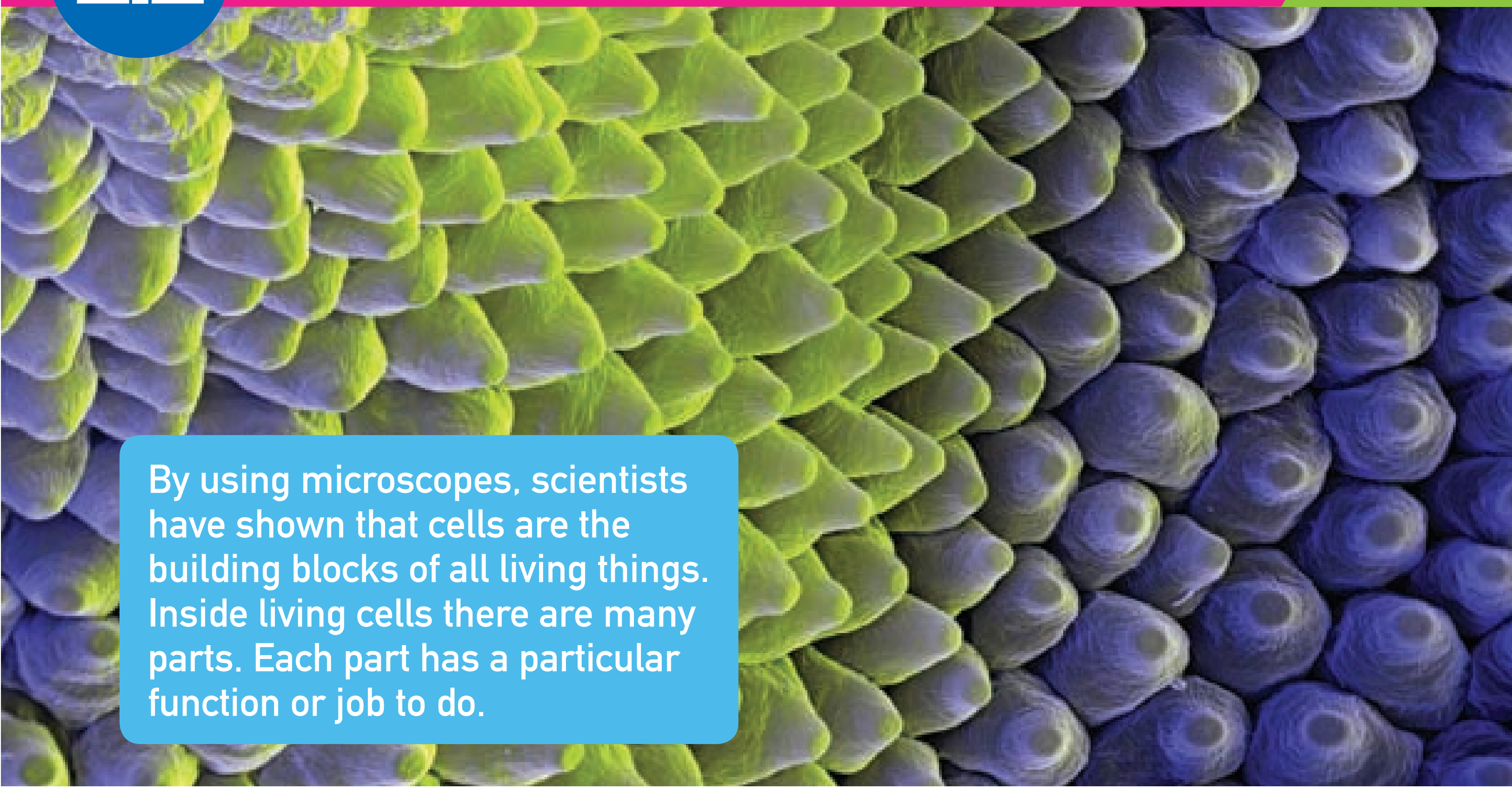
2.2 Natural building blocks



By using microscopes, scientists have shown that cells are the building blocks of all living things. Inside living cells there are many parts. Each part has a particular function or job to do.

Animal cells

Cells are the building blocks of all living things, including animals. If an animal cell was made big enough to hold in your hands, then it would probably feel like a clear balloon filled with water or thin jelly. You would also be able to see that there are tiny things inside the cell. These things are usually only visible using a microscope. Figure 2.2.1 shows the structure of a typical animal cell.

An electron microscope is needed to see some even smaller cell parts in the cytoplasm. These smaller parts are known as **organelles**. Each organelle has a special function:

- **Mitochondria** are the powerhouses of the cell, which release energy from food.
- **Ribosomes** are microscopic factories that produce the proteins used by the body for growth and repair.
- **Lysosomes** are the garbage disposal units that get rid of wastes from the cell.
- **Endoplasmic reticulum** form pathways that allow materials to move quickly and easily through the cell.

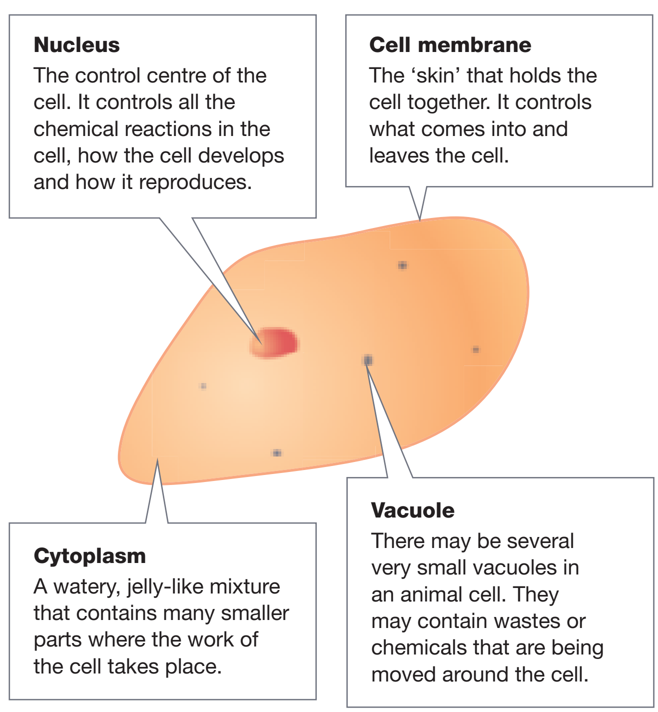


Figure 2.2.1 This typical animal cell contains smaller parts known as organelles. Each organelle has its own specific job to do within the cell.

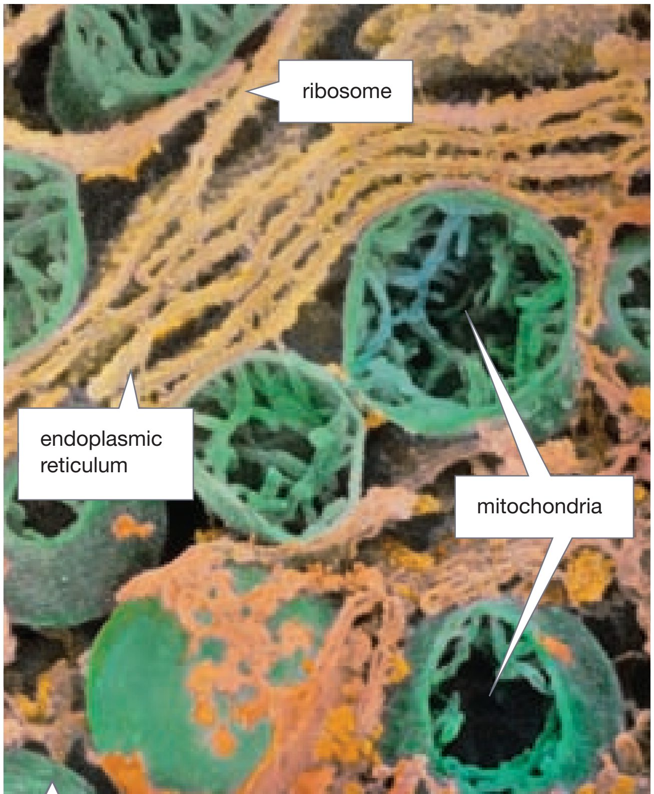


Figure 2.2.2 The organelles within a cell are so small that they can only be seen clearly with an electron microscope at magnifications of over ×100 000.

Plant cells

Plants have the same parts as animal cells plus a few extra parts. Figure 2.2.3 shows the structure of a typical plant cell. Like animal cells, plants cells have a cell membrane, cytoplasm and a nucleus. The vacuole in a plant cell is much larger than in animal cells. Plant cells also have a **cell wall** outside the cell membrane. The cell wall helps support the plant and gives it shape. Many plant cells contain additional organelles called chloroplasts. **Chloroplasts** contain a green substance called chlorophyll and are the site of photosynthesis. Plants cannot go hunting for their food. Instead, they make it themselves using energy from the Sun to chemically combine water and carbon dioxide (one of the gases in air) to make a sugar called glucose. This process, called **photosynthesis**, takes place in chloroplasts, which are found in the green parts of plants.

INQUIRY science 4 fun

Human cells

What do your cells look like?

Collect this ...

- monocular microscope
- lamp
- commercially prepared slide of cheek cells

Do this ...

1 Place the prepared slide of cheek cells on the microscope stage. These cells have probably been prepared using a stain that makes them easier to see.

2 Observe the cells first under low power and then under high power.

Record this ...

Describe what you saw.

Explain the function of each feature you observed in the cell.

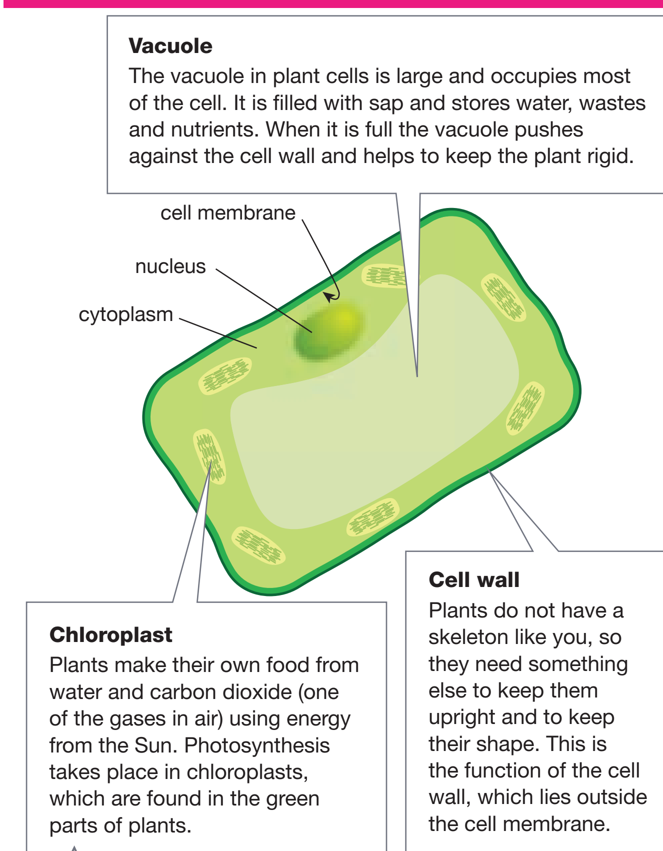


Figure 2.2.3 A typical plant cell has all the organelles that an animal cell has but also has chloroplasts and a cell wall.

How many?

There are about 50 trillion cells in your body. They come in different shapes and sizes, each with their own special job to do. For example, cells in the heart cause it to beat. Some blood cells fight infection, while others carry oxygen around your body.

SciFile

Fungal cells

Cells of fungi have the same parts as animal cells. As shown in Figures 2.2.5 and 2.2.6, fungal cells also have a cell wall like a plant cell. However, plant and fungal cell walls are made of different chemicals. Fungal cells do not have chloroplasts; therefore they cannot make their own food. Fungi produce substances that digest the material they are growing on. They then absorb the digested materials into their cells.

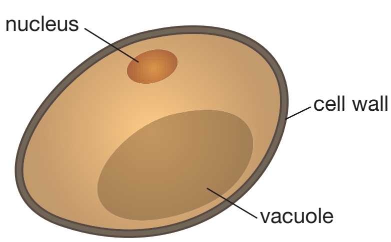
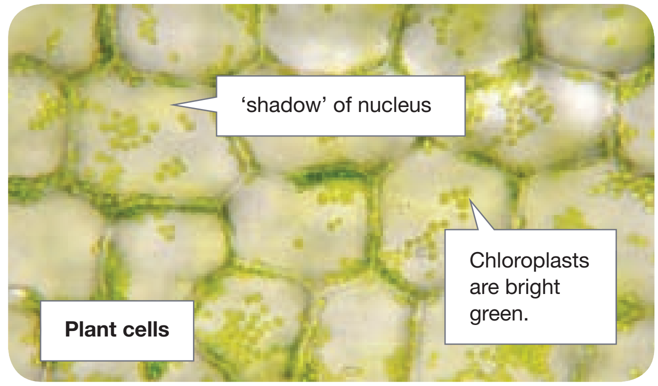


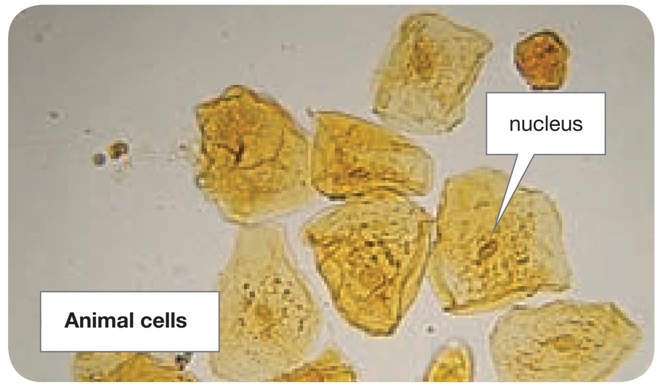
Figure 2.2.4 A typical fungal cell has the same organelles as an animal cell. It also has a cell wall like that found in a plant cell.

