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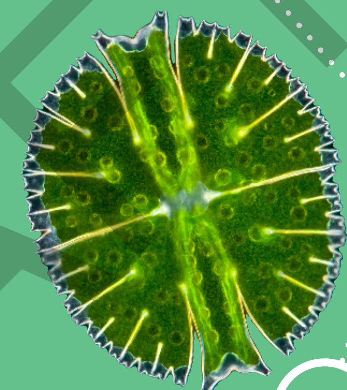
CHAPTER 6

CELLS

What is the smallest living thing?

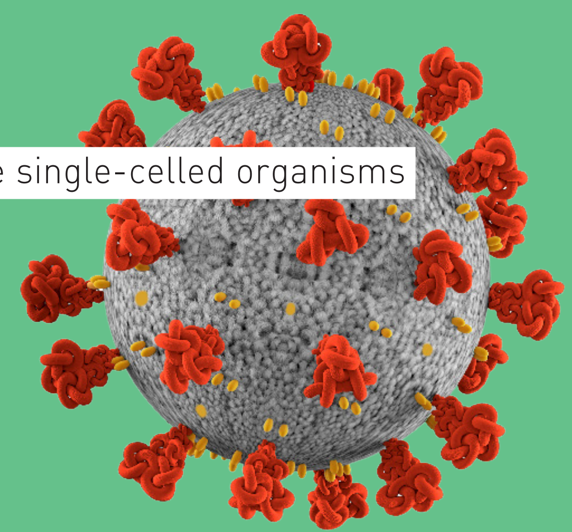
6.1 All living things are made up of cells

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 Fungal cells can save lives

What if?

Building blocks

What you need:

Building blocks (e.g. 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

In this topic, you will learn that:

- microscopes allow scientists to see the building blocks of life (a cell).
- cell theory states that: all living things are made up of cells; cells are the basic unit of life and structure; all living cells are created from existing cells.

Video
All living things are made up of cells

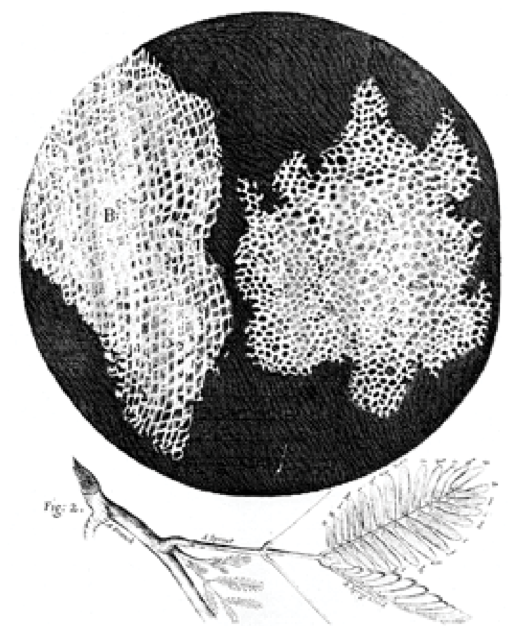
Scientists have not always known that living things are made up of cells. It was the invention of the microscope in the mid-seventeenth century that allowed us to see the building blocks of life – the tiny units that form every living thing. Microscopes showed that each and every living thing is made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

cell
(in biology) the building block of living things

microbiology
the science involving the study of microscopic organisms

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 1). He was surprised to see that, under the microscope, the cork looked like a piece of honeycomb with 'holes' and 'honeycomb'. He called the small structures 'cells' because they reminded him of the small rooms in a monastery, which were also called cells. Hooke had discovered the first plant cells.

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 name-calling 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.

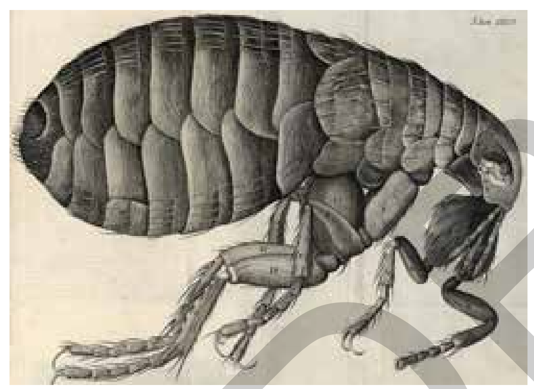


Figure 2 Robert Hooke's detailed drawing of a flea

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**. There are many living things, such as bacteria, that consist of only one cell. These are called **single-celled** or **unicellular** organisms. **Microorganisms**,

cell theory
the theory that all organisms are composed of one or more cells; cells are the basic unit of life, and new cells are created from existing cells

multicellular
an organism that has two or more cells

single-celled
an organism that consists of one cell

unicellular
living things consisting of only one cell (e.g. bacteria)

microorganisms
a microscopic organism

SKILLS LAB
6.1: Drawing cells
Go to page 215.

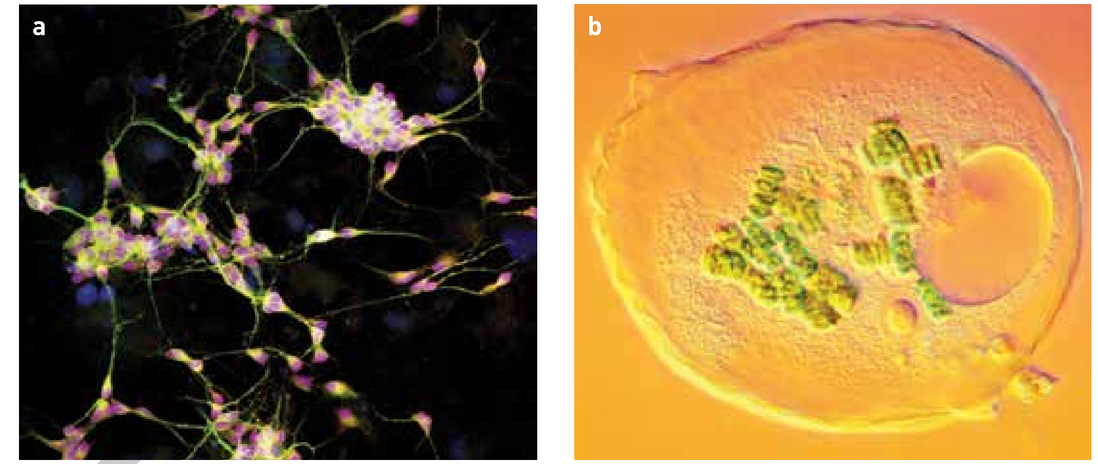


Figure 3 a Human nerve cells are part of multicellular humans but **b** the amoeba is a unicellular organism.

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.

microbes
living things that can only be seen with the use of a microscope; a microorganism

cell membrane
the barrier around a cell that controls the entry and exit of substances into and out of a cell

Why are cells so small?

The outside surface of a cell is called the **cell membrane**. It controls what can move in (nutrients) or out (waste) of the cell.

Large cells have more difficulty staying alive than small cells. Large cells need to move nutrients a long way to reach the centre of the cell. Small cells do not need to make the nutrients travel as far and this makes it easier for all parts of the small cells to stay healthy and alive.

The total space inside the cell is referred to as the cell's volume while the size of the membrane is called the surface area. As a cell increases in size, both its volume and its surface area increase. The problem is, the volume increases much more than the surface area. Eventually the volume becomes so big that it is 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.

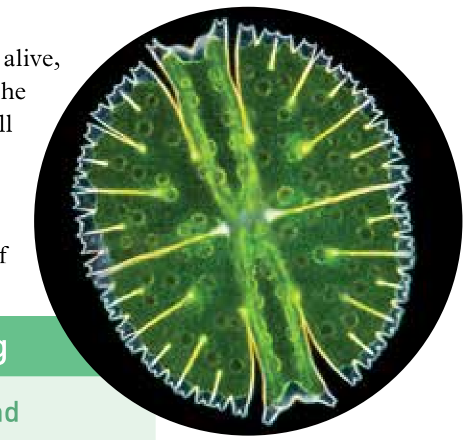


Figure 4 The irregular shape of this unicellular organism (called a desmid) maximises the surface area to volume ratio.

6.1 Check your learning

Remember and understand

1. **Identify** the person who invented the first microscope.
2. **Describe** why cells are called 'cells'.
3. **Define** the term 'multicellular'.
4. **Name** five multicellular organisms.
5. **Identify** three things that all unicellular organisms have in common.
6. **Describe** the three principles of cell theory.

Apply and analyse

7. The common house dust mite is a microorganism. **Explain** if you would be able to see this animal without a microscope. Justify your answer (by defining the term microorganism and linking the definition to the need of a microscope).
8. **Explain** if a cell with a bigger surface area to volume ratio would be able to meet its requirements for nutrients more effectively.
9. **Explain** why unicellular organisms are always very small.

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

SKILLS LAB
6.2: Getting to know your microscope
Go to page 216.

6.2 Microscopes are used to study cells

In this topic, you will learn that:

- a microscope is an instrument that uses lenses to magnify the size of objects.
- the science of investigating small objects using a microscope is called microscopy.

