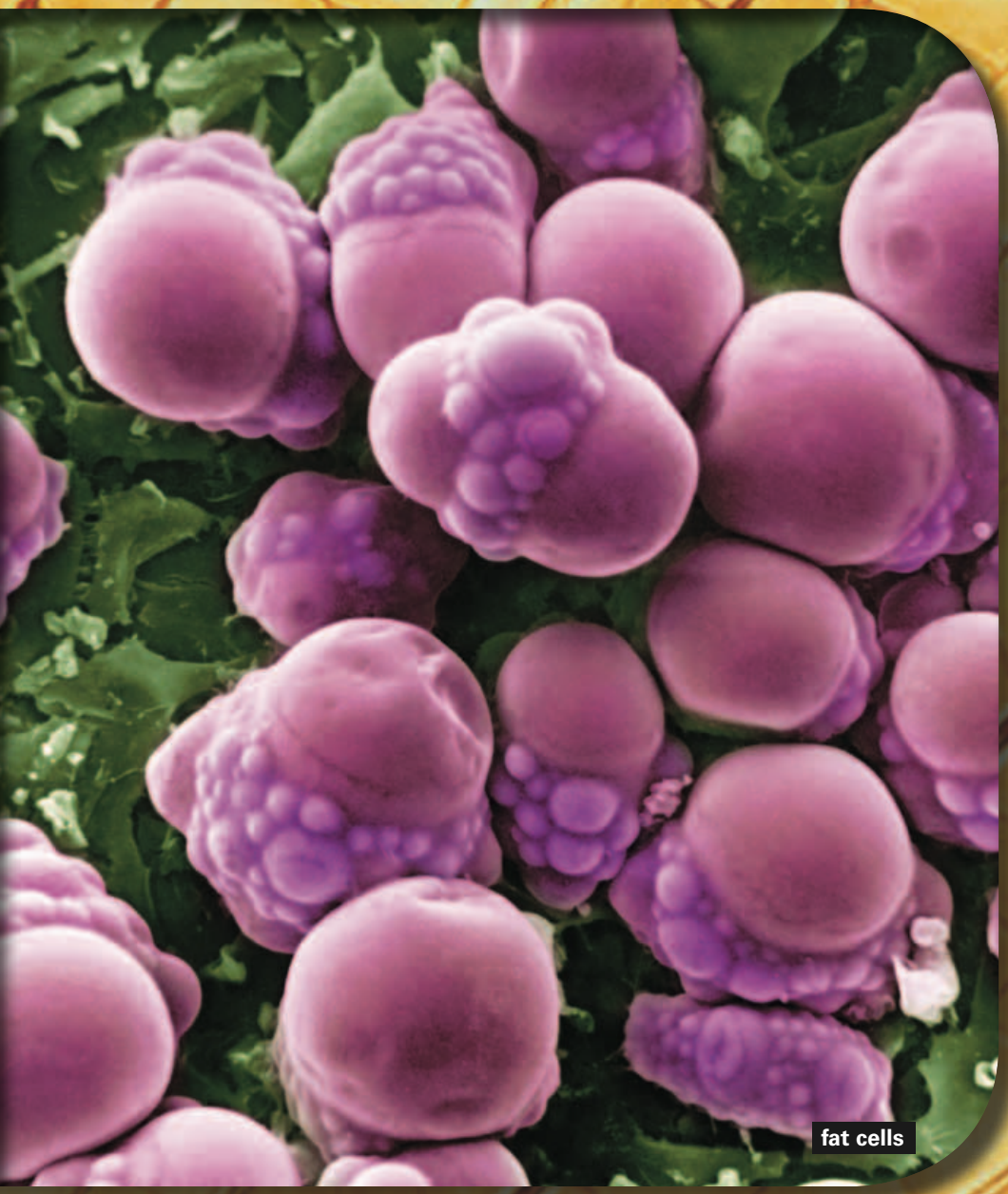


fat cells

6 Cells

In this chapter you will …

Science Understanding

- examine a variety of cells using a microscope
- describe the structure of cells and the functions of the parts of cells
- explain how the structure of a cell relates to its function in tissues and organs
- describe how cell respiration provides the energy for many cell functions
- use a model to explain how substances enter and leave cells

Science as a Human Endeavour

- make choices and present arguments about the benefits and ethics of stem cell research

Science Inquiry Skills

- design experiments to investigate cells and their functions

Getting started

- You are using a magnifying glass to look at a tiny insect on a stick. The magnifying glass has x2 on it. What does this mean?
- Another magnifying glass has x4 on it. How is this different from the first one? What will you see if you look at the insect with this magnifying glass?
- The organisms in this photo live in freshwater ponds and creeks. What does the x100 mean on the photo? Can you think of a way to find out how big these organisms are?

6.1 Cells

Cells are the building blocks of all organisms. Your body contains over 3 billion of them. Most cells are very small and can be seen only with a microscope. However, some cells, such as birds' eggs, are large enough to be seen with your eye. The ostrich egg is one of the largest single cells.

Some organisms are *unicellular*. These single cells are complete organisms. The photo below shows microscopic organisms called euglena (you-GLEEN-a), which live in fresh water and contain chlorophyll to make their own food by photosynthesis.

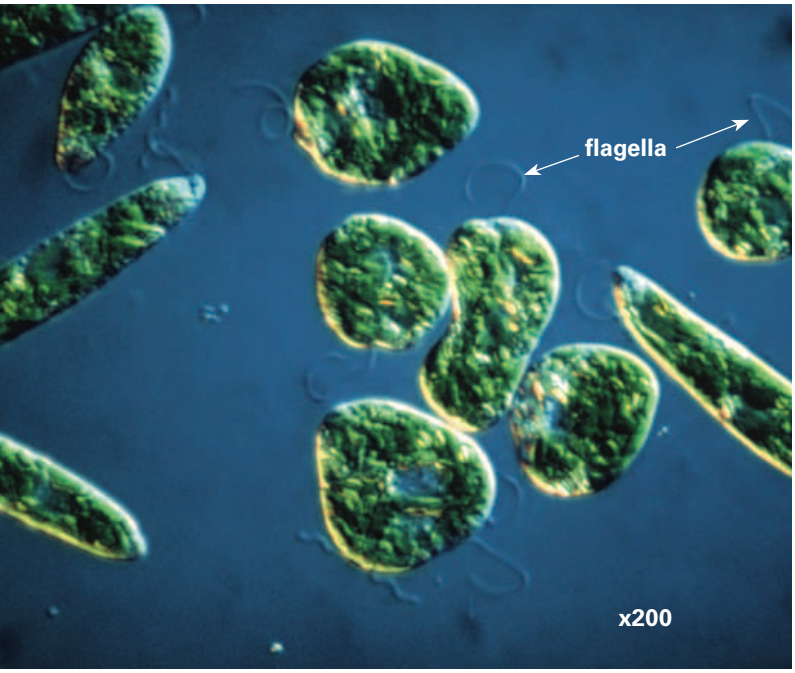


Fig 1 Euglena live in freshwater lakes and ponds. Long, whip-like 'hairs' called flagella at one end of the cell help it move through the water.

Multicellular organisms contain many different types of cells and each type of cell is specialised. This means that each type of cell has a different job to do in the organism. For example, in humans, red blood cells carry oxygen, muscle cells contract and relax to move bones and organs, nerve cells conduct nerve messages, and stomach lining cells make substances which help in the digestion of foods.

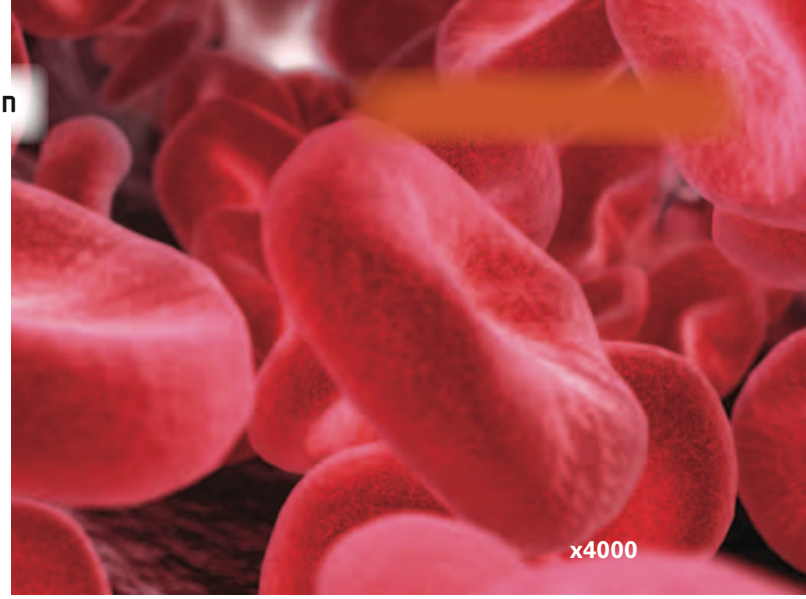


Fig 2 Red blood cells are specialised cells that carry oxygen around your body.

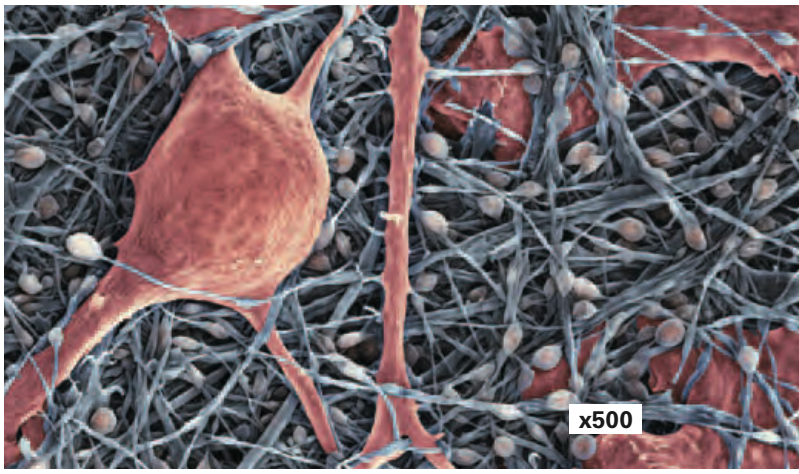


Fig 3 Nerve cells have an irregular shape. They carry nerve messages throughout your body.

Activity

The photos of the cells on this page are many times larger than the actual size of the cells. Each photo shows the number of times that the cell has been magnified. For example, the x200 on the euglena photo means that the cells have been magnified 200 times. You can use this information to find the actual sizes of the cells.

Measure an average-sized euglena cell with your ruler. Then divide this by 200 (the magnification) and give your answer in millimetres.

Use this method to find the sizes of the other cells in the photos.

