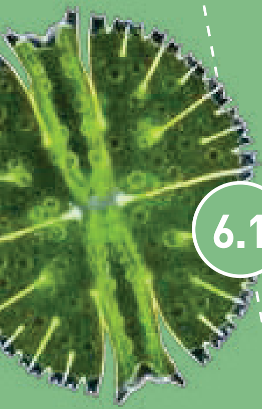
CELLS 6

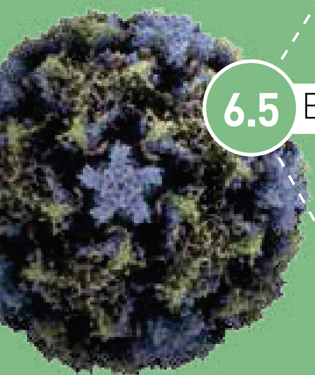


6.1 All living things are made up of cells

6.2 Microscopes are used to study cells

6.3 Plant and animal cells have organelles

6.4 All organisms have cells that specialise



6.5 Bacteria are single-celled organisms

6.6 Eukaryotic cells undergo mitosis

6.7 Fungal cells can save lives

What if?

Building blocks

What you need:

building blocks (for example, Lego blocks)

What to do:

1 Use the blocks to make a cube.
2 Rearrange the blocks to make a pyramid shape.
3 Rearrange the blocks a third time to make a rough circle.

What if?

» What if you wanted to make your shapes bigger?
» What if you just had one large block? How many shapes could you make?
» What if you had different shaped blocks? How many shapes could you make?

6.1 All living things are made up of cells

Scientists have not always known that living things are made up of cells. It was the invention of the microscope in the mid-17th century that allowed us to see the building blocks of life – the tiny units that form every living thing. Microscopes showed that each and every living thing is made up of **cells**.

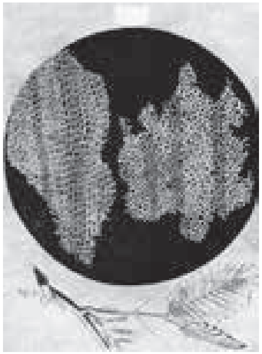


Figure 6.1 Robert Hooke's drawing of cork.

Discovering cells

When Robert Hooke published his book *Micrographia* in 1665 it became a bestseller. Hooke had made one of the first microscopes. With it, he observed many types of living things and made accurate drawings of what he saw.

Hooke's most famous achievement was his diagram of very thin slices of cork (Figure 6.1). He was surprised to see that, under the microscope, the cork looked like a piece of honeycomb. He described the 'holes' and their boundaries in the 'honeycomb' as cells because they reminded him of the small rooms in a monastery, which were also called cells. Hooke had discovered plant cells.

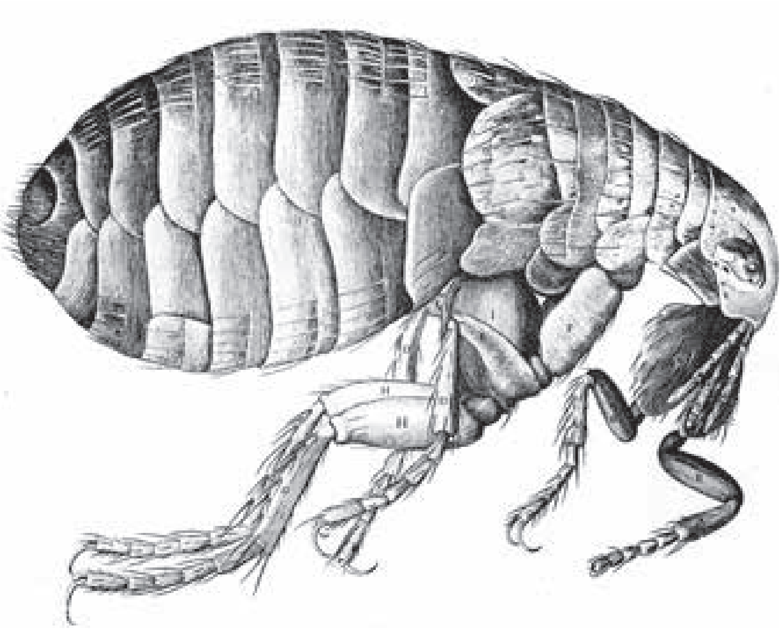


Figure 6.2 Robert Hooke's detailed drawing of a flea.

Although some called *Micrographia* 'the most ingenious book ever', others ridiculed Hooke for spending so much time and money on 'trifling pursuits'. Thankfully for us, and for the whole science of **microbiology**, Hooke ignored the taunts and kept experimenting with microscopes.

It was because of Hooke's contribution to microbiology that other scientists went on to develop a further understanding of cells.

Cell theory

Cell theory describes the properties of cells and their role in living things. It was first proposed in 1839 by two German biologists, Theodor Schwann and Matthias Schleiden. In 1858, Rudolf Virchow concluded the final part of the classic cell theory. The combined cell theory included the following principles:

> All organisms are composed of one or more cells.
> Cells are the basic unit of life and structure.
> New cells are created from existing cells.

Any living thing that has more than one cell is referred to as **multicellular**, but there are many living things, such as bacteria, that consist of only one cell. These are called **single-celled** or **unicellular** organisms. **Microorganisms**, which are also often referred to as **microbes**, are organisms that can only be seen under the microscope – they can be single-celled or multicellular.

SKILLS LAB 6.1: DRAWING CELLS
GO TO PAGE 196.

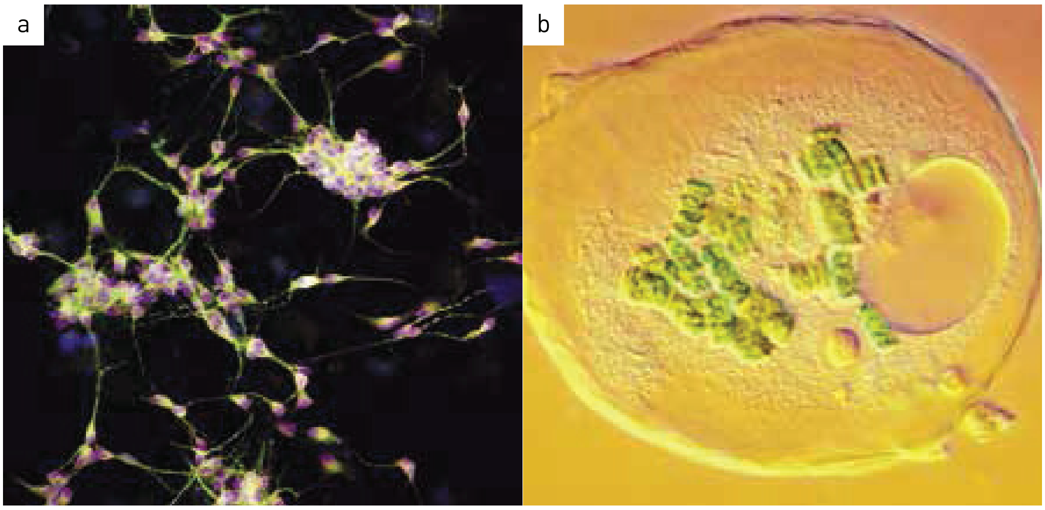


Figure 6.3 (a) Human nerve cells are part of multicellular humans, but (b) the amoeba is a unicellular organism.

Why are cells so small?

The surface of a cell is called the **cell membrane**. Some substances can move across this membrane; **nutrients** enter the cell and wastes exit the cell. In order to survive, cells benefit from the relatively large surface area of the cell membrane to maximise the ability to take in nutrients and remove wastes.

The total space inside the cell is referred to as the cell's volume. As a cell increases in size, both its volume and its surface area increase. The problem is that the volume increases much more than the surface area. Eventually, the volume becomes so big that it becomes difficult for nutrients to get into the centre of the cell and for wastes to get out. We compare the relationship between the amount of surface area and the volume of a cell through a fraction – the **surface area to volume ratio**. Small cells have a large surface area compared to their volume (a large surface area to volume ratio) and are therefore better able to survive.

This explains why single-celled organisms are so small. A single cell must do all the same things that a larger organism does. The cell membrane is particularly important because it provides a barrier between the inside of the cell and the external environment. All the nutrients needed to keep the cells alive, and the waste products made by the cell, are transported across the cell membrane. It is essential that the cell membrane provides a large surface area for the transport of so many molecules into and out of the cell.

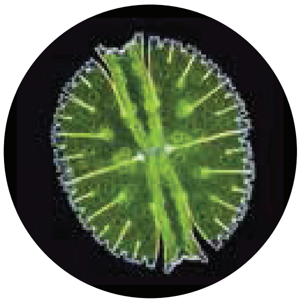


Figure 6.4 The irregular shape of this unicellular organism (called a desmid) maximises the surface area to volume ratio.

Check your learning 6.1

Remember and understand

1. Who invented the first microscope?
2. Why are cells called 'cells'?
3. What does 'multicellular' mean?
4. Name five multicellular organisms.
5. What do all unicellular organisms have in common?
6. What are the three principles of the combined cell theory?

Apply and analyse

7. The common house dust mite is a microorganism. Could you see this animal without a microscope? Explain how you came to your answer.
8. Would a cell with a bigger surface area to volume ratio be able to meet its requirements for nutrients more effectively? Why or why not?
9. Why are unicellular organisms always very small?

