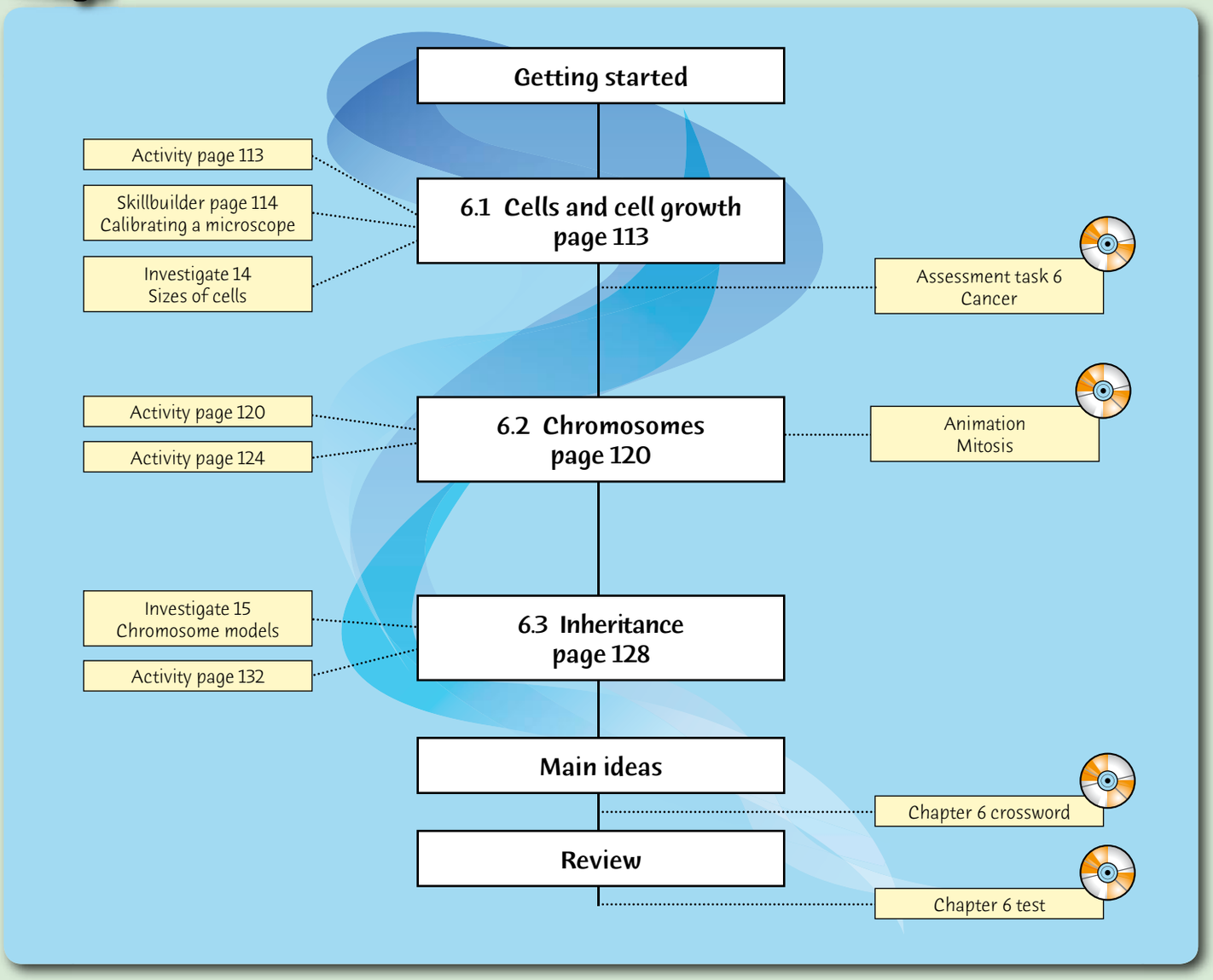
6 Life goes on

Planning page



Essential Learnings for Chapter 6

Essential Learnings	References		
	Student book (page number)	Workbook (page number)	Teacher Edition CD (Assessment task)
Knowledge and understanding ***Life and living*** All the information required for life is a result of genetic information being passed from parent to offspring	pp. 120–134	pp. 46–47	Assessment task 6 Cancer
Complex organisms depend on interacting body systems to meet their needs internally and with respect to their environment	pp. 113–118	p. 36	Assessment task 6 Cancer
Ways of working Select and use scientific equipment and technologies to enhance the reliability and accuracy of data collected in investigations	Skillbuilder p. 114 Investigate 14 pp. 114–115		
Research and analyse data, information and evidence	Activity p. 120 Science bits p. 129		
Reflect on learning, apply new understandings and justify future applications	Science in action p. 116		

QSA Science Essential Learnings by the end of Year 9

Vocabulary

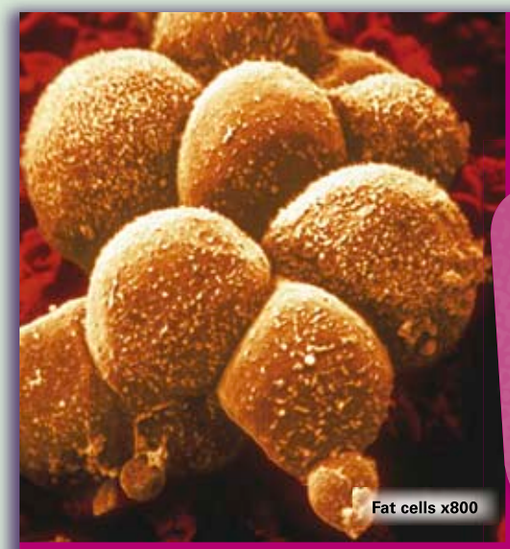
benign
carcinogens
characteristics
chloroplasts
chromosomes
cytoplasm
deoxyribonucleic acid
dominant
fertilisation
genetics
inheritance
leukaemia
malignant
melanoma
mitosis
organelles
ovum/ova
pedigree
phosphates
recessive
testis/testes
tumour
vacuole

Focus for learning

Check their knowledge of cells, inheritance and DNA testing (p 112).

Equipment and chemicals (per group)

Skillbuilder page 114	microscope, clear plastic ruler
Investigate 14 pages 114–115	microscope, 3 microscope slides and cover-slips, onion 'skin' (class use), toothpick, spirogyra or other filamentous algae, methylene blue stain, prepared slides of various cells
Activity page 120	microscope, prepared slide showing cell division (eg onion root cells)
Activity page 124	ruler, 16 different-coloured plastic pegs (eg 4 blue, 4 yellow, 4 red, 4 green)
Investigate 15 page 130	6 plastic-covered coloured paperclips or coloured pipe cleaners (3 of one colour and 3 of another colour), wire cutter or pliers (class use), 2 sheets of plain A4 paper



6 Life goes on

Getting Started

In a small group, decide on answers for each of the questions below. This should give you some idea of how much you already know about cells and inheritance.

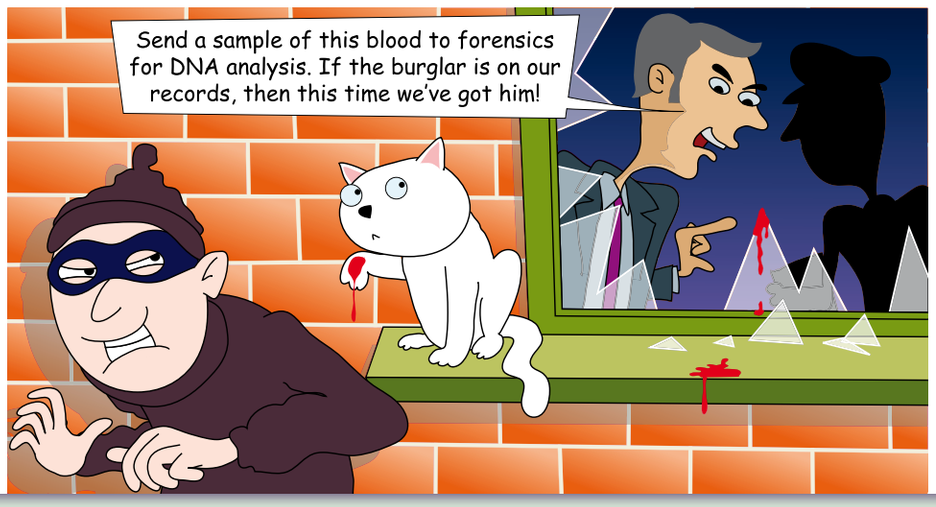
1 Which parts of a cell can you observe with a microscope?

2 Certain cells in the body divide to make new cells for growth and replacement of dead cells. In which areas of your body would you find dividing cells?

3 Many human characteristics are inherited. How are the inherited characteristics passed from one generation to the next?

4 In the Wilson family, the mother has brown eyes, the father has blue eyes and all the four children have brown eyes. Suggest an inference to explain this.

5 You are watching a TV crime program in which police scientists ask for a DNA analysis of a trace of blood to try to convict a suspect burglar. What is DNA? And how can an arrest be made using DNA?



Starting point

1 Show a snippet of a TV crime show to set the scene for Getting Started point 5 and discuss as a class. Make sure the segment is not offensive or too gory.

2 Before starting this chapter, it is a good idea to check school records to see if any student in the class is adopted, fostered or experiencing a family trauma. Be aware and sensitive to their feelings and needs. If students are aware of their fellow student's circumstances, encourage acceptance and sensitivity.

3 Ask the students to write their name at the top centre of a piece of paper. On the left-hand side, write 'Features I have the same as Mum' and on the right-hand side, 'Features I have the same as Dad'. Also get them to list features/characteristics that they have from *both* parents. This chart can be used later to discuss inheritance (starting on page 132).

4 Compile a list of words relating to this chapter with the students, and develop a concept map. Choose whether they will draw symbols or pictures, or write linking sentences. A possible word list is: *microscope*, *energy*, *growth*, *repair*, *blood*, *sperm*, *ovum*, *cell*, *chromosome*, *mitosis*, *gene*, *DNA*, *inheritance*, *pedigree*.

This task may be quite difficult at this stage as they may have little or no prior knowledge, so add some words from the previous chapter. They may like to use the glossary in the textbook to help them with their linking sentences. It will be useful for you to see how many students can make correct links. This activity could form the basis of a pre-test.

5 Alternatively, students could start their own glossary and add to it progressively through the chapter. The glossary may be in the form of a table with four column headings for the word, a picture (if appropriate), its meaning and an example of how the word is used.

6.1 Cells and cell growth

You can see in the diagrams below that cells come in a variety of shapes and sizes. In humans, the largest body cells have a diameter of about 0.1 mm and the smallest have a diameter of only 0.008 mm.