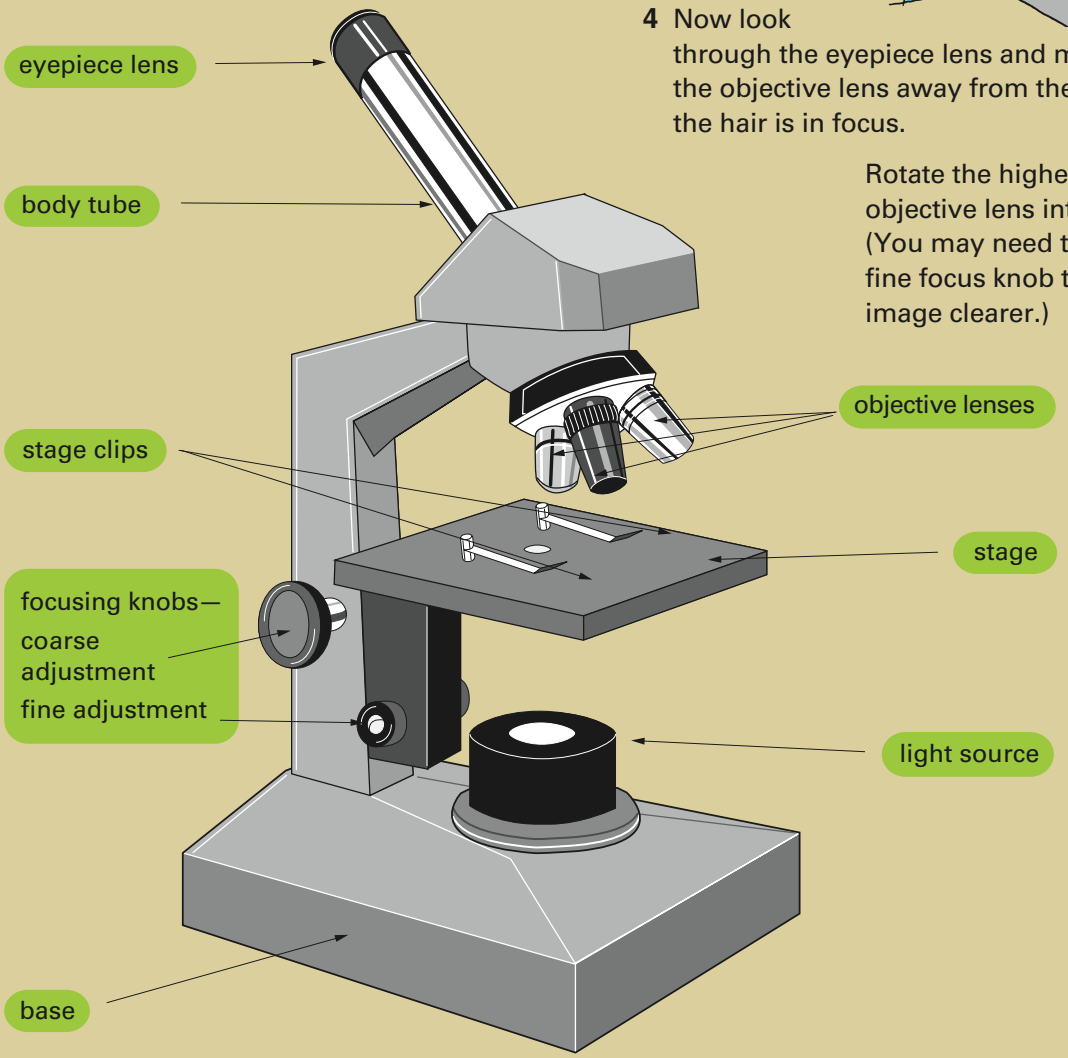
Skillbuilder

Using a microscope

In this chapter you will be using a microscope to view different types of cells.

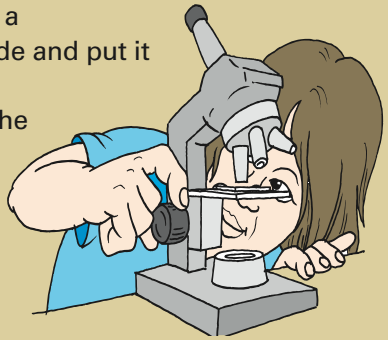
Parts of the microscope

Study the diagram below which shows the parts of a microscope. Your microscope may be slightly different from this one. However, the basic parts will be the same. If you are in doubt, ask your teacher for advice.



Setting up a microscope

1. Rotate the objective lenses until the low power lens clicks into position directly above the hole in the stage. (The low power objective lens is usually the shortest one, and has the lowest number stamped on it, e.g. ×4.)
2. Place a hair on a microscope slide and put it on the stage.
3. Looking from the side, turn the focusing knob to move the lens very close to the slide.
4. Now look through the eyepiece lens and move the objective lens away from the slide until the hair is in focus.



Rotate the higher power objective lens into place. (You may need to use the fine focus knob to make the image clearer.)

What x10 means

A microscope magnifies things. Each lens of a microscope has its magnifying power marked on it.

Look at the eyepiece lens. You may see the number ×10. This means that this lens magnifies things to 10 times their original size. The objective lenses are marked in the same way.

The total magnifying power of the microscope is found by multiplying the power of the eyepiece lens by the power of the objective lens. If the eyepiece is ×10 and the objective lens is ×10, then the microscope will magnify the object 100 times.

Observing prepared slides

Your teacher will give you a microscope slide containing some cells for you to practise your microscope technique.

Observe the shapes and features of the cells.

Questions

1 A microscope has a x4 eyepiece and a x10 objective lens. What is the total magnification of the microscope?
2 When focusing, why do you turn the focusing knob so that the objective lens moves away from the slide?
3 A hair is 0.005 mm wide. How wide would it be if you looked at it with the lenses in Question 1?

Activity

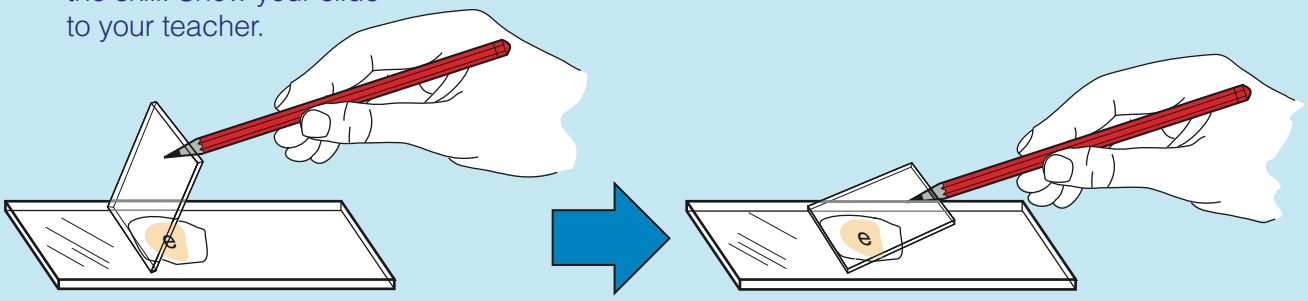
Making a wet-mount slide

1 Place a drop of water in the middle of a microscope slide.
2 Cut out a small lower case 'e' from a piece of newspaper and place it on the drop of water on the slide. Cover the 'e' with another drop of water.
3 Place the edge of the cover-slip on the edge of the drop of water, and lean it on a pencil, as shown.
4 Lower the pencil slowly and let the cover-slip fall flat on the slide. (This stops air bubbles forming under the cover-slip.) You should do this a few times to master the skill. Show your slide to your teacher.
5 Place the slide on the stage and observe the letter under low power.

Record your observations. Is the 'e' the right way up? Move the slide to the left. Which way does the 'e' move when viewed through the lens?

Questions

1 Suppose you place the number '5' under the microscope. Draw what you would expect to see through the lenses. Explain your drawing.
2 A cell is 0.01 mm long and 0.02 mm wide. How big would it be if you viewed it under a microscope with a ×10 eyepiece lens and ×4 objective lens?



Cells in organisms

The cells of living things vary in shape and function, but they do have features in common.

All cells are surrounded by a thin covering called a **cell membrane**, which acts like a fence controlling the movement of substances into and out of the cell. The cell membrane also helps to hold the cell together and to give it shape.

The round, dark-coloured object in the cells in the photos below is the nucleus. This controls all the cell's activities, and without it the cell eventually dies.

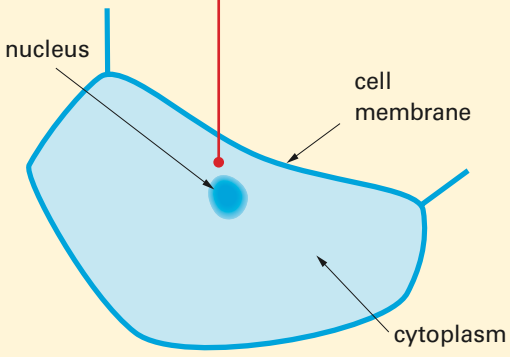
The inside of cells is filled with the jelly-like cytoplasm. This is where many chemical reactions take place. The cytoplasm also contains many other small bodies and structures called **organelles** (OR-gan-els). These help to keep the cell functioning correctly.

How are plant cells different from animal cells? Plant cells have a **cell wall** on the outside of the cell membrane. This is a thick, tough layer that protects the softer parts inside the cell and also provides stiffness that helps support the plant.

Plant cells also contain large liquid-filled spaces called **vacuoles** (VAK-you-oles) where water and dissolved substances are stored. Some animal cells have small vacuoles, but most have none at all. Inside the cytoplasm of plant cells there are organelles called **chloroplasts**. These contain the green pigment chlorophyll, which is needed for photosynthesis. Photosynthesis occurs in the chloroplasts.

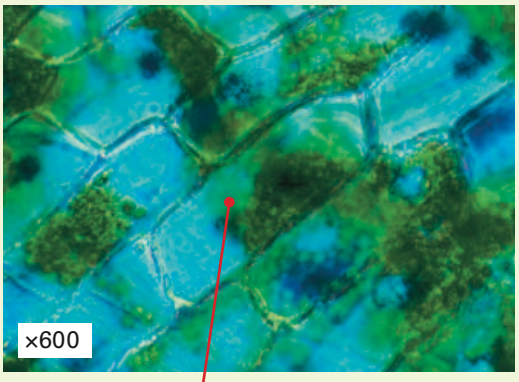
Animal cells

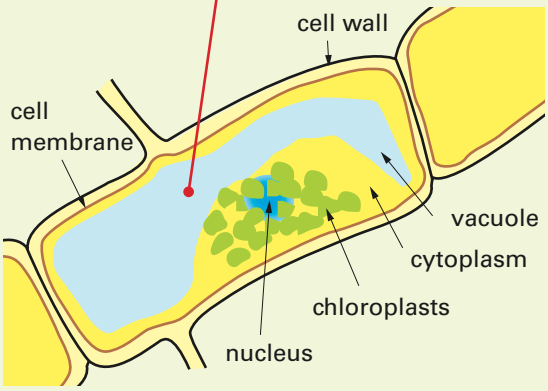
These cells are from the inside lining of a human cheek. The diagram below will help you interpret the photo.



Plant cells

These cells are from the leaf of a plant. The diagram below will help you interpret the photo.





Science as a Human Endeavour

Shane is a baker. He makes different kinds of bread with the help of a unicellular organism called *yeast*.

When making bread, Shane adds the basic ingredients—flour, sugar, water and yeast—and mixes them together to form dough. The dough is then left for a while in a warm place. During this time, the yeast cells grow and multiply rapidly using the sugar as a food.

Yeast cells get the energy needed for growth and reproduction by breaking down the sugar. Carbon dioxide and alcohol are produced as waste products. This process is called *fermentation*.

glucose → carbon dioxide + alcohol

The carbon dioxide gas given off by the yeasts causes the bread to rise and makes the holes in the bread. When the bread is baked, the heat of the oven quickly evaporates the alcohol from the dough.

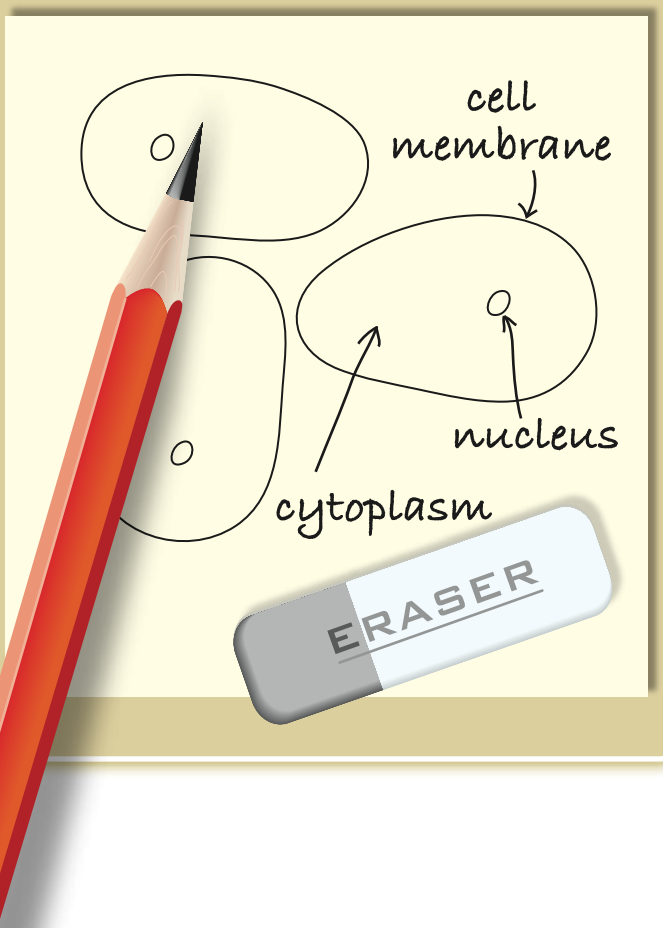
Skillbuilder

Drawing cells

In the next investigation you will be using the microscope to observe some animal and plant cells. In these observations, you should include drawings in your report.

