At the front of a sperm is an acrosome. This contains digestive enzymes, which break down the outer layer of the ovum, allowing the sperm to enter and fertilise it.

Nerve cell



▲ **Figure 1.11** The parts of a nerve cell.

Our nervous system controls and coordinates all our actions. These can be either voluntary actions (like picking up the television remote control) or involuntary actions (like our heart beating faster when we exercise). There are two main parts to our nervous system. The first is our central nervous system (CNS), which is made up of our brain and spinal cord. The other is our peripheral nervous system (PNS), which is all the other nerve cells that connect to the CNS but then spread out across the body. To control our actions, signals must be sent and received. These signals are electrical impulses that travel along nerve cells.

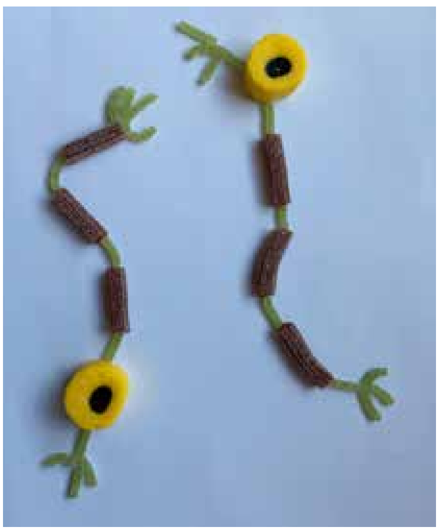
KEY TERMS

Axon The extension of a nerve cell along which electrical impulses travel.

Myelin sheath The insulating cover along an axon, which speeds up the electrical impulse.

TIP

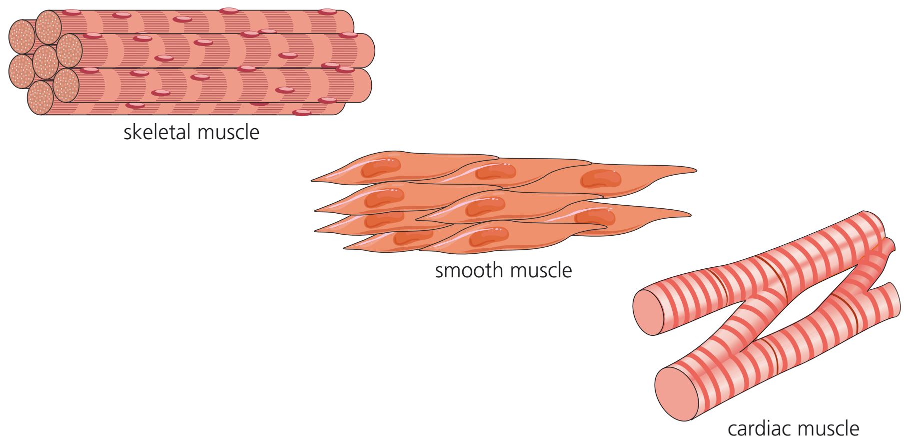
Make a model of a bacterial, plant or animal cell and label it with the cell components and their functions to help you remember them (Figure 1.12).



▲ **Figure 1.12** A model of a eukaryotic cell made from sweets.

To keep these signals moving quickly, some of our nerve cells are the longest cells in our body. Their long extensions are called **axons** and these have a **myelin sheath** surrounding much of their length (Figure 1.11). This acts like the plastic coating on an electrical wire and insulates the electrical impulse. The cell body of the nerve also has smaller extensions called dendrites, which allow it to pick up signals from neighbouring cells.

Muscle cell



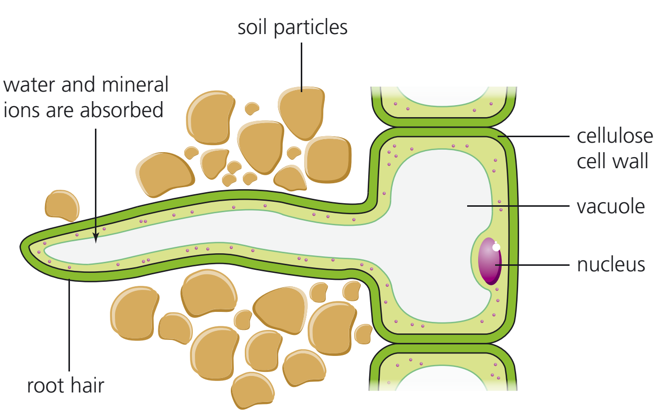
▲ **Figure 1.13** The three types of muscle.