Video
Microscopes are used to study cells

microscope
a scientific instrument used to magnify the size of an object

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

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

objective lens
lens in the column of a compound light microscope

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

stereomicroscope
a microscope with two eyepieces that uses low magnification

compound light microscope
a microscope with two or more lenses

eyepieces
lenses where the eyes are placed when using a microscope

monocular
using one eye; a type of microscope

binocular
using two eyes; a type of microscope

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**. The study of small objects using a microscope is called **microscopy**.

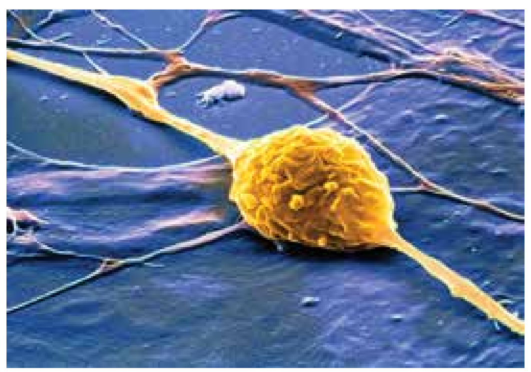


Figure 1 Image of a nerve cell under a scanning electron microscope (SEM).

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 look through 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 two lenses (one in the eyepieces and one further down the column, called the **objective lens**). Most cells are clear or transparent so a **stain**, such as iodine, can be used to help make them more visible.

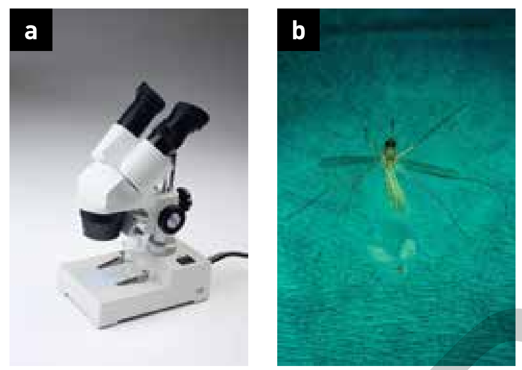


Figure 2 a A stereomicroscope **b** An insect, as seen under a stereomicroscope

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 the surface of a specimen. A computer is used to recreate the image, showing details of its surface.

a

b

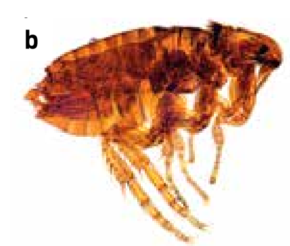


Figure 3 a A compound light microscope **b** A flea, as seen under a compound light microscope

Electron microscopes can magnify up to a million times. Using this technology, many more details of the cell can be seen and understood.

Getting to know your compound light microscope

Figure 4 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 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.
- 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 sharp grey pencil.
- Work out the total magnification.
- Write the magnification next to your sketch.
- Label and date the sketch.

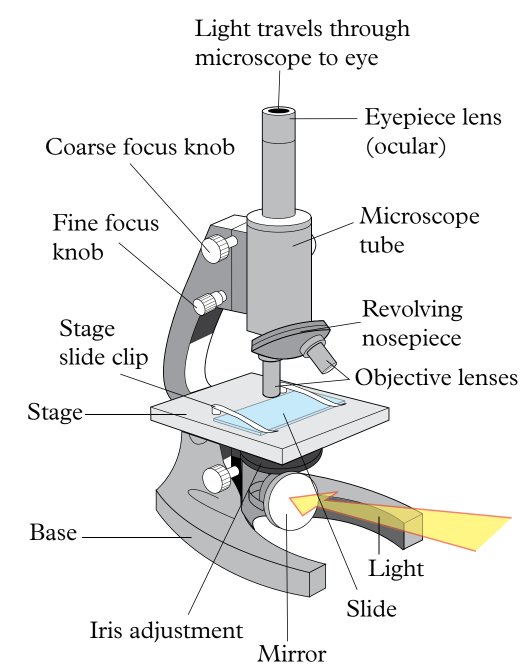


Figure 4 Parts of a compound light microscope

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.

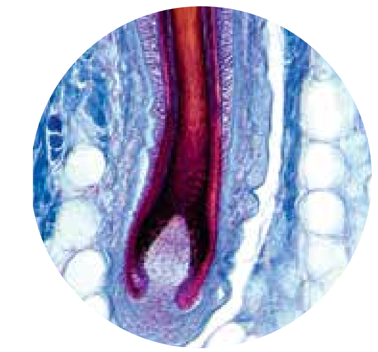


Figure 5 Human hair root that is stained for contrast

Worked example 6.2 Calculating magnification

Calculate the final magnification of a cell that can be seen when using a ×4 objective lens and a ×10 eyepiece lens.

Solution

Magnification = eye piece lens magnification × objective lens magnification
= 10 × 4
= 40

The cell was magnified 40 times larger than normal.

Table 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

6.2 Check your learning

Remember and understand

1. **Identify** the type (or types) of microscopes that are in your science laboratory.
2. Explain why you should look from the side when first adjusting the coarse focus knob.
3. Explain why very thin samples should be used under a light microscope.
4. **Define** the term 'microscopy'.

Apply and analyse

5. **Explain** why it is important to label and date your specimen drawings.
6. Complete the following magnification table for a compound light microscope by calculating the missing values.

Eyepiece magnification	Objective lens magnification	Total magnification
× 5		× 100
	× 20	× 300
× 10	× 50	

6.3 Plant and animal cells have organelles

In this topic, you will learn that:

- a cell is the smallest basic unit of life.
- all cells have a membrane, cytoplasm and genetic material (DNA).
- all plant and animal cells are made up of smaller organelles.

Interactive
Parts of a cell
Interactive
Plant cells

cytoplasm
the 'jelly-like' fluid inside the cell membrane that contains dissolved nutrients, waste products and organelles

DNA (deoxyribonucleic acid)
a molecule that contains all the instructions for every job performed by the cell; this information can be passed from one generation to the next

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

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 and structures inside the cell membrane. 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. Plant and animal cells keep their DNA surrounded by a membrane to form a **nucleus** (the control centre of the cell).

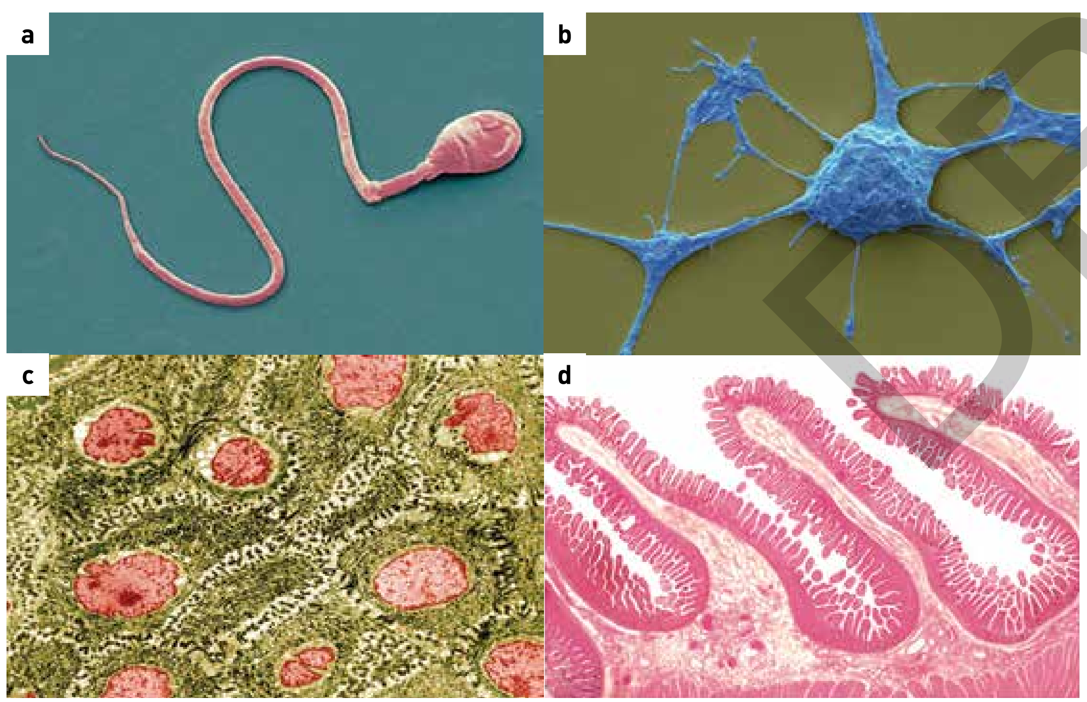


Figure 1 Cells can be different shapes and sizes: **a** sperm cell, **b** nerve cell, **c** skin cell and **d** intestinal cell.

CHALLENGE
6.3a: Comparing the size of cells and their parts
Go to page 217.