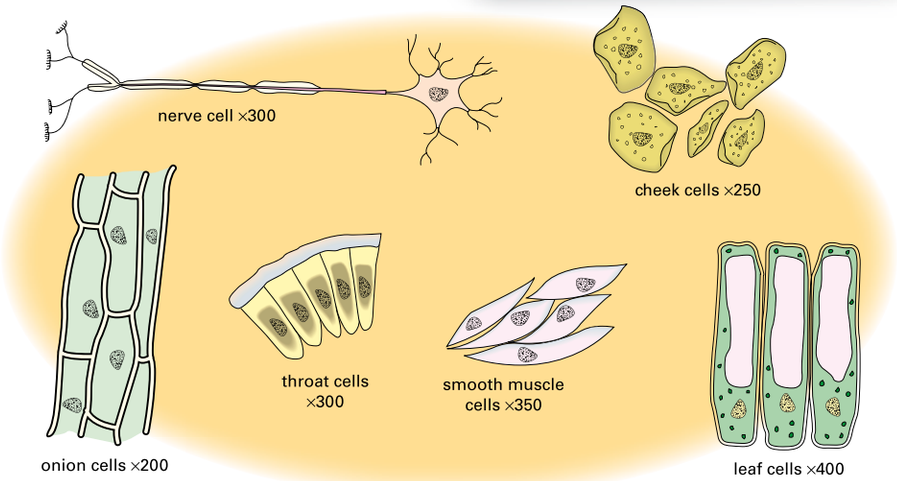
Measuring cells

Because cells are so small, a convenient unit to measure them is a micrometre.

(1 micrometre = 10^{-6} m or 10^{-3} mm).

The abbreviation for micrometre is µm.

A cell 50 micrometres long is 0.00005 m or 0.05 mm.



Activity

You have probably studied cells before. In this activity you can recall your knowledge of cells or revise what you are unsure of.

Work in groups of three or four to discuss the answers to each of the following questions. Your teacher will organise a class discussion to check your answers.

- All of the cells in the diagrams above have a nucleus. What is the function of the nucleus?
- Would you expect all cells to have a nucleus? Why?
- Which of the cells are plant cells? How are they different from animal cells?
- Most plant cells have a vacuole. What is its function?
- What are the approximate dimensions, in micrometres, of an onion cell? What are the approximate dimensions of a cheek cell?
- Copy a leaf cell in your notebook. Label the drawing with the following: cell membrane, cell wall, nucleus, chloroplasts, cytoplasm, vacuole.

Hints and tips

The students may need a refresher lesson on cells (refer to *ScienceWorld 1* Chapter 9).

Activity notes

- The nucleus contains the chromosomes.
- The vacuole provides storage space for nutrients and waste.
- Animal cells do not have cell walls or chloroplasts.
- Animal cells have many mitochondria, while plant cells have few.
- All cells have a cell membrane, cytoplasm, vacuole, nucleus and mitochondria.
- Refer to page 115 for details of a plant cell.

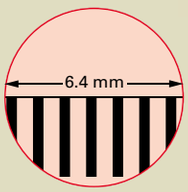
Learning experience

Revise plant and animal cells:

- Give the students a worksheet on labelling the basic parts of an animal cell.
- Provide a word list and the function of each part to assist them, and ask them to colour the diagrams in.

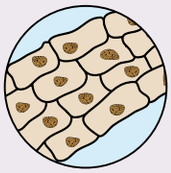
Calibrating a microscope

In the next investigation you are going to use



Method

1 Do you remember how to make a wet-mount slide? In your notebook, list the steps in preparing a slide of stained onion cells. Then show your teacher for approval before you start.



x4, x10 lenses—cells in field of view too small

2 Place your slide under the microscope. Using the lowest power, focus on the cells. Now use higher power so that the onion cells are as large as possible.

x10, x10 lenses—individual cells clearly seen

Use the microscope data from the Skillbuilder to estimate the length and width of one onion cell. Are all onion cells about the same size?

3 Place a couple of strands of spirogyra on a slide and add a drop of methylene blue stain. Place a cover-slip on top. Find the dimensions of a single cell of this alga. Are all the cells about the same size?

Record your data in the table.

4 Your teacher may also have some prepared slides of other types of cells, for example human cheek cells. For each one, estimate the dimensions of a cell.

Record your data in the table.

Discussion

1 In the Skillbuilder you calibrated a microscope. Explain what the word *calibrate* means.

2 Why is it best to use the same microscope in this investigation as you used in the Skillbuilder?

3 What does the term *field of view* mean? Describe in your own words what happens to the field of view of a microscope when the power of the lenses increases.

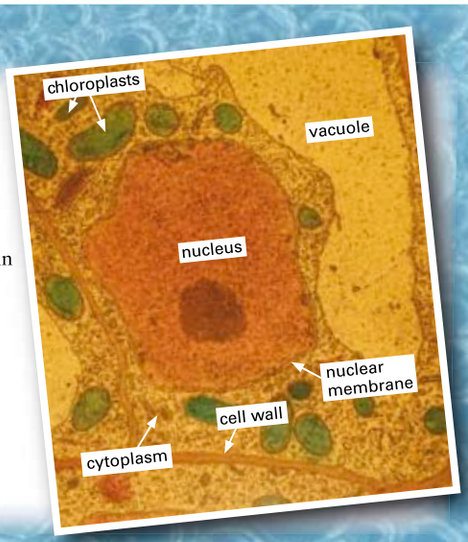
4 For a particular type of cell, are the cells about the same size? Suggest a reason for this. What would determine the size (and shape) of a cell?

science bits

The fine structure of cells

An electron microscope allows you to see the fine structure of cells that is not visible with an ordinary microscope. The plant cell in the photo has been magnified about 4000 times. In this photo you can see in the cytoplasm small structures called *organelles*, which are not visible with an ordinary microscope. Each of these organelles has a special duty in the life of the cell. For example, some organelles make enzymes which destroy foreign or unwanted substances in the cell.

The photo also shows the nucleus very clearly. The nuclear membrane has holes or pores in it which allow substances to move into and out of the nucleus. Use a ruler to estimate the size of the nucleus in this cell.



Hints and tips

If the students have not done the Activity on page 113, they could carefully trace the photo of the cell into their notebooks. Ask them to copy only the main parts (minimal detail) of the cell and then correctly label it. Discuss what they think the function of each part of the cell is.

Lab notes

Students usually need help to draw good diagrams of cells. In general, they should:

- use a sharp pencil
- avoid shading
- draw only a few cells of each type
- clearly label the structures seen
- add a title and the magnification (and, if possible, a scale).

Cell division

All multicellular organisms rely on cell division for growth. For example, in flowering plants cell division in the tips of the stems and roots makes those parts grow larger and longer.

Cell division also occurs when worn out or dead cells, for example dead skin cells, are replaced in your body. Those cells are replaced by new cells produced by cell division at the bottom of the epidermis. The replacement of cells also occurs in the lining of the intestines, the liver and even in bones.

Single-celled organisms such as protists and bacteria also reproduce by cell division.

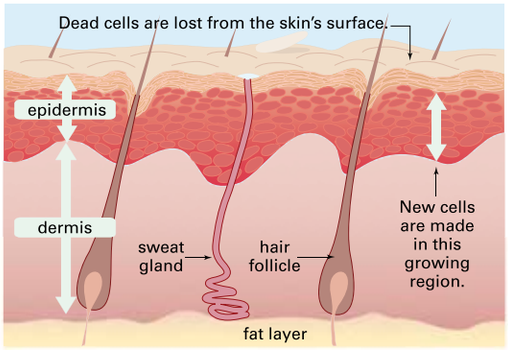


Fig 7 Cell division occurs at the bottom of the epidermis to replace the dead cells lost from the surface of the skin.

Science in action

Spray-on skin

Fiona Wood is Head of Royal Perth Hospital's Burns Unit and has been researching ways to help people with serious burns for many years. Dr Wood found that scarring is greatly reduced if replacement skin is applied to the wound within 10 days.

People with burns to less than 30% of their body can have skin taken from another part of their body and placed over the burned skin. This is called a *skin graft*. However, for widespread burns the patient may not have enough skin available for skin grafts.

Scientists have previously grown skin cells in the laboratory. This process takes many weeks to produce enough skin cells to place over the burn. Dr Wood wanted to drastically reduce the growing time so that she could treat patients within 10 days of them receiving the burn.

Dr Wood discovered a way to take skin cells from a patient and grow them in a special culture. The skin cells multiply and within 5 days enough skin cells have been produced. The harvested skin cells are then placed in a solution and sprayed on to the burn.

Dr Wood's technique was used to treat many of the burns victims of the 2002 Bali bombing. She was awarded an Order of Australia in 2003 and chosen as Australian of the Year in 2005.

WEBwatch

Go to www.scienceworld.net.au and follow the links to the following website.

Burns

This site has interesting information on burns and how they heal, as well as skin grafts and scarring.

Use the website to answer these questions.

1 What are the differences between full thickness, partial thickness and superficial burns?
2 What type of first aid do you use with a burns victim?
3 What are skin grafts? Write a brief report on the procedure.

Use the internet to find out more about Fiona Wood and her spray-on skin treatment for burns. Type *Fiona Wood* or *cellspray* into your internet browser.

Fig 8 A burn has destroyed the dermis and epidermis on this person's leg.

Hints and tips

- Explain what is meant by *multicellular organisms* and ask the class to list some.
- Check out the biology department to see if they have a model of the skin and pass it around the class. If it is a model which can be pulled apart, tactile learners may like to 'dissect' it and then put it back together.
- Ask the school nurse to give a short presentation on first aid for burns. Find out if anyone in the class has ever had a skin burn and what degree of burn it was.

Homework

The Science in action and Webwatch activities are good homework activities. When the students do their own research, make sure to tell them to include an internet bibliography. To do this they should list: author name/s (if appropriate), title of site or web page, URL of site, date last updated.

Learning experience

The students could design a poster about the first aid procedure for burns. The posters could be displayed around the various science laboratories, food technology rooms and school canteen.

Learning experience

A rather fun and challenging activity is to ask the students to compile an A to Z alphabet of words relating to this chapter. You may like to get them started and use the following: *A is for amino acids, B is for bases, C is for chromosomes, D is for DNA … Z is for zygote*, etc. ESL students or students with language difficulties may need extra assistance. Encourage ESL students to write the words in their native language next to the English version. The students could build up their alphabet by adding to it progressively.

Cancer—uncontrolled cell division

Cell division is usually an orderly process which occurs in growth regions of the body, such as bones, or in regions such as the skin that specialise in cell replacement. However, in cancer this orderly process goes wrong. Cancer occurs when certain cells divide rapidly and uncontrollably. The cancer cells look different from the normal cells in the area and they do not function like normal cells. For example, in liver cancer, cancer cells grow rapidly and replace normal liver cells. Gradually the liver loses its function and death usually occurs.