There are three types of muscle in our bodies, all of which can contract and relax. Smooth muscle contracts and relaxes automatically and is found in places such as the linings of the vessels that make up our circulatory system and the iris of our eyes. Cardiac muscle also contracts and relaxes automatically and is found in our heart. The third type is skeletal muscle, which is usually found attached to our bones. We control the contractions of this type of muscle, so its movements are not automatic.

All three types of muscle are made from muscle cells (Figure 1.13). These are long thin cells full of mitochondria. In the mitochondria the energy from glucose is released during respiration. This energy allows the muscle to keep on contracting.

Root hair cell

Root hair cells have a small thin extension, which pokes out into the soil (Figure 1.14). Many plants have such high numbers of long root hairs that they can look like a spider's web. The purpose of these hairs is to increase the surface area of the root that is in contact with the soil. This allows the plant to absorb more water and minerals from the soil. A single rye plant has billions of root hairs, which have a total length of hundreds of miles. Without these it is likely that the adult plant would not be able to absorb enough water to survive.



◀ **Figure 1.14** The parts of a root hair cell.

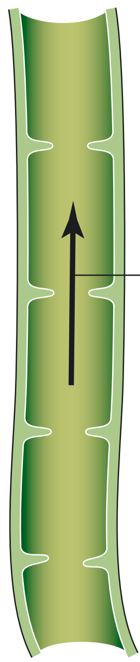
KEY TERMS

Xylem Dead plant cells joined together into long tubes through which water flows during transpiration.

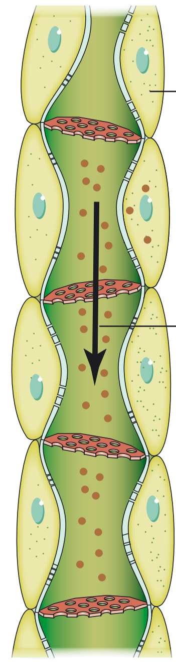
Transpiration The gradual release of water vapour from leaves to continue the 'pull' of water up to them from the soil.

Xylem cell

Xylem cells form long tubes running along the stem or trunk of plants. They are strengthened by lignin fibres. They carry water and some dissolved minerals from the roots upwards to other parts of the plant. This water evaporates and is lost from leaves as water vapour during the continual process of **transpiration**. It is also used in the green parts of plants for photosynthesis during the day. Xylem tubes are made from lots of individual cells that have died. The ends of these cells erode away, leaving long tubes through which water is naturally drawn upwards (Figure 1.15). They have reinforced cell walls to support the weight of the plant.



▲ **Figure 1.15** The parts of a xylem tube.



▲ **Figure 1.16** The parts of a phloem tube.

KEY TERMS

Phloem Living cells that carry sugars made in photosynthesis to all cells of a plant.

Translocation The movement of sugars made in photosynthesis from the leaves of plants.

Organelle A part of a cell with a specific function.

Phloem cell

Phloem cells carry the glucose (as sucrose) made in photosynthesis from the leaves of a plant to all other parts of the plant in cell sap. This process is called **translocation**. The sugar is used immediately in respiration to release energy for the plant or is stored as starch in cells or particularly in structures such as the roots of vegetables. Unlike xylem, phloem cells are living. They have fewer cell **organelles** than many other types of cell, which allows the sugar to travel easily. Connecting adjacent phloem cells are sieve plates. These have small holes to speed up translocation (Figure 1.16).

Phloem cells are arranged with xylem cells to form bundles. These make up the veins you can see in a leaf (Figure 1.17).

◀ **Figure 1.17** The veins of a leaf are made from xylem tubes transporting water to the leaf and phloem tubes transporting sugars away from it.

Cell differentiation

The previous two sections have looked at generalised and specialised animal and plant cells. After generalised cells are formed they become specialised as an organism develops. This process is called cell differentiation. Your cells did this while you were in your mother's uterus. Part of this process involves cells developing specific structures within them to allow them to function. For example, muscle cells need to release lots of energy during respiration and so require a high number of mitochondria. Unlike animal cells, most plant cells retain the ability to differentiate throughout their life. We would not be able to take plant cuttings without this. You will learn about this in Chapter 14.