ANIMAL CELL

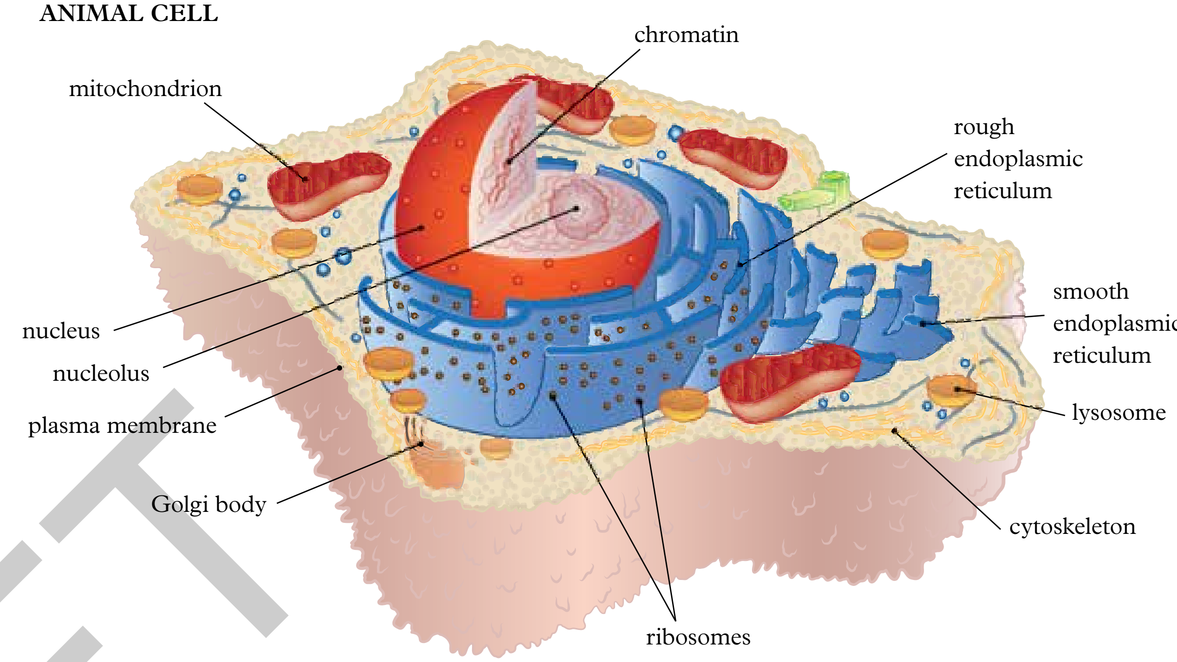


Figure 2 Some key parts (organelles) of an animal cell

A PLANT CELL

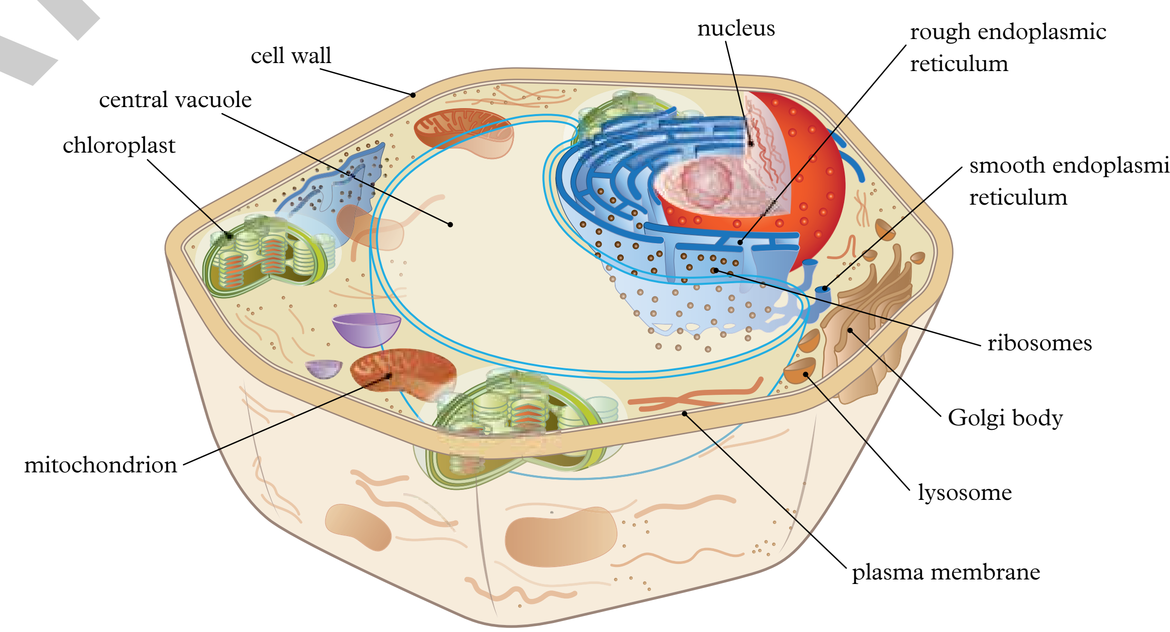


Figure 3 Some key parts (organelles) of a plant cell

A closer look at organelles

Some cells need special areas or **organelles** (mini-organs) to help them do special things (functions). These functions are necessary for the cell to survive. Some organelles, such as ribosomes, are part of the cytoplasm, whereas other organelles are separated from the fluid in 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 organelles that are in some cells – the mitochondria, ribosomes, chloroplasts and vesicles.

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

EXPERIMENT
6.3b: Looking at organelles
Go to page 218

EXPERIMENT
6.3c: Measuring cells
Go to page 219.

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

ribosome
cell organelle where protein production takes place

Mitochondria

Mitochondria (singular 'mitochondrion') are the powerhouse of the cell. They are 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 (see Figure 4). The inner membrane is folded to increase the surface area of the membrane. An important 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.

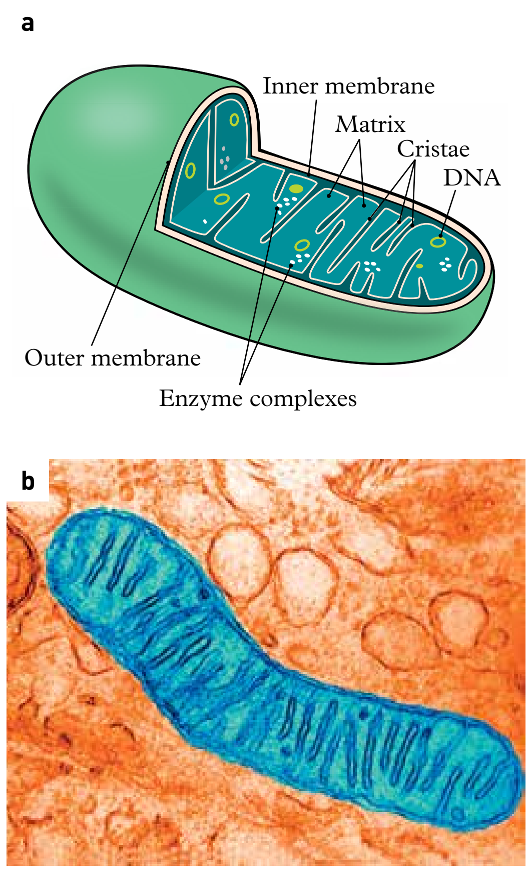


Figure 4 a Schematic diagram showing the structure of a mitochondrion **b** Electron micrograph of a mitochondrion

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

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

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

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 the oxygen that is needed to keep you alive.

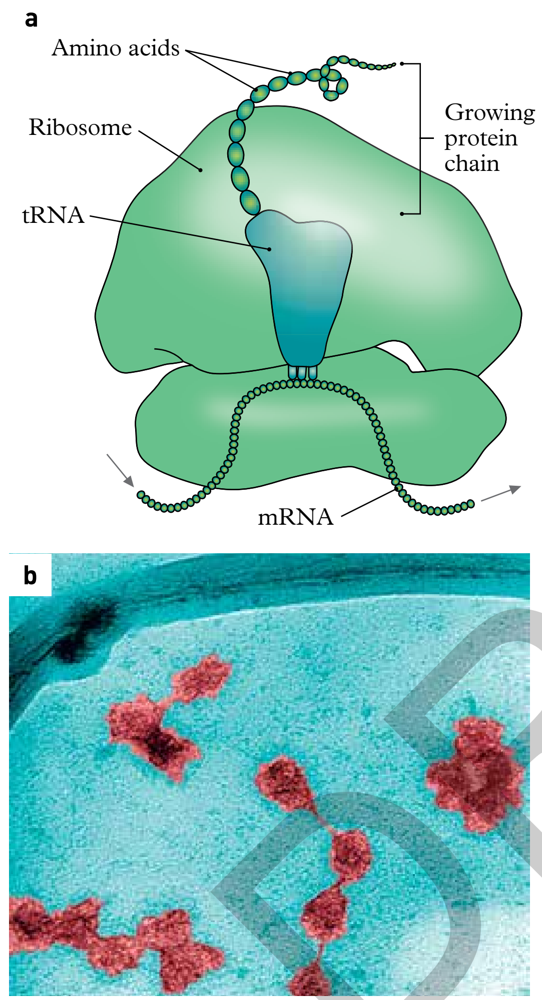


Figure 5 a Schematic diagram showing the structure of a ribosome **b** Electron micrograph of ribosomes

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**.