6.2 Microscopes are used to study cells

In the same way that eyeglasses have a glass or plastic lens for vision correction, a **microscope** is an instrument that uses lenses to magnify the size of the object placed under it. The science of investigating small objects using a microscope is called **microscopy**.

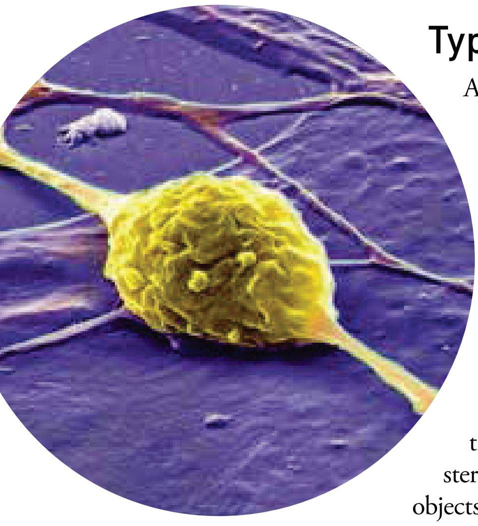


Figure 6.5 SEM image of a nerve cell.

Types of microscopes

As a science student, you will probably use a light microscope in your laboratory. You may also work with images produced by different types of microscopes, such as light microscopes and **electron microscopes**.

Light microscopes

There are two common types of light microscope – the **stereomicroscope** and the **compound light microscope**. The stereomicroscope is used for viewing larger objects, such as insects. It can magnify up to 200 times and shows a three-dimensional view.

The compound light microscope is used to observe thin slices of specimens. It can magnify up to 1500 times. Its view is two-dimensional. The specimen must be thin enough to allow light to pass through it.

The stereomicroscope has two **eyepieces** to look through, whereas the compound light microscope can have one or two eyepieces. The word **monocular** is used to describe a microscope with one eyepiece (mono = one). Microscopes with two lenses are called **binocular** (bi = two). The compound light microscope uses the effect of two lenses (one in the eyepieces and one further down the column, called the **objective lens**) combined with light to give a greater magnification. Most cells are clear in colour so a **stain**, such as iodine, is used to help make them more visible by providing contrast.

Electron microscopes

An electron microscope uses electrons (tiny negatively charged particles) to create images. The first electron microscope, the transmission electron microscope (TEM), was invented in 1933 to help study the structure of metals. The scanning electron microscope (SEM), developed later, uses a beam of electrons to scan across a specimen and to recreate the image, showing details of its surface.

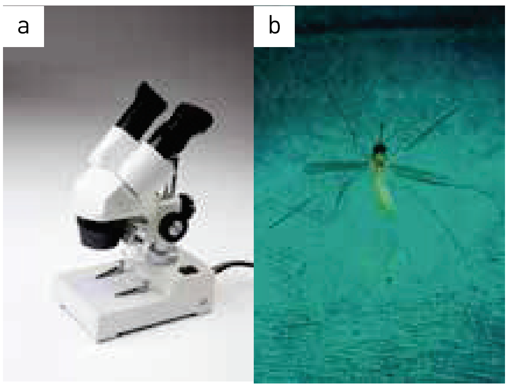


Figure 6.6 (a) A stereomicroscope. (b) An insect, as seen under a stereomicroscope.

Figure 6.7 (a) A compound light microscope. (b) A flea, as seen under a compound light microscope.

SKILLS LAB 6.2: GETTING TO KNOW YOUR MICROSCOPE
GO TO PAGE 197.

Electron microscopes can magnify up to a million times. Using this technology, many more details of the cell that were formerly invisible to scientists are now beginning to be understood.

Getting to know your compound light microscope

Figure 6.8 shows the parts of a monocular compound light microscope. Microscopes are fragile instruments that must be treated with care.

> Always use two hands to carry a microscope – one hand around the main part of the instrument and the other underneath it.
> Some microscopes have a built-in lamp. Others have separate lamps that need to be set up so that they shine onto the mirror. Adjust the mirror to project the light through the stage onto the specimen. Do not allow sunlight to shine directly up the column.
> Place the slide on the stage, then select the objective lens with the lowest magnification.
> Look from the side and adjust the coarse focus knob so that the objective lens is *just above – and not touching* – the slide. Check which way you must turn the knob to move the objective lens away from the slide.

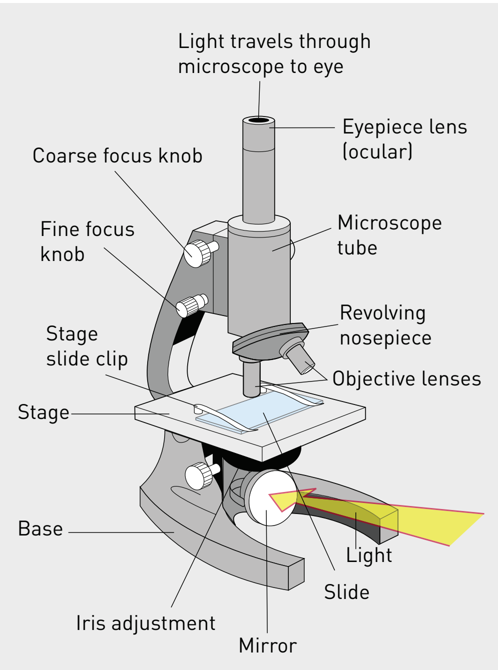


Figure 6.8 Parts of a compound light microscope.

> Use the coarse focus knob to bring the specimen into view. Use the fine focus knob to help you see it more clearly.
> If you want a higher magnification, rotate the objective lens to a higher magnification.
> Draw what you see (as a record) using a pencil.
> Work out the total magnification.
> Write the magnification next to your sketch.
> Label and date the sketch.

Figure 6.9 Human hair root that is stained for contrast.

Magnification calculations

Using different combinations of lenses means you can magnify your object by different amounts. To calculate the total magnification of a compound light microscope, multiply the magnification of the eyepiece lens by the magnification of the objective lens. These figures are marked on each lens.

Table 6.1 The total magnification of a microscope can be determined by multiplying the magnifications of the eyepiece and the objective lens.

EYEPIECE MAGNIFICATION	OBJECTIVE LENS MAGNIFICATION	TOTAL MAGNIFICATION
× 5	× 10	× 50
× 10	× 20	× 200

Check your learning 6.2

Remember and understand

1 What type or types of microscopes are in your science laboratory?
2 Why do you look from the side when you adjust the coarse focus knob?
3 Why must very thin samples be used under a light microscope?
4 What is 'microscopy'?

Apply and analyse

5 Explain why it is important to label and date your specimen drawings. Give three different reasons.
6 Complete the following magnification table for a compound light microscope by working out the missing values.

EYEPIECE MAGNIFICATION	OBJECTIVE LENS MAGNIFICATION	TOTAL MAGNIFICATION
× 5		× 100
	× 20	× 300
× 10	× 50	

6.3 Plant and animal cells have organelles

A cell is the basic unit of life. It is called this because it is the smallest unit of an organism that is considered living. But, just as the basic unit of length – the metre – can be broken down into smaller parts (e.g. centimetres and millimetres), the cell is made up of smaller parts, too. Cells are made up of **organelles** (mini-organs), cytoplasm, DNA, nutrients, wastes and other substances.

Cell structures

All cells, regardless of which type of organism they are found in, share the same basic structure. This basic structure includes three key features.

> **Cell membrane** – this acts like the 'skin' of a cell, forming a barrier around the cell. It controls the entry and exit of things into and out of the cell.

> **Cytoplasm** – this is the jelly-like fluid inside the cell membrane that surrounds everything inside the cell. It helps provide structure to the cell, and contains many dissolved nutrients and waste products.

> **DNA** (deoxyribonucleic acid) – this contains the instructions for every job your cells need to do and is passed from one generation to the next. The code for half your DNA came from your mother, and the other half came from your father. The same complete set of DNA is found in every one of your cells.

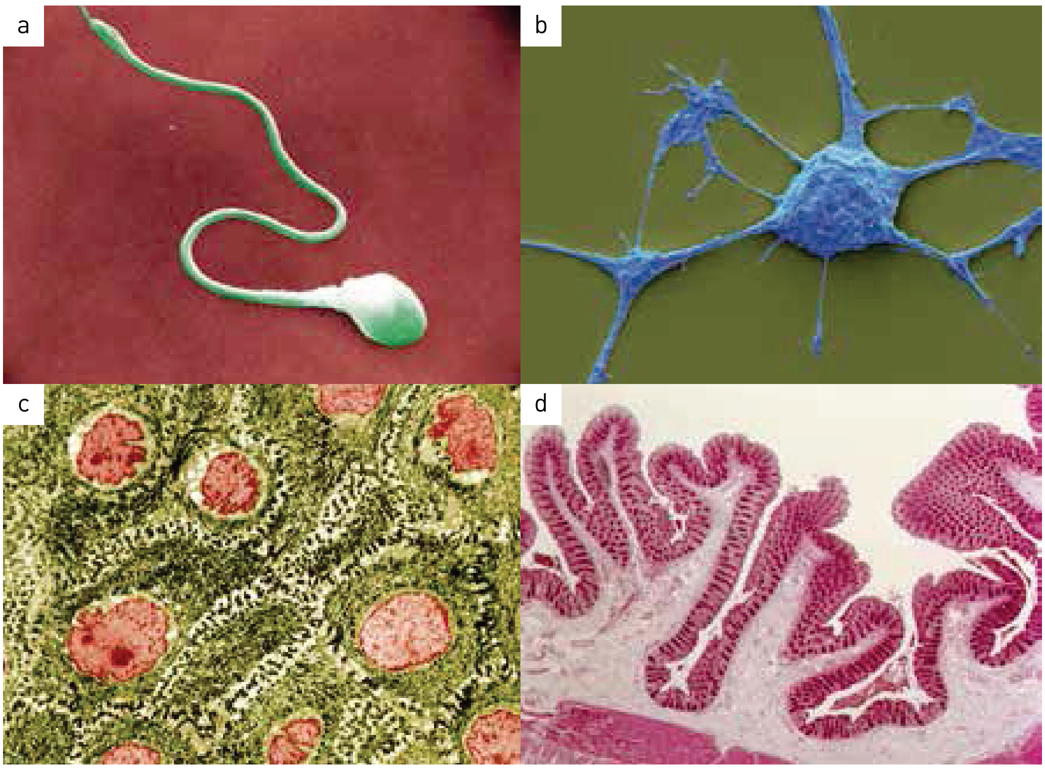


Figure 6.10 Cells can be different shapes and sizes: (a) sperm cell, (b) nerve cell, (c) skin cell and (d) intestinal cell.