Show you can...

Explain why animals and plants have specialised cells.

Test yourself

9 State the function of nerve cells.
10 State the components that are present in nerve cells.
11 Describe how red blood cells are adapted for their function.
12 Describe how root hair cells are adapted for their function.

Microscopy

It is not very easy to know who invented the first microscope or exactly when this happened. It is likely to have occurred in the 1590s in the Netherlands by makers of eye glasses. Seventy-five years later, in 1665, English scientist Robert Hooke published a book called *Micrographia*, which was full of impressive images including a drawing of the eyes of a fly using a microscope. In this book he first used the word 'cell', because when he looked at plant cells using his microscope he was reminded of the cells in a honeycomb.

A decade later, in the mid-1670s, a Dutch scientist called van Leeuwenhoek discovered sperm cells and then single-celled bacteria from a human mouth. This was a tremendously important development in science, because before this no one had ever seen a single-celled organism. Imagine not knowing that bacteria and single-celled fungi existed!

TIP

Use the course focus at low magnification first to find your sample easily. Then increase the magnification lens by lens. Finally use the fine focus to make your image as sharp as possible.

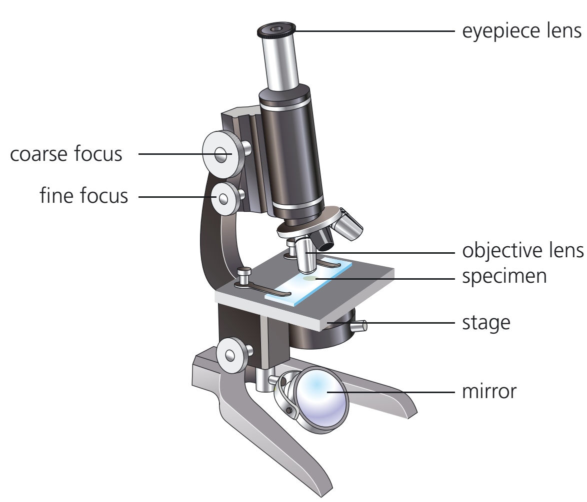


Figure 1.18 A labelled diagram of a light microscope.

The microscopes used by Robert Hooke and van Leeuwenhoek looked very different from those that you may use in your science lessons today. But the thing they have in common is that they all use magnifying lenses to enlarge images.

Light microscopes

The parts of a light microscope and their functions are shown in Table 1.2.

TIP

Copy out the table headings in the first row and column and test yourself by filling in the rest of the table from memory. This will help you remember the processes.

Table 1.2 The functions of the parts of a light microscope.

Part	Function
Eyepiece lens	You will look through this lens to see your sample. This is often ×10.
Objective lens	Usually there are three to choose from (often ×5, ×10 and ×25). The smallest will be the easiest to focus, so select this first. When you have focused this lens try a different one with a greater magnification.
Stage	This holds the sample securely, often using two metal clips.
Specimen	This is usually placed in a drop of water or stain on a microscope slide under a very thin glass cover slip.
Mirror	This reflects the light up through the sample, and then the objective and eyepiece lenses into your eyes.
Course focus	This quickly and easily moves the stage up and down to focus on the sample.
Fine focus	This sensitively and slowly moves the stage up and down to allow you to make your image very sharp.

The total magnification of the image you are looking at is calculated by:

$$\text{total magnification} = \frac{\text{magnification of}}{\text{eyepiece lens}} \times \frac{\text{magnification of}}{\text{objective lens}}$$

Electron microscopes

KEY TERMS

Electron microscope A microscope that uses electron beams in place of light to give higher magnifications.

Electron Negatively charged, tiny subatomic particle that is found in shells surrounding the nucleus of an atom.

Electron microscopes use **electrons** in place of rays of light to make an image (Figure 1.19). The wavelength of electrons can be up to 100 000 times smaller than that of visible light. This means that electron microscopes can take images at significantly higher magnifications. The first electron microscope was made by German scientists Ernst Ruska (1906–1988) and Max Knoll (1897–1969) in 1931. This was a transmission electron microscope (TEM). Several years later, in 1937, German scientist Manfred von Ardenne (1907–1997) invented a second type called a scanning electron microscope (SEM).

▶ **Figure 1.19** A large modern electron microscope.