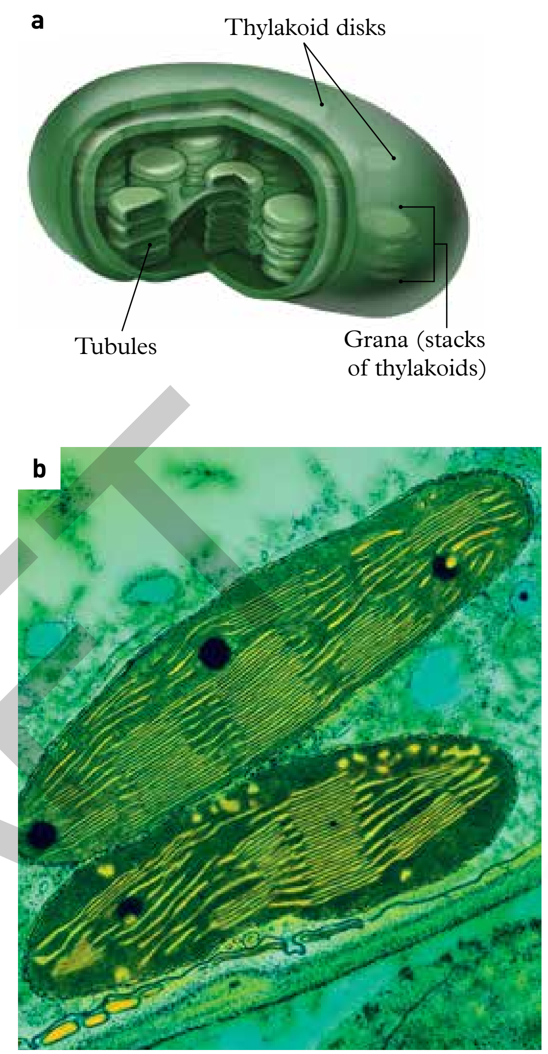


Figure 6 a Schematic diagram showing the structure of a chloroplast **b** Electron micrograph of chloroplasts

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 3). Animal cells may have many small vesicles.

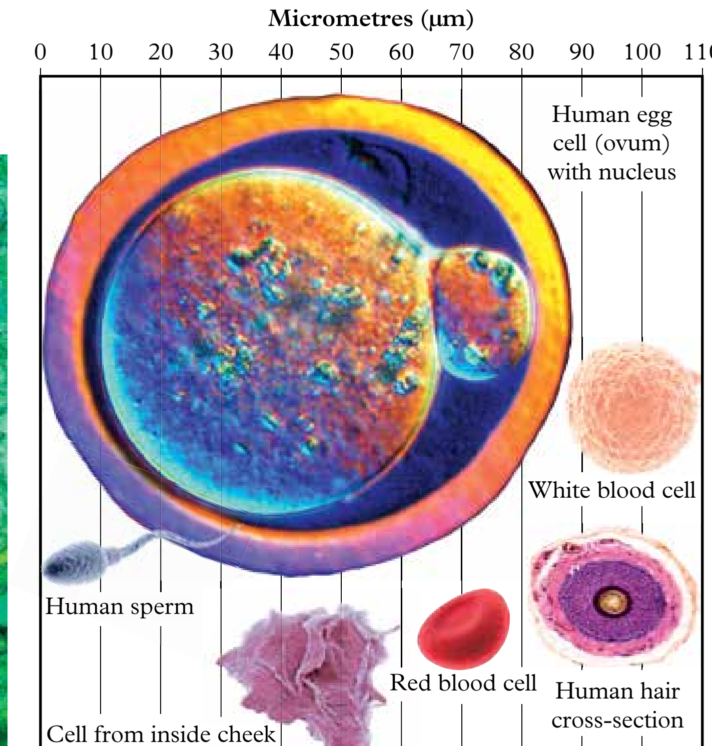


Figure 7 Different types of cells are different sizes and are measured in micrometres (μm). One micrometre is equivalent to one-thousandth of 1 millimetre.

6.3 Check your learning

Remember and understand

1 **Name** three organelles that are surrounded by a membrane.
2 **Describe** the function of the cell membrane.
3 **Describe** two roles of proteins in organisms.
4 **Identify** the organelle where cellular respiration occurs.
5 **Identify** three things that are stored in a vacuole.
6 **Describe** the function of chlorophyll.

Apply and analyse

7 Identify the reactants (present at the start) and products (present at the end) for the chemical reaction called photosynthesis.
8 Describe the features of all living cells. (Hint: Remember MRNGREWW from Year 7.)
9 **Explain** where you would be more likely to find large numbers of mitochondria, in a muscle cell or a bone cell. Justify your answer (by explaining the function of mitochondria in a cell, explaining what each cell does and deciding which cell would need the mitochondrial function most).

6.4 All organisms have cells that specialise

In this topic, you will learn that:

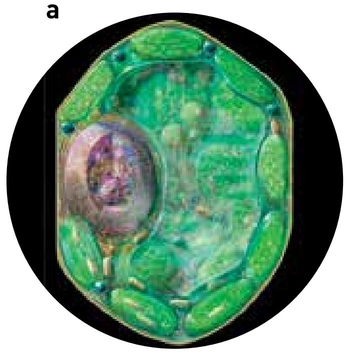
- all cells can be broken into two groups, prokaryotes and eukaryotes.
- prokaryotic cells (bacteria) do not have organelles or a nucleus.
- eukaryotes have a nucleus and different organelles that are used to divide them into Kingdoms.

Video
Eukaryotic cell structure

prokaryotic cell
primitive single-celled organism that has no nucleus

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

a



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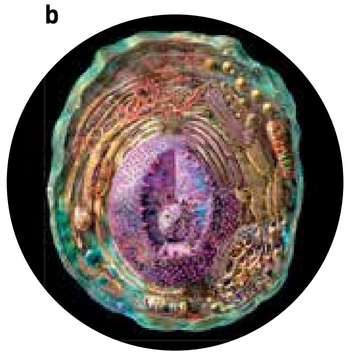

Figure 1 Typical **a** plant and **b** animal cells

Prokaryotes and eukaryotes

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 (single cells). 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 (DNA) is found free in the cytoplasm. Prokaryotes include all the bacteria found on Earth.

Eukaryotic cells are more complex cells and are found in organisms from each of the other four kingdoms – Animalia, Plantae, Fungi and Protista. Eukaryotic cells keep their genetic material in a nucleus and have the membrane-bound organelles described in topic 6.3. Most eukaryotes are multicellular.

Plant cells

When we look at whole organism plants and animals, it's fairly easy to see that they are different. However, once microscopes started to become more powerful, scientists could see differences between the individual plant and animal cells (Figure 1). 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 such as mushrooms are often mistaken as a type of plant. Under a microscope scientists are able to see that fungal cells are different to plant cells. For example, fungal cells don't have chloroplasts, so they cannot photosynthesise, and they don't have large vacuoles filled with liquid. Instead of making their own glucose, fungi such as mushrooms need to absorb their nutrients from the soil.

Table 1 Characteristics of eukaryotic and prokaryotic cells

Characteristic	Kingdom				
	Eukaryotes				Prokaryotes
	Animalia	Plantae	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 6.4a: Classifying using cells
Go to page 219.

EXPERIMENT 6.4b: Plant and animal cells
Go to page 220.

Protists

Protists (Kingdom Protista) are a mixed group of organisms that are mostly unicellular (the whole organism is made up of just one cell). Many live in water, some are photosynthetic (they make their own food, like plants), some eat other organisms and some cause diseases. Depending on where it lives and its food sources, a protist's shape or structure will have evolved to suit its environment. The protists in Figures 3 to 6 have structures particular to their lifestyles.

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. All animal cells have a nucleus and organelles, but no chloroplast or cell wall.

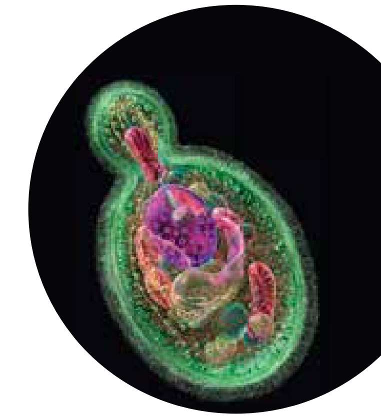

Figure 2 Cells in kingdom Fungi have cell walls and nuclei, but no chloroplasts.

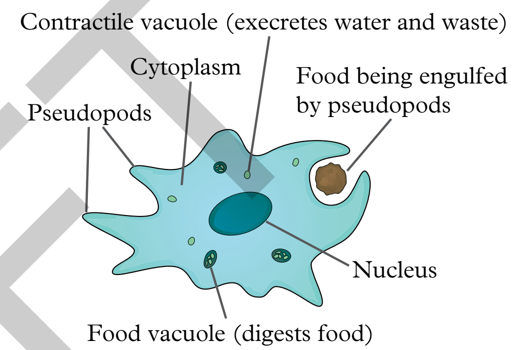

Figure 3 An amoeba can change the shape of its blobby body, creating foot shapes for movement and mouth shapes for swallowing food.