Tough stuff

The cell walls of plants are so ‘chemically tough’ that animals cannot digest them without help. Bacteria in the stomach of cows and other plant-eating animals digest the cell walls, making the nutrients available to the animals. When humans chew, they crush plant cells, releasing the contents, but the cell wall leaves the body undigested. This undigested cell wall is the fibre in our diet.

SciFile





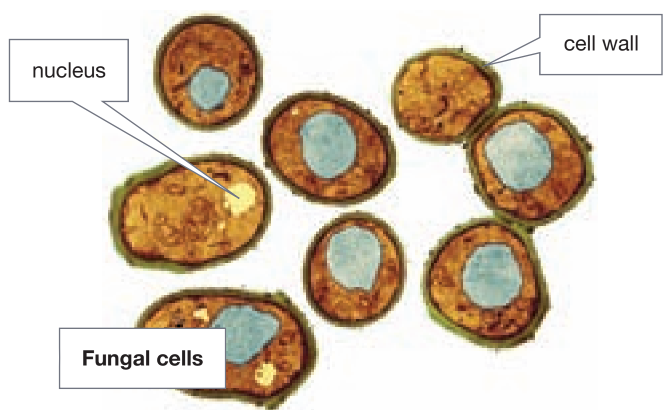


Figure 2.2.5 A nucleus is present in all cells, animal, plant and fungal.

Figure 2.2.6 Yeast is a fungus made of only one cell. Most fungi, however, are made up of many cells. This mushroom is an example.

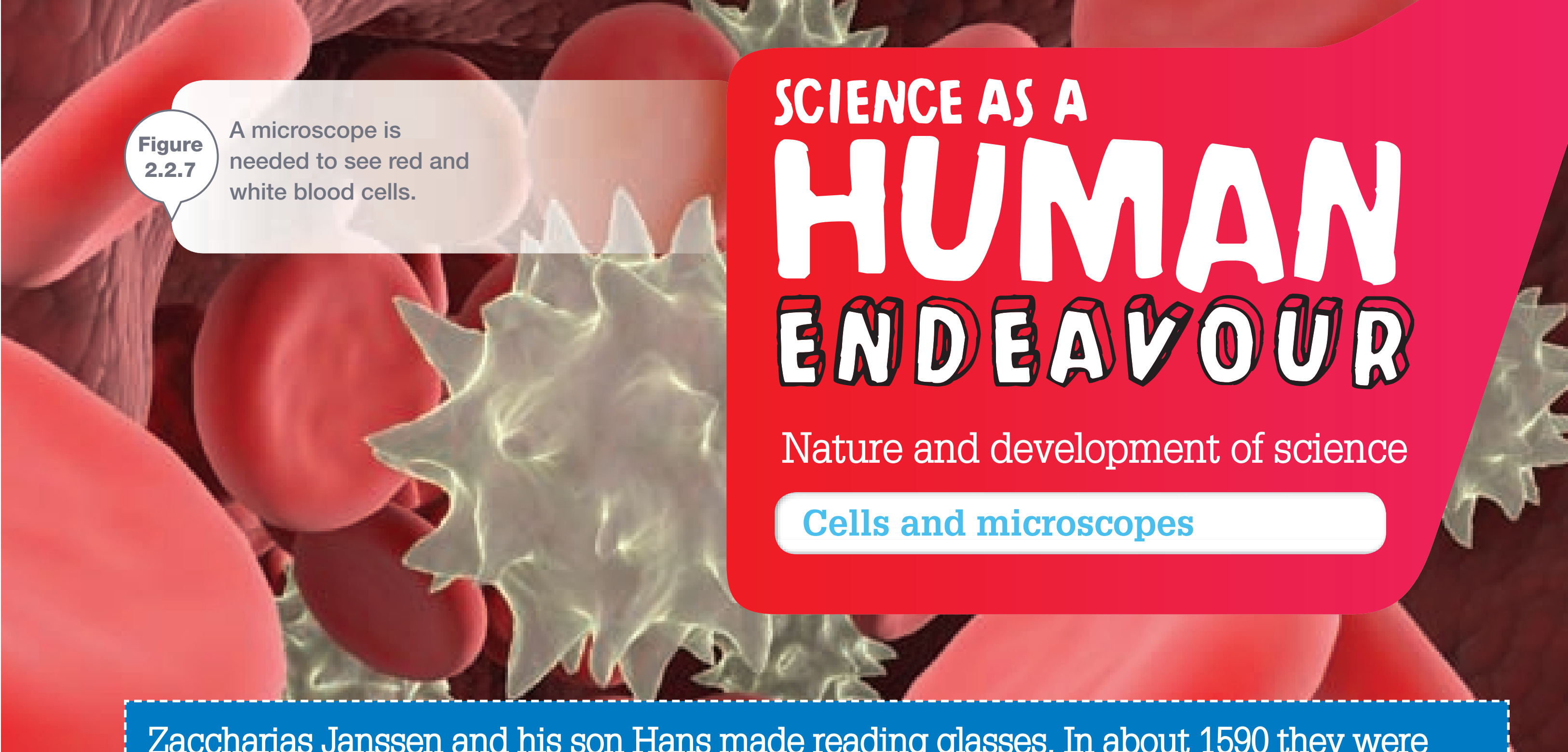


Figure 2.2.7 A microscope is needed to see red and white blood cells.

SCIENCE AS A HUMAN ENDEAVOUR

Nature and development of science

Cells and microscopes

Zaccharias Janssen and his son Hans made reading glasses. In about 1590 they were experimenting with their lenses and placed two lenses inside a tube. They then looked through it. Objects placed close to the tube appeared much larger. This observation was the first step towards inventing the microscope.

In 1665 the English scientist Robert Hooke used a microscope like the one shown in Figure 2.2.8 to investigate cork. He saw that cork resembled a honeycomb. The cork was made of small boxes that Hooke described as *cellulae* (a Latin word meaning 'little storage rooms'). You can see them in his drawing in Figure 2.2.9. Hooke had discovered cells. Cork cells are dead plant cells and have nothing inside them; therefore Hooke saw only cell walls. Since the time of Hooke, the term *cellulae* has changed to become cells.

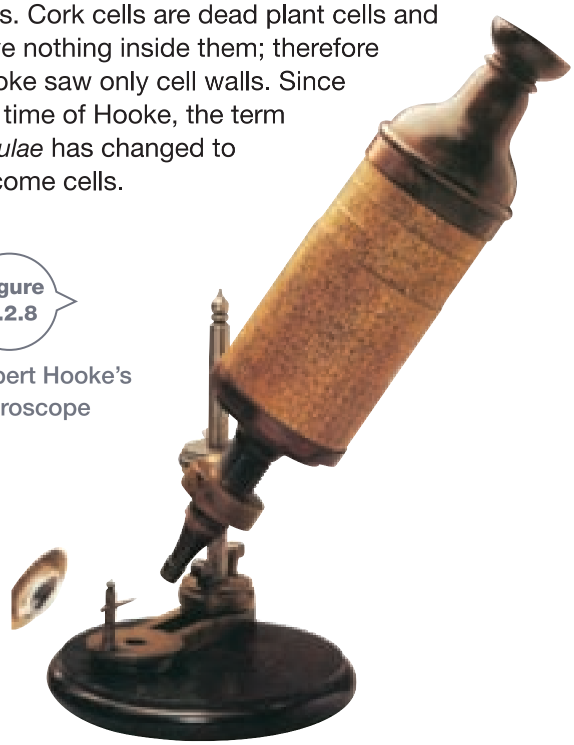


Figure 2.2.8 Robert Hooke's microscope

Figure 2.2.9 Hooke's original 1665 drawing of cork cells

A few years later, in 1674, the Dutchman Antonie van Leeuwenhoek used a microscope to look at pond water and saw small things moving about. What he was seeing were small, single-celled (unicellular) living things. This made Leeuwenhoek the first person to observe and describe microscopic living things. He was also the first person to observe and describe human red blood cells and bacteria. To do this, Leeuwenhoek had improved on the early microscopes and he achieved magnifications of up to ×250.

ENDEAVOUR

Many years later, in 1833, the Scottish scientist Robert Brown discovered that plant cells were not just empty boxes but that they had a nucleus inside them. It took another 70 years to identify other organelles such as the chloroplasts.

In 1838 Matthias Schleiden, a German scientist, analysed the known information about plant cells. He proposed that cells are the basic building blocks of all plants, and that new plants start off as a single cell. As plants grow, new cells are produced.

A year later a friend of Schleiden's, Theodor Schwann, proposed that all animals are made of cells and that the cell is the basic unit of life. Identifying this link between plants and animals is regarded by scientists as one of the most important discoveries in the development of biology.

In 1842 the Swiss scientist Karl Nägeli observed cells dividing to make new cells. This was the first time that scientists understood that new cells came from existing cells.

In 1855 the German scientist Rudolf Virchow linked the observations of Nägeli and Brown. He proposed that all cells develop from existing cells and don't just spring up from nowhere.

The work of these people led to the development of cell theory, which explains the relationship between cells and living things. Cell theory states:

- All living things are made up of one or more cells.
- Cells are the basic building blocks of all living things, making up their structure and allowing them to function.
- New cells are produced from existing cells. This is what is happening in Figure 2.2.10.

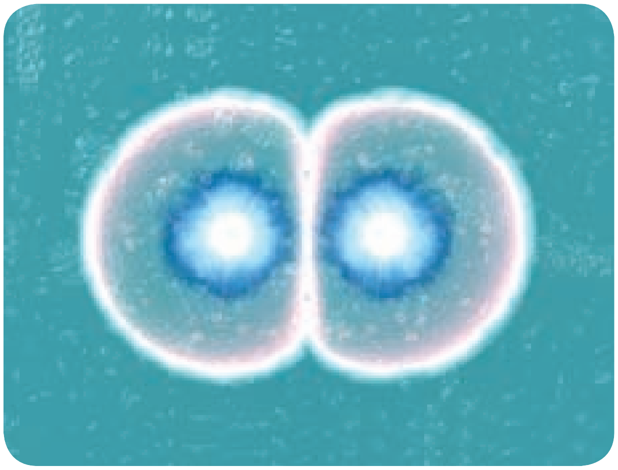


Figure 2.2.10 One cell dividing to produce two cells

In 1931 the German engineer Ernst Ruska (Figure 2.2.11) designed and built the first electron microscope. This allowed scientists to see even smaller things such as viruses, which are too small to be seen using light microscopes.

Figure 2.2.11 Ernst Ruska

It had been known since 1898 that 'invisible agents' called viruses caused diseases in plants and animals. However, it was 1935 before these agents were made visible using an electron microscope and viruses were seen for the first time.

Since their invention, the magnification of electron microscopes has improved and they are now capable of magnifying an object up to 1 000 000 times. A typical electron microscope is shown in Figure 2.2.12.

2.5

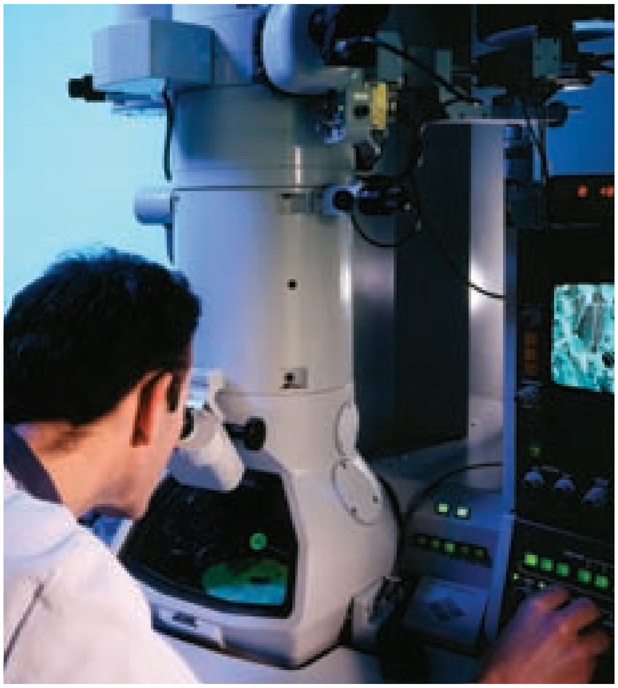


Figure 2.2.12 A scanning electron microscope

2.2 Unit review

Remembering

1 **Name** the part of animal cells that:
- **a** controls the movement of materials into and out of the cell
- **b** controls all the chemical reactions within the cell
- **c** is a watery jelly-like liquid.