How to draw cells

1. Always use a sharp HB pencil, and have a clean eraser handy.
2. The cells you see under the microscope are fairly complicated. Try to keep your drawings as simple as possible.
3. Choose 2 or 3 cells to draw. Draw the lines and shapes. Don't shade or colour the drawing.
4. Make the drawing as large as possible. Include only the structures you can identify. Label these structures.



Investigation 14 Observing cells

Aim

To use a microscope to observe plant and animal cells.

Materials

- microscope
- 4 microscope slides and cover-slips
- piece of onion
- methylene blue stain
- freshwater plant (e.g. elodea)
- small pieces of apple, mince meat, raw chicken, moss, potato, spirogyra, duckweed etc

Planning and Safety Check

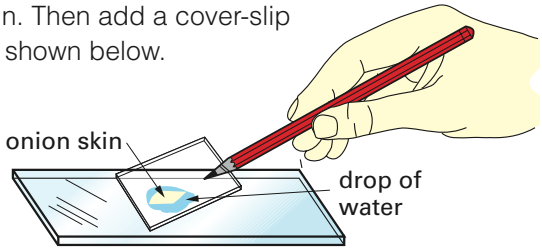
- Carefully read through Parts A, B and C, and make a list of the materials you will need for each part.
- Ask a partner to describe what they are going to do in Part A. Then you describe what you are going to do in Part B.

PART A Onion skin cells

Method

1 Remove one layer from the onion. Then peel a small piece of the very thin skin from inside the layer.

2 Put a drop of water on a slide then place the piece of onion skin on the drop. Add another drop of water on top of the onion skin. Then add a cover-slip as shown below.



3 Repeat Steps 1 and 2 with a second slide, but instead of adding water, add one drop of methylene blue stain. Then place a cover-slip over the onion skin.

4 Observe both slides under low power, then under higher power.

Record the differences between the two slides. In which one are the cells more easily observed? Which parts of the cell can you easily see?

Draw two or three stained cells. Label the cell wall, the nucleus and the cytoplasm.

PART B Looking at chloroplasts

Method

1 Tear a small leaf from the top of the freshwater plant.

2 Prepare a slide as you did for the onion skin, but this time use the leaf. (You can use a drop of water or the methylene blue stain if you wish.)

3 Observe the leaf under low power, then under higher power.

Use the photo of the plant cells on page 129 to help you identify the round chloroplasts, the cell wall, the nucleus and the cytoplasm.

Draw a labelled diagram of what you observe. How do these cells compare with the onion cells from Part A?

PART C Other cells

Method

1 For this part you will look at cells in apple, mince meat, chicken, moss, potato, spirogyra, duckweed etc.

2 Place a small amount of material on the end of a toothpick. Scrape it onto a slide.

3 Add a drop of water and a cover-slip. You can add a drop of stain if you wish.

Observe the cells. Draw and label two or three of the cells.

Discussion

1 Why is a stain used when observing cells?

2 What general shape are the onion cells? Do other types of cells also have a regular shape? Do other cells have the same shape as onion cells?

Video microscope: Your teacher may connect a camera to a microscope to show you different types of cells.

Extra for experts

Sizes of cells

You have seen that cells have a variety of shapes depending on their function. Most animal and plant cells are about 0.005 mm to 0.02 mm in diameter. However, the longest cell is a type of nerve cell found in the giant squid and can be up to 7 metres in length.

Bacteria

Bacteria are unicellular organisms and have a much simpler cell structure than animal and plant cells. A bacteria cell is usually smaller than other cells, ranging in size from 0.0005 mm to 0.003 mm.

Bacteria are usually classified by their shape. There are rod-shaped ones (bacilli), spherical ones (cocci) and spirals (spirilli). Bacteria have a cell wall, but no nucleus. This is the major difference between a bacterial cell and a plant or animal cell.

Questions

1 What is the main difference between an animal cell and a bacterial cell?

2 What is the average diameter of an animal or plant cell? What is the average diameter of a bacterial cell? How much larger is an average animal cell than an average bacterial cell?

WEBwatch

Go to **www.OneStopScience.com.au** and follow the links to **Bacteria**. Use the websites to find out what different bacteria look like, where they're found, what they eat and how they move.

OneStopScience

Cells, tissues and organs

Unicellular organisms such as euglena contain all the structures necessary to exist on their own and be independent from other cells. However, the cells in large, multicellular organisms are generally specialised, and therefore need to work together with other cells for the survival of the organism. For example, a single cheek cell cannot exist on its own for very long and will die after a short time outside the body.

Cells of the same type are generally found together in tissues. A **tissue** is a group of similar cells organised to do a particular job. For example, the muscle tissue in the wall of your stomach and gut is made from muscle cells. The nerve tissue in your brain and spinal cord is made from nerve cells.

In multicellular organisms, various tissues are arranged into a structure called an **organ**. An organ is a collection of specialised tissues that has a particular function. For example, a leaf whose main function is to make food contains food-making tissue, transport tissue, support tissue and lining tissue.

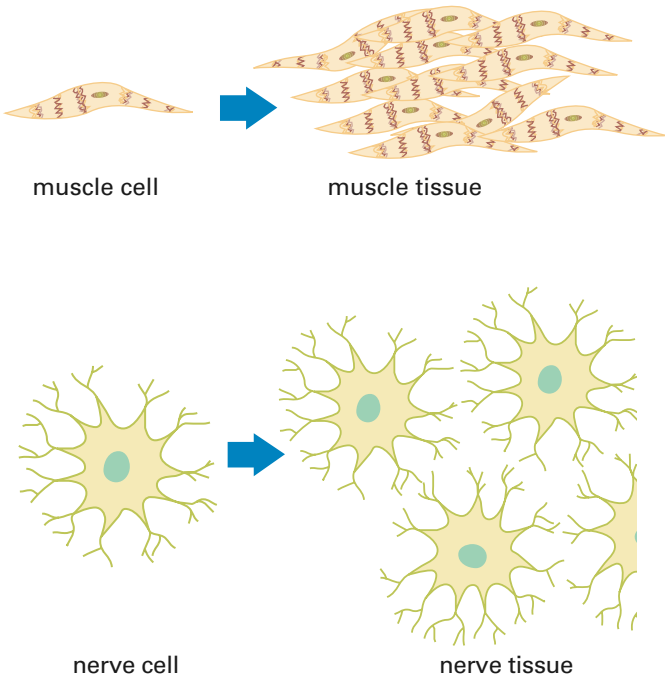
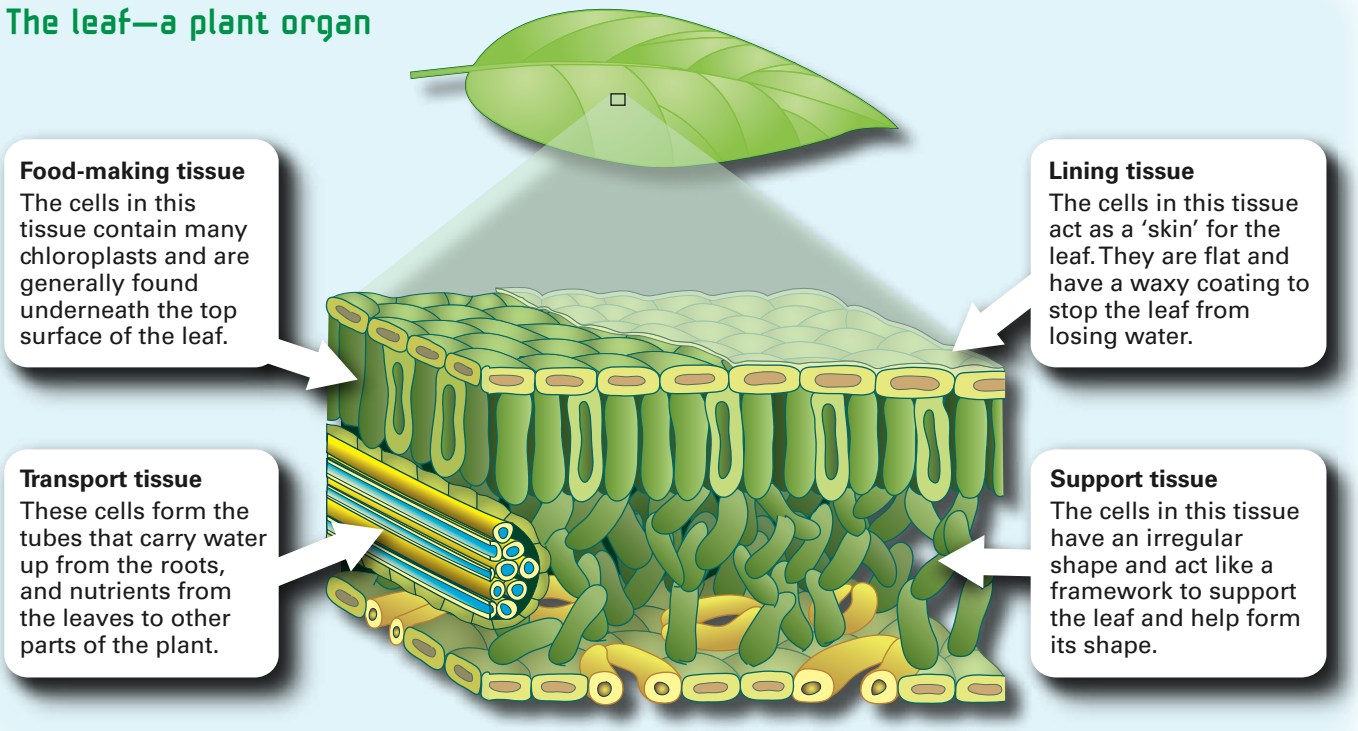


Fig 4 Many cells of the same kind combine to form tissues in the body.

The leaf—a plant organ



Activity

You will need a microscope and slide, some prepared slides of various tissues, some clear nail polish and a leaf.

A Looking at tissues

Set up a microscope and ask your teacher for a prepared slide of a tissue.

Draw a sketch of the cells in a small section of the tissue (about six to ten cells).

Write down the name of the tissue (this will be written on the slide).

B Observing the cells on a leaf's surface

Brush some nail polish on the *underside* of a leaf, so that it covers an area about the size of a 20-cent piece. Let it dry for a few minutes.

Peel the dried nail polish from the leaf and look at it under a microscope. You will see a copy of the surface cells on the leaf.

You will also see cells that form holes or pores in the surface of the leaf. Find out from the library what these pores are called. What is their function?

The stomach is an organ whose function is to break down (digest) food. It contains glandular tissue which produces substances that chemically break down foods, muscle tissue which churns the food, and connective tissue which holds the other tissues together.