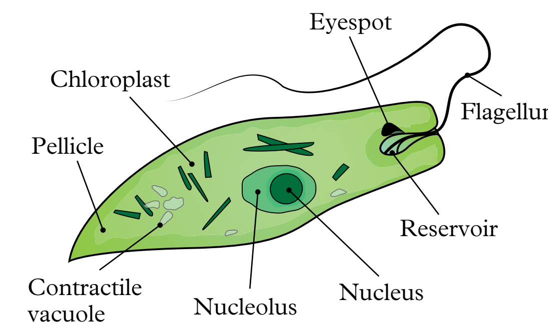

Figure 5 Euglena moves quickly when it needs to, with a bullet-shaped body and a long tail called a flagellum to whip it into action.

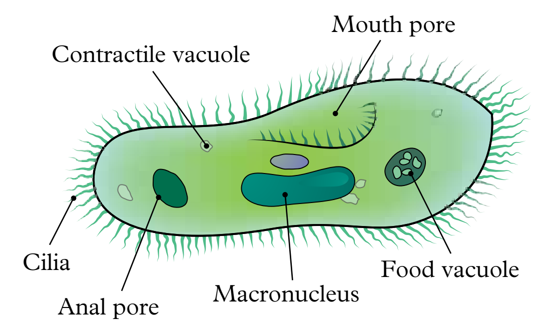

Figure 4 The paramecium moves slowly with lots of tiny hairs called cilia that act like miniature oars.

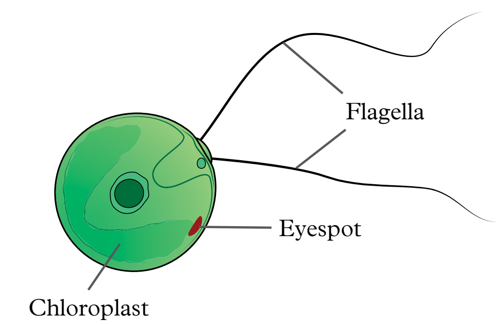

Figure 6 Chlamydomonas has an eyespot to detect light and two flagella to swim.

6.4 Check your learning

Remember and understand

1. **Describe** an example of a unicellular organism and a multicellular organism.
2. **Describe** the two main differences between eukaryotic and prokaryotic organisms.
3. **Identify** where the genetic material is found in a prokaryotic cell.
4. Use Table 1 to **identify** the kingdom that is often referred to as 'the rest' of the cells.

Apply and analyse

5. Table 1 shows that plant cells contain chloroplasts. Although a typical plant cell contains chloroplasts, they are not found in all plant cells.
   a. **Explain** why some cells in a plant root may lack chloroplasts.
   b. Identify the part of a plant where you would expect to find cells with chloroplasts.

Evaluate and create

6. Draw a cell that would be found in a mushroom (eukaryotic fungal cell). Label all of the organelles.

EXPERIMENT
6.5: Microbes all around
Go to page 220.

6.5 Bacteria are single-celled organisms

In this topic, you will learn that:
- non-dangerous bacteria that live in or on our body are called natural flora.
- pathogens are cells that cause disease in other organisms.
- infectious pathogens can be passed between organisms.
- bacteria reproduce through binary fission.
- viruses are non-living because they cannot reproduce alone.

Video
Bacteria are single-celled organisms

natural flora
microbes that live happily in our bodies

pathogen
microbe that can potentially cause a disease

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

symptoms
changes that occur to an individual as a consequence of disease

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 microbes (microscopic organisms) are essential for keeping our body healthy and working correctly. Others can be deadly.

Natural flora

The microbes that live happily on or in our bodies are referred to as **natural flora**. The careful balance between natural flora and the microbes in our environment is important to our health. The right amount of natural flora will protect us against foreign invaders, while 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. The bacteria on our skin act as a protective coating, preventing disease-causing bacteria from growing.

Microbes causing disease

We have all been sick at some stage in our lives. 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 described as contagious, meaning they can spread from one organism to another. Pathogens always live on a host organism, such as a human, animal or plant. You will be investigating pathogens in more detail in Year 9. The **symptoms** of a disease are the changes that occur to a host due to the disease.

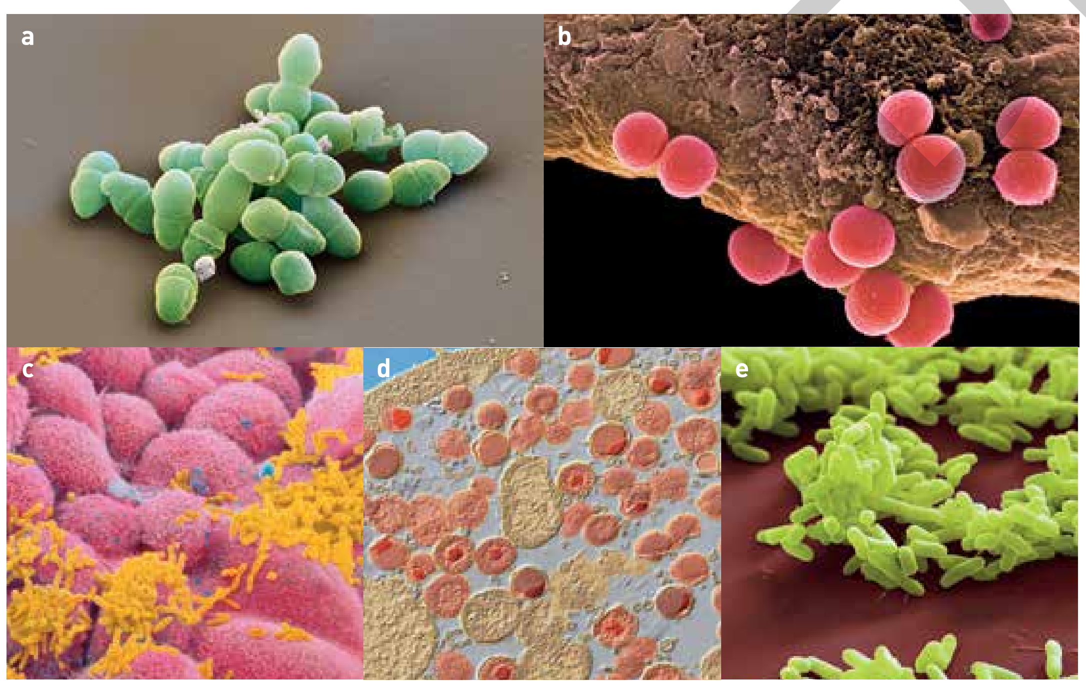

Figure 1
a *Staphylococcus epidermis*
b *Staphylococcus aureus* in the hair
c *Haemophilus influenza* in the nose
d *Chlamydia trachamates* in the eye
e *Escherichia coli* in the intestines

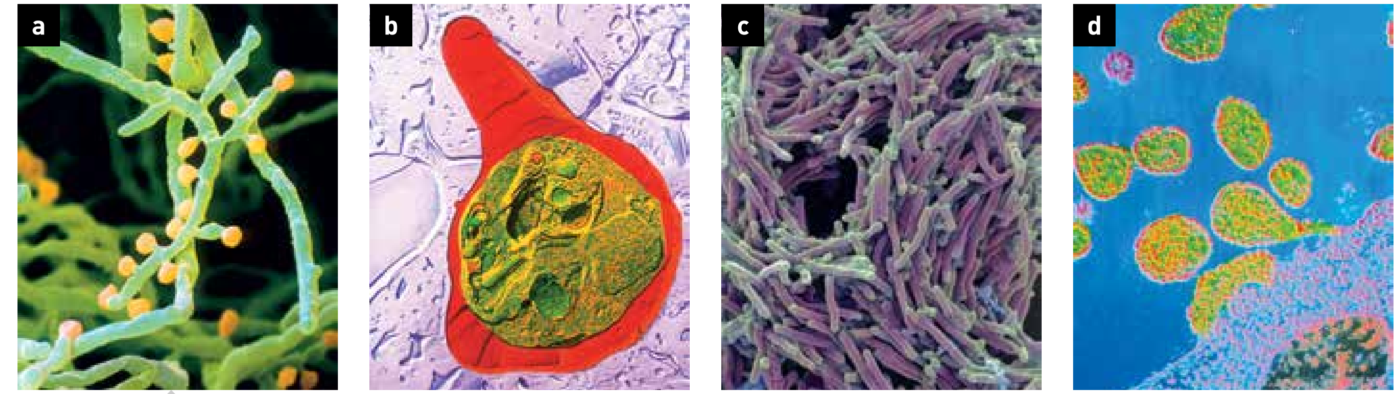

Figure 2 **a** *Trichophyton mentagrophytes* – cause of ringworm and tinea **b** A red blood cell infected with malarial parasites **c** Tuberculosis bacteria **d** Rubella virus

Harmful microbes may be bacteria, fungi, protista 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 covid, the common cold and flu, measles and herpes.

Viruses

Viruses are considered by most scientists to be non-living pathogens. Viruses cannot survive and reproduce outside a host cell. Instead, they need to invade a cell and use the cell's organelles to reproduce.

Viruses (such as influenza and corona viruses) are responsible for most of the common colds that we experience. They 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, eat a healthy diet and let the cells in our body 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 3.