2 **Name** the part of plant cells:
- **a** that controls the movement of materials into and out of the cell
- **b** in which photosynthesis takes place
- **c** that forms the skeleton of the plant.

3 **Name** the parts of the cell labelled A, B and C in Figure 2.2.13.

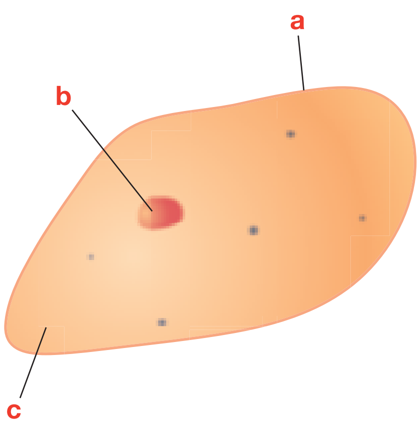


Figure 2.2.13

4 **Name** the parts of the cell labelled A, B and C in Figure 2.2.14.

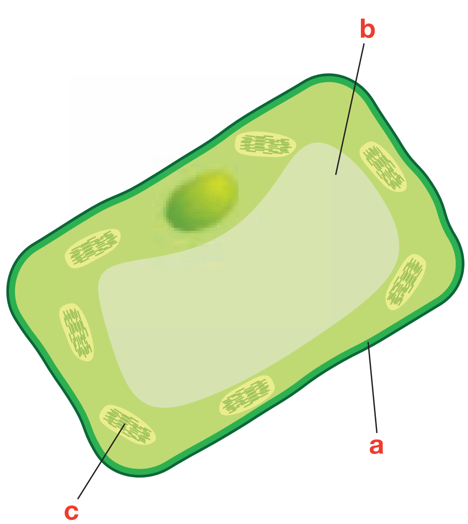


Figure 2.2.14

5 **Name** the process by which plants manufacture their food.

Understanding

6 **Explain** why microscopes are needed to study cells.

7 **Predict** what would happen if:
- **a** the membrane of a cell burst
- **b** the nucleus was removed from a cell
- **c** plant cells had no chlorophyll.

8 **Explain** why it is important to record the magnification used when drawing cells seen using a microscope.

Applying

9 **Identify** which organelles would be present in large numbers in cells that:
- **a** require a lot of energy
- **b** manufacture proteins
- **c** carry out photosynthesis.

10 **Identify** the type of cell or organelle being described in each of the following sentences.
- **a** It is rigid, and when examined under a very high power on the microscope, no green structures could be seen.
- **b** The picture produced by an electron microscope showed channels that criss-crossed the cell.
- **c** Chemical tests revealed that energy was released in large quantities.
- **d** There was a rigid outer layer surrounding a watery jelly with distinct green areas.

Analysing

11 **Compare** plant and animal cells.

12 **Contrast** plant and fungal cells.

13 **Discuss** the benefits and disadvantages associated with cells having a cell wall.

2.2 Unit review

Evaluating

14 **Propose** reasons why humans need a bony skeleton.

15 Sketch a Venn diagram like that shown in Figure 2.2.15. From the descriptions of cells on pages 48–49, **select** the characteristics that would go in each part of the diagram.

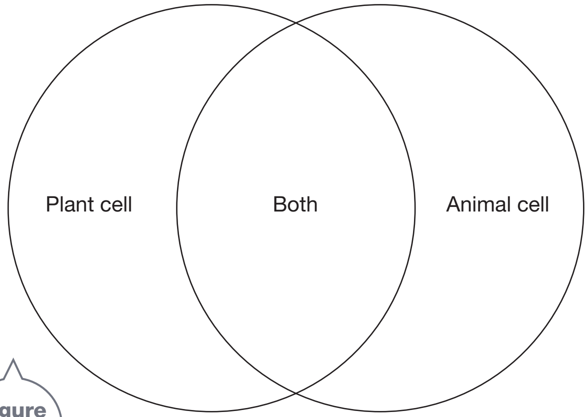


Figure 2.2.15

16 **a** **Classify** the type of cell shown in Figure 2.2.16 as a plant or an animal cell.

b **Justify** your answer.

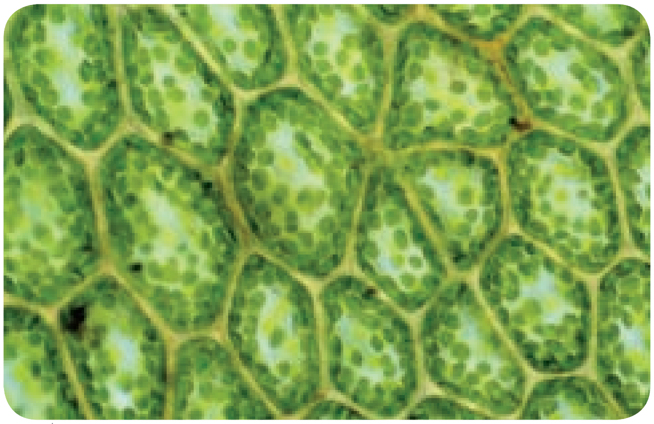


Figure 2.2.16

17 **a** **Classify** the cell shown in Figure 2.2.17 as an animal or a fungal cell.

b **Justify** your answer.

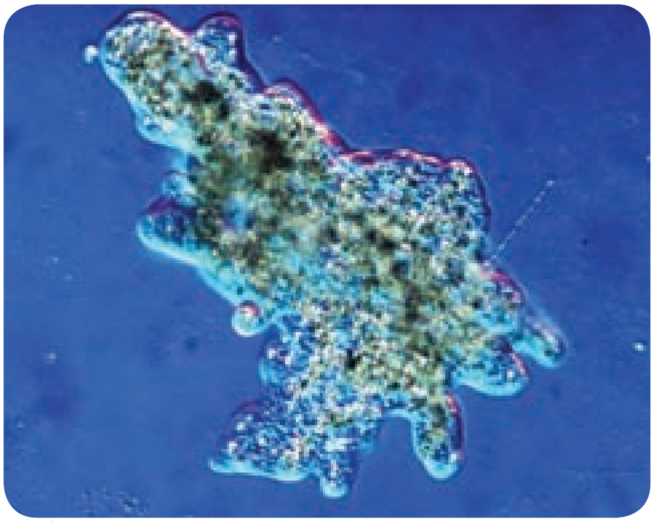


Figure 2.2.17

18 Students were once allowed to prepare their own slides using samples of their own cheek cells. This is now not allowed. **Propose** reasons why.

19 **Propose** the advantages of using prepared slides rather than students making their own slides.

Creating

20 As large organisms such as humans grow, they make more and more very tiny cells. What if they were made of only a very few cells and these cells just got bigger and bigger? **Construct** a scenario (or possible outcome) of how that would change the way we live.

Inquiring

1 Research what people thought living things were made of before cells were discovered.

2 Research the life and times of one of the scientists mentioned on pages 51–52 who helped develop our understanding of cells. Prepare a short biography of the person's life and achievements.

3 Investigate the development of microscopes from the first use of lenses to electron microscopes and the scanning probe microscopes used today. Relate the development of the technology to our knowledge of cells.

2.2 Practical activities

1 Observing cells

Before starting this activity make sure you have read and understood the Skill Builders 'Drawing from the microscope' and 'Increasing magnification' below.

Purpose

To observe and draw cells.

Materials

- microscope and lamp
- filter paper
- microscope slide and cover slip
- eye-dropper
- water
- iodine
- slices of onion and rhubarb leaf stalk
- tweezers

SAFETY

Iodine stains. Avoid contact with skin and clothes.

Procedure

1. Carefully peel a thin (one cell thick) layer of onion skin.
2. Use tweezers to place a small sample of the onion skin onto a glass microscope slide. Make sure the skin is not folded.
3. Place a drop of water and a drop of iodine on the sample and carefully place a cover slip on top of the onion skin and water. The iodine stains the cells and makes them easier to see.
4. Use the microscope to observe the cells at two different magnifications.
5. Carefully peel a thin layer of skin from the outside of the rhubarb leaf stalk. Repeat the procedure, but do not use the iodine stain.

Results

Sketch a few cells at the higher magnification. On your diagram record the type of cell you have drawn and the magnification used.

Discussion

1. Refer back to the diagram of the typical plant cell shown in Figure 2.2.3 on page 49. Of the parts labelled on that diagram, **list** the parts you were able to see clearly in the onion skin cell and in the rhubarb skin cell.
2. **List** the parts you could not see. **Explain** why you were not able to see them.
3. **Compare** the onion cells and rhubarb cells.
4. **Propose** a reason why onion cells were stained with iodine but rhubarb cells were not.

SKILL BUILDER

Drawing from the microscope

Follow these steps to draw what you see through the microscope.

1. Use a sharp lead pencil.
2. Draw only the lines that you see. Don't use shading or colouring.
3. Each diagram should take up one-quarter to one-third of an A4 page.
4. Record the magnification used to draw this specimen next to its diagram.
5. State the name of the specimen and the date of the observation.
6. A written description below the diagram is also often helpful.
7. When the image has many cells of the same type, you only need to draw a few cells to represent the specimen.

SKILL BUILDER

Increasing magnification

When you want to change the magnification of a microscope from a lower magnification to a higher magnification, follow these steps.

1. Make sure that the specimen, or the part of the specimen that you want to look at, is in the centre of the field of view.
2. Focus the specimen on low power.
3. Without moving anything else, carefully turn the objective lenses around so that one with a higher magnification is above the slide.
4. Look through the eyepiece. If the specimen is not in focus, use the fine focus only to sharpen the image.

2 Membrane at work

A hen's egg is really just a very large cell with a shell around it. When you break an egg, you can sometimes see a very thin skin just under the shell. That skin is the membrane of the egg.

Purpose

To observe a membrane at work.

Materials

- 2 eggs
- 500 mL white vinegar
- salt
- 500 mL distilled water
- electronic balance or beam balance
- 200 mL measuring cylinder
- container large enough to hold two eggs immersed in vinegar
- 2 wide-mouthed glass jars with lids

Procedure

Part A

1 Place the two eggs in a container of vinegar so that both eggs are completely covered.

2 Leave the eggs undisturbed for 2 days. By this time the vinegar should have dissolved the eggshell and the membrane inside the shell becomes the outer layer of the egg.

Part B

3 Make a concentrated salt solution by adding a tablespoon of salt to 250 mL of distilled water.

4 Label the two glass jars 'salt water' and 'distilled water'.

5 Measure out 200 mL distilled water and pour it into the container labelled 'distilled water'.

6 Measure out 200 mL of the salt water and add it to the container labelled 'salt water'.

7 Carefully remove the eggs from the vinegar and rinse them. Pat them dry with paper towel.

8 Use a balance to determine the mass of each egg and record the mass in a table like the one shown in the Results section.

9 Place one egg in each container of water and put on the lid or cover with plastic wrap.

10 Each day, for the next 3 days, measure and record the mass of the egg.

11 Predict what you think will happen to the eggs. Record your prediction

12 On day 3 measure and record the volume of the water remaining in each of the containers.

Results

1 Observe and record any changes to the eggs.

Treatment	Mass of egg (g)				
	Day 0	Day 1	Day 2	Day 3	Change
Distilled water					
Salt water					

2 Record any change in volume of the water.

Treatment	Volume of liquid (mL)		
	Day 0	Day 3	Change
Distilled water	200		
Salt water	200		

Discussion

1 **Describe** the changes that took place in the two eggs.

2 **Describe** any change in the volume of the water in the two containers.

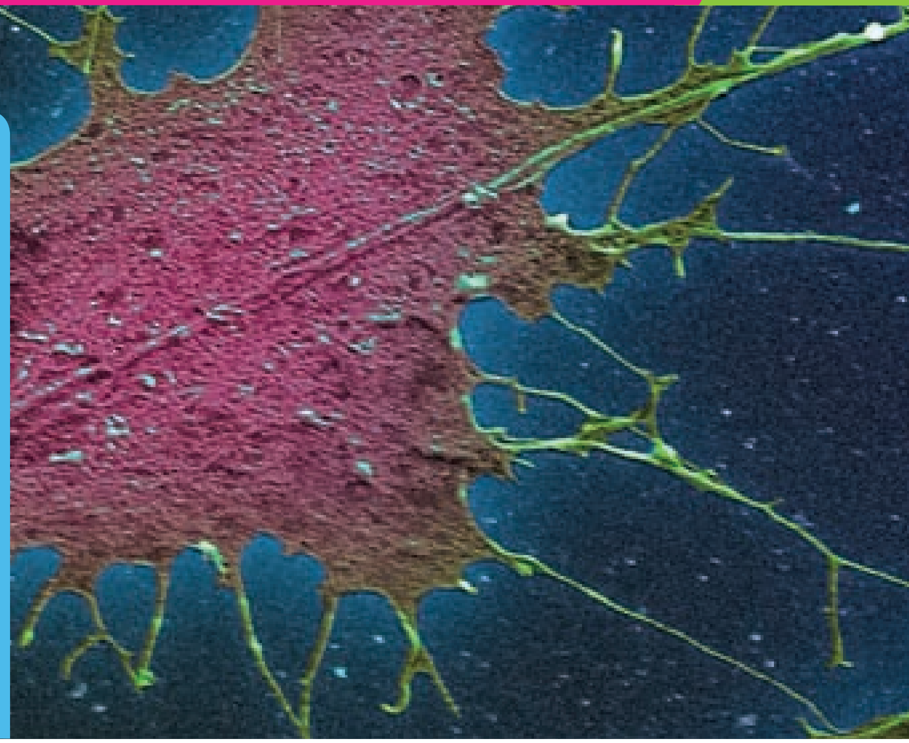
3 **Propose** reasons for the changes in the amount of liquid.