CHALLENGE 6.3: COMPARING THE SIZE OF CELLS AND THEIR PARTS
GO TO PAGE 198.

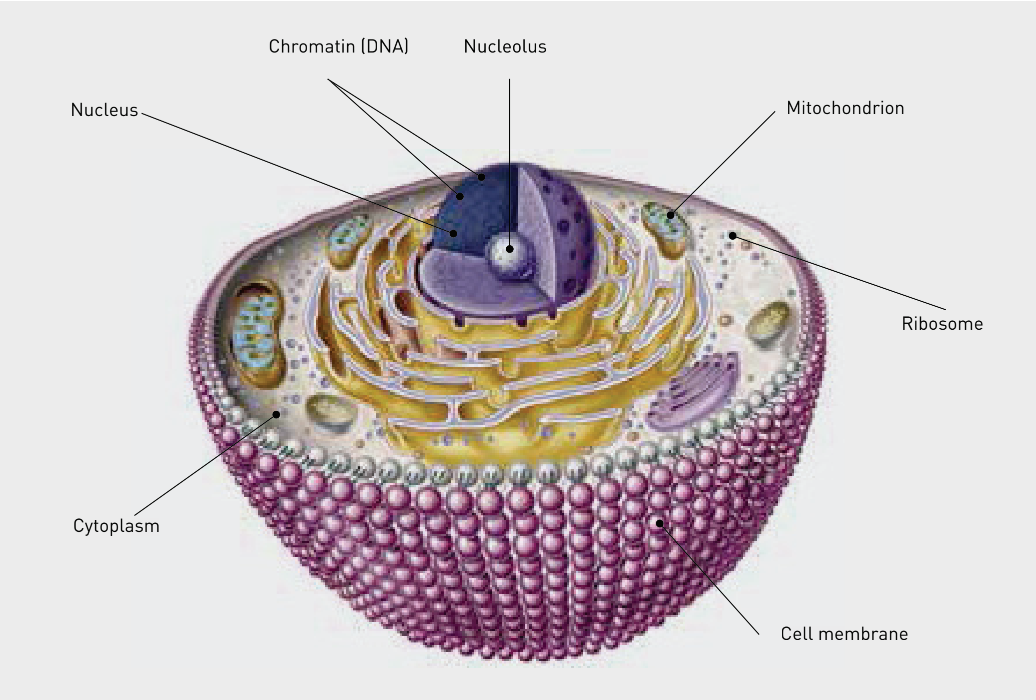


Figure 6.11 Some key parts (organelles) of an animal cell.

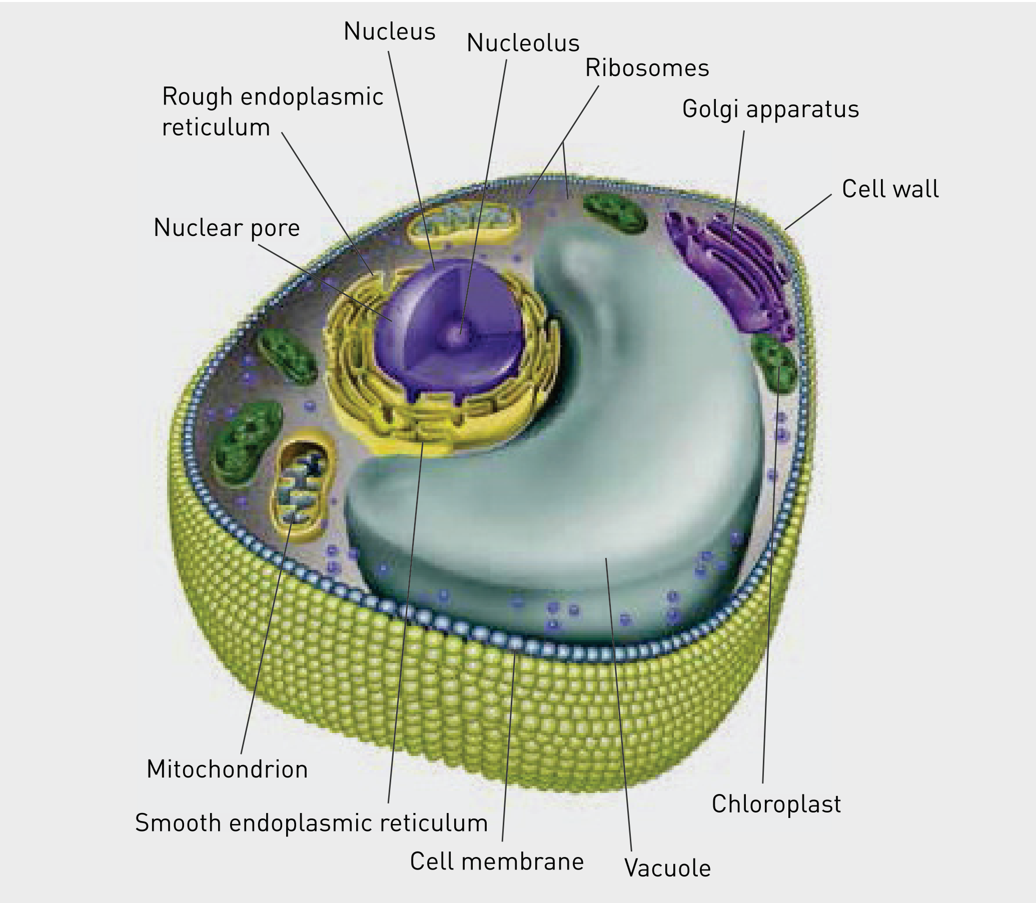


Figure 6.12 Some key parts (organelles) of an plant cell.

A closer look at organelles

The different organelles in cells all have specific functions. These functions are necessary for cells to survive. Some organelles, such as ribosomes, are part of the cytoplasm, whereas other organelles are separated from the cytoplasm by a membrane, much like the cell membrane. These organelles, such as the nucleus and chloroplasts, are called membrane-bound organelles.

Let's take a closer look at four very important membrane-bound organelles in the cell – mitochondria, ribosomes, chloroplasts and vesicles.

Mitochondria

Mitochondria (singular 'mitochondrion') are the powerhouse of the cell, being the site of energy production in the cell. There may be several thousand mitochondria in a cell depending on what the cell does. For example, skeletal muscle cells contain a lot of mitochondria to make sure we have enough energy to run and jump when we need to.

Mitochondria are rod-shaped organelles with an inner and an outer membrane. The inner membrane is folded to increase the surface area of the membrane. A chemical reaction called cellular respiration occurs inside the mitochondria. This reaction involves the rearrangement of the atoms in glucose (from the food we eat) and oxygen to produce water, carbon dioxide and energy. This energy is used by our bodies to help us move and grow.

Ribosomes

Ribosomes are where protein is made in the cell. Proteins are small molecules with different roles. There are many different types of proteins. For example, proteins make up hair and nails, or help transport oxygen through the bloodstream.

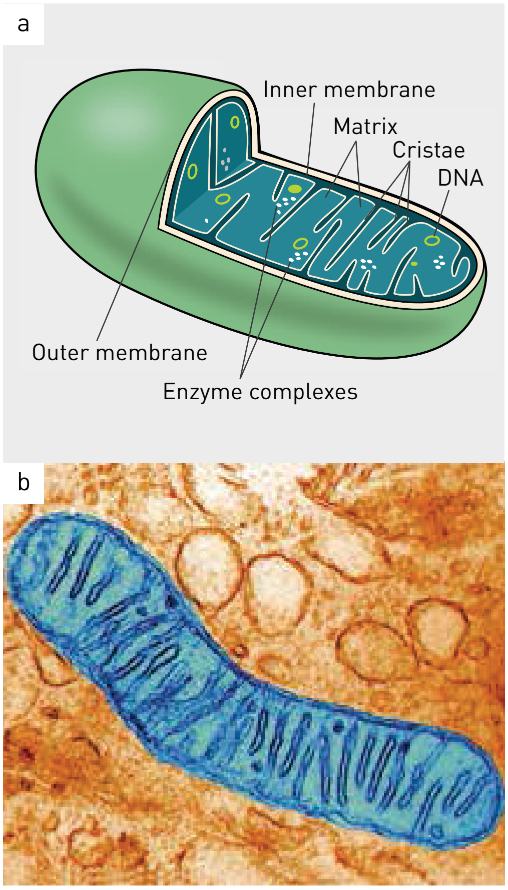


Figure 6.13 (a) Schematic diagram showing the structure of a mitochondrion. (b) Electron micrograph of a mitochondrion.