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.

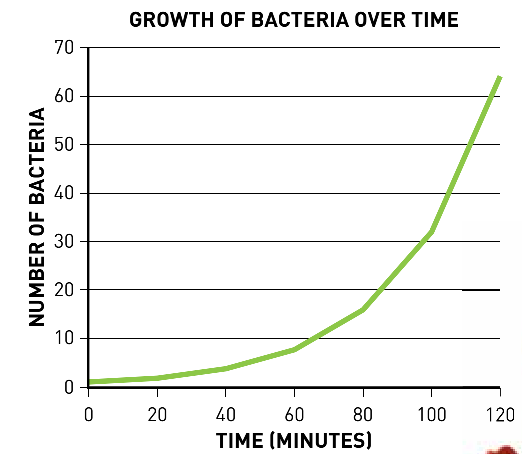

Figure 3 The number of bacteria cells can double every 20 minutes.

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

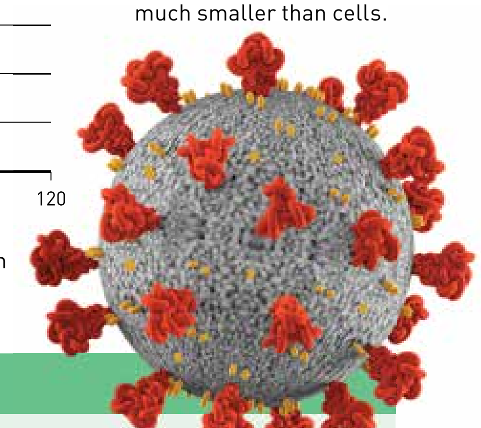

Figure 4 COVID-19 is a disease caused by a type of virus called coronavirus. Viruses are much smaller than cells.

6.5 Check your learning

Remember and understand

1. **Identify** the type of microorganism that your digestive system will rely on.
2. **Define** the term 'natural flora'.
3. **Describe** a situation where natural flora can be harmful to our bodies.
4. **Define** the term 'pathogen'. Identify the four main groups of pathogens.
5. Explain why a virus is not considered to be living.

Apply and analyse

6. It is not recommended that food be left out of the fridge for more than 3 hours. Use the definition of binary fission to **explain** why.

6.6 Fungal cells can save lives

In this topic, you will learn that:

- some fungal cells protect themselves from bacteria by producing antibiotics.
- fast producing bacteria can become resistant to antibiotics.
- 'superbugs' are bacteria that are resistant to many types of antibiotics.

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

Figure 1 Alexander Fleming

Figure 2 A type of penicillin can grow on orange peels.

The discovery of penicillin

It has been accepted for over 3000 years that some fungal cells could kill bacteria. In 1928, Alexander Fleming is credited with discovering the specific chemical that was responsible for this.

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 were 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.

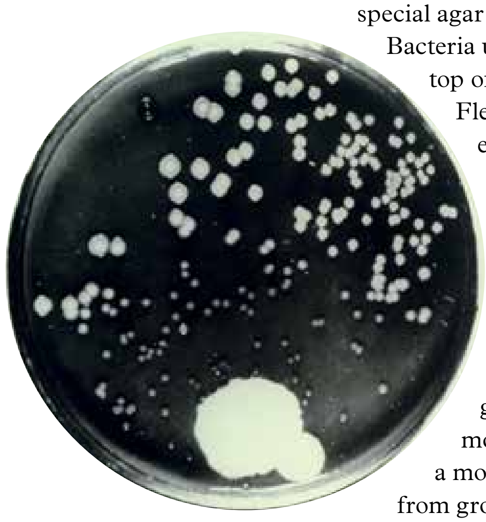

Figure 3 Some moulds are able to prevent bacterial growth.

Producing penicillin

It took ten more years and the work of Howard Florey (an Australian) and Ernst Chain to develop a way to separate the penicillin and produce 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.

Figure 4 Howard Florey

Figure 5 Ernst Chain

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.

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. The researchers tried treating children next, 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 infections.

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. Because bacteria reproduce quickly, 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.

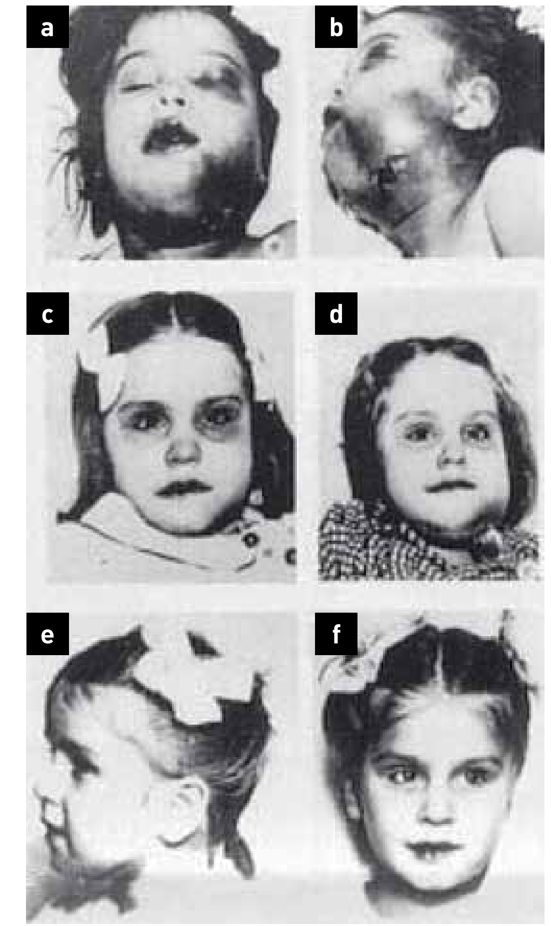

Figure 6 These photos from 1942 show the improvement of a child after penicillin treatment for a bacterial infection.
a, **b** Before treatment
c Four days after treatment
d Nine days after treatment
e, **f** Fully recovered

1000 BCE
Moulds and fermented materials used to treat infections.

1870s
Louis Pasteur: mould prevents anthrax growing.

1871
Joseph Lister: samples of urine do not allow bacteria to grow.

1897
Ernest Duchesne: mould prevents bacterial growth in animals.

1922
Alexander Fleming: a tear (containing lysozyme)from his eye prevents bacterial growth.

1928
Alexander Fleming: mould prevents bacterial growth in the same way as lysozyme.

1930s
Howard Florey and Ernst Chain: able to grow and purify enough penicillin to be used by patients.

1800 | 1870 | 1880 | 1890 | 1900 | 1910 | 1920 | 1930

Figure 7 Penicillin timeline

6.6 Check your learning

Remember and understand

1. **Define** the term 'antibiotic'.
2. Contrast fungi and bacteria.
3. Fungi usually grow best at 22°C. Explain why leaving the agar plate on the bench accidentally helped Fleming to make his discovery.

Apply and analyse

4. **Explain** why Florey and his group of scientists did not give penicillin to four of their mice.
5. **Explain** why fungi might need to protect themselves from bacteria.

Evaluate and create

6. '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.

Multiple choice

1 Identify which of the following is NOT found in an animal cell.
- a mitochondria
- b a cell wall
- c cytosol
- d a nucleus

2 Identify which important process takes place in the mitochondria of a cell.
- a photosynthesis
- b excretion
- c cellular respiration
- d cell division

3 Identify the term that describes the organism that catches the disease.
- a a cell
- b a pathogen
- c a host
- d an organism

Short answer

Remember and understand

4 Identify the fi st person to describe a cell.

5 Describe the benefit of using a stain when viewing some specimens.

6 Describe the cell theory.

7 Identify two types of microscopes.

9 Explain why a specimen needs to be very thin to be viewed under a light microscope.

10 Compare a mitochondrion and a chloroplast.

11 Contrast fungal cells and bacterial cells.

12 Define the foll wing words:
- a nucleus
- b mitochondrion
- c chloroplast
- d binary fission
- e pathogen.

13 Ribosomes are found in every cell on Earth. Describe the function that ribosomes perform in cells.

14 Distinguish between the terms 'unicellular' and 'multicellular'. Provide two examples of each.

Apply and analyse

15 Explain why antibiotics can't be used to treat COVID-19.

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

17 Explain why unicellular organisms are always tiny, and why multicellular organisms are made up of many cells instead of one large cell.

18 Explain why a doctor will not prescribe antibiotics if you are sick with a cold or flu

19 Animal cells have mitochondria, while plant cells have both mitochondria and chloroplasts. Explain this difference.

20 Light microscopes allow you to view living cells. Describe why the cells need to be thin to be seen down a light microscope.

21 Calculate the magnific tion of a cell that is viewed with a 'x40' objective lens and a 'x10' eye-piece lens.

Evaluate and create

22 Identify the microscope most likely to have created the images in Figure 1. Justify your decision (by describing the features in the picture that are unique and deciding which microscope would allow these features to be seen).

23 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 Identify 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. **Evaluate** if it is possible for a plant cell not to have nucleus (by describing the function of a nucleus, describing the importance of a nucleus to the cell staying alive and deciding if it is possible for a plant cell to live without a nucleus).