4 **Propose** reasons for the changes in the eggs.

5 **Explain** what you think was happening to the eggs and the role the membrane played.

6 **Compare** the actual results with your predictions.

2.3 Specialised cells



Many of the living things on Earth are made up of only one cell. This single cell has to carry out all the functions of life. These living things are too small to be seen with the naked eye. The living things that we can see, such as plants and animals, are made up of many cells of different types. Each type of cell is specialised to carry out a particular job.

Unicellular organisms

Living things that are made up of only one cell are known as **unicellular organisms**. The prefix *uni* means one and *organism* means a living thing. Therefore a unicellular organism is a living thing that is made up of a single cell. **Bacteria** are unicellular organisms. Some bacteria cause disease and infection like the infected wound in Figure 2.3.1. Others live on and in your body and help you to stay healthy. Bacteria are also used in the production of cheese and yoghurt.

Figure 2.3.1 The yellow pus on infected wounds is an accumulation of dead white blood cells that have died trying to fight harmful bacteria.

Many different types of unicellular organisms live in watery environments. A drop of pond water seen through a microscope can reveal a variety of living things you will not have seen before like the diatoms and rotifers shown in Figure 2.3.2. Unicellular organisms belong to a group called the **protists**. Most protists are harmless, but some can make you very sick. The water that comes through the taps has been treated to kill any harmful organisms. If you are in the bush and using untreated water, then for your health's sake it is best to boil it before you drink it.

1 p63

Figure 2.3.2 Microscopic organisms such as diatoms and rotifers are found in pond water.

Inside me!

You probably have ten times more bacteria living in your gut than you have cells in your body. You could live without these bacteria but you are healthier when they are present. They help with digestion, produce vitamins and train your immune system to fight disease.

SciFile

Multicellular organisms

Other living things such as humans, fish and the tree and koala in Figure 2.3.3 are made of millions and millions of cells. They are called **multicellular organisms**—*multi* means many.

In multicellular organisms, all the cells work together but they do not all do the same thing. Cells are **specialised**. This means that they have a special job to do in the body, and they have a structure that makes them better able to do their job.

2.6

Figure 2.3.3 This koala and the tree in which it is sitting are both multicellular organisms.

Specialised animal cells

Animals are more complex than plants and they have a greater variety of different cell types. The human body contains about 50 trillion cells and more than 200 different types of cells. A few of these 200 types are described below.

Muscle cells

The three types of muscles in your body are voluntary muscles (also called skeletal muscles), involuntary muscles (also called smooth muscles) and cardiac muscles.

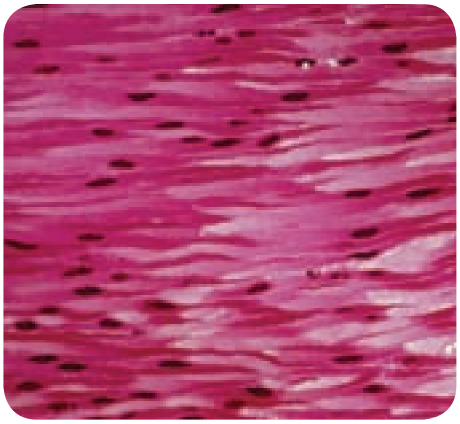
Surrounding the bones of your skeleton are muscles that you use to move around. You can choose to make these muscles move (or not) and so they are referred to as voluntary muscles. For example, your biceps and triceps are voluntary muscles that help control your arm. You can see a magnified view of voluntary muscle in Figure 2.3.4.

Figure 2.3.4 The voluntary muscles (skeletal muscles) attached to our bones have a striped appearance and are also known as striated (striped) muscles.

You have other muscles in your body that work without you having to think about it. They are the muscles involved in breathing and those that keep food moving though your gut. These muscles are known as involuntary muscles. Your diaphragm controls your breathing and is an involuntary muscle, as are the muscles in the wall of your digestive tract or gut. An image of involuntary muscle is shown in Figure 2.3.5.

Figure 2.3.5

Most of the involuntary muscles do not have a striped appearance and are also known as smooth muscles.



All muscles (voluntary or involuntary) contain a large number of mitochondria. This is because muscles require a lot of energy to keep working and it is the mitochondria that provide the energy.

Cardiac muscle (Figure 2.3.6) is the type of muscle in the heart. Cardiac muscle is involuntary muscle but it has a striped appearance like voluntary muscles. Unlike other muscles that are striped, cardiac muscle does not get tired. It has very large numbers of mitochondria to provide a continuous supply of energy. These characteristics allow the heart to beat continuously.

Figure 2.3.6

Cardiac muscle is an involuntary muscle that has characteristics of both striated muscle and smooth muscle.

Nerve cells

Nerve cells make up your brain. They also carry information from your brain to other parts of your body such as your muscles, and from your muscles back to your brain. As Figure 2.3.7 shows, some nerve cells have very long fibres called **axons** extending from the cell. These allow the cell to carry messages over long distances. The longest axon of a human nerve cell reaches from the base of the spine to the toes, and can be over a metre long.

SciFile

New blood

Red blood cells are the only cells in the human body that do not have a nucleus. This means they can't reproduce and need to be continually replaced. Your body makes billions of new red blood cells every day.

Figure 2.3.7

Nerve cells like this one can be found in your brain. The axons make connections with other brain cells.

Blood cells

Figure 2.3.8 shows some blood cells. **Red blood cells** carry oxygen from your lungs around your body to the cells where it is used to release the energy you need. They also carry some of the waste carbon dioxide from the cells back to your lungs so that you can get rid of it from your body. The **white blood cells** have a very different job. They are part of the immune system and help the body to fight infection.

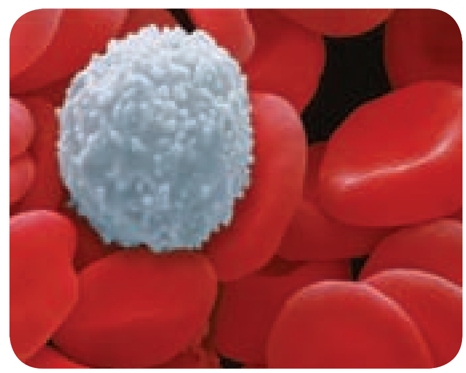


Figure 2.3.8

There are many more red cells in your blood than white cells.

Fat cells

You have two different types of fat cells in your body. Brown fat cells are used to produce heat for the body, especially when it gets cold and you are shivering. The white fat cells in Figure 2.3.9 are used as a store of energy. They also form an insulating layer under the skin that helps to keep your body at a constant temperature.

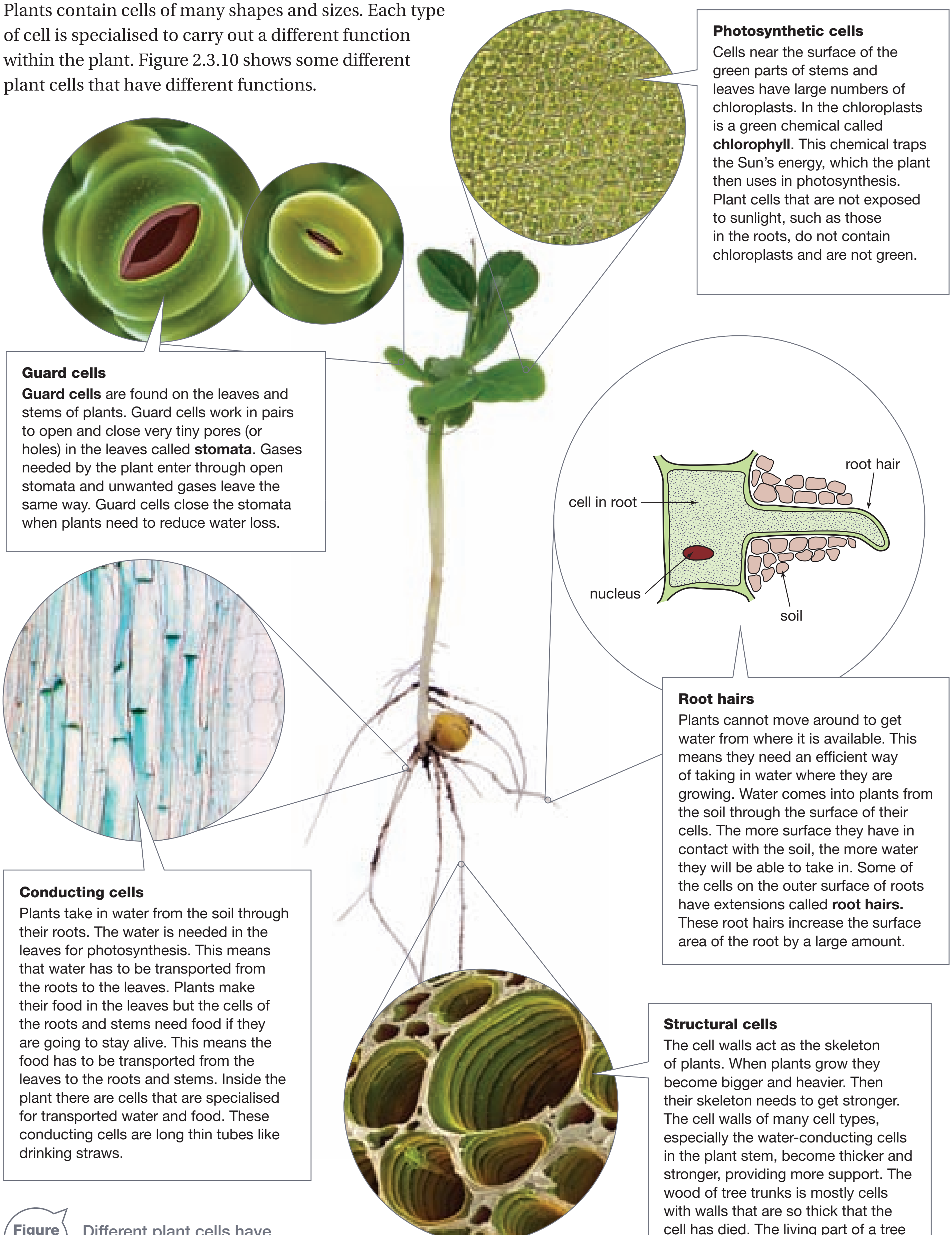
Figure 2.3.9

White fat cells (here stained purple) are found under the skin where they provide an insulating layer that helps to keep you warm.

2.7 p64

Specialised plant cells

Plants contain cells of many shapes and sizes. Each type of cell is specialised to carry out a different function within the plant. Figure 2.3.10 shows some different plant cells that have different functions.



Photosynthetic cells

Cells near the surface of the green parts of stems and leaves have large numbers of chloroplasts. In the chloroplasts is a green chemical called **chlorophyll**. This chemical traps the Sun's energy, which the plant then uses in photosynthesis. Plant cells that are not exposed to sunlight, such as those in the roots, do not contain chloroplasts and are not green.

Guard cells

Guard cells are found on the leaves and stems of plants. Guard cells work in pairs to open and close very tiny pores (or holes) in the leaves called **stomata**. Gases needed by the plant enter through open stomata and unwanted gases leave the same way. Guard cells close the stomata when plants need to reduce water loss.

Root hairs

Plants cannot move around to get water from where it is available. This means they need an efficient way of taking in water where they are growing. Water comes into plants from the soil through the surface of their cells. The more surface they have in contact with the soil, the more water they will be able to take in. Some of the cells on the outer surface of roots have extensions called **root hairs.** These root hairs increase the surface area of the root by a large amount.

Conducting cells

Plants take in water from the soil through their roots. The water is needed in the leaves for photosynthesis. This means that water has to be transported from the roots to the leaves. Plants make their food in the leaves but the cells of the roots and stems need food if they are going to stay alive. This means the food has to be transported from the leaves to the roots and stems. Inside the plant there are cells that are specialised for transported water and food. These conducting cells are long thin tubes like drinking straws.

Structural cells

The cell walls act as the skeleton of plants. When plants grow they become bigger and heavier. Then their skeleton needs to get stronger. The cell walls of many cell types, especially the water-conducting cells in the plant stem, become thicker and stronger, providing more support. The wood of tree trunks is mostly cells with walls that are so thick that the cell has died. The living part of a tree trunk is just below the bark.

Figure 2.3.10 Different plant cells have different jobs to do.

2.3 Unit review

Remembering

1 **List** three specialised cell types found in plants.

2 **List** three specialised cell types found in animals.

3 **State** which has more different types of cells: plants or animals.