Transmission electron microscopes fire a large beam of electrons though a very thin slice of the specimen. All electrons are fired at the same time. Not all of the electrons pass though the specimen. The image is made from only those electrons that do.

Scanning electron microscopes also use a beam of electrons. This beam is much smaller and scans across the whole image but not all at the same time. Electrons scatter from the surface of the sample and are detected to make an image.

As a consequence of their different methods of working, the images that these two microscopes take are very different from each other. Images from transmission electron microscopes are flat and are usually taken in cross-section through a specimen. That is, they are frequently used to look at a section through a cell. Scanning electron microscopes don't need thin samples so can be used to take images that look more three-dimensional. All electron microscope images are black and white. On occasions scientists colour these images to make them look more striking (Figure 1.20).

KEY TERM

Resolution The smallest distance between two separate points.

The **resolution** of microscopes is defined as the shortest distance between two parts of a specimen that can be seen as two distinctly separate points. As a result of the wavelength of light the maximum resolution of light microscopes is 200 nm. (There are one million nanometres (nm) in a millimetre.) The wavelength of electrons is shorter than that of light, and so much closer points can be resolved. An electron microscope can resolve points up to 2000 times closer than a light microscope, at a separation of just 0.1 nm.

▲ **Figure 1.20** (a) A three-dimensional image of an ant's head taken with a scanning electron microscope. (b) A two-dimensional image of a mitochondrion taken using a transmission electron microscope.

Show you can...

Explain why scanning electron microscopes can take images that look three-dimensional.

Test yourself

13 State the range of magnification you might see in a light microscope.
14 State the resolution of an electron microscope.
15 Describe why electron microscopes have greater magnification.
16 Describe a disadvantage of using an electron microscope.

Chapter review questions

1 State two organelles that are only present in prokaryotic cells.

2 State the substances present in a plant cell vacuole.

3 State what substances move into leaf cells.

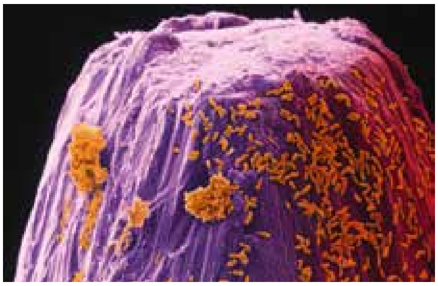
4 Explain why plant cells are often green.

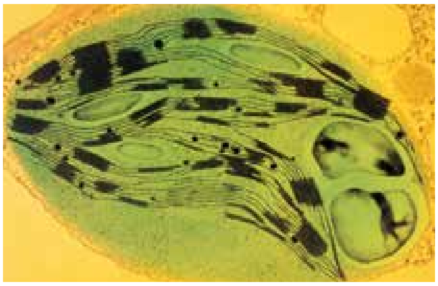
5 Describe how the structure of sperm cells helps their function.

6 State the three types of muscle tissue.

7 Describe how you would make a microscope slide to look at an onion cell.

8 Describe the function of flagella.





9 a) These two images were taken using which types of microscope. Be specific in your answer.

b) Suggest one advantage and one disadvantage of using an electron microscope.

10 Describe the differences between prokaryotic and eukaryotic cells.

11 State the function of cytoplasm and what it is made from.

12 State the function of ribosomes.

13 Describe the differences between plant and animal cells.

14 State the function of a vacuole and in which organism's cells it is often found.

15 Describe how a nerve cell is adapted for its function.

16 Describe how the structure of red blood cells helps their function.

17 Describe what the term 'resolution' means.

18 a) Name the two types of cell can you see in this photo.

b) Use the scale to estimate the length of this sperm cell.

c) Explain why the small cell might have relatively more mitochondria than the large cell.

19 Explain why some cells have more mitochondria than other cells.

20 Define the term 'turgid'.

21 Explain which substances move out of animal cells.

22 Explain how xylem cells are adapted for their function.

23 Explain how many scientists think that prokaryotic and eukaryotic cells first evolved. Explain why in your answer.

24 a) This cell has a total length of 1.3 mm. By how much has it been magnified?

b) Explain how this cell is adapted.