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

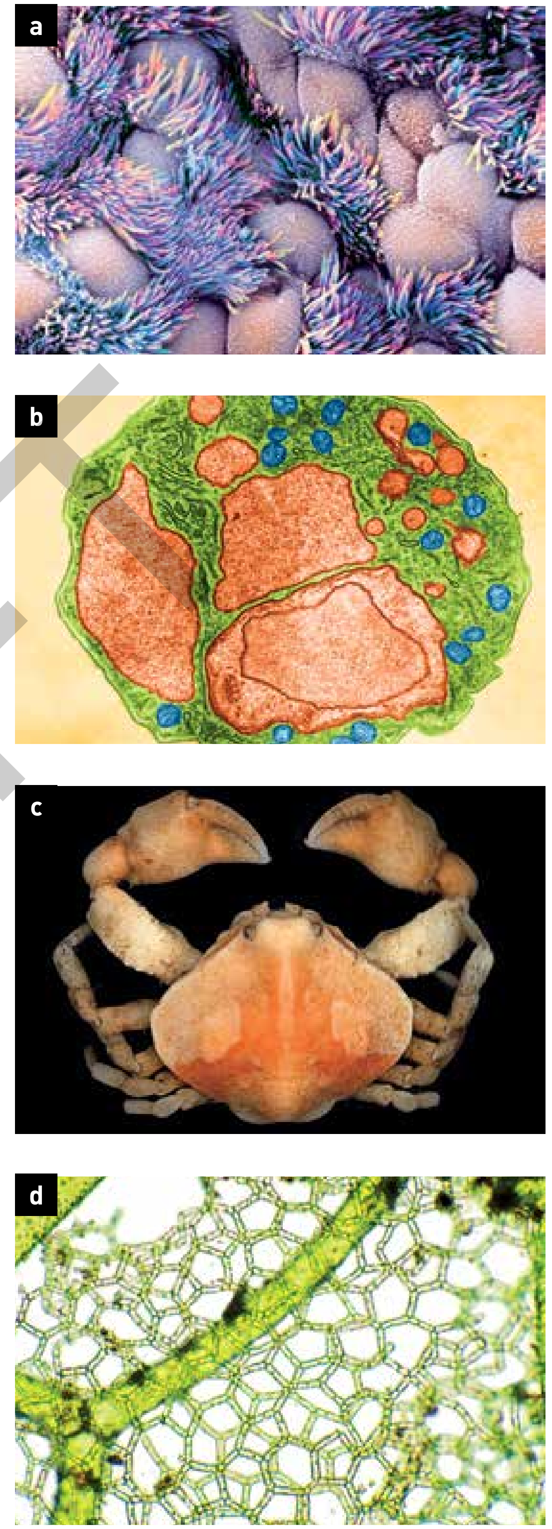

Figure 1

25 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.

26 Discuss how our understanding of cell structure and function has changed with the development of the microscope.

Critical thinking

27 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.

28 Describe how our understanding of how living things function changed with the development of the microscope.

Social and ethical thinking

29 Explain why a doctor should not prescribe antibiotics for a viral infection by describing:
- a the effectiveness of the antibiotics on making the person healthy.
- b the long-term effects of overprescribing antibiotics on resistance.

Research

30 Choose one of the following topics for a research project. A few guiding questions have been provided for you, but you should add more questions that you want to investigate. 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.

» 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.

» 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.

» 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. Describe the conditions that allow the stomata to open. Describe the conditions that cause the stomata to close. Describe how the shape of the guard cells assists the opening and closing of the pore.

Reflect

The table below outlines criteria for successfully understanding Chapter 6 Cells. Once you have completed this chapter, reflect on your ability to do the following:

	I can do this.	I cannot do this yet.
Define cell, microbiology, multicellular, single-celled, unicellular, microorganism, microbe, cell membrane and nutrients. Explain the key concepts of the cell theory and describe the surface area to volume ratio.	☐	☐ Go back to Topic 6.1 All living things are made up of cells Page XX.
Compare and contrast electron microscopes and light microscopes, and stereomicroscopes and compound light microscopes. Calculate magnification and demonstrate the ability to focus a compound light microscope.	☐	☐ Go back to Topic 6.2 Microscopes are used to study cells Page XX.
Identify the cell membrane, cell wall, mitochondria, chloroplasts and nucleus of a cell. Describe the functions of the cell membrane, cytoplasm, DNA, mitochondria, ribosomes, chloroplasts and vesicles.Identify the key differences in structures of plant and animal cells.	☐	☐ Go back to Topic 6.3 Plant and animal cells have organelles Page XX.
Describe the key differences between and provide examples of prokaryotic and eukaryotic cells.	☐	☐ Go back to Topic 6.4 All organisms have cells that specialise Page XX
Define natural flora, pathogen, infectious disease, symptoms and binary fission, and describe the differences between natural floral and pathogens. Explain the benefits of natural flora to human health.	☐	☐ Go back to Topic 6.5 Bacteria are single-celled organisms Page XX
Describe the development of penicillin and explain the problems associated with the overuse of antibiotics.	☐	☐ Go back to Topic 6.6 Fungal cells can save lives Page XX

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Quiz
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Check your Teacher obook pro for these resources and more:

QuizletLive
Launch a quiz for your students on key concepts in this chapter.

CHAPTER 9

6.1 Drawing cells

SKILLS LAB

What you need

Several stations set up around the laboratory with microscopes adjusted to show different kinds of cells.

CAUTION! Do not attempt to adjust any of the microscopes. Ask your teacher or laboratory technician to adjust the microscope if you think it has been bumped or has gone out of focus.

What to do

1. Look carefully at each specimen. Write down its name and a sentence that describes what you see.
2. Make a very simple pencil sketch of a single cell that you can see. Draw the outside edge of the cell fi st, including any bump or unusual shape you notice.
3. Draw two more cells that are close to your original cell. (Do not attempt to draw every cell that you see.)
4. If you can see anything inside the cells (it may only be a dark dot), mark this on your sketch.
5. Label any parts that you can identify.

Questions

1. Identify and describe the cell which, in your opinion, was the most unusual.
2. Identify the cells that had walls around them.
3. Identify the cell which was the smallest.
4. Identify the cells that were the largest.
5. Compare the cells you viewed through the microscope with the images of the cells in Figure 79.
6. Describe some of the difficulties of dr wing cells seen through a microscope.

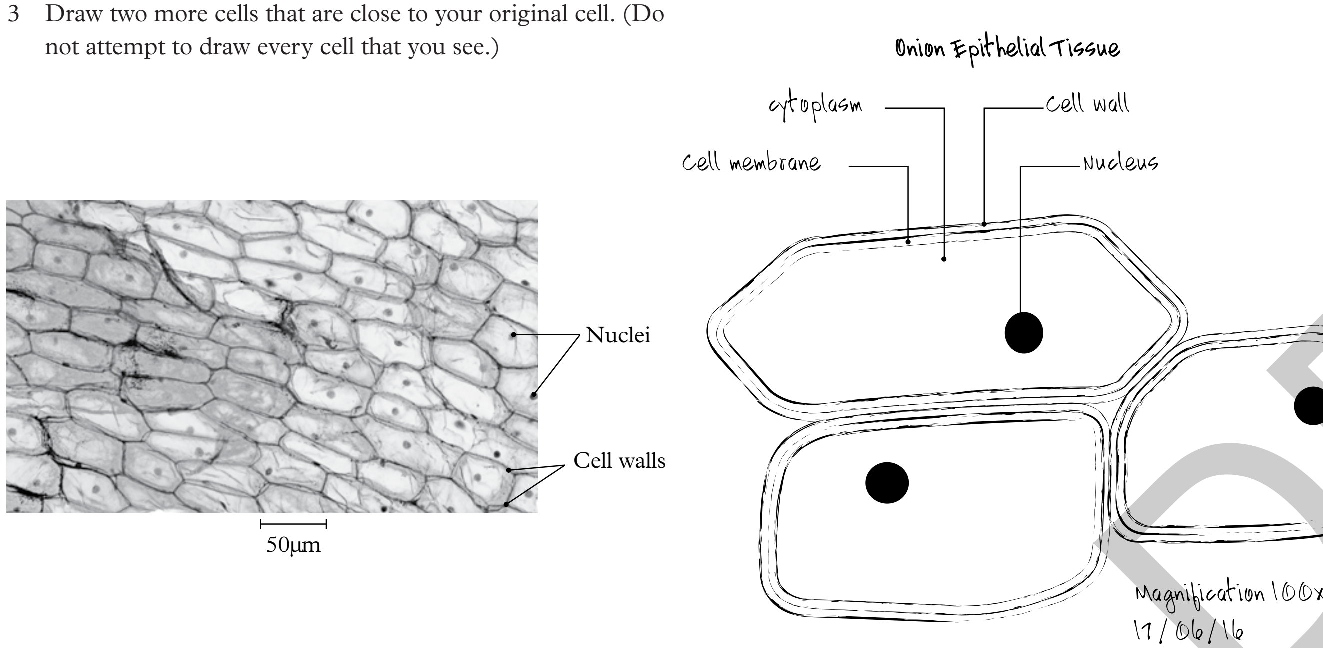

Figure 79 (a) Onion cells through a microscope (b) Drawings of the cells seen through a microscope

6.3A Comparing the size of cells and their parts

CHALLENGE

What you need

- Sheet of poster paper
- Pencil
- 30 cm ruler
- Eraser

What to do

Part A

Use a scale of 1 cm : 1 µm to draw a series of circles to represent the average size of various cells and microbes according to the measurements given in Table 19.