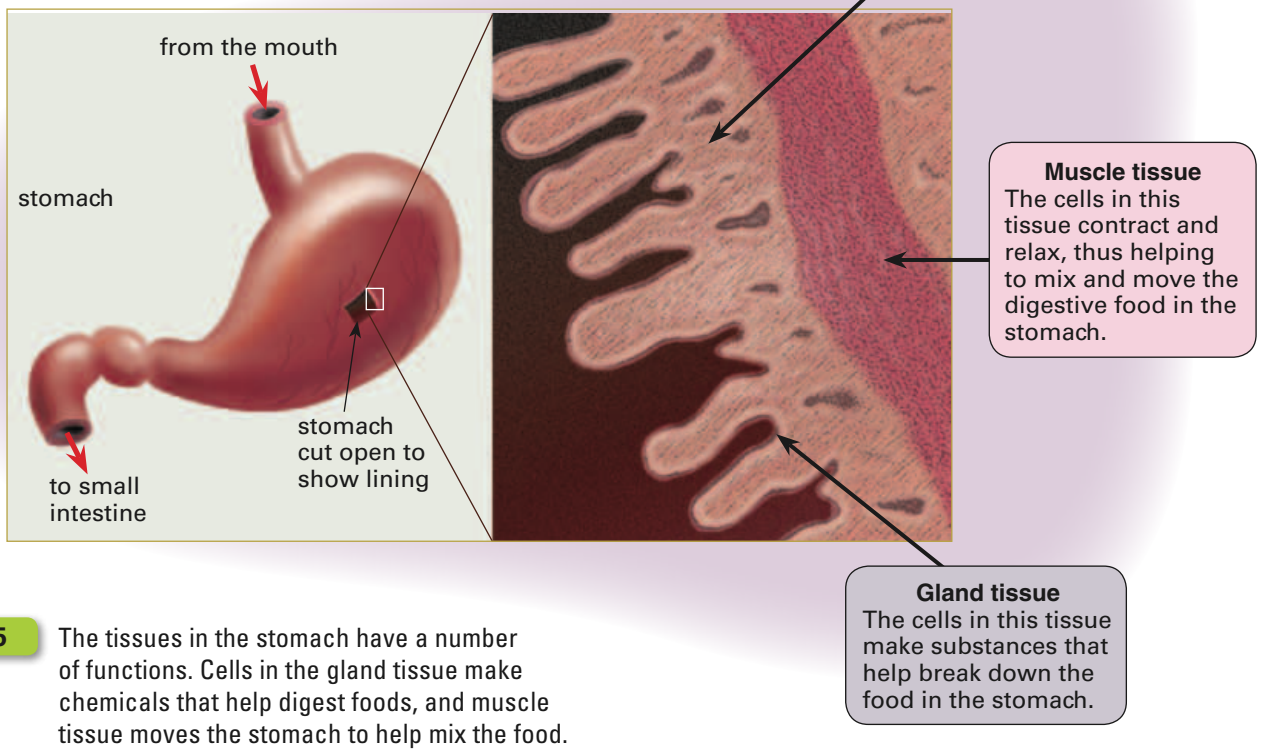


Fig 5 The tissues in the stomach have a number of functions. Cells in the gland tissue make chemicals that help digest foods, and muscle tissue moves the stomach to help mix the food.

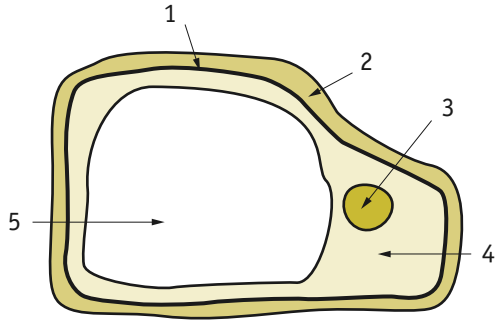
Check

1 Draw up a table similar to the one below and list the features of plant and animal cells so you can compare them. One feature has been done for you.

Plant cells	Animal cells
Have a nucleus	Have a nucleus

2 A microscope lens has ×10 marked on it. What does this mean?

3 Copy the drawing of a cell below into your notebooks. Use the information in the table above to determine whether it is a plant cell or an animal cell, then label the cell.



4 Describe the function of each of the five parts of the cell in Question 3.

5 Copy the following sentences into your notebook, then complete them using the words you have learnt in this section.
- a Organisms are made of building blocks called _____.
- b Cells in large organisms are called _____ cells, because they perform a particular function.
- c The lens that you look through at the top of a microscope is called the _____.
- d Organelles are found in the _____ of a cell.
- e Chloroplasts are organelles that contain _____.

6 Explain the difference between a tissue and an organ. Give an example and use the words *cells* and *function* in your answer.

7 On page 126, the word *multicellular* was used. Explain what this word means.

8 Look at the diagram of the leaf on page 133. Make an inference for each of the following observations.
- a The lining cells are very flat and fit together like tiles.
- b There are many chloroplasts in the food-making cells.
- c There are holes or pores in the underside of the leaf.
- d The cells in the support tissue fit together like trusses in a house frame.

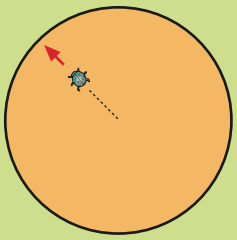
9 You are an illustrator for a Year 8 science textbook. Try to explain, using labelled drawings, how to make a wet-mount slide.

Challenge

1 A microscope has two eyepiece lenses, ×4 and ×10, and three objective lenses, ×4, ×10 and ×40.
- a What combination of lenses gives a ×160 magnifying power?
- b What are the lowest and highest magnifying powers of the microscope?
- c A specimen was photographed using the ×10 and ×10 lenses. On the photo the specimen measured 55 mm in diameter. What is the actual size of the specimen?

2 a What does the letter 'F' look like through a microscope?

b Under a microscope you observe a tiny insect moving diagonally across a slide, as shown in the diagram. Where should you place your finger to prevent it from escaping from the slide?



6.2 Cell processes

A living cell is constantly active. Substances pass into and out of the cell through the cell membrane and, in plant cells, a cell wall. Chemical reactions occur in which large molecules are broken down to small ones and small molecules are built up to larger ones. For example, most of the matter in the cytoplasm of a cell is made of protein. In cell division and growth, the extra protein needed is built up from smaller amino acid molecules that pass into the cell from the blood or the liquid around the cell.

Cell respiration

The cells in your body may have to perform many of the following functions.

- All cells *make proteins* (e.g. enzymes) and other large molecules.
- Muscle cells *cause movement*.
- Nerve cells *send nerve impulses*.
- Many types of cells *divide*.

All of these functions require energy, and the cell's main source of energy is glucose. When glucose is broken down in respiration, oxygen is used and carbon dioxide, water and energy are produced.

glucose + oxygen → carbon dioxide + water
ENERGY IS RELEASED

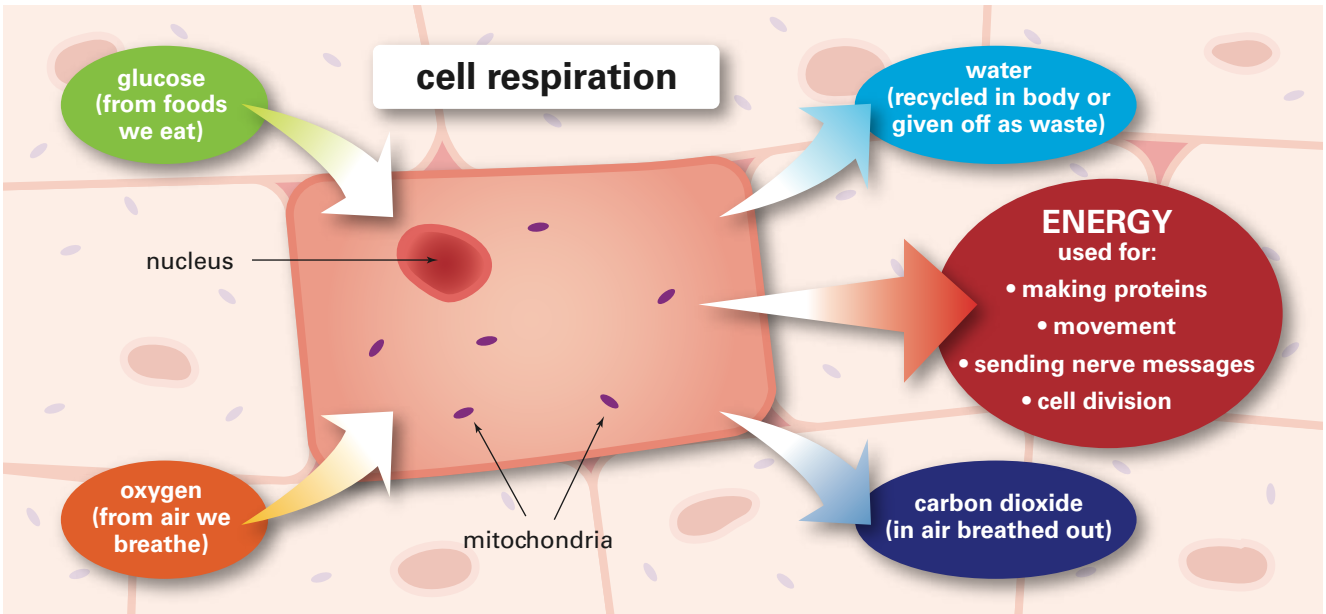
This energy is used for muscle movement and nerve transmission, and in building large molecules such as proteins from smaller molecules.

Cell respiration occurs in organelles called **mitochondria** (might-oh-KON-dree-a). These tiny organelles vary in shape from round to sausage-shaped, depending on the type of cell, and are found in all cells that contain a nucleus. The number of mitochondria in a cell indicates its energy requirement. For example, a muscle cell contains up to 5000 mitochondria, while a skin cell may have fewer than 100.

Energy for muscle movement

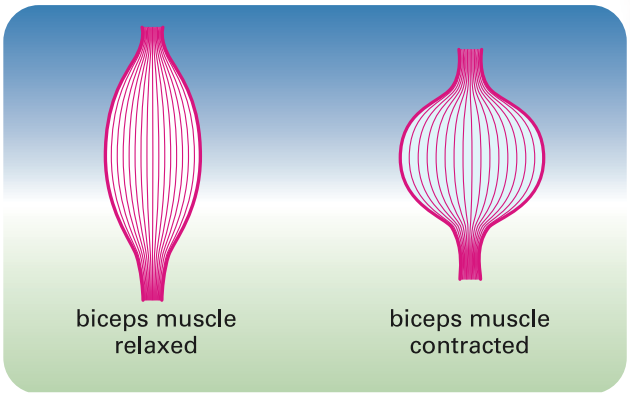
Skeletal muscle is the type of muscle that usually moves bones. It is also called striated muscle because of its striped appearance under the microscope. The other types of muscles in the body are heart muscle, which is found only in the heart, and smooth muscle, which is found in organs such as the stomach and intestine.

Fig 6 A cell performs a number of functions in the body. Most of these functions require energy.



Skeletal muscle

When skeletal muscle contracts, it becomes shorter and thicker. You can feel this by placing your hand over your biceps muscle and bending your elbow.