Cancer terms

Tumour—a mass of cells formed from uncontrolled division of cells.
Benign (be-NINE) **tumour**—a usually harmless, slow-growing mass of cells contained in the tissue where they formed.
Malignant tumour—formed from cells which divide rapidly. The tumour eventually stops the function of the organ or tissue in which it is growing. The cells in malignant tumours often spread to other organs.
Leukaemia—cancer of the blood (white blood cells).
Melanoma (benign)—a harmless brownish-red raised spot on the skin (often called a mole), common in children and adults.
Malignant melanoma—a tumour of the pigment-containing cells of the skin (shown in the photo below). This is a fairly uncommon but very serious skin cancer which can spread quickly throughout the body.

How cancer forms

Cancer is not a single disease. It can affect different cells in different tissues or organs of the body. But in all cancers you will only notice the effects when a growth or swelling caused by the uncontrolled cell division interferes with the normal working of the tissue or organ. For example, in lung cancer the cells form a growth that causes a persistent cough, the spitting up of blood and shortness of breath. The cancerous growth usually starts in the cells in the walls of the bronchioles. These tubes carry air to and from the lungs. The growth spreads throughout the lungs and eventually stops them functioning.

Even though skin cancer is the most common cancer, lung cancer is the biggest killer. It is responsible for about 5% of all deaths from disease in Australia. It is also a type of cancer that is very hard to cure, mainly because the growths become well established throughout the lungs before they are detected. Most people diagnosed with lung cancer have a very small chance of full recovery.

Lung cancer is caused by cancer-forming chemicals called *carcinogens* (CAR-sin-oh-gens) in cigarette smoke and polluted air.

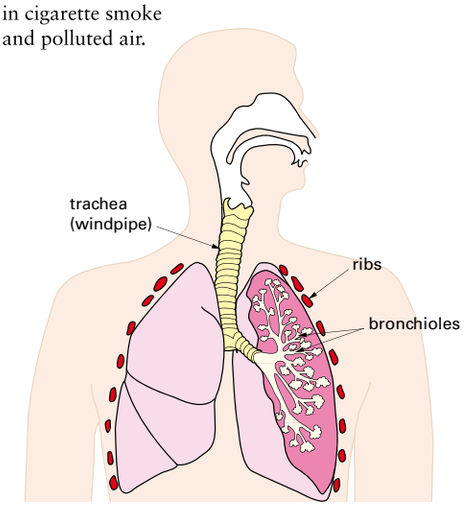


Fig 10 Bronchioles are small air tubes in the lungs. Lung cancer usually occurs in the bronchioles.

Hints and tips

- Be sensitive towards any student who may be suffering from cancer, or who has a family member affected by cancer. Show understanding and be mindful that students in this situation may not know how they will react when this section is discussed.
- Human skin is pigmented with *melanin*. A large number of genes are involved in controlling skin colour and this is why there is so much variation. The difference in colour isn't due to the number of melanocytes present in the lower epidermis but instead to the activity of the melanocytes, and differences in the number and type of melanin granules. Both forms of melanin are present in the skin but occur in varying proportions. Dark-skinned African people have larger melanosomes, more eumelanin granules and more melanin in the outer skin. Light-skinned people have smaller melanosomes, more phaeomelanin granules and less melanin. Large amounts of melanin in the outer skin protect the underlying tissues from harmful UV radiation. The melanin effectively absorbs UV radiation, preventing it from penetrating further to the melanocytes of the lower epidermis and the connective tissue. Melanin also provides protection through its chemical properties. You may like to explore this further, relating it to the chapters on chemistry.

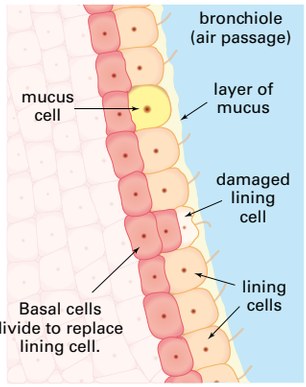
Learning experience

If your school does not have a sun-smart policy, get the students to initiate a campaign to inform students why protective measures should be taken, especially in summer. If your school does have a sun-smart policy, discuss its merits and encourage students to follow it. Colour-changing UV-sensitive beads can be purchased (eg from the CSIRO online shop). These could be given to the students to sew onto their hats, allowing them to see that even on cloudy days the sun's UV rays are present.

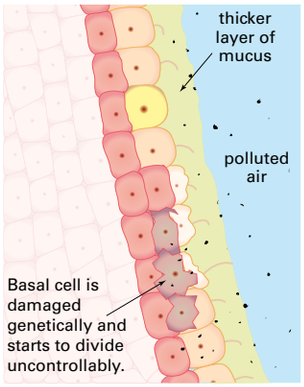
Learning experience

Students could prepare a project on skin cancer in the form of posters to be placed around the school, information booklets or multimedia presentations. Their information could include:

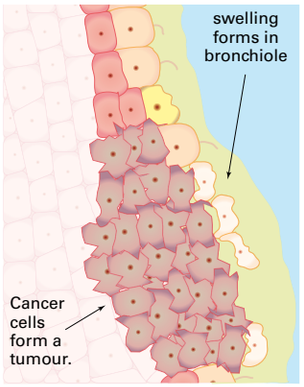
- why it is important to protect yourself from the sun
- what sun damage to the skin is
- what may happen if you are exposed to prolonged damage
- types of skin cancer
- who is at risk
- what the school is doing/could do.



In a healthy bronchiole, the basal cells divide from time to time to replace cells that have become damaged and are no longer of use to the body.



The pollutants cause genetic damage to a basal cell. This cell divides rapidly to produce other abnormal cells. When this happens these cells are called cancer cells.



The cancer cells divide in an uncontrolled way. A cancerous growth forms, causing a swelling. This is called a tumour. Cancerous cells may also pass into the blood.

Nine out of ten people to die in Australia this year from lung cancer will be smokers. The carcinogens in the cigarette smoke and polluted air irritate the cells in the walls of the bronchioles, and can sometimes do genetic damage to the cells. This may cause the cells to start dividing uncontrollably. For non-smokers, more deaths occur in people who live in cities than those who live in the country.

Lung cancer is especially dangerous because the cancerous cells can spread to other parts of the body. The lung tissue contains a lot of blood vessels, and if cancerous cells get into the blood they can be carried to other tissues or organs such as the liver, brain or stomach where they can form further cancers.

Cancer prevention

Many cancers can be treated. For example, in the case of childhood leukaemia, more than 70% of children are completely cured. Treatment with chemicals (chemotherapy) and radiation (radiotherapy) can kill cancer cells, and tumours can be surgically removed. However, it is very difficult to remove all cancer cells, and if the body's defence system is unable to kill these cancer cells, they could start multiplying again.

Many cancers can be prevented. The various forms of skin cancers, which will affect more than half of all Australians, can be prevented by reducing sun exposure, particularly in the middle of the day. Most cases of lung, throat and bladder cancer can be linked directly to smoking or polluted air. In 2005, nearly 50 people a day died from tobacco-related diseases, and most of these deaths could have been prevented.

The following websites have interesting information about cancers and their prevention.

WEBwatch

Go to www.scienceworld.net.au and follow the links to the following websites.

Information about cancer

The website of the Cancer Council of Australia has information about causes and prevention of cancers, facts and figures and cancer questions and answers.

Students' information

The Cancer Council of Victoria website has information about all types of cancer and their prevention.

Hints and tips

You may like to get enthusiastic students to organise an 'Anti-Cancer Day' (eg getting involved in the Cancer Council's Daffodil Day or fundraising for CanTeen).

Assessment task

This would be a good place to set *Assessment task 6: Cancer*, found on the CD.

Research

- Ask the students to surf the internet and compile a Word document on cancer. They should organise their information so it displays the type of cancer, symptoms, treatment and prevention.
- Using this information, they could then write a doctor and patient role play. Make sure you remind the students to include a bibliography.
- Alternatively, the students could write an article for the school newsletter. In the article they could outline the importance of cancer prevention and list where further information can be obtained, including web addresses.

Challenge solutions

1 a A higher magnification means that Theo will see less of the specimen but in more detail. The field of view in this case will be 2.2 mm.

b The field of view will be only one tenth of that at ×40 magnification. This means it will be 0.55 mm or 550 µm. Each cell is about one third as long as the field of view, or about 180 µm, and about half as wide as they are long, which is about 90 µm.

2 The main cause of skin cancer is damage to the skin cells caused by ultraviolet rays from the Sun. Most of these harmful rays are usually absorbed by a gas—ozone in the upper atmosphere. However the amount of ozone has recently been reduced, particularly above Australia, and this explains why skin cancer is so common in Australia.

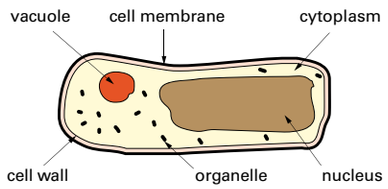
3 a The number of deaths due to lung, skin and stomach/colon cancers in 2001 was 12 756.

b There were a total of 6938 people who died from lung cancer in 2001. This is 6938/36241 × 100 = 19.1% of all people who died from cancer in 2001.

c Lung cancer deaths are so high because of the chemicals in the air people breathe, in particular cigarette smoke.

Check!

1 Tony observed leaf cells under a microscope. He then sketched and labelled one cell. Some of his labels are incorrect. Draw the cell in your notebook and label it correctly.



2 What is the power of a microscope with the following lens combinations?
- **a** ×5 eyepiece and ×5 objective
- **b** ×5 eyepiece and ×10 objective
- **c** ×10 eyepiece and ×40 objective

3 A microscope has a ×10 eyepiece lens and three objective lenses: ×4, ×10 and ×40. What range of magnifications can you obtain with this microscope?

4 A plant cell was found to be 0.12 mm long and 0.05 mm wide. What is the size of the cell in micrometres?

5 Many years ago the cytoplasm in a cell was thought to be a clear jelly-like substance. We now know that it is a complex structure containing many organelles. Why has our knowledge of cells changed?

6 What is the difference between a benign and a malignant tumour?

7 Suggest why the incidence of lung cancer is lower in people who live in the country than in people who live in cities.

8 In which parts of your body would cell division be occurring at this moment? Would cell division be occurring in an 80-year-old person? Explain.

9 Why are most cancers such as lung and stomach cancer detected more often in older people than in young people?

challenge

1 Sam and Theo used a ×10 eyepiece and a ×4 objective lens and found the field of view of their microscope was 5.5 mm.
- **a** Calculate the field of view when a ×10 eyepiece and a ×10 objective are used.
- **b** The diagram shows what Theo observed when he viewed some cells with a ×10 eyepiece and ×40 objective. How long and wide are these cells?

2 Australia has one of the highest incidence rates of skin cancer in the world. In 2004 over 380 000 cases were treated. Suggest why skin cancer is such a common disease in Australia.