Table 19 Average diameters of different cell types

Cell type	Average diameter (µm)
Human cheek cell	30
Human red blood cell	7
Human white blood cell	25
Epidermal plant cell	50
Staphylococcus bacterium (spherical)	1
Escherichia coli bacterium (rod shaped)	3

Part B

Organelles vary in size. Some organelles, such as chloroplasts, are large enough to be visible under the light microscope. Others, such as mitochondria, are usually too small to be visible.

Use the measurements given in Table 20 to add a chloroplast and a mitochondrion (singular) to your set of diagrams.

Table 20 Size of cell organelles

Cell organelle	Average size (µm)
Chloroplast	5 µm long × 1.5 µm wide
Mitochondrion	2 µm long × 1 µm wide

Questions

1. Rank the cells and microbes in part A from smallest to largest.
2. Identify which of the cell organelles in Table 20 are not visible under the light microscope?
3. Viruses are much smaller than bacterial cells. For example, the influenza vi us, which causes the flu is 0.1 µm in diameter. Add the influenza vi us to your diagrams.

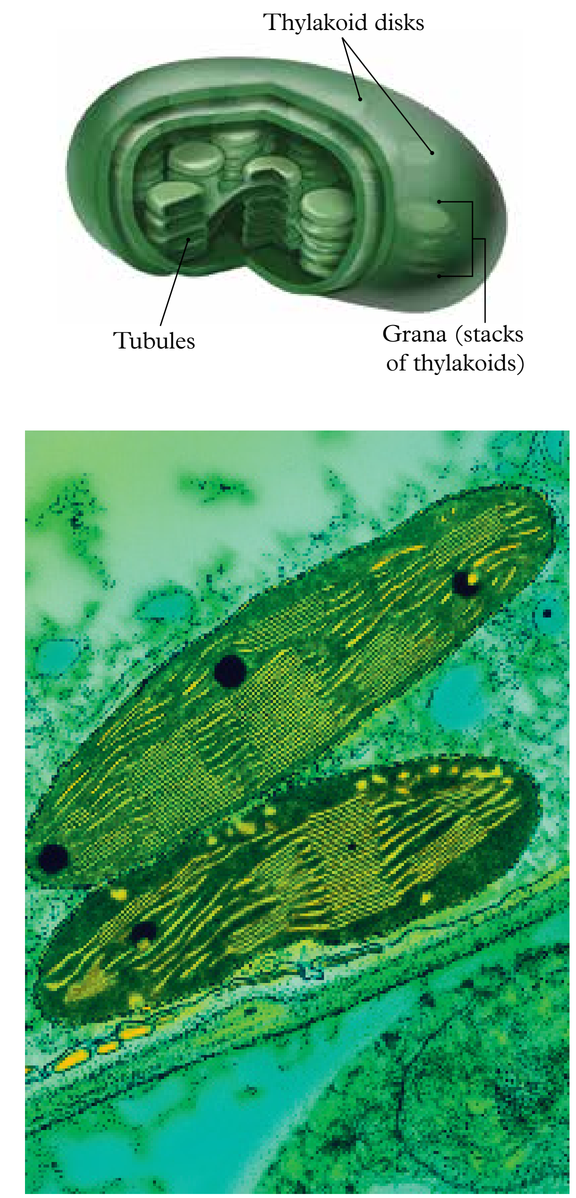

Figure 84 (a) Schematic diagram showing the structure of a chloroplast (b) Electron micrograph of chloroplasts

6.5 Microbes all around

EXPERIMENT

Background

In this activity you will investigate if common detergents can kill the bacteria found in the local environment. Most human pathogenic bacteria and fungi (those that are potentially harmful to humans) grow optimally at 37°C. For this reason, samples should be sealed with paraffin wax or tape prior to incubation and destroyed immediately after analysis.

Aim

To determine the effectiveness of detergents in killing or restricting bacterial growth.

Materials

> 3 Petri dishes containing nutrient agar (called an 'agar plate')
> 2 sterilised swabs
> Paraffin wax strips
> Incubator

CAUTION! Do not open the agar plate after incubation.

Figure 92 Carefully wipe the swab over the agar plate.

Method

1 Two of the agar plates are to be used for growing microbes and the third is the negative control plate. The negative control plate should not be opened at any stage of the activity, but must be incubated alongside the sample plates.
2 Decide on a site around the school to be tested for microbes.
3 Keep the swabs sterile (germ free) until you reach the site.
4 Rub the swab over the site and then gently rub it across the surface of the agar in both directions. Take care not to damage the surface of the agar.
5 Quickly place the lid on the plate, seal it with a wax strip and then incubate it, along with the control plate, at 37°C for 2–3 days. Do not open the agar plate again.

Inquiry: What if a detergent was spread over the surface of the agar plate?

> Choose a detergent that you would like to test.
> Write a hypothesis for your experiment.
> What (independent) variable will you change from the first method?
> Describe how you will know if the detergent is effective in killing/restricting bacterial growth. (This is your dependent variable.)
> Identify two variables that you will need to control to ensure a fair test. Describe how you will control these variables.
> Write in your logbook the method you will use to complete your investigation.
> Draw a table to record your results.
> Show your teacher your planning (for approval) before starting your experiment.

Discussion

1 Describe the growth on your sample plates after the incubation period. A labelled diagram may help you to do this. Identify the growth of bacteria and fungi that may be growing on your sample plates.
2 If your sample plate showed evidence of bacterial growth, describe any differences in colour, shape and size of the bacterial colonies.
3 Identify if your detergent was effective in controlling bacterial growth. Justify your answer by describing the differences in bacterial or fungal growth that occurred between the plates.
4 Describe why there may be some differences between the growth on your plates and those of other students.
5 Explain why it is important that both the swab and the plate are sterile and are only exposed to the environment for a short period while collecting the sample.
6 If the negative control plate was sterilised appropriately prior to the beginning of this activity and then incubated alongside the sample plate, it should have shown no bacterial or fungal growth. Explain the purpose of the negative control plate.

Conclusion

Describe the conclusions that you can make about the effectiveness of your detergent.

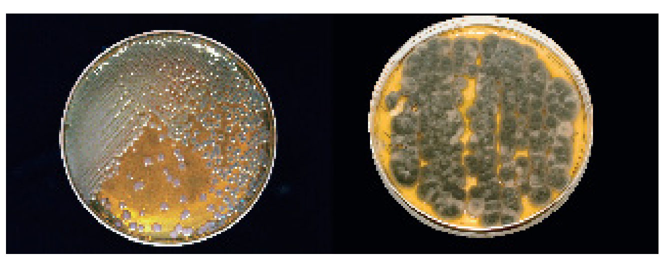

Figure 93 (a) Bacterial colonies growing on an agar plate (b) Fungi tend to have a dusty or fuzzy appearance.

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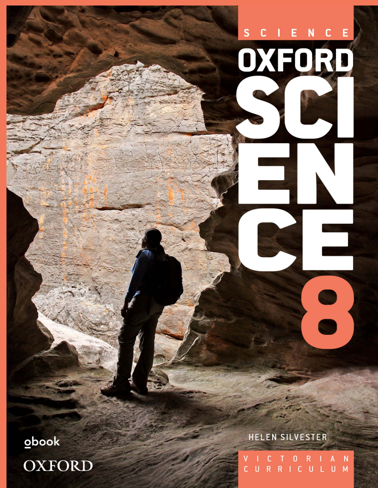

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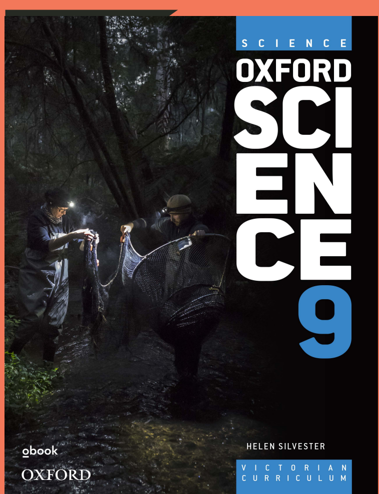

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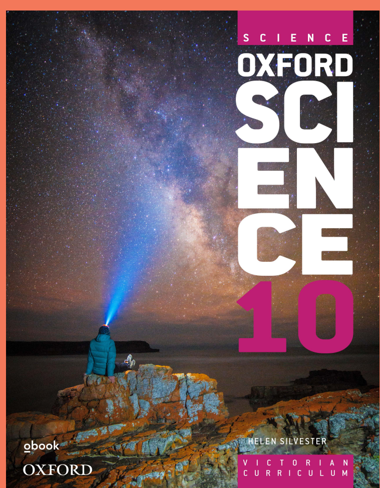

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