4 **State** what the following prefixes mean.
 a *uni* as the prefix to unicellular
 b *multi* as the prefix to multicellular

5 **Name** the following types of cells.
 a leaf cells where the plant's food is made
 b animal cells that send electrical messages around the body
 c animal cells that help fight infection
 d cells that control the gases going into and leaving a leaf

6 **Recall** the different types of animal cells by matching the ones below with their specialised tasks.

a	fat cells	cells that contract, causing bones to move
b	cardiac muscle	carry oxygen from the lungs to the cells
c	red blood cells	where the body stores energy
d	skeletal muscle	muscle that does not get tired and keeps the heart pumping

Understanding

7 a **Define** the term *specialised cell*.
 b **Explain** why the cells of multicellular organisms are not all the same.

Applying

8 There are about 5 million red blood cells in every millilitre of blood. **Calculate** the number of red blood cells in an:
 a average blood donation of about 450 mL
 b adult human (about 6 litres of blood).

Analysing

9 **Classify** each of the organisms in Figure 2.3.11 as unicellular or a multicellular.

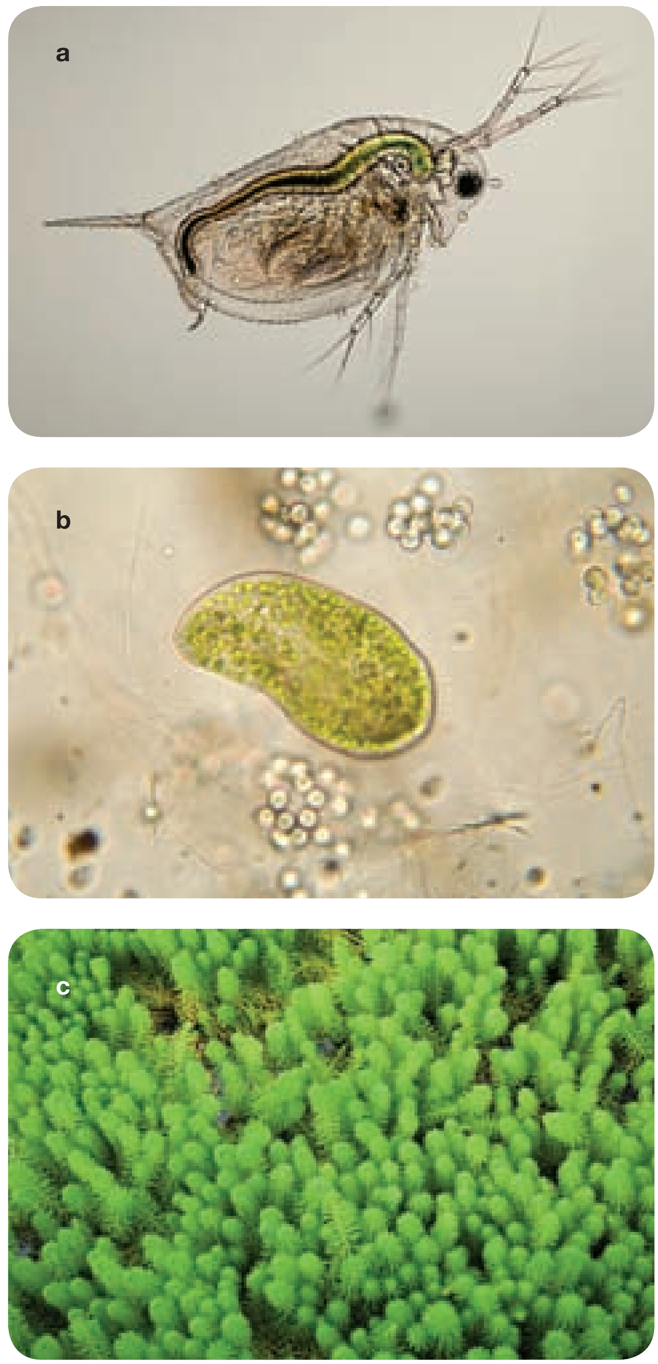


Figure 2.3.11

2.3 Unit review

10 **Compare** unicellular and multicellular organisms.

11 **Classify** the following muscles as voluntary or involuntary.
- **a** muscles of upper leg
- **b** tongue
- **c** muscles in the oesophagus (the tube carrying food from the mouth to the stomach)

12 **Contrast** the three types of muscle of the human body.

Evaluating

13 **a** **Propose** ways in which a cell from the root of a plant would be different from a leaf cell.
- **b** **Justify** your answer.

14 What if the cells in your body were all the same? **Propose** ideas of how this would change the way your body works.

15 There are many mitochondria in the muscle cells of animals.
- **a** **Propose** which type of plant cells could also have very high numbers of these organelles.
- **b** **Justify** your answer.

Creating

16 **Construct** a table with three columns.
- **a** In the left-hand column, **list** four specialised plant cells.
- **b** In the middle column, **describe** what the cells do.
- **c** In the right-hand column, **describe** how the cell is specialised to do this job.

17 You have been shown a type of cell you have never seen before. It is a small cell but the membrane on the outside has many extensions, giving it a very large surface area.
- **a** **Create** a picture of what this cell would look like.
- **b** Use your knowledge of specialised cells to **predict** the sort of job this cell would do and whether the cell is from a plant or an animal.

Inquiring

1 Jellyfish have very specialised stinging cells. Investigate how these cells help the jellyfish to survive.

2 Considering the function of red blood cells, research why the lack of a nucleus is an advantage.

3 **a** Research the characteristics of cells of fungi and diatoms.
- **b** Compare their characteristics with the cells of plants and animals.
- **c** Discuss the classification of these cells.

4 Bacteria are very simple unicellular organisms. They are very important to humans for many reasons. Research bacteria and why they are important to humans.

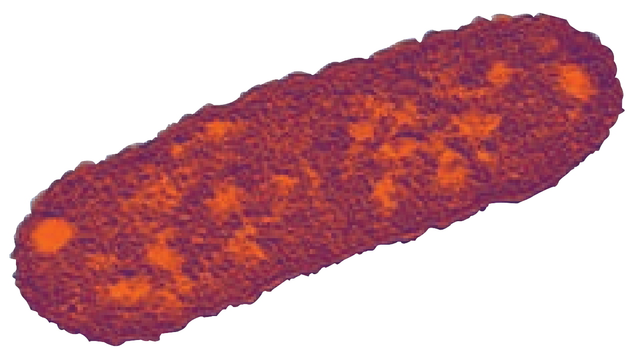


Figure 2.3.12 Bacteria are simple, very small organisms made of just one cell. A bacterium has no organelles.

2.3 Practical activities

1 Looking at pond water

Purpose
To observe microscopic organisms in pond water.

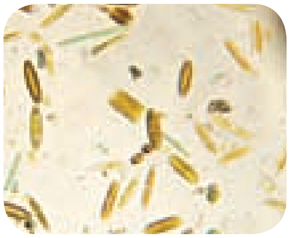
Materials
- light microscope
- microscope slides
- cover slip
- pond water
- eye-dropper
- cotton wool
- paper towel or tissue

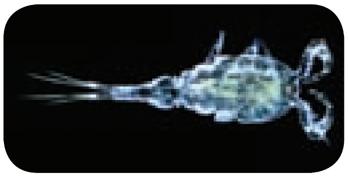
SAFETY
Do not drink pond water. Wash your hands thoroughly after the activity.

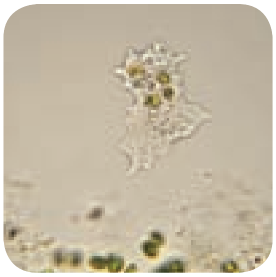
Procedure
1. Place two drops of pond water on a slide.
2. Tease out a few fibres of cotton wool and place them on the slide.
3. Carefully lower the cover slip onto the slide and dry off any excess water.
4. Examine the slide using the low power of the microscope.
5. Now try high power. Remember that you are not only magnifying the size of the organisms but it also looks as though you are magnifying the speed at which they move.

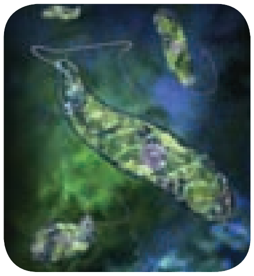
Results
1. Record the number of different types of organisms.
2. Sketch the organisms you see and label any parts you can identify.
3. Use Figure 2.3.13 to identify the organisms you saw.

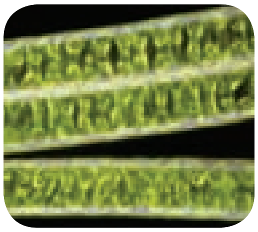
Discussion
1. a **List** the different types of organisms you saw.
   b For each organism:
      i **state** whether it was unicellular or not
      ii **describe** its characteristics.
2. **Describe** the difficulties you had when observing the organisms.
3. **Propose** a reason why the fibres of cotton wool were added to the slide.
4. **Describe** the most interesting organism you observed.


Diatoms


Cyclops

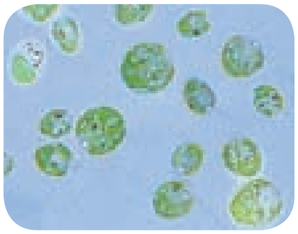

Amoeba


Euglena


Spirogyra


Nematode


Paramoecium


Chlamydomonas


Daphnia

Figure 2.3.13

2.3 Practical activities

2 My cell

Purpose

To make a model of a cell.

Materials

You can decide on your own materials. Suggestions include:

- plastic food wrap or freezer bags
- cotton wool, wool, thread
- gelatine and hot water
- container for mixing gelatine
- container for heating water
- buttons, marbles, lollies such as jelly beans
- stiff cardboard

SAFETY

Be careful if you are using hot water or sharp instruments.

Procedure

1. Decide whether you are going to make a plant cell or an animal cell, a typical cell or a specialised cell.
2. Make a list of the parts of the cell and their characteristics.
3. Decide what you could use to represent the cell parts. Make a list of your choices, giving a reason for each choice.
4. Construct your cell.
5. Explain to other members of the class how you have constructed your cell and why you chose the material you did.

Discussion

1. **Assess** how successful your model cell was.
2. **List** the positive comments others in the class make about your cell.
3. **List** the suggestions of areas you could improve on.
4. **Describe** what you would change if you were to make another cell.

Figure 2.3.14 This model of an animal cell was made using felt, fabric and toy stuffing.

2.4 Cell to organism

Wombats and wattles, fish and frogs, crows and crabs are all complex organisms that perform a variety of functions. They breathe, reproduce, digest food and get rid of wastes. To perform these functions, the cells of multicellular organisms are organised into tissues, which in turn are organised into organs and then into systems.

INQUIRY science 4 fun

Soft bones

Bones are complex organs with living cells and deposits of calcium. Vinegar is a weak acid that dissolves calcium.

Yes

Collect this ...

- 2 uncooked chicken bones
- vinegar
- jar

Do this ...

1. Fill a jar with vinegar and place one chicken bone in the jar overnight.
2. Leave the other chicken bone untreated.
3. Observe the bones the next day.
4. Predict what you think will happen to the bone in the vinegar.
5. Compare the two bones the next day.

Record this ...

Describe what happened. Was your prediction correct?
Explain why you think this happened.

Tissues and organs

Many different things need to happen in an organism if it is going to stay alive and function well. There is a need for some form of organisation. In complex organisms such as the human and dog in Figure 2.4.1 on page 66, there are several different levels of organisation. These levels are shown in Figure 2.4.2 on page 66.

- **Tissues**: Cells that perform the same function are not scattered throughout the body; they are grouped together to form tissues.
- **Organs**: The next level of organisation is into organs. An organ is a structure that contains at least two different types of tissue that work together to complete a task.
- **Organ systems:** Organs are then arranged into organ systems. Organ systems have two or more different organs that work together.

Figure 2.4.1 The boy and the dog are both complex organisms. Their cells are organised into tissues, tissues into organs, and then organs into systems.

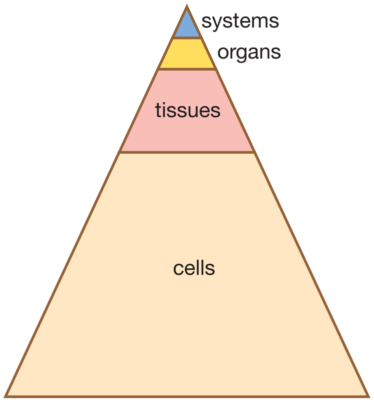


Figure 2.4.2 In a complex organism, there are many more cells than there are tissues, many more tissues than organs, and many more organs than systems.

Tissues

In the human body there are four different types of tissues:

- epithelium
- connective tissue
- muscle tissue
- nerve tissue.

Epithelium is just another name for skin. The cells of an epithelium form a continuous layer that is more than just the skin covering the outside of your body. It continues into the body. It lines the inside of your mouth right down to your stomach and through the rest of your insides. It also covers all the organs of the body. You can see epithelium cells in Figure 2.4.3.

Figure 2.4.3 Column-shaped cells make up the epithelium lining your small intestine.

Connective tissue adds support and structure to the body. Examples of connective tissue are fat, bone, cartilage, ligament and tendon such as that shown in Figure 2.4.4. Some types of connective tissue are strong and fibrous. Ligaments hold bones together at the joints. If you sprain your ankle or wrist badly, then it is likely that you have torn some of the fibres of the ligaments holding the bones together. Tendons join muscles to bones.