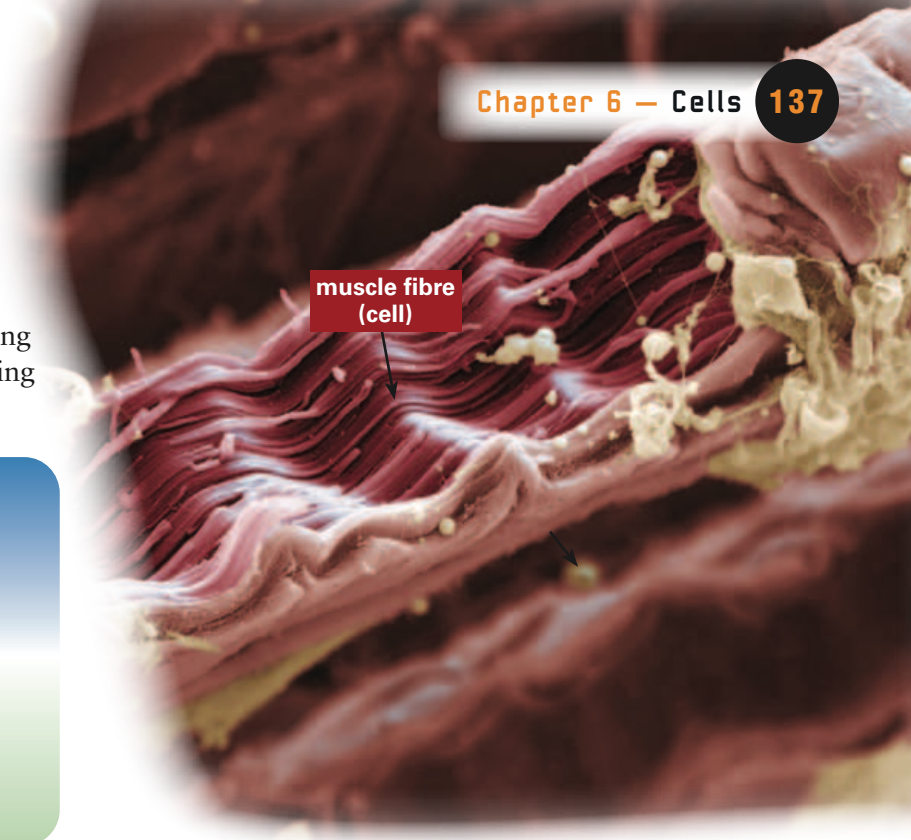
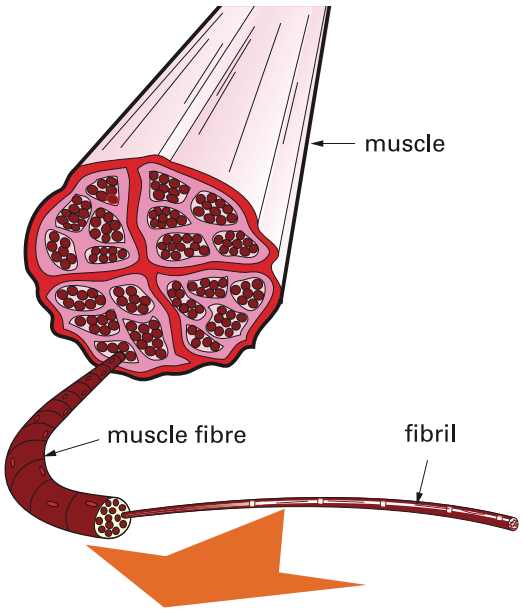


Fig 7 An electron microscope photo of skeletal muscle fibres (cells)

The photo in Fig 7 shows the structure of skeletal muscle. Each muscle contains many muscle cells. These cells are different from other cells in that they are very long. Because of their length, muscle cells are often called *muscle fibres*.

Muscle cells are also different from other cells because they contain more than one nucleus. These are usually found on the surface of the cells.

Muscle fibres are made up of tiny threads of protein called *fibrils*. When the muscle contracts, the strands in the fibrils slide over each other and become shorter. This process requires energy from cell respiration, and this is why muscle cells contain many mitochondria.



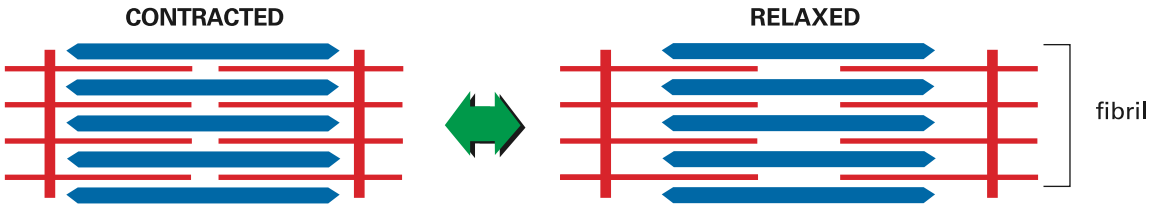


Fig 8 The structure of skeletal muscle (right). The model below shows how a muscle fibril is thought to contract.

The muscle contracts when the strands in the fibril slide over each other, making the muscle shorter than in the relaxed state.

A fibril in a relaxed muscle

Regular exercise builds up skeletal muscle. This is due to an increase in the number of blood capillaries that take blood to the muscle fibres, and an increase in thickness of the muscle fibres.

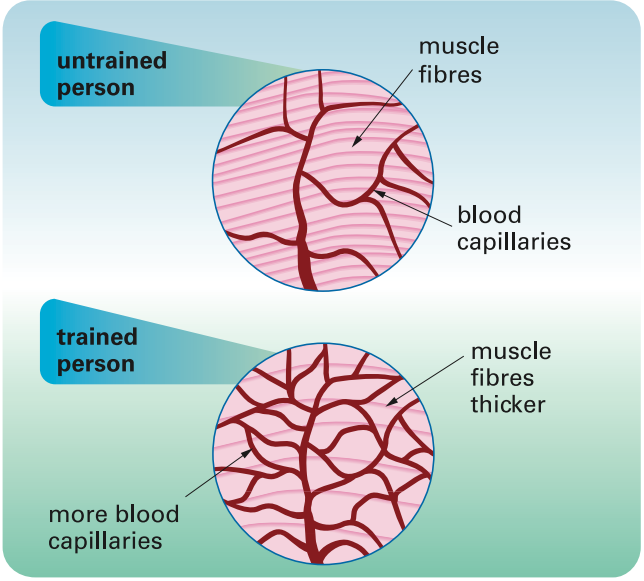


Fig 9 The muscles in a trained person contain many more capillaries and thicker muscle fibres than in an untrained person.

Muscles and energy

When glucose is broken down to produce energy in the mitochondria of cells, oxygen is normally used. This is called **aerobic respiration** (air-OH-bic). Aerobic means *with air*. However, muscle cells can also produce energy anaerobically, or *without air*. During vigorous muscular activity, the blood cannot supply the muscles with all the oxygen they need and glucose is broken down without oxygen. In this process, glucose is broken down to lactic acid, a molecule half the size of glucose. A much smaller amount of energy is produced anaerobically than aerobically.

After vigorous exercise, the blood brings more oxygen to the muscles and the lactic acid is gradually broken down to carbon dioxide and water. This is why your breathing and heart rates remain higher than normal for a short time after exercise.

The fitter you are, the more exercise you can do without feeling fatigued. This is because the muscles in a fit person have more blood capillaries which carry more oxygen to the tissues. Here the oxygen is used to break down the lactic acid.

Science as a Human Endeavour

Busting the myth—lactic acid and fatigue

In 1929 a now-famous experiment performed on a twitching frog's leg showed that as the lactic acid accumulated in the muscle cells, fatigue increased. As a result, lactic acid was identified as the cause of muscle fatigue.

However, Professors Graham Lamb and George Stephenson from La Trobe University believe that lactic acid is not the cause of muscle fatigue. It is a mistaken cause and effect! Lactic acid does build up in exercising muscles, but it is not the cause of fatigue.

Adenosine triphosphate, or ATP, is the energy carrier in cells. When ATP molecules split apart, energy is released for muscle activity. Professor Lamb has found that a low level of ATP inside muscle fibres may be one of the causes of fatigue. When the ATP drops to a critically low level, the muscle fibres stop contracting. When the energy usage drops, the concentration of ATP builds up again, and the muscles are able to do more exercise. Other substances such as potassium ions, phosphate ions and magnesium ions may also increase muscle fatigue.

Professors Lamb and Stephenson believe they and other researchers have busted the lactic acid-fatigue myth. 'This is a great lesson for young science students,' said Professor Lamb. 'Just because two variables correlate, it doesn't mean one is the cause and the other is the effect.'

Questions

1. Top athletes have their blood lactic acid levels checked after exercise. How does this indicate their level of fitness?
2. Use a dictionary to help you explain what the word *correlate* means. Then write a sentence using the word to help explain its meaning.
3. What does the sentence *It is a mistaken cause and effect!* mean?

Activity

In this activity you are going to test the effect of temperature on muscle activity.

1. Pour some ice-cold water into a small plastic bucket or ice-cream container.
2. In your notebook, write a sentence (any sentence) of about 12 words.
3. Now put your writing hand and lower arm into the cold water for 2–3 minutes or for as long as you can.
4. Quickly wipe your hand dry with a towel and try to rewrite the sentence from Step 2.

Describe the appearance of your hand after being in cold water. Suggest reasons for its appearance.

Suggest reasons for the difference between the two samples of handwriting.

Experiment 5 Muscles and exercise

PART A Temperature and muscles

The problem to be solved

In the activity above you saw the effect of temperature on muscle contraction. Use the results of this activity to design an experiment to *measure* the effect of temperature on muscle activity.

Designing the experiment

1. Work in a small group and discuss the tests you will do.
2. What variables will you control?
3. Write a draft of your experimental design, including safety issues and a materials list, and show it to your teacher.
4. After your teacher's approval, do the experiment and write a full report of your findings.

PART B Muscles and fatigue

The problem to be solved

In this part of the experiment you are going to use the equipment in the photo, or other equipment you think is necessary, to test one or more of the following questions.

a How much exercise can your middle finger do before it becomes fatigued?

b Can all fingers exercise at the same rate before they become fatigued?

c Does a short period of rest, say 10 seconds, between periods of exercise affect the time it takes for muscles to become fatigued?

d Do muscles become fatigued sooner in an unfit person than in a fit person?

Your report

Write a report of your findings, displaying your data so that other people can easily understand them. Your teacher may ask you to present your report to the class.

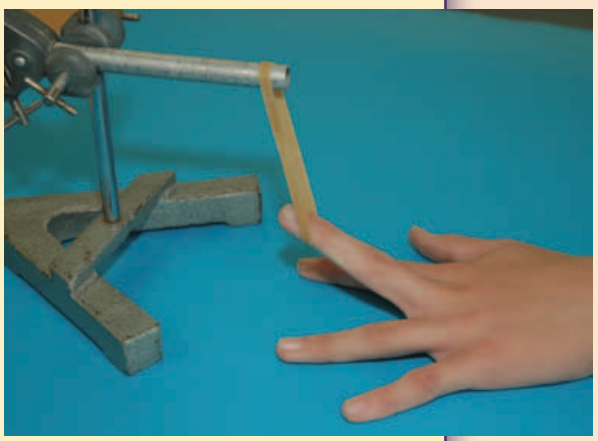
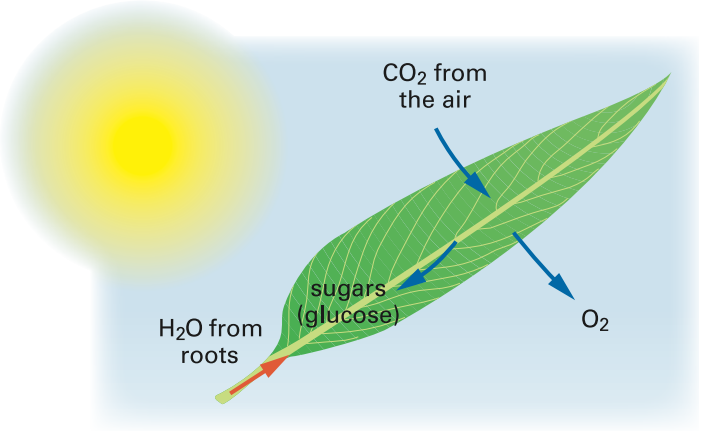


Fig 10 Adjust the height of the clamp so that your finger is raised as high as possible and the rubber band is stretched a little.

Photosynthesis

Photosynthesis is an endothermic process which occurs in organisms that contain chlorophyll. The energy source for this process is light, and the products are glucose and oxygen.



carbon dioxide + water $\xrightarrow{\text{ENERGY}}$ **glucose + oxygen**

Fig 11 Photosynthesis is an endothermic process that uses light as its energy source. Glucose is made in the process.