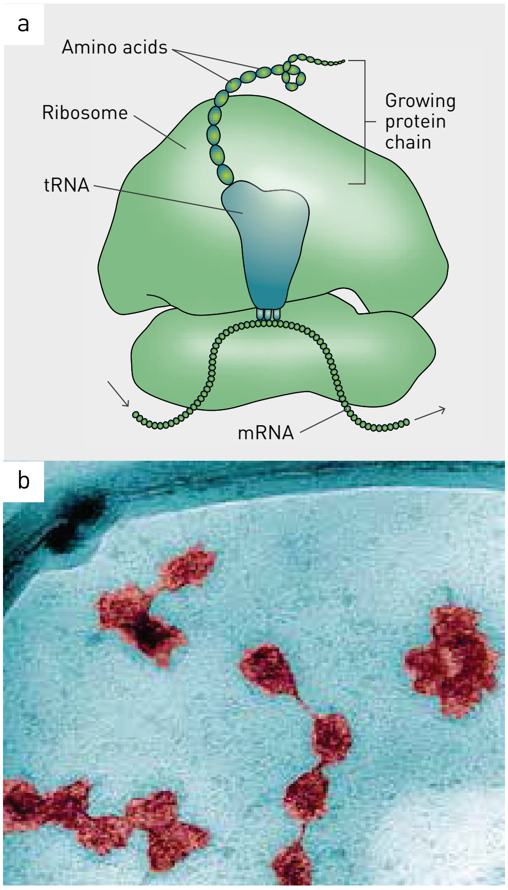


Figure 6.14 (a) Schematic diagram showing the structure of a ribosome (b) Electron micrograph of ribosomes.

EXPERIMENT 6.3A: LOOKING AT ORGANELLES
GO TO PAGE 199.

EXPERIMENT 6.3B: MEASURING CELLS
GO TO PAGE 200.

Chloroplasts

Chloroplasts are only found in plant cells and some unicellular organisms. These organelles are like microscopic solar panels that transform solar energy into chemical energy.

Chloroplasts are usually green because of a molecule called **chlorophyll**. Chlorophyll uses the Sun's light energy to rearrange molecules of carbon dioxide and water into glucose (a sugar) and oxygen. This chemical reaction is called **photosynthesis**.

Vesicles

Vesicles are organelles that are used by plant and animal cells to store water, nutrients and waste products. A membrane surrounds the vesicle, separating the substances from the rest of the cell. Plant cells usually have one large vesicle called a vacuole (see Figure 6.12). Animals cells may have many small vesicles.

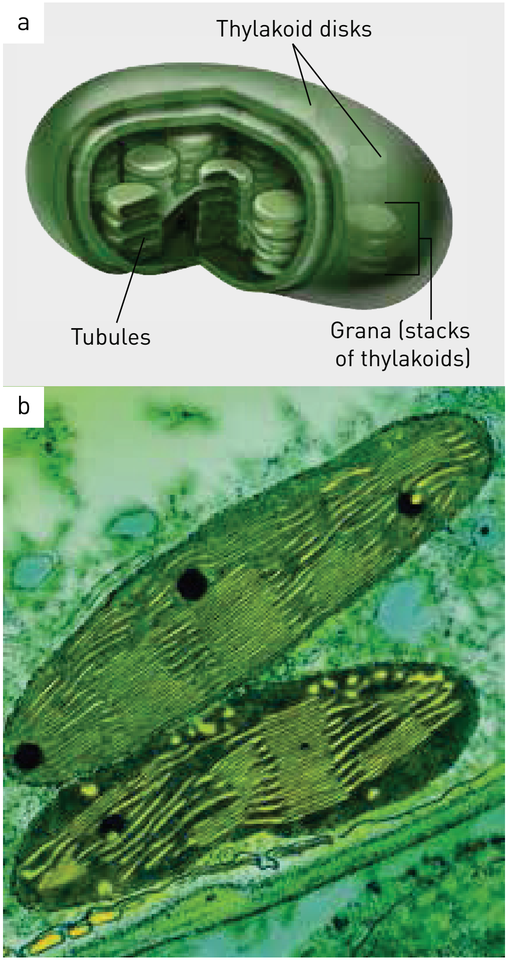


Figure 6.15 (a) Schematic diagram showing the structure of a chloroplast. (b) Electron micrograph of a chloroplast.

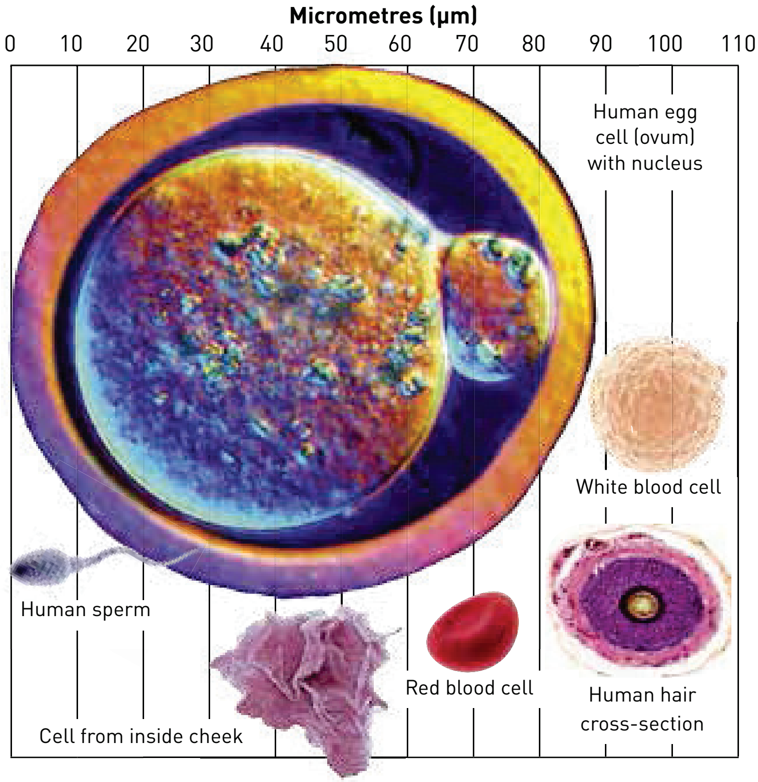


Figure 6.16 Different types of cells are different sizes and are measured in micrometres (μm). One micrometre is equivalent to one-thousandth of 1 millimetre.

Check your learning 6.3

Remember and understand

1. Name three organelles that are surrounded by a membrane.
2. What is the function of the cell membrane? In other words, why does a cell need a membrane?
3. What are some of the roles of proteins in organisms?
4. In which organelle does cellular respiration occur?
5. What is stored in a vacuole?
6. What is photosynthesis?

Apply and analyse

7. What features of cells mean they are classified as living things? Remember MRNGREWW from Year 7?
8. Where would you be more likely to find large numbers of mitochondria, in a muscle cell or a bone cell? Explain your reasoning.

6.4 All organisms have cells that specialise

A giraffe, a worm and a mushroom are all classified as living organisms, yet they have many differences. Although they all share cells as their basic building blocks, the structure and function of these cells are different. Because cells are the basic building blocks of life, understanding the structure of cells enables us to better understand how organisms function.

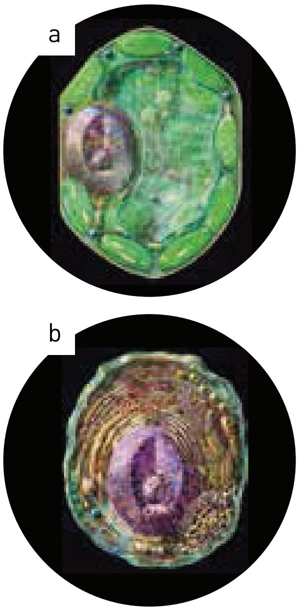


Figure 6.17 Typical (a) plant and (b) animal cells.

Prokaryotes and eukaryotes

An organism's cell type can be used to classify it. Cells are classified into two main groups – prokaryotic cells and eukaryotic cells. **Prokaryotic cells** belong in the kingdom Monera. They are the most primitive cellular forms on Earth and are unicellular. They are much simpler than eukaryotic cells and do not have many of the organelles described in the previous section. For example, they have no nucleus and their genetic material is found free in the cytoplasm. Prokaryotes include the diverse range of bacteria.

Eukaryotic cells are more complex cells and are found in organisms from each of the other four kingdoms – animals, plants, fungi and protists. Eukaryotic cells contain a nucleus as well as most of the membrane-bound organelles. Most eukaryotes are multicellular.

Plant cells

By looking at different characteristics of plants and animals, it's fairly easy to see that they are different types of organisms. However, once microscopes started to become more powerful, suddenly scientists could see that there were differences between plant and animal cells (Figure 6.17). Plant cells use their chloroplasts to photosynthesise and need cell walls to provide structure. Many plant cells also store their nutrients in large vacuoles (large spaces surrounded by a membrane).

Fungal cells

Fungi have often been considered as types of plants; however, with the development of the microscope, scientists were able to see that fungal cells are not the same as plant cells. For example, fungal cells don't have chloroplasts, so they cannot photosynthesise, and they don't have large vacuoles filled with liquid.

Figure 6.18 Cells in kingdom Fungi have cell walls and nuclei, but no chloroplasts.

Table 6.2 Characteristics of eukaryotic and prokaryotic cells.