Practice questions

1 Orchids are often found growing high up on other plants. They are unusual plants in that they often have green roots.

a) Choose the name of the chemical substance that makes parts of plants green:

A chloroplast

B chlorophyll

C mitochondria

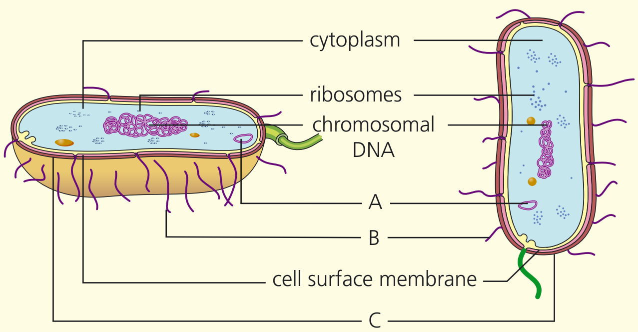
D ribosome. [1 mark]

b) Suggest why orchids grow on other plants. [1 mark]

c) Explain why some orchids have green roots. [3 marks]

d) Explain how root hair cells are adapted for their function. [3 marks]

2 Life exists on Earth as single-celled or multicellular organisms. Bacteria are single-celled organisms that grow in many places.



a) Complete the labels on the diagram of a bacterial cell. [3 marks]

b) Which of the following cell comp onents is not found in prokaryotic organisms?

A cell wall

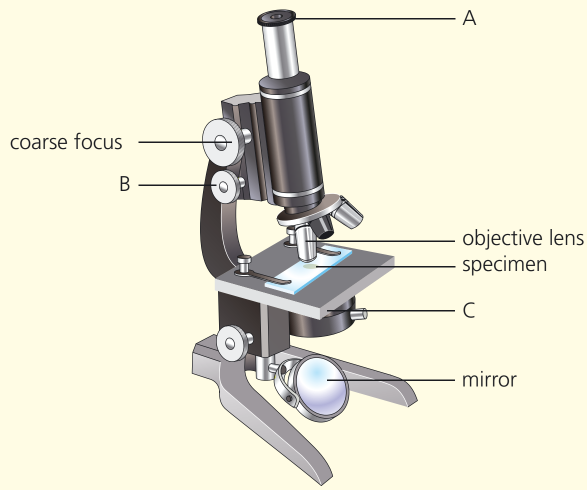
B DNA

C nucleus

D mitochondria [1 mark]

c) State what process keeps bacteria alive. [1 mark]

3 Microscopes have been around since the end of the 16th century. Their invention allowed us to see single-celled organisms for the first time and also understand that multicellular organisms are made from single cells.



a) Complete the labels on the parts of the diagram of a light microscope. [3 marks]

b) Choose the part of the microscope that light first passes through:

A fine focus

B objective lens

C eyepiece lens

D slide. [1 mark]

c) State how the total magnification of a light microscope is calculated. [1 mark]

d) Describe the differences between a light microscope and an electron microscope. [4 marks]

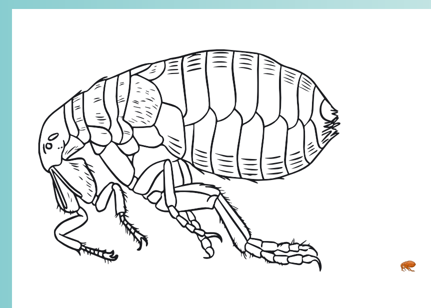
Working scientifically: Data skills

Microscopy and magnification

It is important that you can carry out calculations involving magnifications, real size and image size.

Magnification is a measure of how many times an object has been enlarged. If a sesame seed is actually 3 mm long, but in a diagram has been drawn to be 3 cm long, then it has been magnified 10 times. You can work out magnification using the formula:

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



For example, this drawing of a flea is 40 mm long but the actual flea is 2 mm.

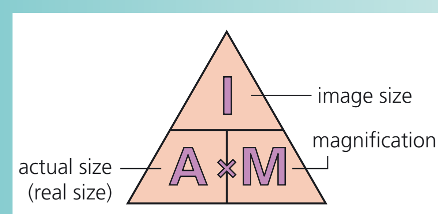
To work out the magnification the formula is used:

$$\text{magnification} = \frac{40}{2} = \times\ 20$$

Sometimes you might want to know the real size of an object if you know the magnification and size of the image. To work this out the formula for magnification can be rearranged:

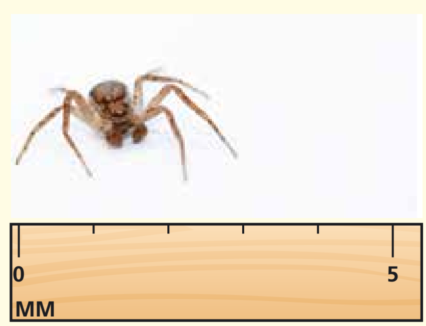
$$\text{real size} = \frac{\text{image size}}{\text{magnification}}$$

A formula triangle can be used to help you rearrange the equation.