3 The table on the right shows the deaths due to various cancers in Australia in 2001.

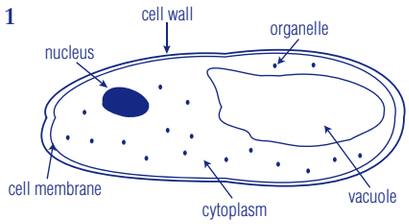
Type of cancer	Male	Females
lung	4 798	2 140
skin	605	345
stomach/colon	2 631	2 237
all cancers	20 408	15 833

- **a** How many people died from lung, skin and stomach/colon cancers in 2001?
- **b** Of all the people who died from cancer in 2001, what percentage died from lung cancer?
- **c** Suggest why lung cancer deaths are so high.
- **d** Suggest why the number of deaths due to lung cancer is much greater in males than in females.
- **e** What is passive smoking? Why is it so dangerous?

4 Suppose you are the state Health Minister and you are concerned about the death rate due to skin cancer. Work in a small group to design a way to inform people about skin cancer prevention.

Check! solutions

1



2 The powers of magnification are:
- **a** ×25
- **b** ×50
- **c** ×400

3 The range of magnification is from ×40 to ×400.

4 There are 1000 microns (or micrometres) in 1 millimetre. This plant cell is 120 µm long and 50 µm wide.

5 Our knowledge of cells has changed because in recent times scientists have used electron microscopes to see detailed structures in the cytoplasm. More recently they have also used laser microscopes and other new technologies.

6 A benign tumour is a growth of cells that is usually harmless and does not move to other parts of the body. In contrast, a malignant tumour is a mass of cells formed by the uncontrolled division of cells. These cells may break off and move to other parts of the body to begin new tumours. Malignant tumours interfere with the function of body organs and can cause serious illness and death.

7 The most likely factor which could cause a higher incidence of lung cancer in the cities is the higher level of pollution in the air. The chemicals and particles in polluted air can irritate the tissues, particularly in the lungs, and cause some cells to divide in an uncontrolled way.

8 Cell division occurs in all body tissues but at different rates. The bone marrow and tissues such as the lining of the gut and skin are regions of rapid division. Cell division continues even in older people because even though there is not any growth there is a constant repair of cells and tissues in the body.

9 The reason is that older people have eaten more food and breathed more air than younger people. This means that their intestines and lungs have been exposed to more chemicals and their cells are likely to have been damaged more and are more likely to develop cancer than in a younger person. Ageing itself causes damage to cells which can lead to cancer.

d The most likely suggestion is that more males than females smoke cigarettes. Another possibility is that more males work in situations where the air is polluted with smoke and other chemicals.

e Passive smoking occurs when a person breathes in smoke that comes from another person's cigarette or has been breathed out by another person. Passive smoking is dangerous because the smoke still contains some of the chemicals which can cause lung cancers.

4 People learn about taking care of their health in various ways and this includes methods of skin care when people are in the sun. Some methods of communication that are usually effective are:
- an information pack that can be used by teachers and classes in schools
- posters in such places as chemist shops and doctors' surgeries
- a TV advertisement
- sponsorship and/or signs at outdoor sporting events.

Hints and tips

- Students often confuse chromosomes and genes, so be clear with your explanations of each. Reinforce that chromosomes are not just part of the human body but anything living, including plants.
- Chromosomes carry the genetic code for an organism. This genetic code determines the organism's features and characteristics. The chromosomes are the blueprint used to make new cells. Generate a class discussion about why chromosomes are necessary for all living things. Why do cells need to reproduce/divide? Do all cells reproduce? Why or why not? From the discussion, set some inquiry-based learning questions with the focus on cell division.

Activity notes

Prepared slides can be obtained from the following suppliers:

- Kambio Biological Preparations
  Ph: (07) 4939 4756 Email: <kambio@cqnet.com.au>
- Southern Biological
  Ph: (03) 9877 4597 Web: <www.southernbiological.com>
- Haines Educational
  Ph: (03) 9568 6966
  Web: <www.haines.com.au>

Homework

Ask students to investigate whether other animals have 46 chromosomes in their cells. Are all chromosomes paired? You could suggest they write their answers as a series of dot points. (For example, koalas have 16 chromosomes and dogs have 78. Plant cells have the fewest number and peas have only 14.)

6.2 Chromosomes

Cell division

The photo below shows some plant cells. The nuclei have been stained blue so that you can see them easily. The cell in the middle of the photo is in the process of dividing. In this cell sausage-shaped objects have become visible in the nucleus. These objects are called **chromosomes** (KROME-oh-somes).

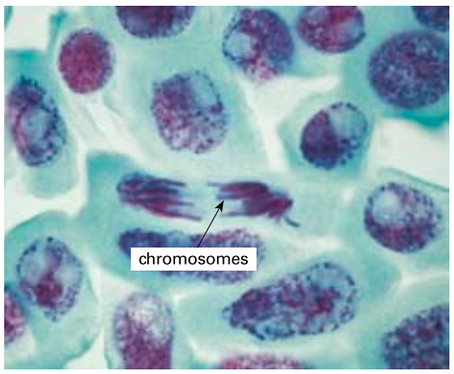


Fig 14 A dividing plant cell showing chromosomes

Chromosomes carry the genetic code for an organism. It is this genetic code which determines the features and characteristics of your body. In humans 46 chromosomes carry the genetic code for all the human characteristics: for example, the colour of your eyes, hair and skin, the general shape of your body and the way your organs and systems operate.

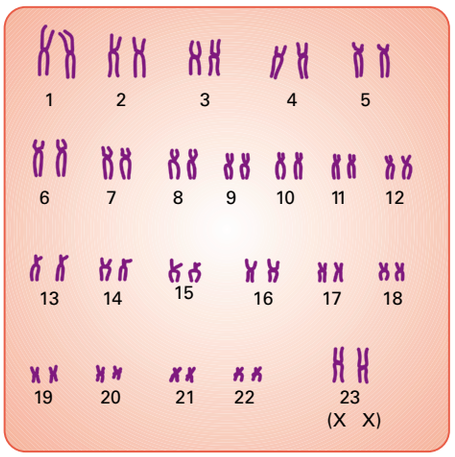


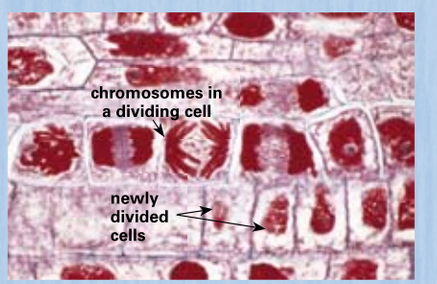
Fig 15 The 46 chromosomes in a human female are arranged in pairs based on size. The pair numbered 23 are the sex-determining chromosomes.

Activity

For this activity you will need a microscope, a prepared slide of onion root cells dividing, and slides of other cells showing cell division. Set up a microscope and observe the cells in the slide of the growing tip of an onion root.

Use the photo to identify the cells undergoing cell division. Draw and label the cell wall, cytoplasm and chromosomes in one of these cells.

Estimate the proportion of the cells in the photo that are in some stage of division.



Learning experience

If the students are writing an alphabet for this chapter (see Learning experience on page 116), now would be a good time to add to it (C for chromosome, M for mitosis, etc).

Learning experience

If you have access to a presentation camera, display some magnified cells on a TV or a data projector. (If the school doesn't have one, the AVerVision 300p multimedia camera may be worth considering. Its magnification capabilities are excellent, and when it is used in conjunction with a microscope the displayed image is further magnified at a high resolution. This technology also has many uses beyond biology. Video and still images can be stored on a computer and it can also be connected to a data projector.)

Mitosis

The diagram on this page shows a cell dividing into two. This process is called **mitosis** (my-TOE-sis). Mitosis occurs in cells in the regions of the body that are producing new cells for growth or replacement of dead cells. For example, this occurs in the skin where dead cells are constantly being replaced.

The simplified cell shown in the diagram on the right has only two pairs of chromosomes, although organisms normally have many more than this.

When a cell is not in the process of dividing, the chromosomes cannot be seen with an ordinary microscope because they are long and thin and tightly coiled up inside the nucleus (diagram **1**).

At the very beginning of the cell division process, the chromosomes become shorter and thicken and they duplicate. In diagram **2** the chromosomes are visible and are seen to be doubled and joined in the middle. In the doubling process, each chromosome makes an exact *duplicate* of itself. So this process is called *duplication*.

In diagram **3** the duplicated chromosomes line up across the middle of the cell. The chromosomes then split where they are joined.

In diagram **4** the single chromosomes separate and move apart.

A nuclear membrane grows around each group of chromosomes. Then a cell membrane forms producing two daughter cells (diagram **5**) exactly the same as the original cell. So each daughter cell contains the same genetic material as the parent cell in diagram **1**.

Working with technology

To see an animation of the process of cell division, open **Mitosis** on the CD.

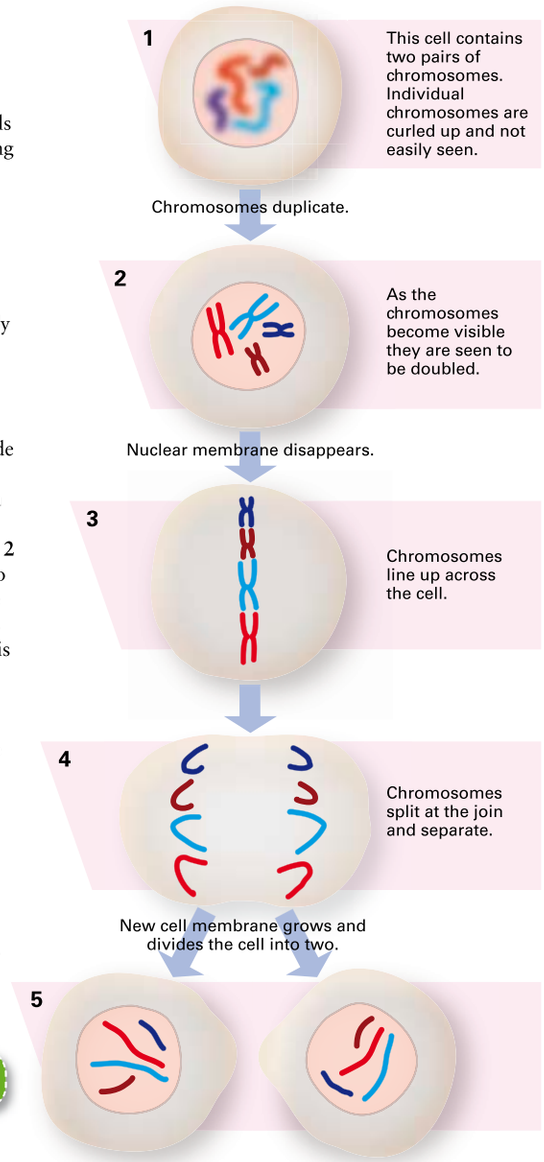


Fig 17 The process of cell division is called mitosis.