CHARACTERISTIC	KINGDOM				
	EUKARYOTES				PROKARYOTES
	ANIMALS	PLANTS	FUNGI	PROTISTA	MONERA
Number of cells	Multicellular	Multicellular	Multicellular, some unicellular (e.g. yeasts)	Multicellular or unicellular	Unicellular
Cell wall	Absent	Present	Present	Present in some	Present
Genetic material	Present	Present	Present	Present	Present
Nucleus	Present	Present	Present	Present	Absent
Mitochondria	Present	Present	Present	Present	Absent
Chloroplasts	Absent	Present	Absent	Present in some	Absent
Large vacuoles	Absent	Present	Absent	Present in some	Absent
Ribosomes	Present	Present	Present	Present	Present

CHALLENGE 6.4: CLASSIFYING USING CELLS
GO TO PAGE 200.

EXPERIMENT 6.4: PLANT AND ANIMAL CELLS
GO TO PAGE 201.

Protists

Protists are a diverse group of organisms that are mostly unicellular. Many live in water, some are photosynthetic (i.e. make their own food, like plants), some eat other organisms and some causes diseases. Depending on where it lives and its food sources, a protist's shape or structure will have evolved to suit. The protists in Figures 6.19 to 6.22 have structures particular to their lifestyles.

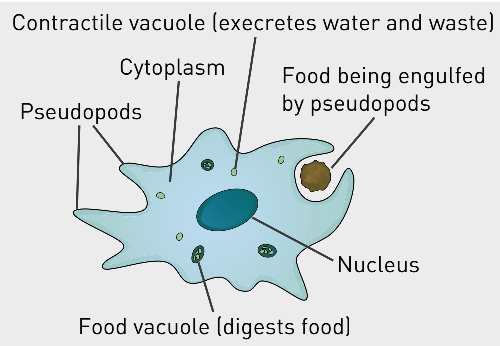


Figure 6.19 An amoeba can change the shape of its blobby body, creating foot shapes for movement and mouth shapes for swallowing food.

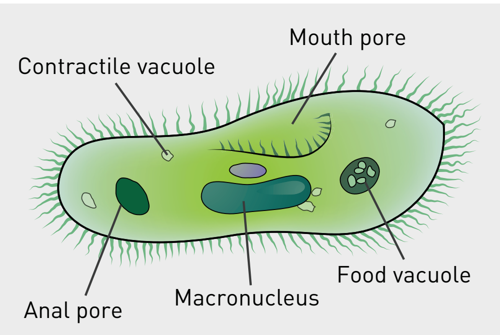


Figure 6.20 The paramecium plods along slowly with lots of tiny hairs called cilia that act like miniature oars.

Animal cells

Single-celled or unicellular organisms, such as bacteria, are made of one cell only. Multicellular organisms, like us, are made of more than one cell and often many billions of cells. The different cells in a multicellular organism communicate and work together to produce a functioning organism. Their different roles in the body mean they have different sizes and shapes.

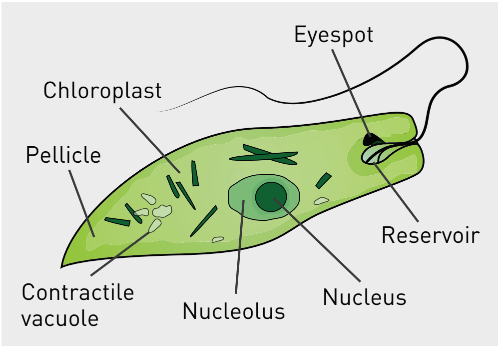


Figure 6.21 Euglena moves really quickly when it needs to, with a bullet-shaped body and a long tail called a flagellum to whip it into action.

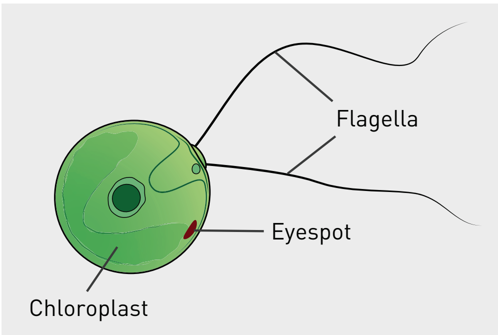


Figure 6.22 Chlamydomonas has an eyespot that can detect light for photosynthesis and two flagella that help it swim along in a breaststroke-like motion.

Check your learning 6.4

Remember and understand

1. Give an example of a unicellular organism and a multicellular organism.
2. Describe the two main differences between eukaryotic and prokaryotic organisms.
3. Where is the genetic material found in a prokaryotic cell?
4. Table 6.2 shows that plant cells contain chloroplasts. Although a typical plant cell contains chloroplasts, chloroplasts are not found in all plant cells.
   a. Suggest why some cells in a plant root may lack chloroplasts.
   b. In which part of a plant would you expect cells to contain many chloroplasts?
5. Look back at Table 6.2, and then suggest which kingdom is often referred to as 'the rest'.

6.5 Bacteria are single-celled organisms

Unicellular organisms, such as bacteria, are living in and around us all the time. The average adult human has 1 kilogram of non-human life inside their large intestine alone. Some bacteria and microbes are essential for keeping our body healthy and working correctly. Others can be deadly.

Natural flora

The microbes that live happily in our bodies are referred to as **natural flora** and it's the balance between natural flora and the microbes in our environment that we need to keep an eye on. The right amount of natural flora will protect us against foreign invaders, whereas too much of the natural flora can actually make us ill. Bacteria in our intestines help our bodies digest food and provide vitamins to keep us healthy

Microbes causing disease

We have all been sick at some stage in our lives and much sicker at some times than others. Some forms of sickness are caused by pathogens. A **pathogen** is a microorganism that can potentially cause a disease. With **infectious diseases**, the pathogen may be passed from one organism to another. Such diseases are said to be contagious. The host is an organism, such as a human, animal or plant, on which another organism lives. You will be investigating pathogens in more detail in Year 9. The **symptoms** of a disease are the changes that occur to an individual as a consequence of the disease.

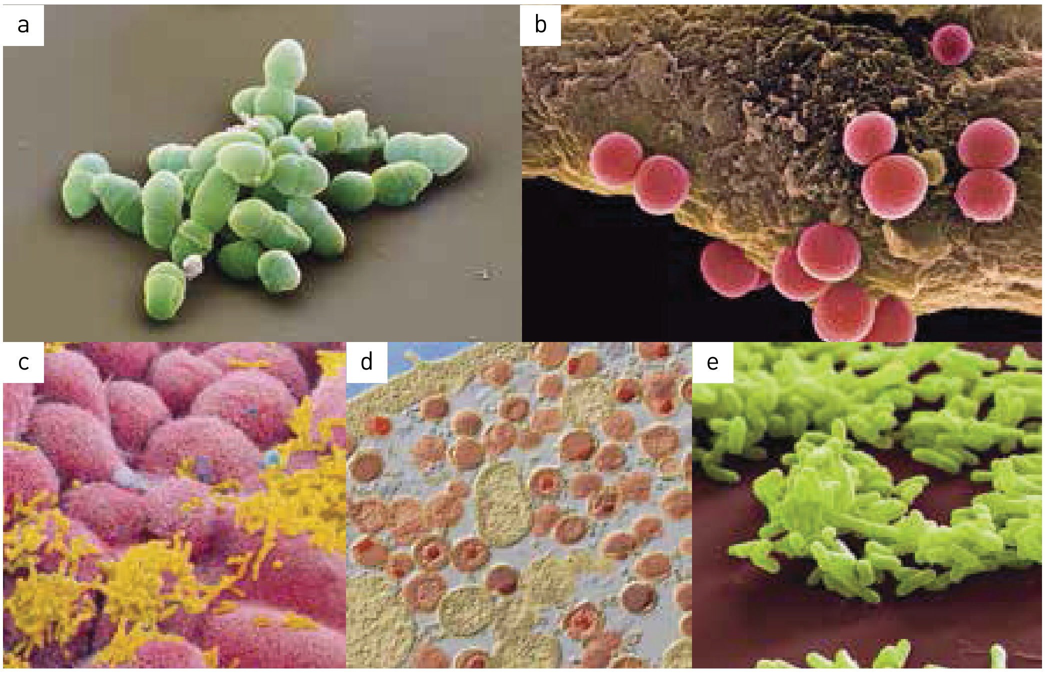


Figure 6.23 (a) *Staphylococcus epidermis*, (b) *Staphylococcus aureus* in the hair, (c) *Haemophilus influenza* in the nose, (d) *Chlamydia trachamates* in the eye, (e) *Esherichia coli* in the intestines.

EXPERIMENT 6.5: MICROBES ALL AROUND
GO TO PAGE 202.

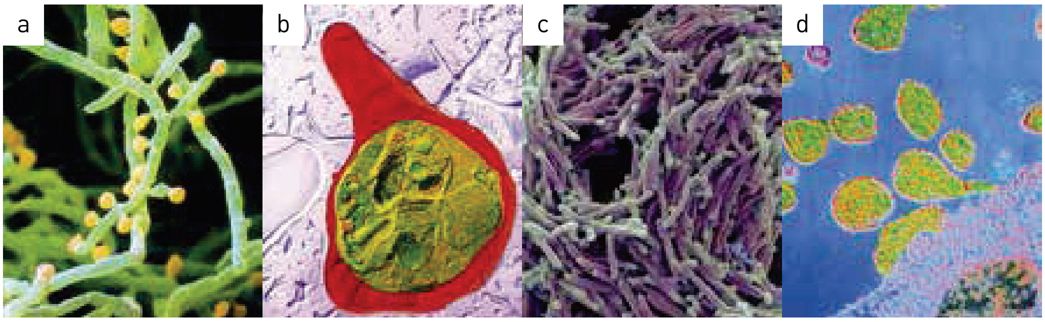


Figure 6.24 (a) *Trichophyton mentagrophtes*, cause of ringworm and tinea; (b) a red blood cell infected with malarial parasites; (c) tuberculosis bacteria; (d) Rubella virus.