The rate of photosynthesis depends on many factors, including the intensity and the colour of the light. White light from the Sun is made up of the colours of the visible spectrum. Chlorophyll molecules absorb light strongly in the blue and red regions of the spectrum, and poorly in the green region (see Fig 31).

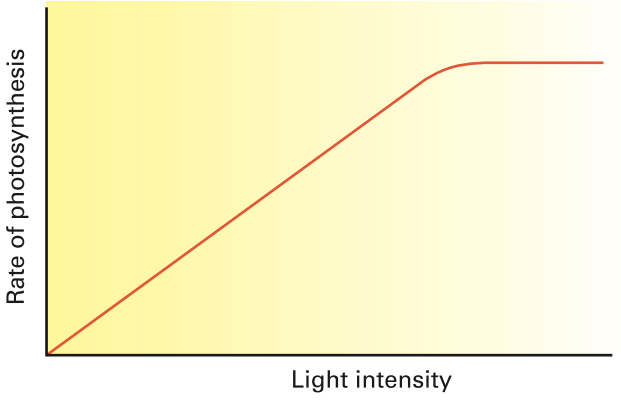


Fig 12 The effect of light intensity on the rate of photosynthesis

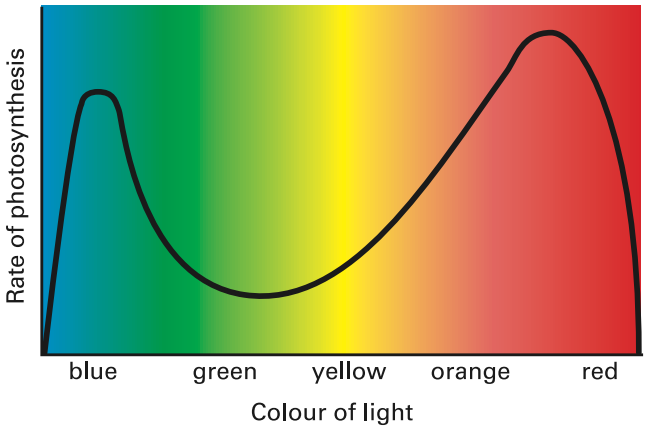


Fig 13 The effect of different coloured light on the rate of photosynthesis

If plants are placed in an area covered with a green plastic roof, they will grow poorly. This is because the green roofing allows only the green light in the sunlight to pass through to the plants. The rate of photosynthesis is much lower in green light than in other colours, causing poor growth in the plants.

The chlorophyll in plant cells is contained in the chloroplasts. Using an electron microscope, chloroplasts can be seen to contain *granules*. These can be stained with iodine, which indicates that they contain starch. When plants are kept in the dark for some time, the chloroplasts no longer contain granules. This is further evidence that the granules contain starch which is made by photosynthesis.

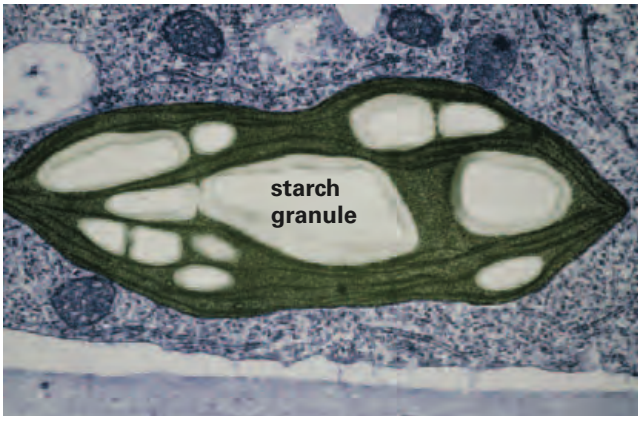


Fig 14 A chloroplast viewed through an electron microscope. The white patches inside it are starch granules.

Investigation 15 Observing chloroplasts

Aim

To observe chloroplasts in aquarium plants.

Materials

- piece of pondweed, e.g. elodea
- spirogyra
- microscope
- 2 microscope slides and cover-slips
- **iodine** stain (10 g potassium iodide in 100 mL water, then add 5 g iodine)
- aquarium water

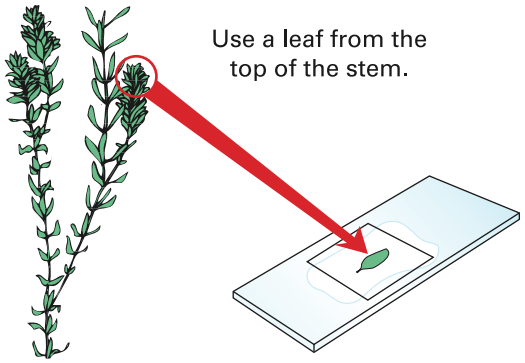
Teacher note: A videoflex microscope camera can be used to show students the chloroplasts and other cell structures.

Method

1 In Investigation 14 on page 131 you saw the structures in a plant leaf. In this Investigation you will make more detailed observations.

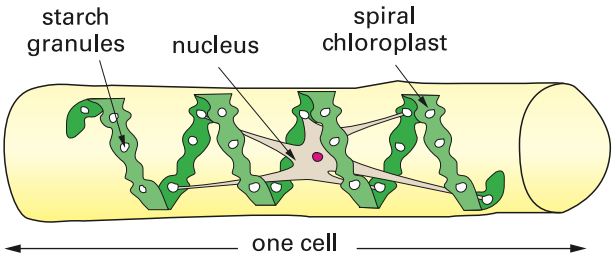
2 Choose a young leaf from a pondweed stem and mount it on a slide with a drop of aquarium water. Add a cover-slip.

3 Observe the leaf under low power and then higher power.
Identify the cells in the leaf. Then identify the round green chloroplasts. You might see the chloroplasts moving. This is caused by the movement of the cytoplasm in the cell.



3 Place a strand or two of spirogyra on a slide and add a drop of iodine stain. Then add a cover-slip and let it stand for a minute or two. Use low power to try to identify the spiral chloroplast.

4 Use high power and look for darkly stained granules in the chloroplast. These are where starch is stored.



Check

1 Describe the four functions of body cells that require energy.

2 Cell respiration is said to be the reverse of photosynthesis. Explain what this statement means.

3 Mitochondria and chloroplasts are cell organelles.
- a What are organelles and where in the cell are these two organelles found?
- b Do all cells contain these organelles? Do all cells have the same numbers of these organelles? Explain both answers.
- c Mitochondria vary in size between 2 µm and 5 µm. What is their size in mm?

4 How is a skeletal muscle cell different from other cells in your body?

5 Describe how skeletal muscle contracts. Why are there many more mitochondria in muscle cells than there are in skin cells?

6 What happens in muscle cells when they have to contract vigorously and there is not enough oxygen available?

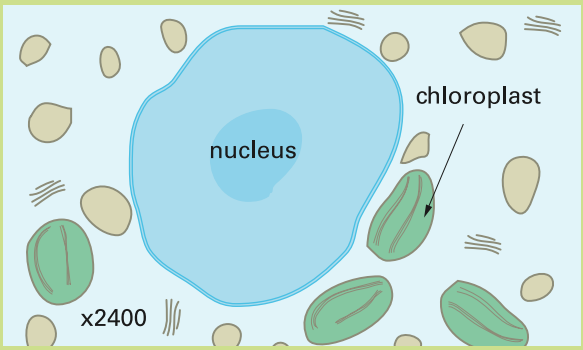
7 What type of respiration occurs in each of the following situations?
- a a 20-metre sprint for the bus
- b doing housework
- c 20 chin-ups
- d a walk with the dog

8 Describe how the muscles of body builders are different from your muscles.

9 What are the advantages to the body of muscles using energy supplied anaerobically?

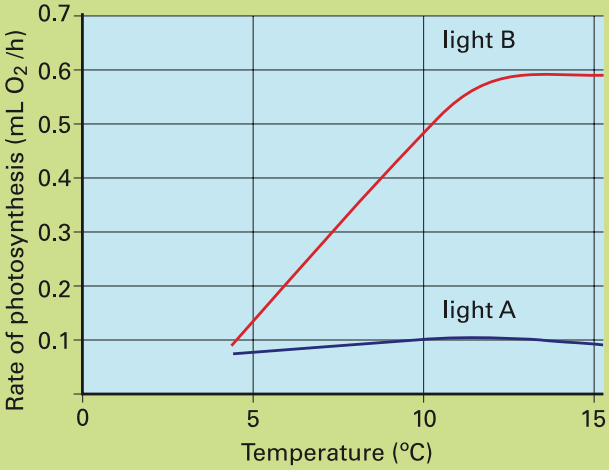
Challenge

1 The drawing below shows part of a plant cell that has been enlarged many times. Use the magnification to calculate the actual size of the nucleus and the chloroplast in micrometres.



2 Look at the graph, Fig 12 on page 140.
- a Explain the shape of the graph.
- b Antonia suggested that if the intensity of light shining on her plants doubled, the amount of oxygen released would also double. Is Antonia correct? Explain.

3 A light was shone onto a freshwater plant, and the rate of photosynthesis was measured at different temperatures. The experiment was repeated with a second light of a different intensity. The graph at the top right shows the results.
- a What is the aim of the experiment?
- b Which light was of higher intensity? Why?
- c Which variables were changed? Which would have been controlled?
- d What was measured in the experiment?
- e Draw the apparatus that might have been used.
- f Write a conclusion for the experiment.
- g Suggest why the slope of the light B graph decreases above 10°C.

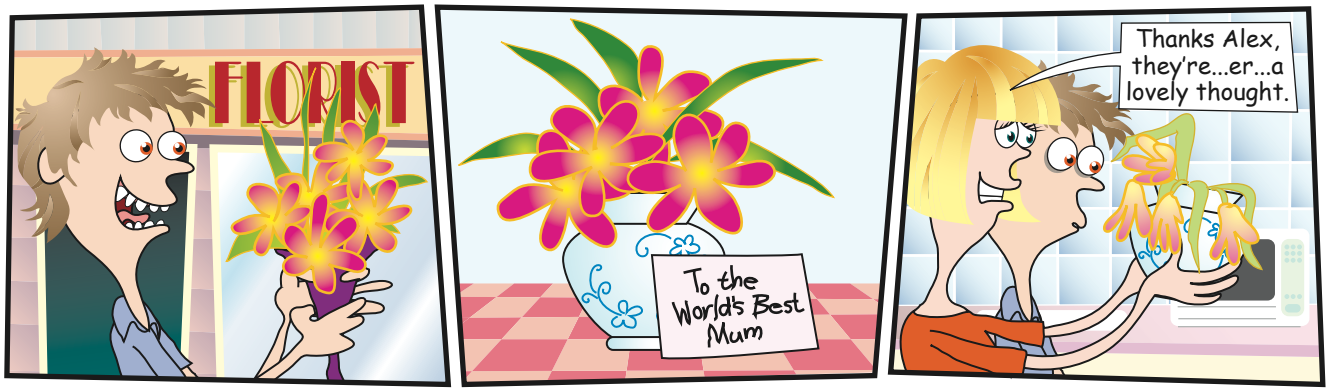


4 Three people agreed to take part in an experiment to test the amount of lactic acid in their blood after vigorous exercise. The three people exercised in the gym every day for 30 days. The table below shows their results.

Blood lactic acid (mg/100 mL of blood)			
Day	**Person A**	**Person B**	**Person C**
0	72	70	90
5	40	72	45
10	32	28	32
15	26	28	—
20	25	24	46
25	21	22	28
30	21	21	22

- a How does the training affect the amount of lactic acid in the blood?
- b Suggest two inferences to account for the lower lactic acid in the blood after regular vigorous training for 30 days.
- c Account for the results of person C.

6.3 How materials get into cells



Alex decided to buy his mother some flowers for helping him with his science project.

He placed them in a container on the kitchen table and wrote a note on a card.

When his mother came home from work many hours later the flowers had wilted.

Alex's flowers wilted because the cells in the plant lost water to the air. Instead of being tight and rigid, the cells became loose and floppy, like a fully inflated balloon that has lost some of its air. Water particles passed out of each cell, through the cell membrane and the cell wall. This movement of particles is called **diffusion**.