Muscle tissue is a specialised tissue that can contract, becoming shorter and fatter. For example, the muscle on the front of your upper arm (the bicep) bulges when you pull up your forearm. You can see this in Figure 2.4.5. Each individual cell of the muscle has contacted. However, one cell on its own, or even a few cells contracting, would not be strong enough to pull up your arm. It takes thousands of cells working together to move the bones of your arm.

1 p72

Figure 2.4.4 The white tissue in this model is tendon. It connects muscles and bone.

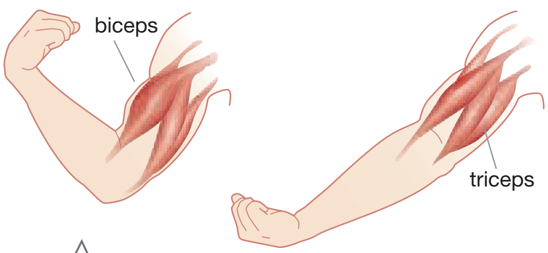


Figure 2.4.5 Muscles in the front of the arm contract to pull the arm up. Muscles cannot expand. Another set of muscles (the triceps) at the back of the arm contract to pull the arm back down.

Nerve tissue such as that in Figure 2.4.6 can send electrical signals around the body. These electrical signals are managed by nerve tissue in the brain and passed down the spinal cord (a large bundle of nerve tissue) to the body. One nerve cell would not be able to pass information around your body effectively. Thousands of nerve cells are grouped together to form your nerves.

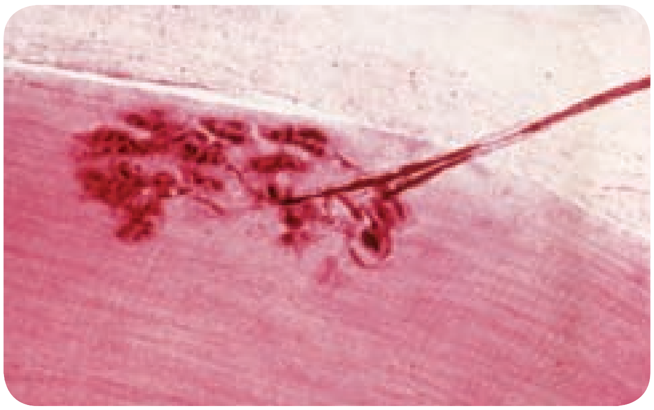


Figure 2.4.6 These nerve endings are attached to the muscle. The message passing along the nerve causes the muscle to react.

Organs

Tissues are grouped together into organs. All the different tissues contribute to the job that the organ has to do. There are many different organs in your body, such as the liver, kidneys and heart. Even your skin is an organ—the largest organ of your body. As you can see in Figure 2.4.7, it has many different parts.

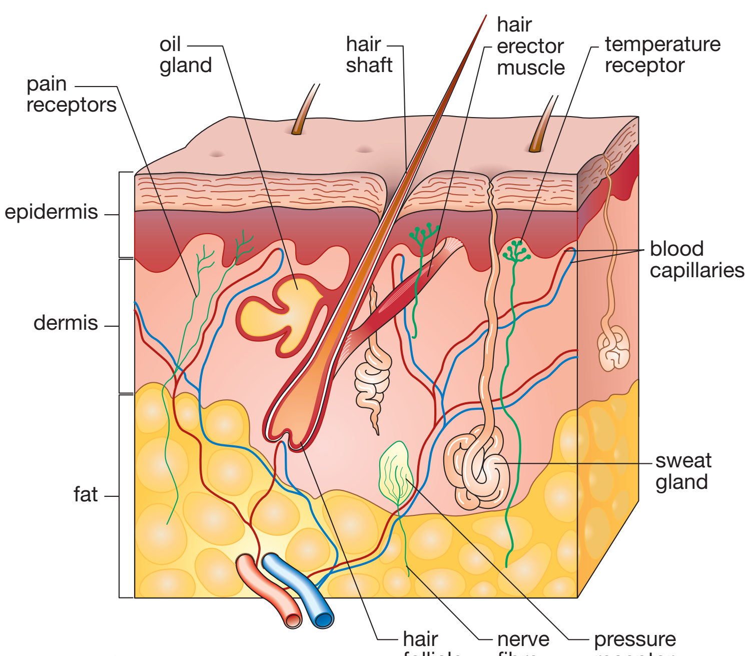


Figure 2.4.7 The skin is a complex organ.

In the heart shown in Figure 2.4.8, the tissues are grouped together for the specific purpose of ensuring that the blood flows round your body, carrying to the cells all the things they need to function. Your blood also carries away wastes that could harm your cells.

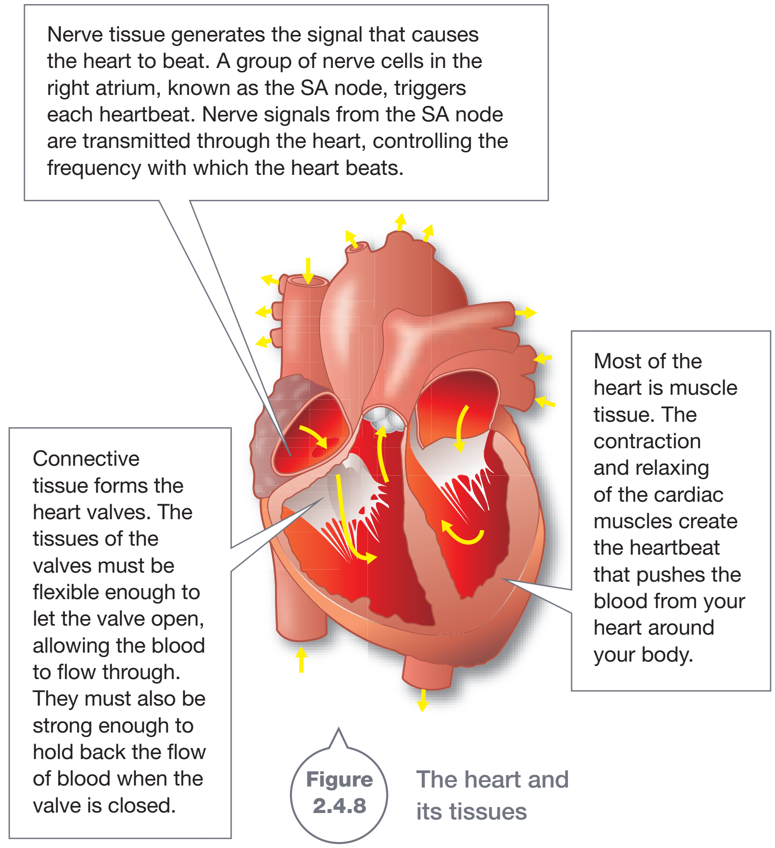


Figure 2.4.8 The heart and its tissues

Systems

The organs of your body do not work independently. Organs are organised so that they can work together to complete a task. These organs then form a system. For example, a series of organs work together to change the food you eat into a form that the body can use. This system digests the food. The system is therefore called the digestive system. It is shown in Figure 2.4.9 on page 68.

There are other systems in your body such as the:

- respiratory system, which gets oxygen from the air into your body and gets rid of waste carbon dioxide
- skeletal system, which is your skeleton and muscles
- excretory system, which gets rid of wastes from the body
- nervous system, which sends messages from your sense organs to the brain and from the brain to other parts of the body, including the muscles
- reproductive system.

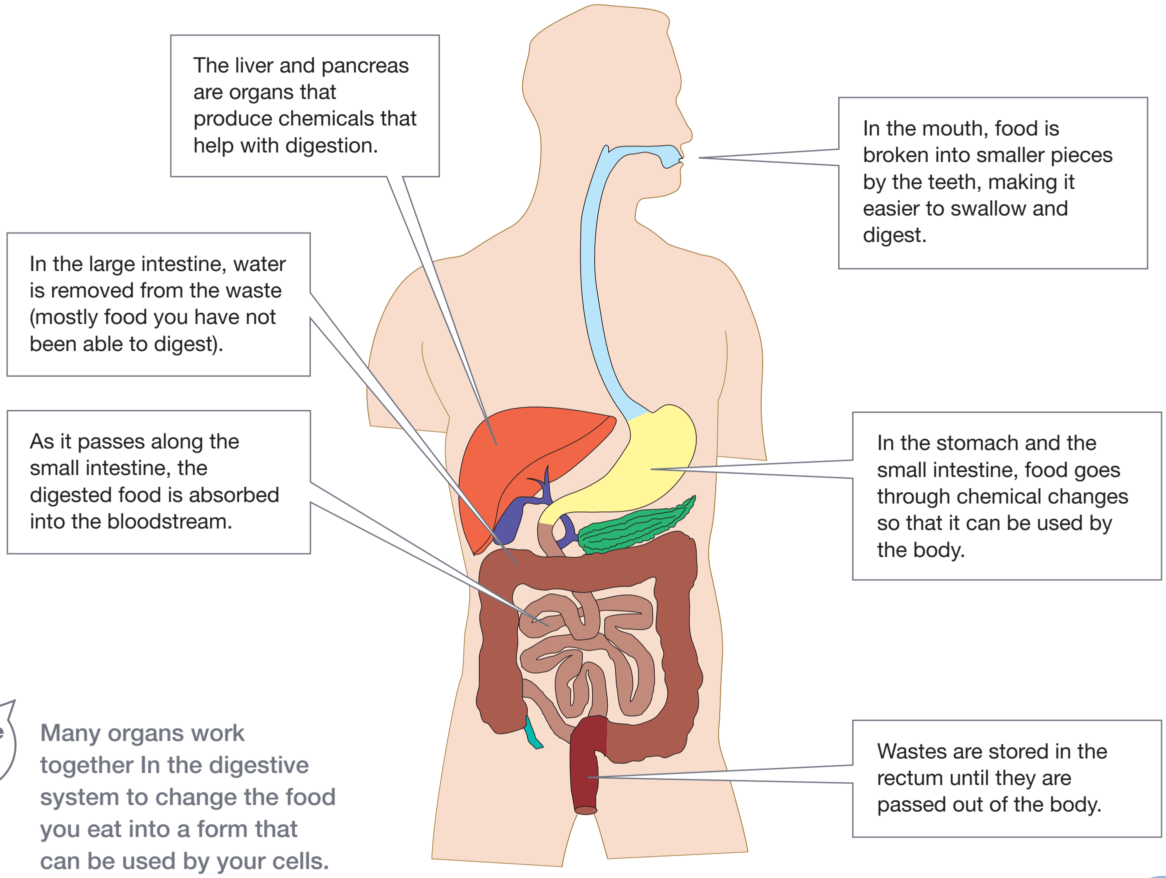


Figure 2.4.9 Many organs work together In the digestive system to change the food you eat into a form that can be used by your cells.

2 p72

Dividing cells

Unicellular organisms reproduce by their cell dividing to produce two new identical cells; that is, two new organisms. Multicellular organisms grow because existing cells divide to produce new cells. This type of cell division is called mitosis. **Mitosis** is cell division that produces two new identical cells. This process is happening in Figure 2.4.10

At the beginning of mitosis, there is one cell. First the nucleus divides into two. Then the cytoplasm divides. At the end of the process, there are two identical cells.

You started life as a single cell. Now your body is made of billions of cells. Most of the cells in your body were produced by mitosis. Each time you cut yourself or scrape the skin off your knee, the damage is repaired by mitosis producing new cells.

Bacteria do not have a nucleus, but their cells can still divide to produce two identical bacteria. One way of controlling bacteria that cause disease is to find ways of preventing them reproducing.

Cancer is a disease caused by uncontrolled mitosis. Scientists are looking for ways of controlling cell division in these cells and hope that will help to cure the disease.

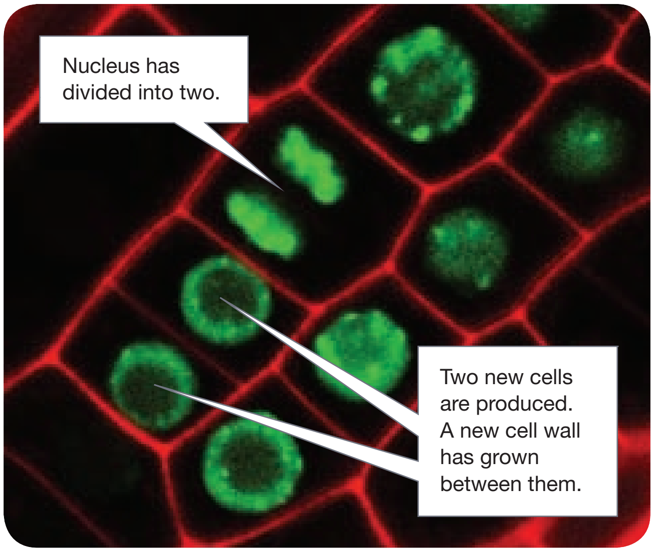


Figure 2.4.10 These cells are dividing by mitosis.