Harmful microbes may be bacteria, fungi, protists or viruses. All these microbes can invade the body and cause disease. You will probably be familiar with some diseases caused by harmful microbes. Fungi can cause infections such as tinea, which is also known as athlete's foot, and ear infections. Protists can cause malaria and dysentery. Bacteria cause diseases such as tuberculosis (also known as TB), pneumonia, legionnaires' disease and cholera. Viruses can cause diseases like the common cold and flu, measles and herpes.

Viruses

Viruses are actually considered by most scientists to be non-living pathogens. Viruses cannot survive and reproduce outside a host cell.

Viruses are responsible for most of the common colds that we experience and cannot be controlled by antibiotics because they're hiding inside our cells. This also makes it much harder for our own immune cells to find and fight them, so our best defence is to rest and to eat a healthy diet to let our bodies concentrate on getting rid of the viruses by themselves.

Bacterial growth

Bacteria reproduce using a process called **binary fission** (binary = two; fission = split). As the name suggests, a bacteria cell grows slightly larger and then splits in two. This is a very quick process, sometimes taking as little as 20 minutes. This can be represented on a graph, such as the one in Figure 6.25.

Most bacterial growth is stopped at temperatures below 4°C and above 60°C. For this reason, your fridge should be below 4°C and cooked food waiting to be served should be stored above 60°C.

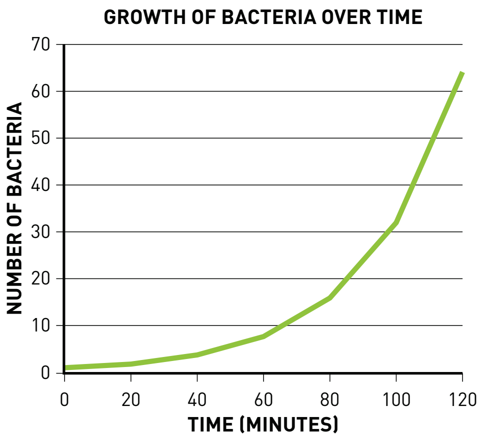


Figure 6.25 The number of bacteria cells can double every 20 minutes.

Figure 6.26 Human rhinovirus, responsible for the common cold. Viruses are much smaller than cells.

Check your learning 6.5

Remember and understand

1. What type of microorganism does our digestive system rely on? What does this organism do?
2. What is natural flora?
3. Can natural flora ever be harmful to our bodies?
4. What is a pathogen? What are the four main groups of pathogens?
5. Why is a virus not considered to be living?

Apply and analyse

6. It is not recommended that food be left out of the fridge for more than three hours. Use binary fission to explain why.

6.6 Eukaryotic cells undergo mitosis

Cells, like organisms, need to carry out many functions for survival. They need to process many substances, harness energy and, ultimately, reproduce. When your cells grow and repair, they undergo **mitosis**. When a cell is no longer needed, it is destroyed (**apoptosis**). When mitosis gets out of control, a tumour can grow.

Making more cells

The instructions for all these jobs are in the form of DNA – lengths of codes that can be 'read' when required to make sure jobs are done correctly. The DNA is stored in the **nucleus**, which is often referred to as the control centre or 'brain' of the cell.

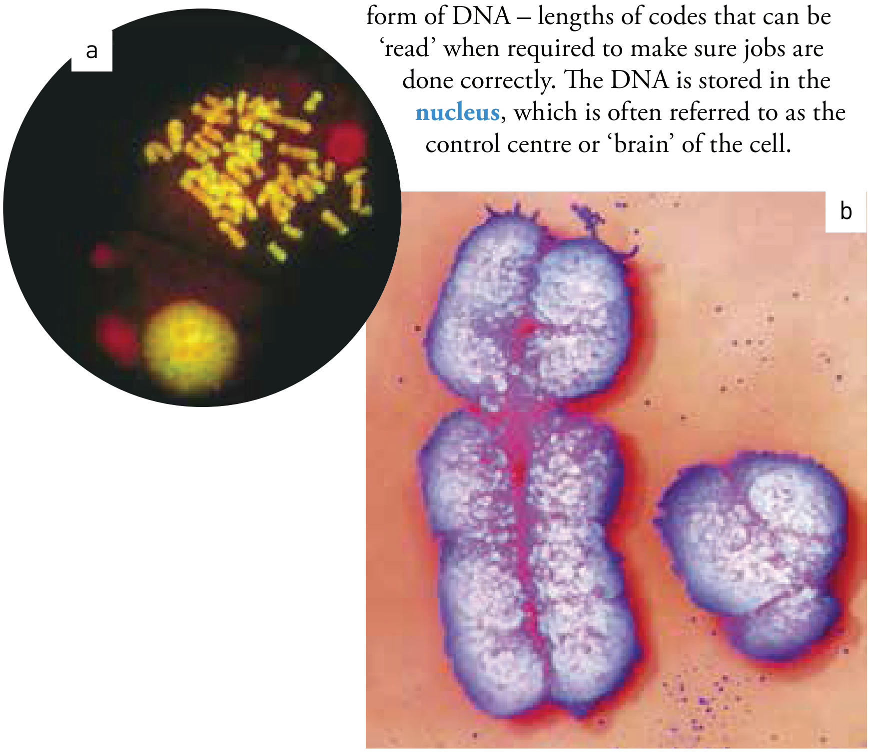


Figure 6.27 (a) Light microscope and (b) electron microscope images of human chromosomes.

When cells are ready to reproduce they simply split in half, but each new cell needs its own copy of the full set of instructional DNA. Before the **parent cell** can split, a completely new set of DNA needs to be made. The DNA also needs to organise itself so that each new **daughter cell** has nothing missing. Each new cell needs one full set of DNA instructions.

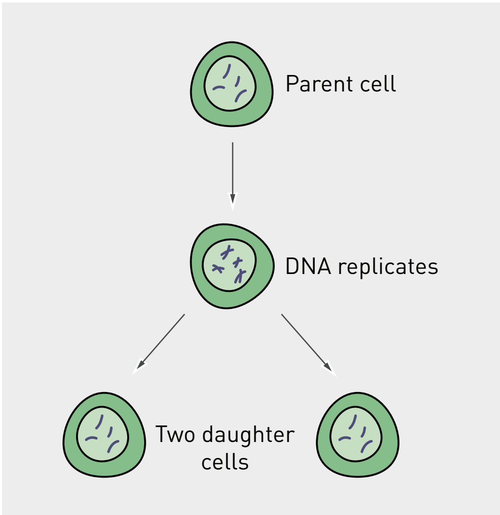


Figure 6.28 The process of mitosis.

The organelles are also roughly split into two groups. This process of organised cell division is called mitosis.

We need new cells every day to replace old or damaged cells. Every scratch on your skin needs new cells to fix it. Some of your red blood cells need to be replaced every time you bleed. You need to grow taller. All these things need mitosis to make the new cells.

Cancer: mitosis out of control

Cells do not survive indefinitely within an organism. They have a use-by date, after which they self-destruct. This ensures that cell division is controlled.

The term '**cancer**' describes a group of diseases that result from uncontrolled cell division. A cancer can form in any part of the body. Cancer affects humans and other animals.

CHALLENGE 6.6: MODELLING MITOSIS
GO TO PAGE 203.

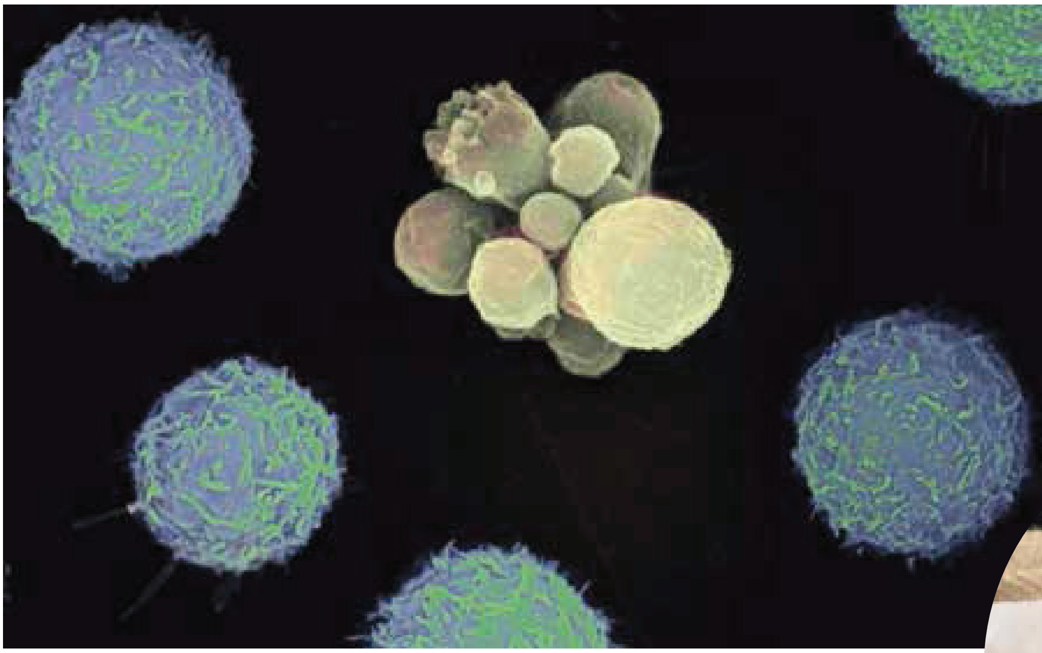


Figure 6.29 The yellow cells are undergoing apoptosis, or programmed cell death.