In Investigation 15 on page 141 you added iodine stain to your slide of spirogyra. After a few minutes the iodine had passed into the cell and the chloroplasts had become stained. The iodine had diffused into the cell from the outside.

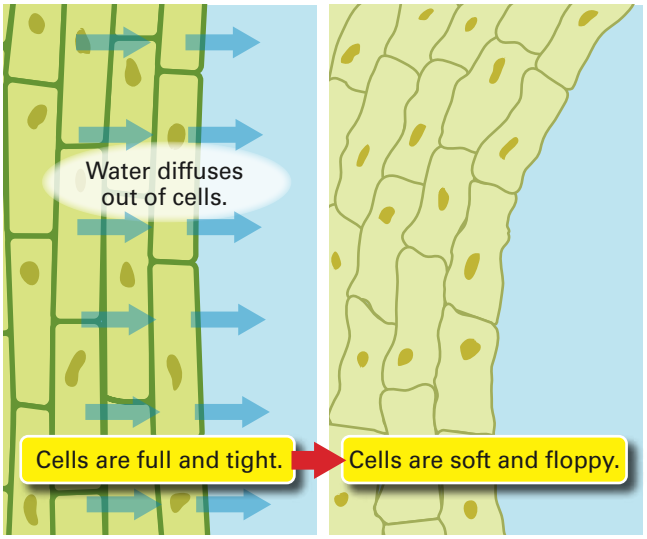


Fig 15 Water diffused out of the cells in the stem of Alex's flowers and they wilted.

Why did the iodine diffuse into the cell? Particles are constantly moving and bumping into other particles. In doing this they tend to move away from each other and spread out. The iodine particles moved from outside the cell where they were concentrated to inside the cell where they were less concentrated. Eventually the iodine particles spread evenly throughout the water inside and outside the cell.

Working with technology

To see how diffusion works, open the Diffusion animation at www.OneStopScience.com.au.

OneStopScience

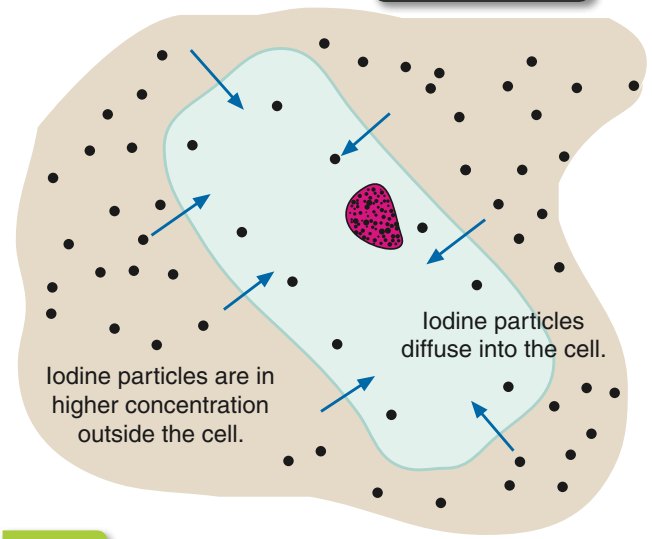


Fig 16 The iodine particles diffuse through the cell membrane and into the cell.

Experiment 6 A model for diffusion

Your task

To use a model to explain how various substances diffuse through membranes.

Your task is to use lengths of cellophane tubing to design an experiment to show that substances such as salt or sugar diffuse through membranes.

Planning and Safety Check

- Work in a group to discuss and design your tests. Draw up data tables where necessary.
- You will use silver nitrate solution to test for salt. Silver nitrate is toxic and it stains skin and clothes. Wash any spills immediately with plenty of water. Use disposable gloves and wash your hands thoroughly at the end of the lesson.
- Check with your teacher about how to dispose of the waste liquids.

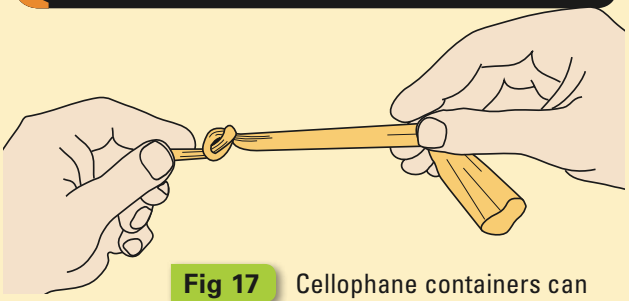


Fig 17 Cellophane containers can be made by tying a knot at one end of the tubing.

Helpful hints

1. The cellophane tubing can be made into a container to hold a solution as follows: Wet a piece of cellophane tubing with tap water. Tie a knot in one end. Rub the other end with your fingers until the tubing opens.
2. Try using a salt or sugar solution in the tubing and distilled water in the beaker. Then see if the salt or sugar diffuses into the beaker. (You could also try the reverse of this and see if salt or sugar diffuses into the tubing.)
3. You will need to leave your set-up overnight.
4. The presence of salt can be tested with a drop of dilute silver nitrate solution. Sugar can be tested with a Clinistix or Benedict's solution.
5. Make a list of the equipment you will need. Your teacher will need to supply you with:
   - 10% glucose solution or 20% sodium chloride solution
   - lengths of cellophane tubing (20 cm long)
   - 5% **silver nitrate** solution in a dropper bottle.

Writing your report

Write a report of your findings. How does this model explain how substances might move into and out of cells?

Diffusion in your body cells

Sugar or salt will diffuse across a membrane from a region of high concentration to a region of lower concentration.

This same process applies to the cells in your body. In your muscles, glucose and oxygen diffuse into the muscle cells from the capillaries that surround them. This is because the glucose and oxygen are constantly used up as the muscle cells contract. Hence the amounts of these two substances decrease in active muscle cells.

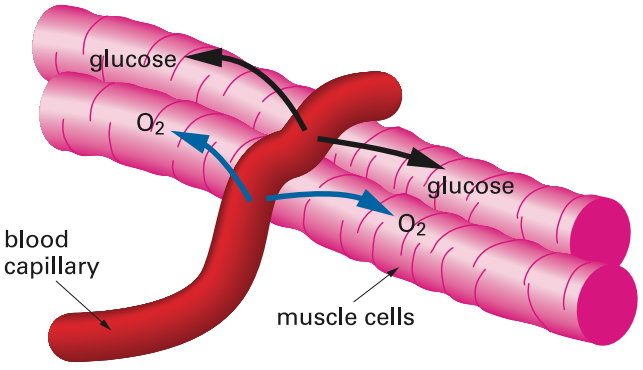


Fig 18 Glucose and oxygen diffuse into the cells from the blood because they are used up during respiration.

Glucose and oxygen diffuse into the muscle cells from the capillaries that surround them because the concentrations of glucose and oxygen are higher in the blood than in the cells.

Carbon dioxide is produced in respiring muscle cells as a waste product. In active muscles the concentration of CO_2 increases in the cells. Since the concentration of CO_2 becomes greater than in the blood, it diffuses out of the muscle cells and is carried away to be expelled by the lungs. Other wastes from cellular activities also build up in the cells and diffuse out into the blood.

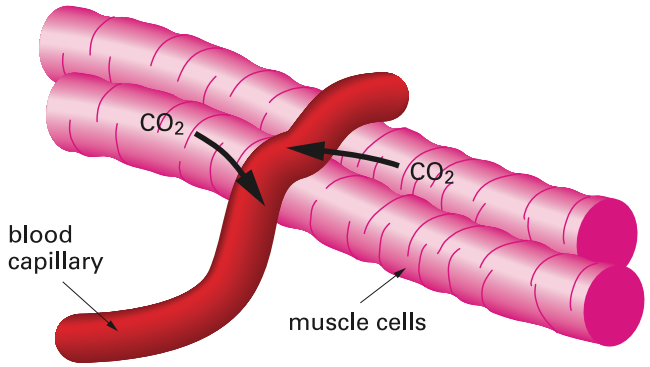


Fig 19 During respiration carbon dioxide builds up in the muscle cells and diffuses out into the blood.

Osmosis

If a potato cube is left in distilled water for about an hour, it becomes hard. If another potato cube is left in salt water, it becomes soft. These results are due to a special case of diffusion of water molecules through the cell membranes of the potato cells. This process is called **osmosis** (oss-MOW-sis).

Osmosis occurs in all cells because the cell membranes are *semi-permeable*. This means that the cell membrane allows water particles to move freely across it but slows down the movement of dissolved substances, for example salts and sugars.

The cells in the potato cube contain about 90% water. When the potato is placed in distilled water (100% water), water particles diffuse into the cell from where they are at a higher concentration to where they are at a lower concentration. This makes the potato firm and larger. This is why vegetables, such as carrots and celery, that are a little soft become firm and crisp when you put them in water.

When the potato is placed in the salt solution (only 80% water), the water diffuses out because the water is now at a higher concentration inside the cell. The cells become soft and smaller because there is a movement of water particles from inside the cell to the outside.

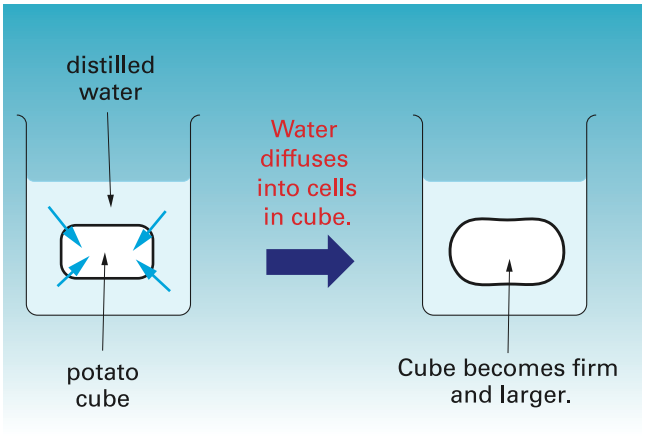


Fig 20 A potato cube becomes firm when placed in distilled water because water diffuses into the cells.

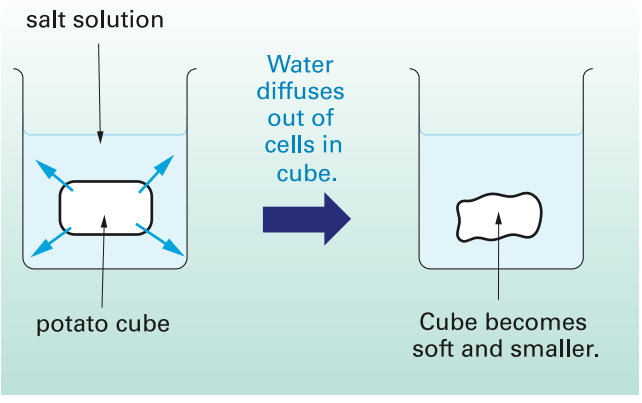


Fig 21 A potato cube becomes soft when placed in salt water because water diffuses out of the cells.

Investigation 16 Osmosis—the movement of water

Aim

To observe the effects of the movement of water into and out of cells.

Planning and Safety Check

- Carefully read through the two parts of this investigation so that you know what to do.
- Make a list of the safety precautions you will need to take.
- How will you dispose of the solids and liquids after you finish the investigation?

PART A

Materials

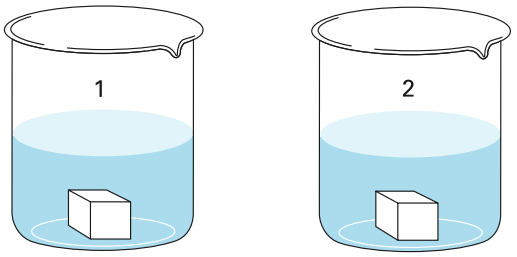
- fresh potato
- distilled water
- salt (sodium chloride) solution (20%)
- 2 small beakers or jars

Method

1 Peel the potato and cut two 2 cm cubes from it.

2 Place one cube in a beaker of distilled water and the other in a beaker of salt solution.

3 Leave the potato cubes in the liquids for at least an hour, or overnight. While you are waiting, go on with Part B.



4 Take the potato cubes out of the liquids.

How do they feel? Record your observations.