Hints and tips

- Although you may feel it is important to explain meiosis, it is probably better left until *ScienceWorld 3* Chapter 8. This way the students will not be confused about the difference between meiosis and mitosis.
- Mitosis is the cell division that occurs during asexual reproduction. New cells are formed when parent cells (older cells) split to make two identical duplicates (copies) called daughter cells.

Learning experience

Ask a set of critical thinking questions about this chapter. Consider giving each student a photocopied worksheet for them to fill in individually. Then, in pairs, they could exchange ideas and add to or modify their sheet. Collect the sheets for review. This way you can analyse students' ability to think critically and see how well they can apply the concept in a wider context. The following sets of questions could be a useful model. They are based on the critical thinking/Socratic thinking process.

Clarification	What do you mean by mitosis? How does this relate to our body? What happens in the process of mitosis? Where does mitosis occur in the body? Why do cells undergo mitosis?
Assumptions	Have any assumptions been made? Why would someone make that assumption?
Reasons and evidence	What would be an example of mitosis? How do you know when the process has occurred?
Viewpoint or perspective	What effect does cell division have on the body? Does the body have an alternative to mitosis?
Implications	How can you find out if there is an alternative process to mitosis? If cell division goes wrong, what implications are there? Are there any ethical implications of mitosis?
Questions about the questions	(This section is for any further questions that might be asked.)

Learning experience

Ask the students to make mobiles of the process of mitosis. Each diagram should be neatly labelled, explaining each step of the process. Hang the mobiles around the room. You may like to extend some mobiles by joining the top of two other mobiles to step 5 so the students can see that the process continues. Alternatively, they could make bookmarks of the process to keep in their textbook, and later use them as a revision tool.

Learning experience

Students could make their own PowerPoint presentations showing the process of mitosis. They could scan the images in from this page of their textbook, or find some alternative ones on the internet. They could then create summary points from the notes on this page. Allow the students some time to show each other their slide shows.

Chromosomes and DNA

Chromosomes are made of a substance called **d**eoxyribo**n**ucleic **a**cid (de-OXY-rye-bow-new-KLEE-ic acid) or **DNA** for short. DNA is only found in the nucleus of cells in multicellular organisms.

In the 1950s Watson, Crick and Wilkins discovered that the DNA molecule has a *double helix* shape. This is a double spiral shape similar to the shape of the lookout tower at King's Park in Perth (see Fig 18 below). In 1962 Watson and Crick were awarded the Nobel prize in chemistry for their work. (You saw a model of the DNA molecule in Chapter 4 on page 78.)

The DNA molecule is made up of three types of smaller molecules:

- sugars (deoxyribose is a type of sugar)
- phosphates
- bases (there are four types of bases).

Look at Fig 19 on the right.

Think of the DNA molecule as a twisted ladder. The sugars and phosphates make up the two vertical supports while the bases make up the rungs of the ladder.

Fig 18 The lookout tower in King's Park in Perth is a double helix shape.

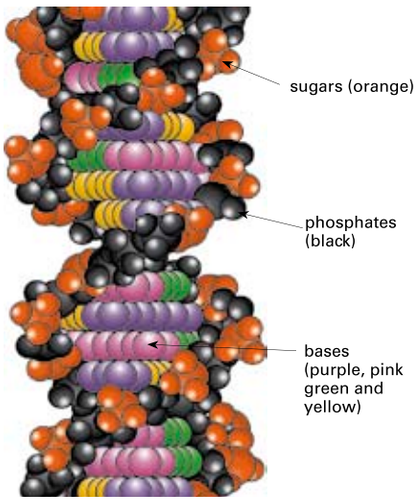


Fig 19 A model of DNA

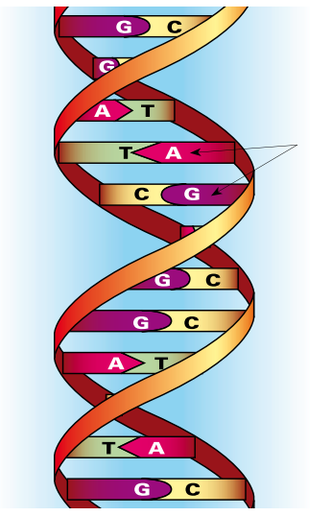


Fig 20 A simple diagram of DNA showing the bases in the double helix. The bases are like rungs in a spiral ladder.

Hints and tips

- The sides of the DNA ladder are made up of chains of phosphate molecules and 5-carbon sugar (deoxyribose sugar) joined together. The rungs of the ladder are made up of bases, which are ring-shaped molecules. The bases bond with the sugar molecules on the rungs. The bases are joined together with hydrogen bonds, completing the DNA ladder. (A hydrogen bond is a weak bond between a hydrogen atom in one molecule and an oxygen or nitrogen molecule in a neighbouring molecule.) The two DNA strands run in opposite directions to each other.
- A phosphate molecule + sugar + base is given the name nucleotide. DNA is made up of millions of these nucleotides bonded together.

Homework

Ask students to find out what the letters in Fig 20 represent. Can they identify a pattern? Ask them to carefully draw a simple diagram of DNA—they may copy Fig 20. Next to their diagram, they should write down in point form what they found out.

Research

Students could construct a timeline of significant events about DNA. They could research the names of scientists; their country of origin; event date; and what the discovery, event or advancement was. Which event appears to be the most significant? Why?

Learning experience

Ask a set of quick questions at the end of the lesson on the material covered. This will reinforce the concepts and definitions. It also helps students to know what the key points are, and helps identify any areas which may need revising.

DNA and genes

Notice in the simplified molecule of DNA in Fig 20 that there are four kinds of bases labelled A, T, G and C. In the 'rungs' of the DNA double helix, A bonds with T and G bonds with C.

It is the arrangement of the four kinds of bases along the DNA that determines what an organism will be like. The bases form the genetic code of an organism.

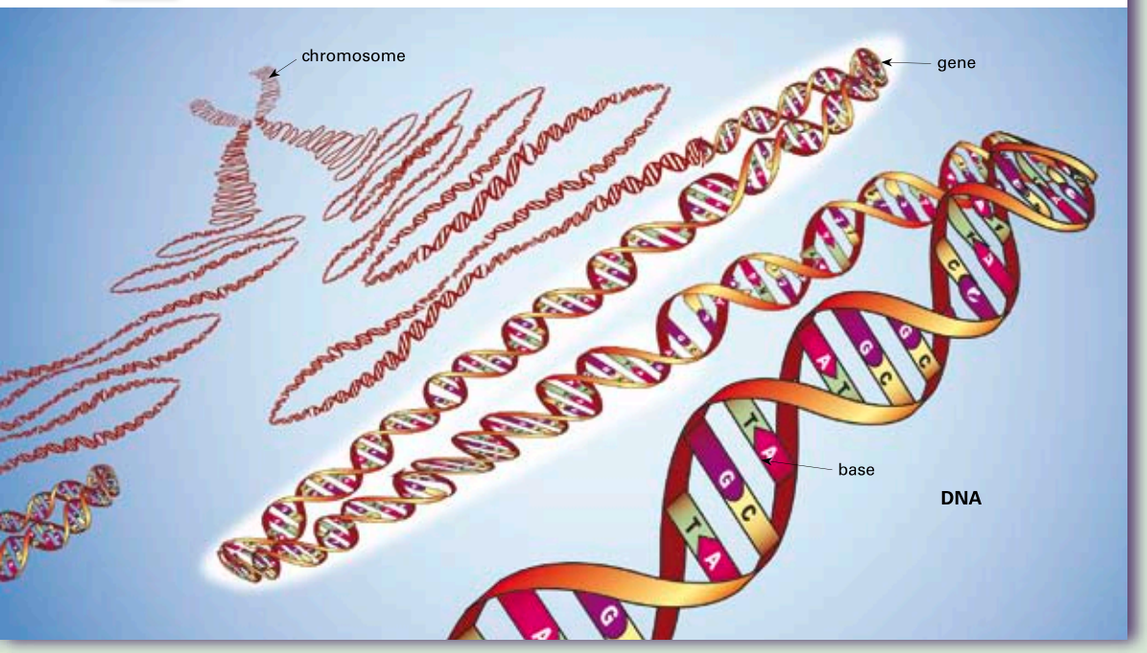
A section of the DNA containing a sequence of bases is called a **gene**. A gene will determine a particular feature or characteristic of an organism. For example, in pea plants a particular gene will determine whether the pea pod is green or yellow. In humans, a gene determines whether you have an unattached earlobe or an attached earlobe.

How big is a gene?

Scientists have found more than 25 000 genes in the human body. On average, a gene contains about 2000 bases. Fig 22 shows a simplified diagram of a chromosome, a gene and the bases on the DNA in the chromosome.

Fig 21 A particular gene determines whether you have unattached earlobes (A) or attached earlobes (B).

Fig 22 A gene is a section of DNA containing a number of bases in a particular order or sequence.



Hints and tips

Each chromosome has its genes arranged in single file along its length (the rungs of the ladder). The sequence of bases is the gene.

Learning experience

Investigate some of the myriad of commercial DVDs available that explain DNA, genes and inheritance. Find one appropriate for your students and put together a worksheet for the students to do while watching the DVD.

Learning experience

Get the students to produce their own film clip to explain DNA, chromosomes and genes. They could present the clip in the form of an interview with a scientist or a segment for a TV science program, such as *Catalyst* on ABC TV. Alternatively, they could write their information as a role play of an interview.

Learning experience

Divide students into pairs and ask them to spend 5–10 minutes sharing with each other the main points covered so far in this chapter. It may be a good idea for them to jot down their points, together with additional points from their partner.

Activity

A model for DNA

For this activity you will need a ruler and four different coloured plastic pegs, for example blue, yellow, red and green. You will need about four of each colour.

1 As a class, decide which peg colour will represent each of the four bases in DNA.
Write the colour code in your notebook.

2 Choose 3 pegs at random from the pile of pegs. Attach these to a ruler as shown.

What do the coloured pegs represent in this model? What does the ruler represent?

3 Rearrange the pegs on the ruler or select others from the pile to make a different sequence of three pegs.
How many different sequences of three pegs can you make?

In real life, a sequence of three bases along a strand of DNA form a *triplet* code. Each triplet forms a code that the cell uses to make a particular amino acid molecule. For example, the base sequence, TTT, could be a code for the cell to make amino acid X, and TAT might make amino acid Y.

How many different molecules can be made from a triplet code using four bases?

If an average gene contains about 2000 bases, how many amino acids can a gene code for?

The DNA code

A small section of a single strand of DNA is shown below. The order or sequence of the bases along the DNA strand forms the genetic code.