Figure 6.30 Tasmanian devil facial tumour is a malignant tumour.

As an organism grows, cells reproduce to replace cells that are old or those that have died through injury. The process of a cell dying is a very normal and an important part of the development and functioning of an organism. Programmed cell death is known as apoptosis. In fact, it was only through the programmed death of cells around your hands and feet that your fingers and toes formed during your early development.

Sometimes the DNA of a cell becomes damaged. This may be caused by a number of things, such as radiation, viruses or chemicals, called **mutagens**. Cancer-causing chemicals are also called **carcinogens**. The change to the DNA results in a change in the instructions for the cell.

Damage to the genetic material may prevent a cell from self-destructing. When a damaged cell starts dividing uncontrollably, it is called a growth or **tumour**. The tumour is the cancer. The tumour may split off and spread throughout the body, causing secondary cancers. The secondary cancers can damage or destroy other organs.

There are two types of tumours: benign and malignant. Benign tumours do not spread and they are not normally fatal (causing death), unless they grow in a vital organ, such as the brain. In contrast, malignant tumours can spread to different parts of the body and can be fatal if their growth is not stopped.

Figure 6.31 The hazard symbol for a carcinogen.

Check your learning 6.6

Remember and understand

1 List three reasons why new cells need to be made.
2 On a sheet of paper, draw diagrams to describe the steps involved in mitosis. Label the parent cells and daughter cells.
3 What is the name of the substance that provides instructions for the cell and where is it found?
4 What is apoptosis? When does it occur?
5 Where is DNA found in your skin cells?
6 Red blood cells do not have a nucleus. Explain why this makes it impossible for them to undergo mitosis.

Apply and analyse

7 Cigarette smoke is considered a carcinogen. What does this mean?
8 Explain why a single cancer drug cannot destroy all types of cancer.

//SCIENCE AS A HUMAN ENDEAVOUR//

6.7 Fungal cells can save lives

Have you ever scratched yourself on a rose bush, or pricked yourself with a needle? Before the discovery of antibiotics, such a simple break in the skin would have been enough to kill you.

Figure 6.32 Some moulds are able to prevent bacterial growth.

The discovery of penicillin

It has been accepted for over 3000 years that some moulds could kill infection. The discovery in 1928 of the chemical that was responsible for this is attributed to Alexander Fleming.

Fleming was trying to grow bacteria on special agar plates as part of his research. Bacteria usually grow very well across the top of agar plates. However, this day Fleming failed to clean up after his experiment and left an agar plate open on his bench before leaving for a holiday. When he returned from his break, a small spot of mould had started growing in the centre of the plate. All around the mould was a clear circle where the bacteria was unable to grow. Fleming concluded that the mould (*Penicillium*) was producing a molecule that prevented the bacteria from growing. The molecule, which was named penicillin, had the ability to stop bacterial growth by preventing the bacteria repairing or making a new cell wall.

Figure 6.34 Alexander Fleming.

Producing penicillin

It took ten more years and the work of Howard Florey (an Australian) and Ernst Chain to develop a method of isolating penicillin and producing it on a large scale. They were part of a team of specialists brought together to grow the mould, extract the penicillin, purify it and trial its treatment on patients.

Their most important experiment occurred in May 1940. Eight mice were infected with streptococcal bacteria, and four of the mice were treated with the newly extracted penicillin. These four mice survived while the mice without the penicillin died.

Figure 6.33 Howard Florey.

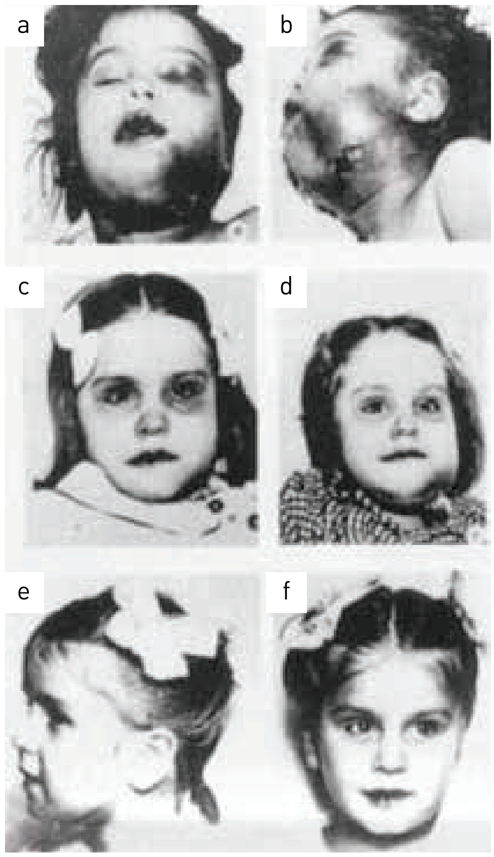
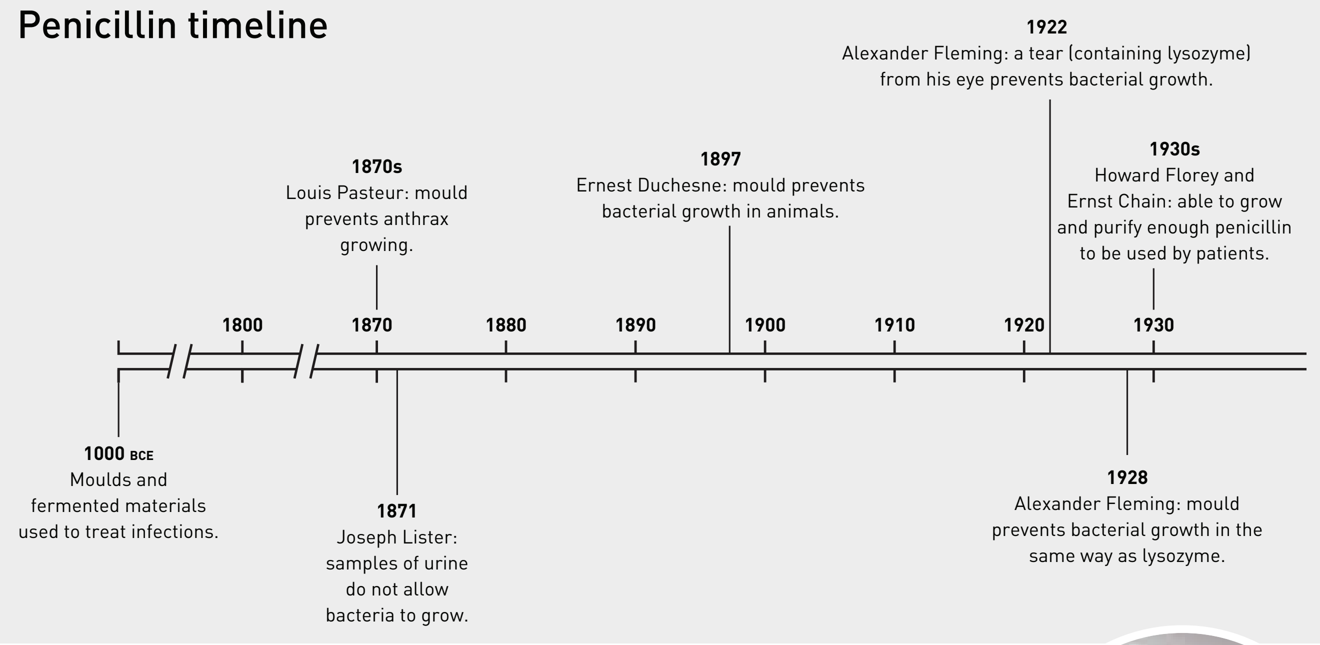


Figure 6.35 These photos from 1942 show the improvement of a child after penicillin treatment for a bacterial infection. (a, b) Before treatment. (c) Four days after treatment. (d) Nine days after treatment. (e, f) Fully recovered.

Penicillin timeline



This led the researchers to trial the penicillin on their first patient. Albert Alexander's whole face was swollen after being scratched by a rose thorn. One eye had been removed, while the other had been lanced to drain the pus. Within one day of being given penicillin, he started to improve. Unfortunately, Fleming's group did not have enough penicillin to finish the treatment and the patient suffered a relapse and died. As a result the researchers tried treating children, as smaller doses could be used and the treatment could last longer. Eventually, their purification methods and resulting treatment were successful. They were awarded a Nobel Prize in 1945 for their work.

The use of penicillin as an antibiotic revolutionised health care and the lives of many people who, without such treatment, would have died from bacterial infection.

Overuse of antibiotics

There are now many more different antibiotics available, most of which are extracted from fungi. The overuse of antibiotics is a cause for concern. Due to the rapid rate at which bacteria reproduce, some strains of bacteria are becoming 'resistant' to treatment. That is, they are not affected by antibiotics. Scientists are continually searching for new types of natural and artificial antibiotics to treat these new 'superbugs' that are resistant to all known antibiotics.

A dose of antibiotics destroys not only the harmful bacteria, but also the good bacteria in your body, so they should only be used to treat bacterial infections when absolutely necessary.