Discussion

1 Account for the texture and feel of the potato cubes in each beaker. Could you return the salt potato cube to its original condition? How?

2 Repeat the experiment but this time weigh the potato cubes before and after.

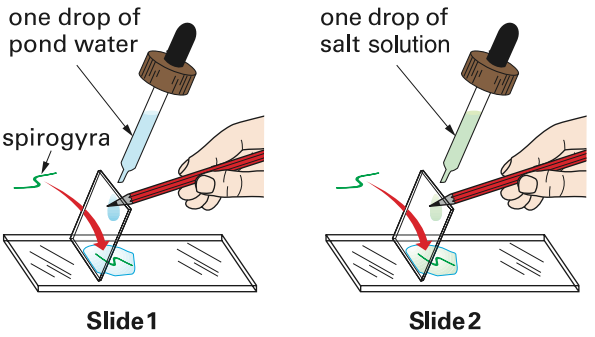
PART B

Materials

- microscope
- 2 slides and cover-slips
- spirogyra in pond water
- salt solution from Part A

Method

1 Use the diagrams below to prepare two slides of spirogyra to observe under the microscope.



2 Look at each slide under a microscope.

Draw the cells of spirogyra on each slide.

Discussion

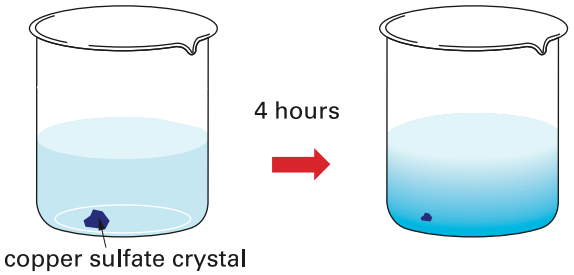
1 The movement of water through cell membanes is responsible for the results in Part A and Part B. Suggest why this is so.

2 Use your results to explain why wilted carrots or celery will become crisp again when you soak them in water.

3 How do the results explain why freshwater fish do not have to drink water?

Check

1 A small crystal of copper sulfate was placed in a beaker of distilled water. The beaker was observed 4 hours later. The diagrams show the results. In terms of particles, explain what happened in the beaker.



2 A piece of limp celery is placed in a glass of water. After 30 minutes the celery is firm and crisp. When this piece of celery is placed in sea water it becomes limp after 30 minutes. Explain what has happened in each case.

3 What is a semi-permeable membrane? Design a test to show that glucose will diffuse through cellophane tubing but starch will not. (Hint: Starch turns black when iodine solution is added to it, and Benedict's solution turns red when glucose is present.)

4 Explain why a cube of apple after being placed in distilled water for an hour is firmer than the original cube.

5 Some red blood cells were placed on a microscope slide and a drop of liquid was added. When the slide was observed under a microscope, the cells had shrivelled up. Was the liquid that was added to the blood cells distilled water or salt solution? Explain your answer.

Challenge

1 Starch solution was poured into two pieces of cellophane tubing which were each tied at one end. One piece of tubing was placed in a beaker of lukewarm distilled water. Saliva was added to the second tubing which was then placed in a second beaker of lukewarm distilled water.

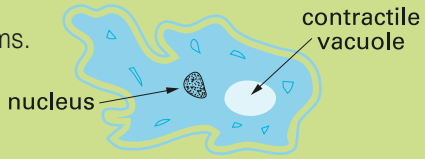
The set-ups were left for a few hours. Then the liquids in each beaker and piece of tubing were tested with iodine and Benedict's solution. (Note: Benedict's solution turns red when glucose is present in the solution.)

a What results would you expect in each of the set-ups? Explain your answer.

b What was the aim of the experiment?

c Why were the pieces of tubing placed in lukewarm water?

2 An amoeba is a protist that lives in still water such as lakes, ponds and dams.



It has a vacuole that is able to contract (contractile vacuole). Water that diffuses into the cell is expelled to the outside by this contractile vacuole.

The following data show the number of contractions of the vacuole when the amoeba was placed in different solutions.

Solution	No. of contractions per 10 minutes
distilled water	60
pond water	40
dilute sugar	10
solution A	none

a Explain why the number of contractions is less in the dilute sugar solution than in distilled water.

b Suggest why there are no contractions in solution A.

c Predict what would happen to the amoeba if it did not have a contractile vacuole.

MAIN IDEAS

Copy and complete these statements to make a summary of this chapter. The missing words are on the right.

1 All organisms are made of _____. There are many different types of cells, with different shapes and different functions.

2 A _____ can be used to identify the various parts of a cell: the nucleus, cell membrane, cytoplasm and organelles. A _____, chloroplasts and vacuoles can be observed in plant cells.

3 Cells of the same type are generally found together in _____. Each type of tissue has a particular _____ in an organism.

4 Tissues are arranged in structures called _____ in multicellular organisms. Each tissue has a specific function in an organ.

5 _____ uses glucose and oxygen and produces energy for cell functions such as cell division and _____.

6 _____ respiration occurs in cells that have a good supply of oxygen. Certain cells such as muscle cells can produce energy _____ (without oxygen).

7 In plants, _____ occurs in organelles called chloroplasts. The rate of photosynthesis depends on the _____ and its colour.

8 Substances move into and out of cells by the process of _____.

aerobic
anaerobically
cell
cell respiration
cell wall
diffusion
function
light intensity
microscope
organs
photosynthesis
proteins
tissues

Try doing the Chapter 6 crossword at www.OneStopScience.com.au.

OneStopScience

REVIEW

1 A cell is observed under a microscope to have a nucleus, cytoplasm and organelles. The cell is:
- **A** definitely an animal cell.
- **B** definitely a plant cell.
- **C** either a plant cell or an animal cell.

2 Which one of the following statements about cells is *false*?
- **A** Plant cells have large vacuoles.
- **B** A nerve cell is an example of a specialised cell.
- **C** All cells are rectangular or brick-shaped.
- **D** Plant cells have cell walls.

3 Match the cell part in the list with the correct description below.

cell membrane	cytoplasm	vacuoles
chloroplast	nucleus	cell wall

- **a** an organelle that is involved in the process of photosynthesis
- **b** the jelly-like material that fills a cell
- **c** the part of the cell that controls its activities and keeps it alive
- **d** a covering that controls the movement of materials into and out of a cell
- **e** a thick, tough layer that helps support and protect the cell
- **f** liquid-filled spaces found in some cells.

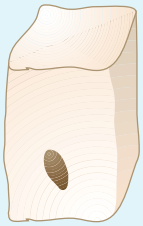
4 A microscope has a ×10 objective lens and a ×4 eyepiece lens. How big would an object 0.05 mm in diameter appear through the microscope?

5 Photosynthesis is a process that requires energy, while respiration is a process that produces energy.
- **a** Explain what this sentence means.
- **b** Why is respiration important for an organism like you?

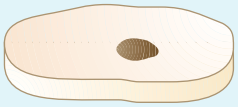
6 Explain how a unicellular organism is different from a multicellular organism.

7 Why is your stomach called an organ? Use the words *cells* and *tissues* in your answer.

8 The two cells in the drawing below are found in different tissues in your body. The cell from tissue A is box-like and makes a watery substance called mucus. The cell from tissue B is very flat. Infer the function of each tissue and where it might be found in your body.

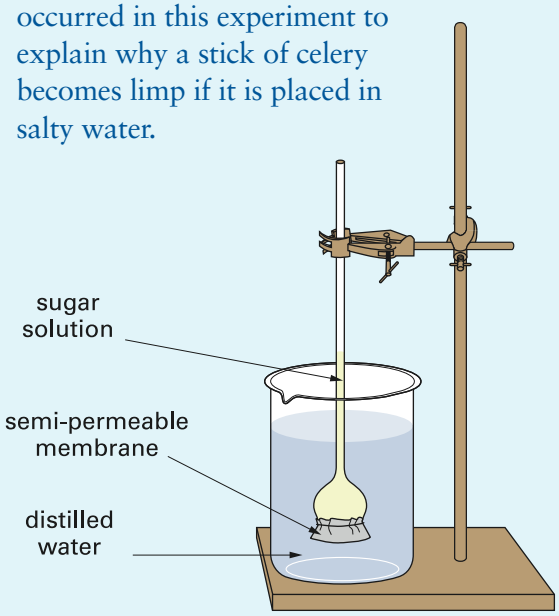


cell from tissue A



cell from tissue B

9 Sugar solution was poured into a thistle funnel and the top was covered with a semi-permeable membrane. The funnel was then turned upside down, placed into a beaker of distilled water and left for 2 hours. The diagram above right shows the set-up.
- **a** Why did the liquid rise in the funnel?
- **b** Predict what would have happened if the liquid in the funnel had been a more concentrated sugar solution.
- **c** Predict the results if the experiment was repeated with distilled water in the funnel and sugar solution in the beaker.
- **d** Use your knowledge of the process that occurred in this experiment to explain why a stick of celery becomes limp if it is placed in salty water.



LAB REVIEW

Microscope licence test

You will be working in pairs and assessing each other's work in this practical test of microscope skills.

You will be given—a microscope, microscope slide and cover-slip and a small piece of newspaper which contains a few letters. Your teacher will also give you an assessment grid to help you assess your partner's task.

Your task—to make a wet-mount slide of some letters on a small piece of newspaper without any air bubbles or excess water, and then draw it under the microscope.

The test—your teacher and the class will discuss what you have to do to pass the licence test. Your partner will then assess the quality of your wet-mount slide and drawing and record your results on the assessment grid. Remember, you can only pass or fail this test. If you fail you must repeat the test until you pass.

Your teacher may issue you with a microscope operator's licence when you pass the test.

Check your answers on page 280.

Science as a Human Endeavour

Stem cell research

Christopher Reeve, the star of the film *Superman* (1978), was paralysed when he fell from a horse in 1995. He was confined to a wheelchair, and until his death in 2004 he lobbied politicians to approve stem cell research to find a cure for people with spinal cord injuries. But what are **stem cells**?

Stem cells are unspecialised cells that can develop into any one of over 200 different types of cells in the body. They can also divide and make accurate copies of themselves (see page 78). Scientists see the possibility of using these stem cells to treat some diseases and to replace damaged tissue.

Where do scientists get stem cells? They can be found in bone marrow, but unfortunately these stem cells have already started to become the cells they will replace. However, stem cells in human embryos (3–5 days old) have not yet started to develop, so they are much better to use. So far scientists have used donated embryos remaining after IVF procedures. However, the problem is whether it is *ethically* correct to use these human embryos.

Imagine if scientists could produce …	If they could do this they could treat …
nerve cells	spinal cord injuries and Parkinson's disease
heart muscle cells	damage caused by heart attacks
insulin-producing cells	diabetes
skin cells	burns and ulcers
retina cells	some kinds of blindness

With any scientific development there will always be people who are for it and people against it. Religious groups and right-to-life groups are against the use of embryonic stem cells because they believe that even though they are unborn, the embryos have the right to life. There is also a fear that the use of stem cells could lead to humans being grown in the laboratory. On the positive side, the potential medical benefits of stem cell research are enormous, as listed in the table above.

As Christopher Reeve once asked, 'Is it more ethical for a woman to donate unused embryos that will never become human beings, or to let them be tossed away as garbage when they could help save thousands of lives?'

Corner discussion

1. Your teacher will put the following signs in the four corners of the room: 'agree', 'disagree', 'unsure but I think I agree' and 'unsure but I think I disagree'.
2. *Do you think leftover human embryos should be used for stem cell research?* Move to the corner that applies to you.
3. People in each corner now try to convince the people in the two unsure corners to join them. Everyone should be given a chance to contribute to the discussion.