Scientists have found that a sequence of three bases on the DNA forms a code that a cell uses to make a particular type of amino acid molecule. The three bases are said to form a *triplet* code.

For example, GAT will code for the manufacture of a particular amino acid molecule, while TCG will code for the manufacture of another amino acid molecule. In this way the base sequences in the genes on DNA code for what type of molecules the body makes.

The base sequences in genes are the codes for inheritance.

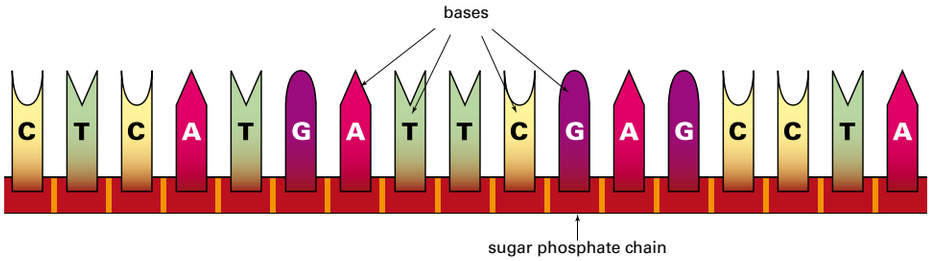


Fig 24 A base sequence along a strand of DNA

Activity notes

- Coloured paperclips can be used instead of pegs, and strips of cardboard in place of the rulers.
- The pegs represent the bases ATCG and the ruler represents the sugar phosphate chain.
- The students could attempt to model the number of possible triplet codes from four bases, but it may be a better use of their time to work it out mathematically. Encourage them to start writing the sequences out.

Hints and tips

Discuss what amino acids are and what the letters ATCG represent (adenine, thymine, cytosine, guanine). Explain to the students that certain bases pair together. A pairs with T, and C pairs with G. Point out to the students the two different key shapes in Fig 24. (A arrowhead locks with T, and G oval head locks with C.)

Learning experience

Design some questions which allow the students to reflect on the material covered and their involvement in group activities. Reflective questioning is a technique that can be used constantly throughout lessons to determine students' engagement and to develop their deeper understanding. Here are some possible questions:

1 What did you learn from the work you did today?
2 Why is being able to solve a problem an important science skill?
3 Why do you think understanding DNA is helpful?
4 Has our understanding of DNA improved our quality of life?
5 What is an example of a problem solved or being solved in this chapter?
6 How did you feel when you had to share your ideas in a group?
7 What did you learn about yourself during the activity?
8 What role did you play in your group and how did you assist the group?

science bits

DNA fingerprinting

Scientists have found that only a small proportion of the DNA in chromosomes is used as the genetic code. The larger proportion of DNA is non-coding DNA, sometimes called 'junk' DNA.

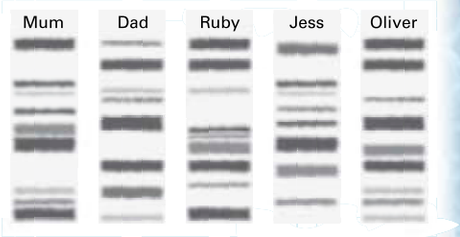
This junk DNA contains lots of repeating patterns of bases. And the number of repeating patterns is unique to an individual. For example, you might have a large number of repeating patterns in your DNA, while your best friend might have a small number.

The DNA that is used to make a *fingerprint* or *profile* is inherited in the same way as the DNA (genes) that determine eye colour, length of nose, etc. You get some from both your mother and your father. This is very important because it can be used to identify a person or determine whether a person is related to another person.

The DNA is chopped up into fragments using enzymes. This results in DNA fragments of different lengths. The position of the bars depends on the length of the fragment. The longest fragments are at one end and the shortest at the other. The thickness of the bars indicates how much of each fragment there is.

Family fingerprints

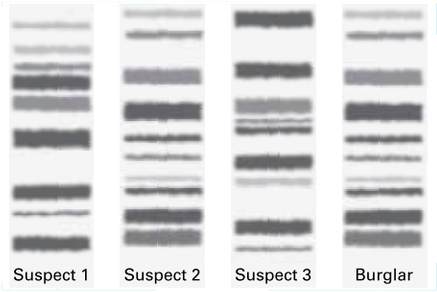
The fingerprints of five people in a family are shown top right. Mum and Dad have three children between them. You can see that the DNA bands for Mum and Dad are different from each other. But Ruby and Oliver share some DNA from Mum and some from Dad. Jess is a daughter from Mum's previous marriage. She has DNA from Mum but none from her stepfather.



Questions

1 What is the difference between your DNA and the DNA of the person sitting beside you?

2 A burglar left a drop of blood on the glass of a broken window. Police scientists used the cells in the blood to make a DNA fingerprint. They then compared this to the DNA fingerprints of three suspects.
   a Which suspect might be the burglar?
   b Could you convict the suspect on this evidence alone. Why?



WEBwatch

Go to www.scienceworld.net.au and follow the links to the following websites.

DNA fingerprinting
This site has information about different applications of DNA fingerprinting.

Create a DNA fingerprint
Has interesting information and interactive demonstrations on making a DNA fingerprint.

Hints and tips

- Make sure the students are aware that the term 'fingerprinting' is used because just as no two persons have the same fingerprint, no two persons have the same DNA. The only exceptions are children from identical multiple births. Have a class discussion on this, and discuss why DNA profiling is used to help solve crimes.
- Remind students that enzymes do not chemically change a reaction but are used as catalysts.

Homework

The Webwatch can be completed as a homework activity. Students should write down at least five interesting points from each website.

After a crime has been committed, sample DNA is run through a police database to determine if there is a match to any known person. DNA profiling has forced a review of some shaky criminal cases and has led to evidence being re-examined.

Ask the students to find out if there have been any notable cases where a person who was found guilty of a crime has now been acquitted, based on DNA profiling.

They could also investigate cases where DNA profiling got it wrong. For example, there have been cases when DNA samples have been contaminated. In one case, cottonwool swabs used to collect DNA were contaminated with DNA from people who handled them during manufacture.

Alternatively, students could do a SWOT analysis of DNA profiling. SWOT analysis is a tool used to assess an issue or process. They should divide a page into quarters and put one of the following SWOT headings in each section: 'Strengths', 'Weaknesses', 'Opportunities' and 'Threats'. A task like this allows students to see the big picture rather than only a few perspectives.

Research

DNA profiling is currently being used to help prove identity. What are some advantages of this and some possible implications? Is DNA matching foolproof, that is, is it 100 per cent reliable? Ask the students to do some research to answer this question. Consider the following success rates of matching DNA from different samples.

Sample	Matching success %
Saliva on a cigarette	67
Hair	25
Blood	90

extra for experts

DNA and proteins

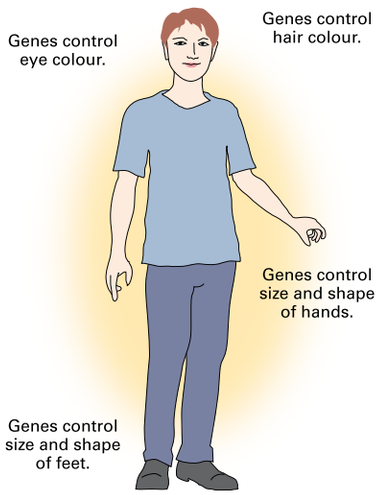
All humans have 23 pairs of chromosomes in their body cells, and on the DNA in those chromosomes are about three billion bases. These bases form the genes that determine what your body looks like and how it works.

How do genes make you what you are?

You learned in the last chapter that enzymes catalyse various reactions in the body, like the digestion of foods in your gut. Enzymes also control reactions in cells. Many of these reactions build large molecules from small ones: for example, large carbohydrate molecules from small sugar molecules.

Your genes contain the code which determines the types of enzymes that are made, which in turn control the types of large molecules that are made. These large molecules become the building blocks and structure of cells, tissues and organs.

Genes control body shape, size and features.



The genetic code and enzymes

Scientists throughout the world have spent years experimenting to find out how genes work. Late last century it became clearer that the triplet code on DNA controlled the manufacture of proteins. Enzymes are made of proteins, and proteins are made of many amino acids. The number of amino acids in a protein molecule can vary between 50 and 50 000. So if a DNA molecule contains a million bases, the DNA can code for many thousands of enzymes (proteins).

The table below shows some of the 64 base triplet codes and the amino acids they code for.

DNA triplet code	Amino acid
AAT	leucine
AGA	serine
ATA	tyrosine
GGA	proline
GCA	arginine
TTT	lysine
CAA	valine

Suppose a small part of DNA had the following base sequence:

AGAGGATTTCAAAAT

Let's separate the bases into triplets:

AGA GGA TTT CAA AAT

Using the table, the amino acid chain would be:

serine proline lysine valine leucine

Questions

1. Write the DNA base sequence for the amino acid chain that contains:
   valine proline leucine tyrosine proline serine arginine valine serine valine lysine
2. Suppose the triplet GGA changed to GCA in the five-triplet code in the example above. Write the new amino acid sequence.
3. A particular enzyme contains 5259 amino acids. How many triplet codes does the gene contain? How many bases does the gene contain?

Hints and tips

When a fault occurs in the duplication of a new cell this is called a mutation. This means a daughter cell has slightly different genes from the parent cell.

Learning experience

Every human is likely to have around 18 or so faulty genes. Ask the class to come up with possible implications of this. Do all faulty genes cause major health issues? You may like to use the learning tool called *Placemat* (see Learning experience below).

Learning experience

Placemat

Divide students into groups of four to six. Draw a placemat on a large sheet of paper. Divide the page so that each group member has a section to write in, with a square or circle in the middle of the mat to record the group response.

Ask the students to investigate a question. For example, keen or gifted/talented students could investigate what gene therapy is and then report to the class. Another alternative is to investigate genetically modified food.

Allow them sufficient research and preparation time. They should consider the question being asked and begin the investigation process by thinking about their own responses before consulting with their group. Responses are recorded in their section of the placemat. Students can then share their ideas to form a team response recorded in the middle of the sheet.

Extension

An extension activity could include all class members walking around the classroom, reading the responses given by different groups and seeing how they varied from their own.

Learning experience

Have a box with assorted short science activities/puzzles for students who complete their class work early. Rate each activity according to the difficulty of the task/problem. Set the challenge for each student in the class to complete a certain number of activities each term. They should have a record sheet which you can sign after they complete each task, and award them marks according to the level of difficulty. At the end of the term you may like to issue certificates to 'Science Challenge' students. Be mindful of slow-working students and those with learning difficulties.

Check!

1 What are chromosomes? Where in your body are they found? How many chromosomes are found in each cell in your body?

2 Explain in simple terms what mitosis is and what its purpose is.

3 You are a writer for an educational publisher. Write a brief, step-by-step description of mitosis for an artist who is going to create an animation of mitosis. (Use words only, no drawings.)