Figure 6.36 Ernst Chain.

Figure 6.37 A new strain of deadly antibiotic-resistant bacteria 'superbug' was found at Royal Perth Hospital in 2013 and had to be brought under control.

Extend your understanding 6.7

1. What is the difference between fungi and bacteria?
2. Fungi usually grow best at 22°C. How did leaving the agar plate on the bench accidentally help Fleming make his discovery?
3. Why did Florey and his group of scientists not give penicillin to four of their mice?
4. Many of our medicines today originate from the molecules made in nature. How does the purity of penicillin prepared in a laboratory compare with the fermented materials used in 1000 BCE?
5. 'The most exciting phrase to hear in science, the one that heralds discoveries, is not "Eureka" but "that's funny ..."' Use Fleming's discovery to explain this quote from Isaac Asimov.

* REVIEW

6

Remember and understand

1 Who was the first person to describe cells? What cells did they draw?

2 What is the benefit of using a stain when viewing some specimens?

3 What is the cell theory?

4 Explain two key ideas presented in the cell theory.

5 Explain why programmed cell death is necessary.

6 Why does a specimen need to be really thin to be viewed under a light microscope?

7 Explain at least one similarity and one difference between a mitochondrion and a chloroplast.

8 How are fungal cells different from bacterial cells?

9 Define the following words:

   a mitosis

   b cancer

   c mutagen

   d binary fission

   e pathogen.

Apply and analyse

10 A cell membrane is 'partially permeable'. This means that only certain substances are able to cross the membrane. List some substances that would need to get into the cell and some that would need to get out.

11 Explain why unicellular organisms are always tiny, and why multicellular organisms are made up of so many cells.

12 Ribosomes are found in every cell on Earth. What function do ribosomes perform in cells? Why is it so important?

13 If you were sick with a cold or flu, a doctor might prescribe antibiotics. But antibiotics are quite useless against viruses, the pathogens responsible for colds and flu. So why would a doctor prescribe antibiotics?

14 Light microscopes allow you to view living cells. Electron microscopes view either dead cells or cells that have been killed in the process of viewing them. In what situations might light microscopes be preferable to electron microscopes?

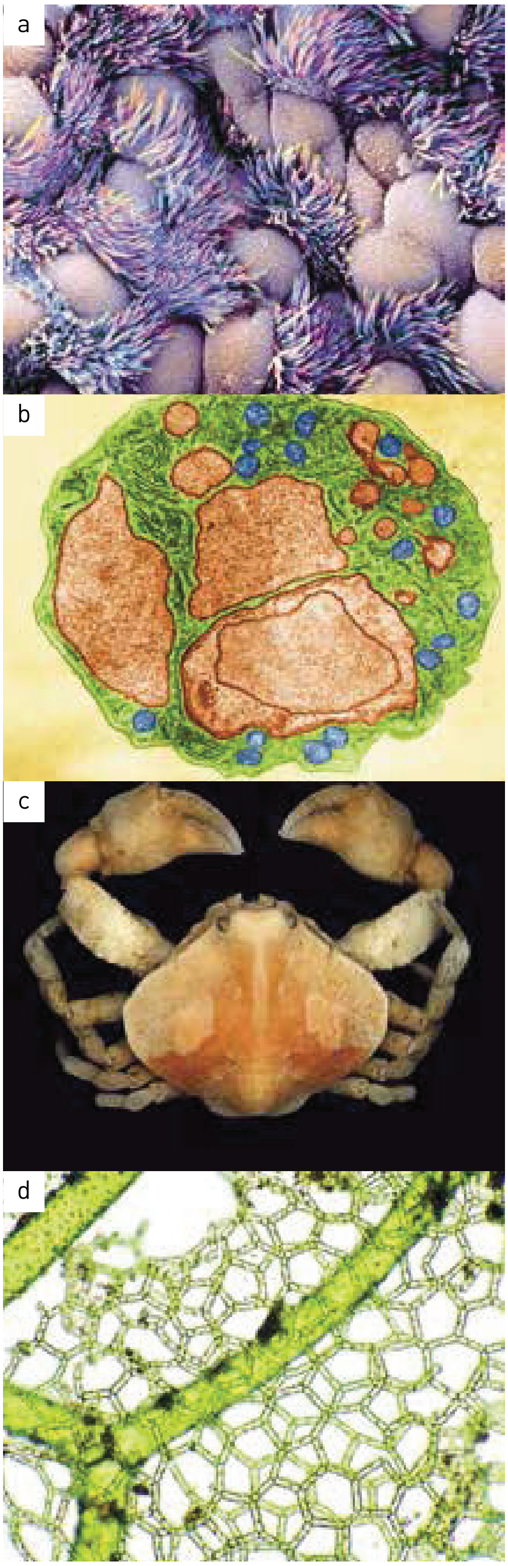


Figure 6.38

15 Identify the microscope most likely to have created the images in Figure 6.38.

16 Two students prepare slides from different sections of a spring onion under a light microscope in their school laboratory. James views a section of the green leafy part and observes many chloroplasts within each cell, but has difficulty identifying a nucleus in each cell. Emily views a section of the white stem of the plant. She comments that a nucleus is clearly visible in most of the cells, but does not identify any chloroplasts.

 a Suggest why James identified many chloroplasts within each cell when they appeared to be absent from the cells viewed by Emily.

 b Emily commented that she could identify a nucleus in most cells. If a nucleus is not visible in a particular cell, does this mean that the cell does not contain a nucleus?

Evaluate and create

17 Similes are often used in creative writing to compare two things using the words 'like' or 'as'. Explain the similarities that allow these similes to be used.

 a Cells are like building blocks.

 b The nucleus is like a control centre.

 c The mitochondrion is like a power station.

18 Write a very short creative story about a virus. Your story needs to be from the point of view of a cell. The first line of your story is: 'Once upon a time, a virus arrived for an uninvited visit'.

19 How has our understanding of how living things function changed with the development of the microscope?

20 Use the lenses from an old pair of reading glasses or a magnifying glass to create a model of a microscope. Describe how your model is similar and different to Hooke's microscope and modern compound microscopes.

Research

21 Choose one of the following topics for a research project. Present your research in a format of your own choosing, giving careful consideration to the information you are presenting.

> **Linking big concepts**

In this chapter, six big concepts about cells were discussed. Think of a creative way to represent these concepts and make links between them, using as many of the key words in the chapter as you can. You might use a concept map or mind map with each of the questions as major bubbles. You could choose to use diagrams only or draw a picture that shows all the aspects of the particles of life. The method of presentation that you select must enable you to share your ideas with others.

> **Stem cells**

Stem cells are cells in multicellular organisms that haven't become specialised yet – they're like blank canvases. Find out what scientists have learnt about stem cells, where they find them and what they hope to be able to do with them.

> **Discovery of penicillin**

The discovery of penicillin was considered an important factor behind the outcome of World War II. Soldiers who were injured on the battlefield could be mended, given a shot of penicillin, and returned to the battlefield again instead of having limbs amputated. Write a newspaper article describing the importance of this major discovery.

> **Plant cells**

Plants do not have lungs to breathe. Instead, they have small pores called stomata, which allow air to pass in and out of the plant. These stomata are made up of two guard cells that can change their shape. Find out how stomata open and close in response to changing environmental conditions. Under what types of conditions are the stomata likely to open? What are the triggers for the stomata to close? How does the shape of the guard cells assist the opening and closing of the pore?

6

* KEY WORDS

apoptosis
programmed cell death

binary fission
a form of asexual reproduction used by bacteria; the splitting of a parent cell into two equal daughter cells

binocular
using two eyes; a type of microscope

cell
(in biology) the building block of living things

chlorophyll
green pigment found inside chloroplasts that absorbs solar energy and uses it in photosynthesis

chloroplast
organelle found in plant cells that transforms solar energy into chemical energy

compound light microscope
a microscope with two or more lenses

daughter cell
a cell that results from parent cell division

electron microscope
a microscope that uses electrons (tiny negatively charged particles) to create images

eukaryotic cell
complex cell that contains a nucleus and membrane-bound organelles

infectious disease
disease caused by the passing of a pathogen from one organism to another; also known as contagious disease

microbe
a living thing that can only be seen with the use of a microscope; a microorganism

microbiology
the science involving the study of microscopic organisms

microorganism
a living thing that can only be seen with the use of a microscope

microscopy
the study of living things that can only be seen with the use of a microscope

mitochondrion
powerhouse organelle of a cell; the site of energy production; (plural 'mitochondria')

mitosis
process of cell division to provide growth or repair

monocular
using one eye; a type of microscope

multicellular
an organism that has two or more cells

mutagen
a substance that may damage a cell's genetic material (DNA)

natural flora
microbes that live happily in our bodies

nucleus
(in biology) control centre of a cell that contains all the genetic material (DNA) for that cell

objective lens
lens in the column of a compound light microscope

organelle
smaller part of a cell, each one having a different function

parent cell
the original cell before it undergoes cell division

pathogen
microbe that can potentially cause a disease

photosynthesis
chemical process that plants use to make glucose and oxygen from carbon dioxide and water

prokaryotic cell
primitive single-celled organism that has no nucleus

ribosome
cell organelle where protein production takes place

single-celled
an organism that consists of one cell

stain
substance, such as iodine, used to make cells more visible under a microscope

stereomicroscope
a microscope with two eyepieces that uses low magnification

surface area to volume ratio
the relationship between the area around the outside of a cell and its volume, as a fraction

unicellular
an organism that exists as a single cell