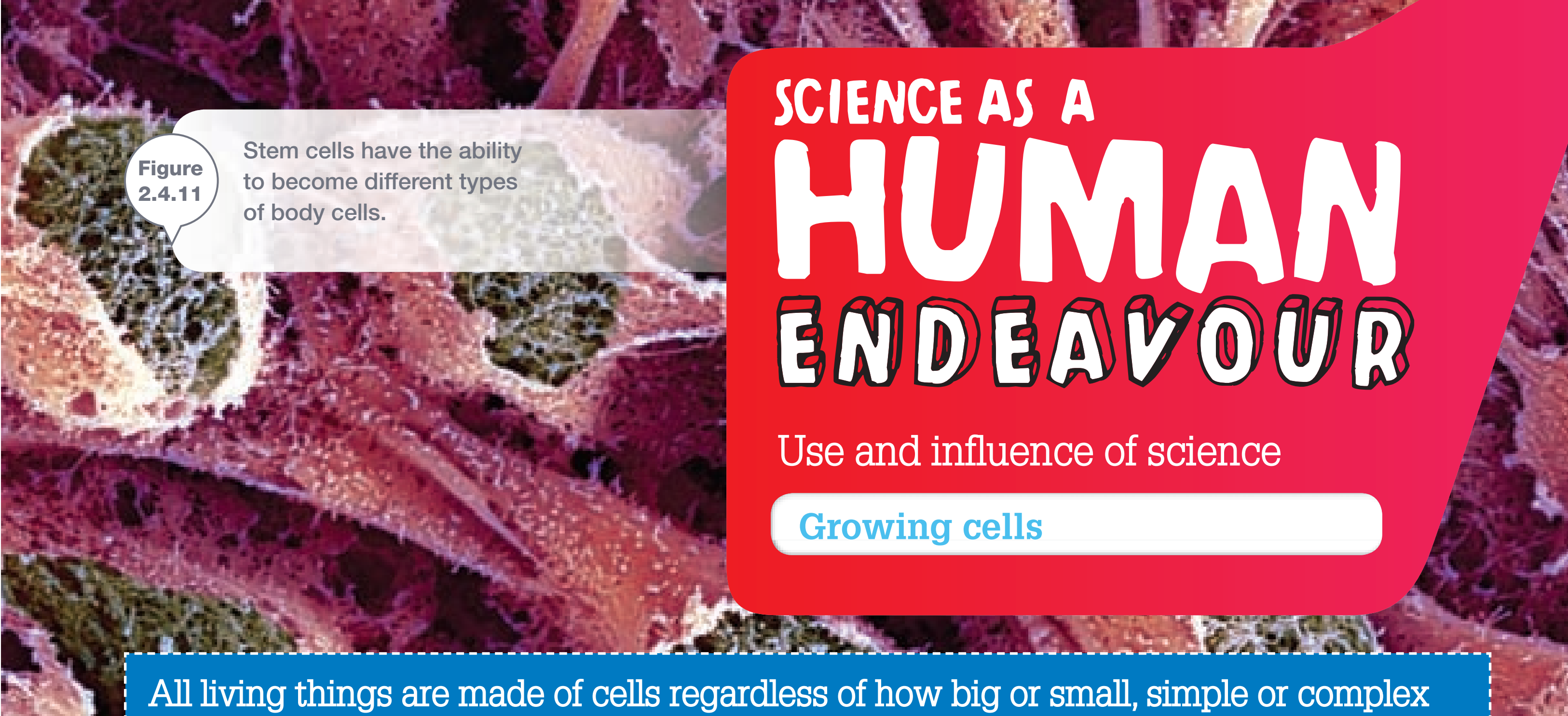


Figure 2.4.11 Stem cells have the ability to become different types of body cells.

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Growing cells

All living things are made of cells regardless of how big or small, simple or complex the organism is. The cells from all living things have many features in common and so the study of cells can provide information about all living things.

In the last 100 years scientists have learnt how to grow cells separate from the organism they came from. This process is called **cell culture**. The cells are kept at the correct temperature and in a solution that provides them with all the minerals and nutrients they require to keep them alive. You can see a scientist working with cultured cells in Figure 2.4.12.

Cultured cells have been used to produce the vaccines that protect us from diseases such as measles, rubella, mumps, chickenpox and polio. These cells are also used to produce agents that can help fight cancer.

Most cultured cells are not from humans. However, there are times when human cells are cultured. The bottles in which they are cultured are shown in Figure 2.4.13.

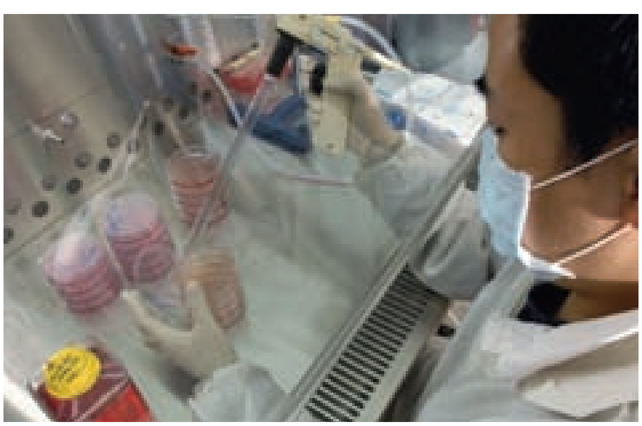


Figure 2.4.12 This researcher is working in a tissue culture laboratory.

Figure 2.4.13 Tissues are cultured in flat bottles like these.

Growing tissue

When your body is damaged or new cells are required to replace ones that are worn out, the cells in your body divide. Skin cells divide to produce new skin cells, and muscle cells produce new muscle cells. In the human body, there are also special cells called **stem cells**. Stem cells are able to become different types of cells under special conditions. They can be found in the roots of your hair. Cells from a few hairs could be very useful if you had a large wound such as a burn. You can see some stems cells in Figure 2.4.14 on page 70.

ENDEAVOUR

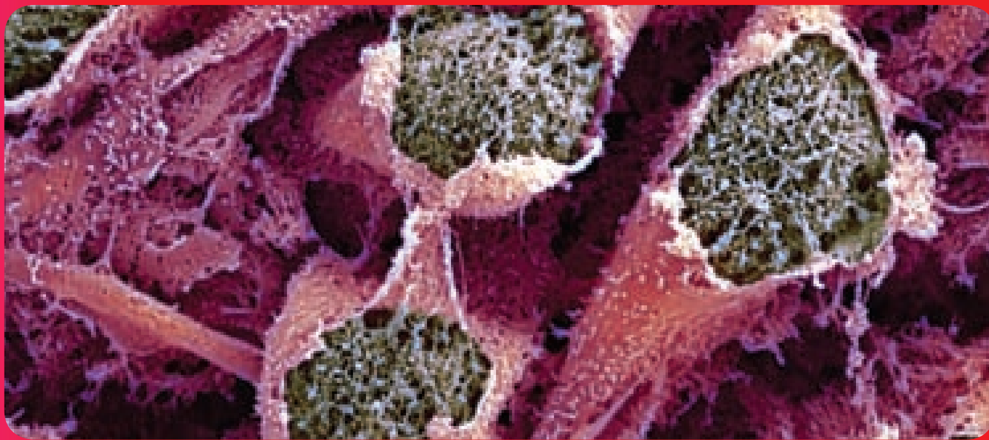


Figure 2.4.14

Stem cells seen under a scanning electron microscope

Stem cells extracted from the hair root are grown in culture for about two weeks. They are completely surrounded by liquid and divide, forming small masses of cells. After two weeks the upper surface of the cell mass is exposed to the air. This is the trigger for the stem cells to turn into skin cells and skin like that in Figure 2.4.15.

The skin is then grafted onto the wound. Within a few days, doctors will know if the graft is going to work. A successful skin graft will look just like your old skin within 10 weeks.

In traditional skin grafts, healthy skin is taken from another part of your body to put over a wound. You then end up with two scars. Which way would you prefer—the traditional method of cell culture or the latest technology?

Figure 2.4.15 A strip of skin is held above the culture medium.

Growing organs

Scientists hope that in the future complete organs can be grown for transplant. This is becoming closer to reality.

There are children in the USA who have new bladders that were grown from their own cells. These children were born with defective bladders. Doctors took two types of cells from the child's own bladder—cells from the lining of the bladder, and muscle cells from the outside. These cells were grown in culture solution and when there were enough cells they were placed on a bladder-shaped shell made from a biodegradable material. The lining cells went on the inside of the shell and the muscle cells on the outside. The new bladder continued to grow in culture for another seven weeks. After that it was sutured (stitched) into the body of the patients where the new bladders continued to grow and remain healthy.

Figure 2.4.16 The ear on the back of this mouse was grown from cartilage cells from a cow implanted on a mould in the shape of an ear. The experiment suggests that replacement body parts may be able to be grown in the future.

2.8

2.4 Unit review

Remembering

1 **List** these words in order from simplest structure to most complex.
- tissue
- system
- cell
- organ

2 **Name** four different organs in the body.

3 **List** two types of tissues found in the human body.

4 **List** three systems in the human body.

5 **Name** the type of cell division that makes new cells in your body.

Understanding

6 **Describe** what is meant by the term *organ system*.

7 **Explain** why skin is an organ rather than a tissue.

8 The contraction of muscle tissue can cause your arm to bend, whereas contraction of a single muscle cell would have no effect. **Explain** why.

Applying

9 Sketch diagrams to **demonstrate** the difference between cells, tissues and organs.

Analysing

10 **Contrast**:
   a a cell and a tissue
   b an organ and a system.

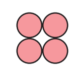
11 Imagine what it would be like without some of your tissues. **Compare** the way your body works now with how you think it would work if you did not have:
   a nerve tissues
   b connective tissue in the form of tendons and ligaments.

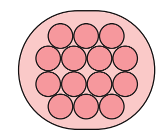
12 **Compare** cardiac muscle and skeletal muscle.

Evaluating

13 In the Science4fun activity on page 65, vinegar (an acid) slowly removed calcium from chicken bones.
   a **Propose** what might happen to bones that have lost calcium.
   b **Predict** what could happen if you do not have enough calcium in your diet.

14 In the diagrams A–D each small circle represents a cell. **Select** the diagram that best represents:
   a individual cells
   b a body system
   c an organ.

A


B


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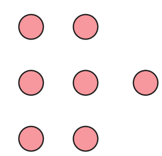
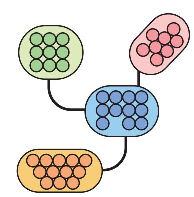


D


15 **Propose** reasons why the muscles of your legs get tired when you have been running fast.

Creating

16 **Construct** a drawing showing the organisation of muscles, tendons and bones in the arm and how they work together to bend and straighten the arm.

Inquiring

1 Research information about one of the systems of your body. Present a report to your class.

2 Research the parts of a flower. Identify the organs it contains and the part each plays in plant reproduction.

2.4 Practical activities

1 Muscles get tired

Purpose

To find out what contributes to muscle fatigue.

Materials

- soft foam or rubber ball
- stop watch

Procedure

Part A: Arm relaxed

1 Work in pairs. Squeeze the ball as many times as you can in 30 seconds. Your partner should time you as you count.

2 Rest for 10 seconds.

3 Repeat steps 1 and 2 until you have completed 10 trials. Record your results in a table, showing the number of squeezes per trial.

Part B: Arm raised

4 Repeat steps 1–3 but this time hold your arm above your head.

5 Do not lower your arm during the resting time.

Results

1 Record your results in a table like this.

Trial	Number of squeezes	
	Part A	Part B
1		
2		
3		
4		

2 Graph your results by constructing a line graph for each part. You can have two graph lines on the same axes.

Discussion

1 **Analyse** your results for Parts A and B. Was there any evidence that your muscles were becoming tired (fatigued)? **Explain** why.

2 **Compare** the two graphs. What can you say about the amount of fatigue experienced by the arm?

3 **Describe** any effect that raising your arm would have on the:

a blood supply to your arm

b oxygen supply to your arm.

4 **Explain** why oxygen and blood are important to muscles that are working.

5 **Propose** links between the results shown in the graphs and what could be happening in your arm.

6 **Summarise** the results of this activity.

2 Where in my body?

Purpose

To find out what you know about organs in your body.

Materials

- large piece of butcher's paper—you need to be able to lie on it and draw round your body
- felt pen

Procedure

1 Work in pairs. One person lies on the paper and the other person draws an outline of their body.

2 Make a list of all the parts you know are inside your body.

3 Think about the position in the body and size of the organs. Start drawing the organs into the outline of the body.

4 When you have finished all you can do, share your ideas with another pair.

5 Discuss any differences you have and make any changes you want to your drawing.

6 Share your drawing with the rest of the class.

Discussion

1 **Assess** your knowledge of the body by giving it a rating out of ten.

2 **Discuss** why it is important that we know about the structures inside our bodies. Do you think you need more information?

2 Chapter review

Remembering

1 Draw a table with two columns.
   a In the first column, **list** the parts of an animal cell that can be seen under a light microscope.
   b In the second column, **list** the parts of a plant cell.

2 **Name** the lens of the microscope that:
   a you look through.
   b is closest to the specimen.

3 **Name** the process that occurs in chloroplasts.

4 **State** what is different between unicellular and multicellular organisms.