4 **a** Describe the shape of the DNA molecule.
b The DNA molecule is made up of three smaller molecules. What are they?

5 Write a sentence or two containing the words *chromosome*, *DNA* and *genes* so another person will understand what these terms mean.

6 The bases in a DNA molecule are like the rungs in a spiral ladder. What is the purpose of the sugar-phosphate molecules in a DNA molecule?

7 Suggest what the difference might be between one gene and another.

8 Make up your own simple model as in the activity on page 124 of a strand of DNA showing the following bases:

T T A G C G T C A G G C

9 Put the following objects in order from largest to smallest.

chromosome cell gene nucleus

a Give reasons for your decision.
b Where in the list would you put enzyme?

10 What is a DNA fingerprint? Describe its uses.

challenge

1 The table below shows the number of chromosomes in the cells of various animals.

Animal	No. of chromosomes
pigeon	80
dog	78
mosquito	6
carp (fish)	104
kangaroo	12
blue whale	44

a Rewrite the table showing the animals in order from least to most chromosomes. Include humans in the list. Add another column showing the number of pairs of chromosomes.

b Is there a relationship between the size of the animal and the number of chromosomes in its cells?

c Is there a relationship between the intelligence of an animal and the number of chromosomes in its cells?

2 There are only certain times when DNA is visible in a cell. When does this occur, and what happens to the DNA during this time?

3 The diagram below shows the sequence of bases on a short piece of one strand of DNA. Draw this in your notebook and draw the matching bases on the other strand of DNA that makes up the double helix.

4 Suppose the police investigators found some hair and saliva on the goods stolen by the burglar in question 2 on page 125.

a Would the DNA fingerprints be the same for the hair cells and cells in saliva as that for the blood?

b Would this additional evidence be enough to convict the suspect? Explain.

For the Challenge solutions, see the next page.

Check! solutions

1 Chromosomes are long structures found in the nucleus of cells in the body. They consist of DNA that carries the genetic information needed by cells. Every cell in the body contains 46 chromosomes, except sperm and egg cells that contain only half this number (ie 23).

2 Mitosis is the name of cell division in which one cell divides to produce two identical 'daughter' cells. The purpose of cell division is to allow the body to grow in size, and also to replace old or damaged cells.

3 The brief for the animation would be something like this. (You could check the animation of mitosis on the student CD.)
- *Step 1*: draw a cell showing the cell membrane, cytoplasm and nucleus containing two pairs of chromosomes.
- *Step 2*: slightly modify the drawings to show that each of the chromosomes has duplicated and is now double.
- *Step 3*: the nuclear membrane disappears and the chromosomes line up across the middle of the cell.
- *Step 4*: the halves of the chromosomes split and are pulled apart to opposite sides of the cell.
- *Step 5*: the cell splits into two, the nuclear membranes reappear and there are two new cells.

4 **a** The shape of the DNA molecule is a double helix and looks like a rope ladder that is twisted into a spiral shape.
b The units of DNA are sugars, bases and phosphates.

5 *DNA* stands for deoxyribonucleic acid, which is a long molecule found in the *chromosomes* in the nuclei of cells. Small sections of DNA that carry the information for making particular substances in the cells are called *genes*.

6 The sugar and phosphate molecules make up the sides of the helix, sometimes called the 'backbone' of the ladder, and the bases make up the 'rungs'.

7 The difference between one gene and another is the sequence of bases they contain. These sequences carry the information to make different substances in the cell.

8 To help with this task, you could try tracing or photocopying the bases and then cutting them out and assembling them in the given order. Or you could use a ruler and pegs as you did in the Activity on page 124.

9 The correct order is: cell, nucleus, chromosome, gene. Genes are found in chromosomes which are found in the nucleus of a cell.
a The reason is that this is what is seen under the microscope
b An enzyme is a molecule that can be smaller than a chromosome but bigger than a gene (although some enzymes are quite small).

10 A DNA fingerprint is a pattern made from a sample of an organism's DNA that has been chopped up into fragments. Because DNA is inherited, there are similarities in the patterns of the fingerprints of related organisms. This technique is proving to be very useful. For example, it is used to identify people who may have been involved in a crime, to establish how different species are related, and to determine who is the father of a particular child.

Challenge solutions

1 a The revised order is shown in the table below.

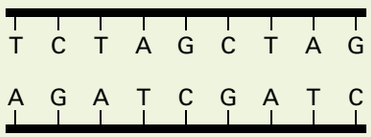
Animal	*No. of chromosomes*	*No. of pairs of chromosomes*
mosquito	6	3
kangaroo	12	6
blue whale	44	22
human	46	23
dog	78	39
pigeon	80	40
carp	104	52

b From the information given, there does not seem to be a relationship between the size of the animal and the number of chromosomes.

c Similarly, from the information given, there does not seem to be a relationship between intelligence and the number of chromosomes.

2 DNA is only visible in a cell as a part of chromosomes when the cell is dividing. During this time the chromosome is seen to be double and the identical halves move apart when the cell divides.

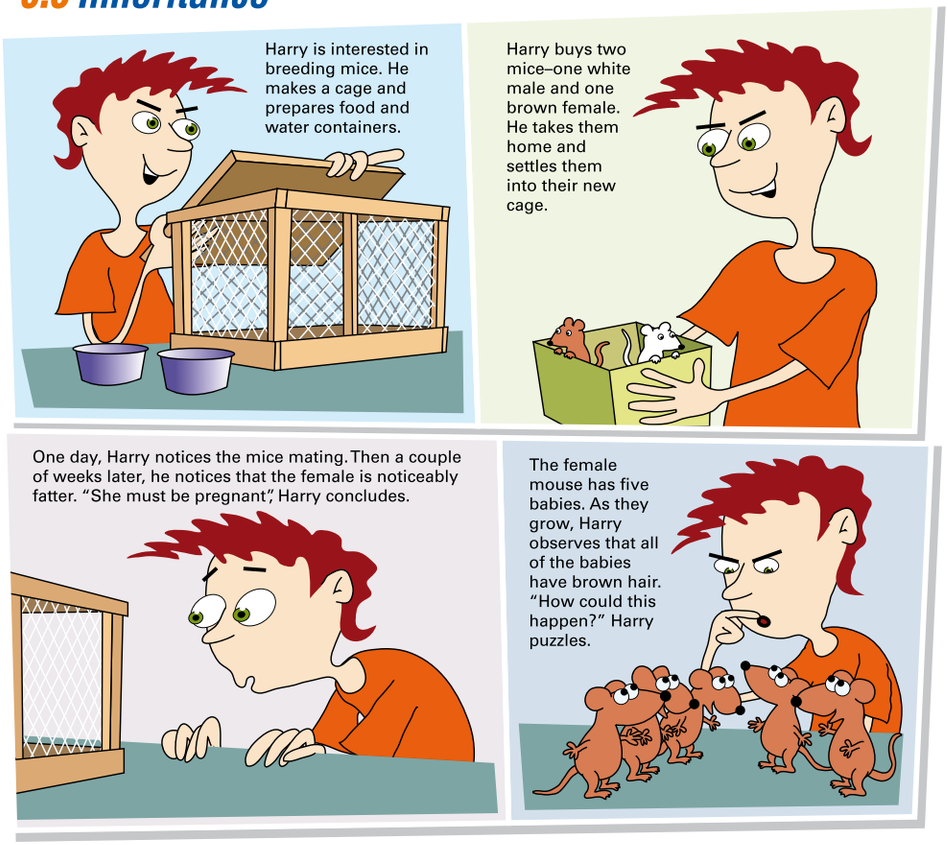
3 The matching bases are T C T A G C T A G, as in the diagram below.



4 a Yes, the DNA in all body cells of a person will produce the same DNA 'fingerprint'.

b The hair and saliva is extra evidence that could be used to convict the suspect. However it is possible that the DNA could have been obtained from the suspect and placed at the scene by someone else. Usually other evidence, such as a motive and the lack of an alibi, are needed for a conviction.

6.3 Inheritance



To find out why all the baby mice had brown hair requires knowledge of genes and how they work.

The passing of characteristics from one generation to another is called **inheritance**. The baby mice inherited the genes for coat colour from both parents. When the two parent mice mated, the genes from the male combined with the genes from the female and produced baby mice with brown hair. Before you learn more about this, you have to know about chromosomes and sex cells.

Making sex cells

On page 121 you learnt that during cell division (mitosis) the two new cells get one of every chromosome in the original cell. This means that all new cells have exactly the same number of chromosomes as the original cell. In humans every cell has 46 chromosomes or 23 pairs.

Sex cells are different from other body cells. They have only *one* chromosome of the pair of chromosomes. In humans, sex cells have 23 single chromosomes or one chromosome from each pair.

Hints and tips

- This section is designed to allow teachers to develop the Essential Learning: All the information required for life is a result of genetic information being passed from parent to offspring, eg hereditary information is contained in the genes located on chromosomes. The section is in no way meant to be a more detailed study of genetics, eg Punnett squares and pedigrees, which are covered in *ScienceWorld 3* Chapter 8. Teachers need to resist the temptation to try to do more than is suitable for students at this level.
- Spend some time revising the chapter and encourage students to spend about five minutes explaining what they have learnt so far to a classmate. You may choose to select some students to share their ideas with the whole class.
- It would also be a good idea to give a short quiz so you can identify areas which may need further clarification. Design a true/false, multiple-choice or 'Who am I?' quiz.

Learning experience

If you have set up an animal room, the students may find it fun to breed some mice. Make sure the students take responsibility for their care and know the ethical procedures for handling them. Ask the lab technician to choose two different coloured mice so the class can, hopefully, see variation in the offspring. Alternatively, guinea pigs could be used.

Check with your lab technician if the school has an Animal Handling Certificate. Ethical guidelines for handling animals need to be adhered to.

Male sex cells are called **sperm**. These are made in the *testes* (singular: testis). In humans these are situated below the *penis* in a sack-like *scrotum* outside the body. Millions of sperm can be made each day in an adult male.

In females, the sex cells are called **ova** (singular: ovum) and are made in the *ovaries*. In humans, usually only one ovum develops each month. In other mammals such as mice, cats or dogs, multiple births occur because the ovaries release more than one ovum.

The cell division that occurs in testes and ovaries is different from mitosis. This cell division produces cells with only one of each of the pairs of chromosomes.

Fertilisation

Fertilisation occurs when a sperm joins with an ovum. In this process the nucleus containing the single chromosomes in the sperm fuses with the nucleus of the ovum. This produces a new living thing whose body cells have a full complement of chromosome pairs.