Questions

1. What is the magnification of this spider?
2. If a pinhead measures 1.7 mm and is magnified ×12.5, how large would the image be?
3. If an image of a snake's fang is 22.5 cm and it has been magnified ×7.5, how large is the actual fang?
4. What is the actual size of this frog's eye if the image has been magnified 1.5 times?



TIP

It is really important to ensure that measurements are always in the same units. So if you have mixed units you will need to convert them all to the same format.

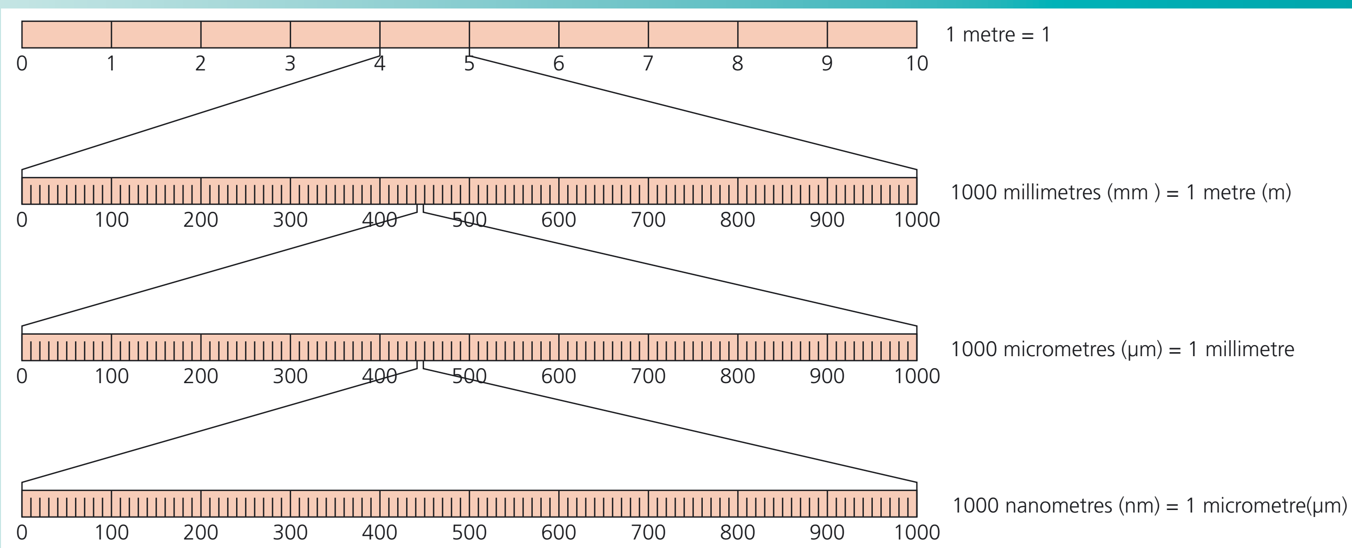
Extension

Often the actual object being studied is too small to be measured using a ruler, which means that a scale lower than a millimetre is needed. A micrometre (μm) is a thousandth of a millimetre and a millionth of a metre.

Using standard form, this can be written as:

$1\,\mu m = 1 \times 10^{-3}\,m$ and

$1\,\mu m = 1 \times 10^{-6}\,m$.



Example

If the actual size of this cheek cell is 60 μm, by how much has it been magnified?

- First measure the size of the cell in mm. In this micrograph, the cell is 45 mm wide.
- Then convert this to μm by multiplying by 1000.

  So $45 \times 1000 = 45\,000\,\mu m$
- To work out the magnification:

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

$$\text{magnification} = \frac{45\,000}{60}$$

$$\text{magnification} = \times 750$$

Question

What is the actual size of this cell if it has been magnified ×6000?

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