Understanding

5 **Outline** the function of the following cell parts.
   a plant cell wall
   b cell membrane
   c nucleus

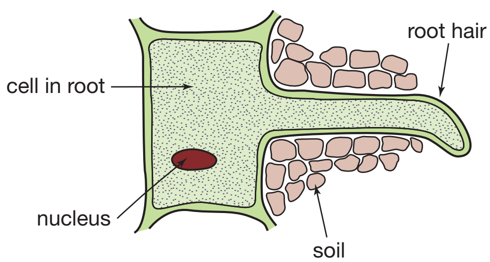
6 **Explain** the difference between a specimen and an image when using a microscope.

7 **Describe** what happens to the field of view when a microscope is changed from low power to high power.

8 **Predict** what will happen to the field of view when a ×10 objective lens is replaced by a ×4 objective lens.

9 When focusing a microscope, you are supposed to look from the side as you bring the stage and objective lens close together. **Predict** what could happen if you were looking through the ocular lens as you did this.

10 Study the diagram below, which shows a root hair cell.
   a **Describe** the function of the root hair cell.
   b **Explain** how the shape of this cell helps it to carry out its function.



11 **Explain** why muscle cells need to have large numbers of mitochondria.

Applying

12 **Use** diagrams to **demonstrate** the differences between plant, animal and fungal cells.

13 The term *organelle* means little organ. Organs and organelles are very different. **Use** words and diagrams to **demonstrate** why organelle is an appropriate name for these structures.

14 **Calculate** the magnifications to fill in the blanks in this table.

Ocular lens	Objective lens	Total magnification
×4		×40
	×10	×100
×4	×100	
×10	×40	
×10		×1000

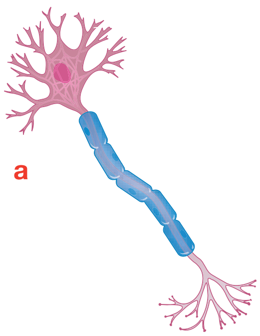
15 The field of view of a microscope was measured and found to be 3 mm using a magnification of ×10.

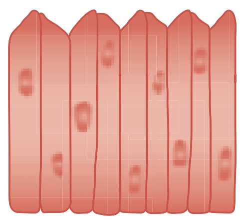
Calculate the diameter of the field of view at the following different magnifications and using the two different units.

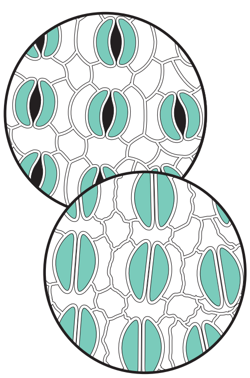
Magnification	×10	×100	×1000
Diameter of field of view (mm)	3		
Diameter of field of view (μm)			

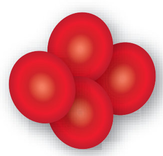
2 Chapter review

16 **Identify** the types of cells represented in these diagrams.

a


c


b


d


Analysing

17 **Classify** each of the following cell types as plant or animal cells.
- a guard cells
- b nerve cells
- c muscle cells
- d photosynthetic cells
- e root hair cells

18 **Compare** the outer layer of plant cells and:
- a animal cells
- b fungal cells.

Evaluating

19 **Select** information from Figure 2.5.1 to use in your responses.

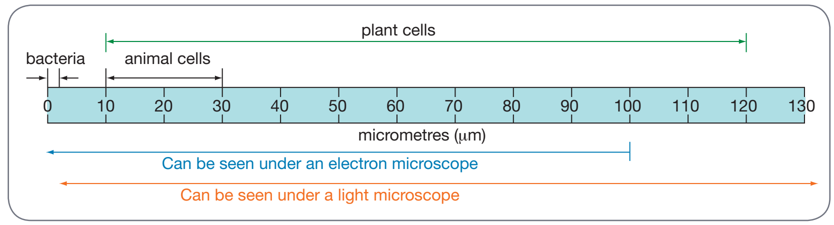


Figure 2.5.1

- a **Compare** the size of plant cells and animal cells.
- b **Suggest** a reason for plant cells being the first ones to be seen.
- c Bacteria were not discovered until long after plant cells. **Suggest** why this was so.

20 **Select** the correct statements from the following list.
- A A structure made up of different types of tissues is an organ.
- B When cells of the same type are grouped together they form a system.
- C There are many different organs in a tissue.
- D Tissues are groups of cells of the same type.
- E In a system many organs work together.

21 Look back at Figure 2.3.6 on page 59, showing cardiac muscle. The fibres of cardiac muscle are arranged in a network. **Propose** a benefit to you of having the fibres interlocking in this way.

Creating

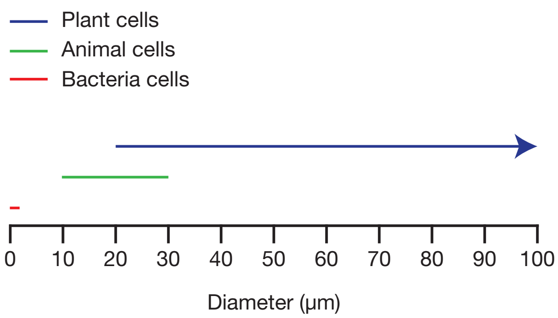
22 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

cell
plant
animal
unicellular organism
multicellular organism
tissue
organ
organ system
specialised cell
microscopic

2.9

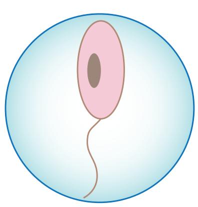
Thinking scientifically

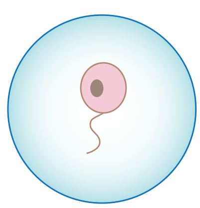
Q1 Four cells were viewed under a microscope and their diameter was measured. Use the information in the diagram to decide which one was most likely to be a cell from an animal.

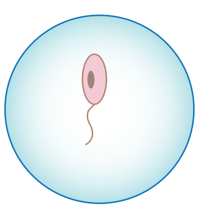


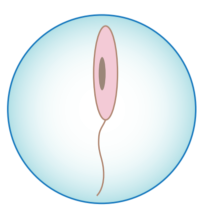
A 100 µm **B** 2 µm
C 15 µm **D** 45 µm

Q2 The unicellular organism shown was viewed under a microscope with a magnification of ×2. Which diagram represents the image you would see?

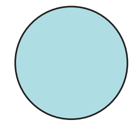
A


B


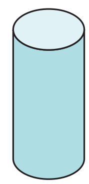
C


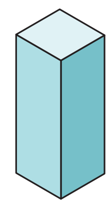
D


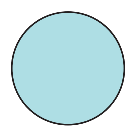
Q3 When a cell was cut from a section of a plant stem and viewed under a microscope, it appeared as a circle as shown.

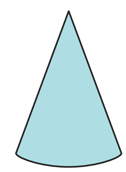


Which one of the following could *not* be the three-dimensional shape of the cell?

A


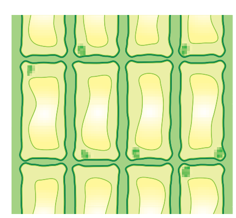
B


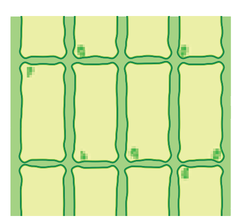
C


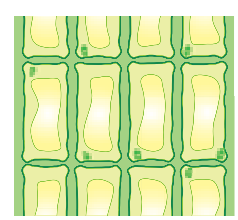
D


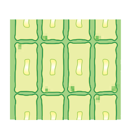
Q4 Figure 2.6.1 shows a normal plant cell. What would the cell look like if the plant it came from had no water for 3 days?

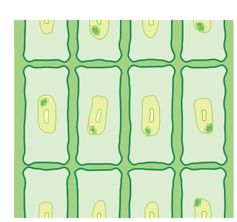
Figure 2.6.1



A


B


C


D


Glossary

Unit 2.1

Binocular microscope: a light microscope that has two ocular lenses

Dissection: when a scientist cuts apart a dead plant or animal to study it

Binocular microscope

Electron microscope: microscope that uses beams of electrons to magnify up to a million times. There are two types of electron microscopes: transmission electron microscopes (TEM) and scanning electron microscopes (SEM)

Field of view: the amount of the specimen seen through a microscope

Image: what is seen using the microscope

Light microscope: a microscope that uses light to reveal the image

Magnification: the amount by which the image is magnified (made bigger) compared to the real object (specimen)

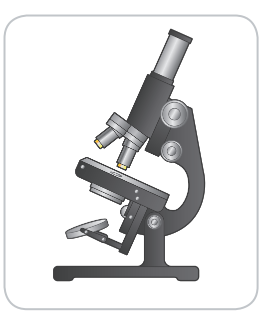
Magnified: made bigger

Micrometre: one-thousandth of a millimetre, or one-millionth of a metre

Microscope: instrument used to make very small things look bigger

Microscopic: describes objects that can only be seen using a microscope

Monocular microscope: a light microscope that has only one ocular lens



Monocular microscope

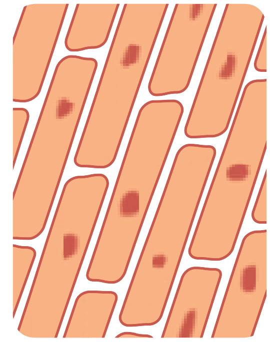
Objective lens: the lens of the microscope closest to the stage

Ocular lens: the lens of the microscope closest to your eye

Specimen: the object being looked at through a microscope

Stereo microscope: a binocular microscope that creates a three-dimensional image

Unit 2.2



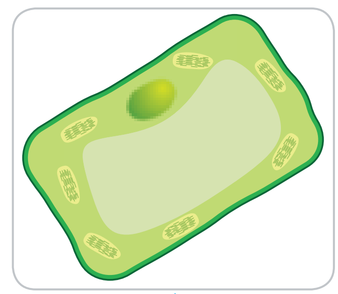
Cell

Cells: the building blocks of all living things

Cell membrane: the 'skin' that holds the cell together. It controls what comes into and leaves the cell

Cell wall: the skeleton of the plant

Chloroplast: organelle within the cell where photosynthesis takes place



Chloroplast

Cytoplasm: a watery, jelly-like mixture that contains many smaller parts where the work of the cell takes place

Endoplasmic reticulum: pathways along which materials move through a cell

Lysosomes: organelles that get rid of wastes from cells

Mitochondria: the powerhouses of the cell where the energy is released from food

Nucleus: the control centre of a cell

Organelles: the smaller parts of a cell

Photosynthesis: process used by plants to make food from water and carbon dioxide using energy from the Sun

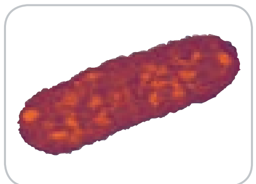
Ribosomes: organelles that produce proteins

Vacuole: small structure in animal cells that may contain wastes or chemicals, or large sap-filled structure in plant cells that stores water, wastes and nutrients

Unit 2.3

Axon: long fibres that extend from nerve cells and carry messages over long distances

Bacteria: very simple unicellular organisms that lack a nucleus and other organelles



Bacteria

Chlorophyll: the green chemical in chloroplasts that traps the Sun's energy for photosynthesis

Guard cells: cells that work in pairs to open and close the stomata

Multicellular organisms: living things made of many cells

Nerve cells: cells that carry information in the body

Protists: a group of unicellular organisms often found in ponds and soil

Red blood cells: cells that carry oxygen from the lungs around the body

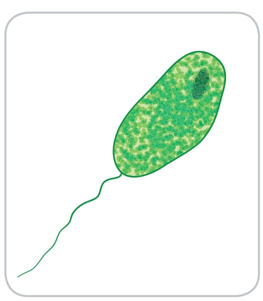
Root hairs: extensions on the outer surface of some root cells

Specialised cells: cells that have a special job to do in the body and have a structure that makes them better able to do their job

Stomata: very tiny pores in leaves

Unicellular organisms: living things made up of only one cell

White blood cells: part of the immune system; helps the body to fight infection



Unicellular organism

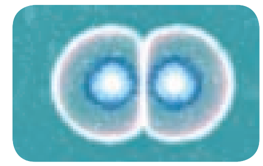
Unit 2.4

Cell culture: growing cells separately from organisms in the laboratory

Connective tissue: adds support and structure to the body, e.g. fat, bone, cartilage, blood tendon and ligament

Epithelium: skin

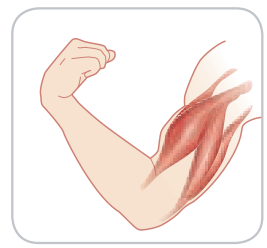
Mitosis: cell division that produces two identical cells



Mitosis

Muscle tissue: specialised tissue that can contract

Nerve tissue: many nerve cells grouped together



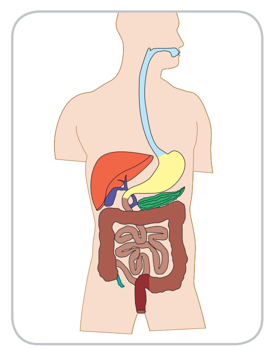
Muscle tissue

Organ: a structure that contains at least two different types of tissues that work together to complete a task

Organ system: two or more different organs that work together

Tissue: groups of cells that perform the same function in the body

Stem cells: cells that can become different types of cells under specific conditions



Organ system