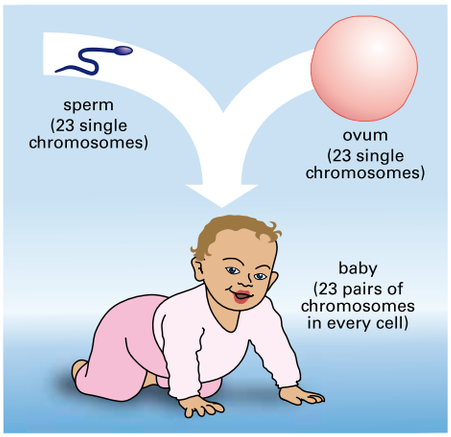


Fig 30 In humans a sperm containing 23 *single* chromosomes fertilises an ovum containing 23 *single* chromosomes, producing a new cell with 23 *pairs* of chromosomes.

science bits

Sex-determining chromosomes

The chromosomes on the right are from a human male. Look at chromosome pair 23. Now compare this with the chromosomes from a human female shown on page 120.

A human male has one X chromosome and one smaller Y chromosome. A human female has two X chromosomes. These chromosomes are the sex-determining chromosomes.

When sperm are made in the testes, they contain one of each of the 23 pairs of chromosomes. Therefore half of the sperm will contain an X chromosome and the other half will contain a Y chromosome. On the other hand, all ova contain an X chromosome. Can you explain why?

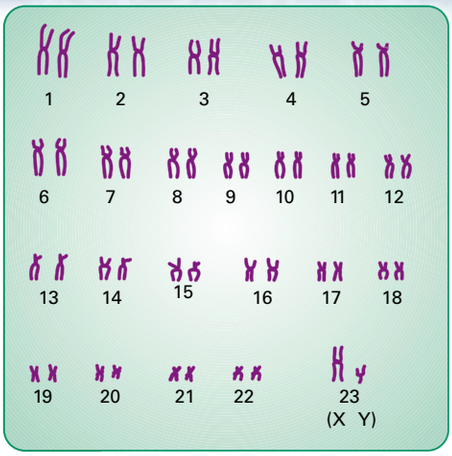


Fig 31 The 46 chromosomes in a human male. Chromosome pair 23 (X and Y) determines sex.

Hints and tips

Sperm and ovum (egg) cells are formed by meiosis. This is a process where each parent cell makes four daughter cells. Each daughter cell has only half the number of chromosomes as the parent cell (see Fig 30). During fertilisation the 23 chromosomes from the sperm and ovum combine to make 46, or 23 pairs in every cell. The process is explained in *ScienceWorld 3* Chapter 8.

Homework

Ask students to come up with a reason why sexual reproduction is advantageous over asexual reproduction. They should be able to justify their reason scientifically, and may first need to find out what the difference between sexual and asexual reproduction is.

The aim is to have students understand that asexual reproduction produces an offspring which is an identical copy. A change in the organism's environment could therefore be devastating and wipe the species out because all individuals are the same. There is much greater variation in a species that reproduces sexually.

Learning experience

Ask the students to bring in some family photos of parents, grandparents and siblings. (You will need to remind them to do this before this lesson.) Get them to make a table listing the similarities they have with other family members, and the characteristics they have which are very different.

Learning experience

Is it the male or female sex cell that determines what sex the baby will be? Is there an equal chance of conceiving a female and a male? Get the students to come up with their own lists of questions like this based around the information on these pages. If possible, they should order their questions into closed and open-ended questions. They could use the closed questions to construct a crossword for their classmates to solve. The open-ended questions could be used as discussion starters, or answered as a Think/Share/Pair activity (see Learning experience on page 34).

Investigate

15 CHROMOSOME MODELS

Aim

To model the production of sex cells.

Materials

- 6 plastic-covered coloured paper clips (3 of one colour and 3 of another colour)
  (Note: Coloured pipe cleaners can be used instead of paper clips.)
- wire cutter or pliers (class use)
- 2 sheets of plain A4 paper

PART A
Making model chromosomes

Method

1 Draw a large circle about 12 cm in diameter at the top of one sheet of paper.

2 Straighten the paper clips and lay them side by side in pairs (one of each colour) in the circle.

3 Use the wire cutters to cut off about 3 cm off the second pair of paper clips, and about 6 cm off the third pair.

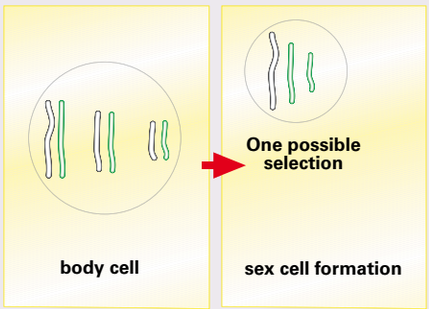
4 You should have three pairs of wires, each pair of a different length.

PART B
Making models of sex cells

Method

1 Make sure the pairs of model chromosomes are in the circle on one sheet of paper. (Note: Each pair should contain paper clips of two different colours.)

2 Your task is to make sex cells on the other piece of paper. For this you select one long chromosome, one medium one and one short one. One selection is shown below.



Discussion

1 How many different sex cells can you make? Use coloured pencils to draw the three single chromosomes in each of the sex cells.

2 Assume the chromosomes of one colour in the original cell came from the person's father. What is the chance that a sex cell will contain all the father's chromosomes (and hence genes)?

Challenge

How many different sex cells can be made from *four* pairs of chromosomes? Try do deduce a mathematical formula that will allow you to find out how many different sex cells can be made by humans (23 pairs of chromosomes).

Lab notes

- It is a good idea for the students to work in pairs to complete this investigation. If the groups are larger, one or more students may not participate.
- The students should record their information in a table. Students who prefer to learn visually could use two different coloured pens and draw the combinations as their tally.
- The mathematical rule can be described as: 2^n, where n is the number of chromosome pairs. Hence, Discussion question 1 is $2^3 = 8$, Challenge is $2^4 = 16$, and $2^{23} = 8\ 388\ 608$.

Issues

As an extension exercise, the class could debate the 'one-child policy' used in China. Because of better nutrition, health and medical care, we are generally living longer. What implications does this have for the world population and why do you think China introduced the 'one-child policy'? Divide the class into two, making sure to have a strong leader in each team.

Debating is a strategy that lends itself to analysing issues and expressing different viewpoints. Students need to be aware of the rules of debating and cooperate in establishing a respectful environment.

Harry's mice

Harry's baby mice were all brown even though one parent had brown hair and the other had white hair. The colour of hair in this type of mouse is controlled by a particular gene. This gene has two forms, one that codes for brown hair and another that codes for white hair.

Brown mice and white mice

The puzzling thing about Harry's mice is that the parents with different hair colour produced babies all with brown hair. To answer this puzzle, we need to draw a model.

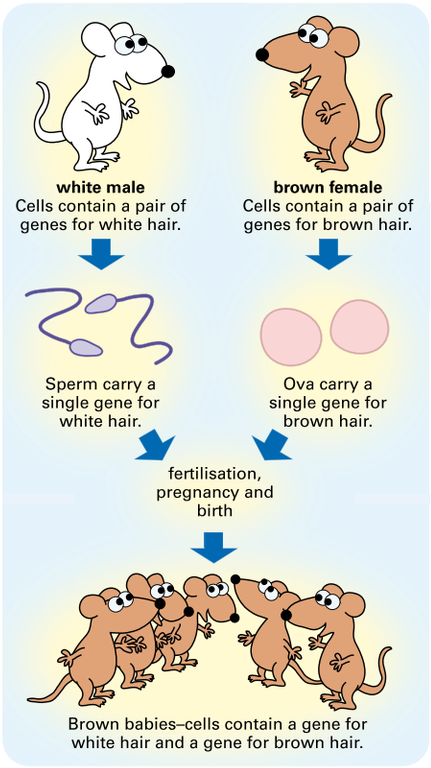


Fig 34 One white-haired parent and one brown-haired parent produced all brown-haired babies.

If the baby mice have a gene for white hair and also a gene for brown hair, why don't we see any white colour? This is because the gene for brown hair completely masks the gene for white hair. The gene for brown hair is said to be the **dominant gene**. The gene for white hair is called the **recessive gene**. You will learn more about the inheritance of genes in *ScienceWorld 3*.

Genes in humans

The table below shows some of the genes in humans that are dominant and those that are recessive.

Dominant	Recessive
curly hair	straight hair
brown hair	blond hair
brown hair	red hair
freckles	no freckles
right-handed	left-handed
face dimples	no face dimples
straight thumb	Hitchhiker's thumb
long eyelashes	short eyelashes

Science in action

How genetics got started

In 400 BC, the Greek philosopher Hippocrates put forward his ideas about inheritance. He proposed that tiny particles from every part of the bodies of both parents combine to produce children with characteristics of both parents.

It was difficult in those times to test Hippocrates' ideas. However, farmers could have told him he was wrong. They knew that good characteristics of plants and animals can be selected and bred from one generation to the next. And often the offspring have characteristics of one parent (like Harry's baby mice) rather than a combination of characteristics.

The first person to do simple scientific tests was Gregor Mendel. He is often called the 'father of genetics' because his work sparked the interest of many other scientists.

To find out more about the life and experiments of Gregor Mendel go to www.scienceworld.net.au and follow the links to **Gregor Mendel's story**.

Hints and tips

Give the students some time at the end of the lesson for reflective questioning. This is a way of engaging students in thinking about how they are learning new concepts and skills. Some questions to consider are:

- What did you learn?
- How do you know that you have learnt it?
- How might you use what you have learnt at some other time?

Research

Working in pairs, students could choose a question/point about genetics to research, compile a list of dot points and report back to the class. Their final report could be presented orally, as a multimedia presentation or as a booklet. The whole class can learn from the students' research so allow time for them to view the booklets or multimedia presentations by placing them around the room.

Some possible research questions are:

- How have people's ideas about heredity changed over thousands of years?
- How did Gregor Mendel live and how did he establish the foundations for the science of heredity?
- What was the famous pea experiment and how did Mendel do it?
- What did Mendel discover? Review Mendel's most important findings.
- Genetics is considered to be a powerful science and many new discoveries were made in the twentieth century—from chromosomes to the DNA double-helix. Review the most important findings.
- How are scientists today using genetics to tackle cutting-edge questions in ethics, biomedicine, conservation and crop cultivation?

Homework

Get students to use the table on this page to list any features they have which are dominant. Do the same for any recessive features. Which family member (Mum or Dad) do they think they inherited these features from? Do they share more features from their mother or father, or are they evenly distributed? (See Starting point 2 on page 112.)

Activity

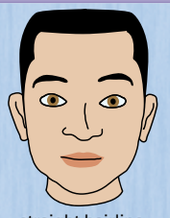
Inherited human characteristics

The list below shows some of the inherited characteristics in humans.

1 Make a list of the characteristics you have.

2 Look at the features in your family and work out which characteristics you have inherited from your father and which you have inherited from your mother.


widow's peak


straight hairline


ear lobes attached


ear lobes unattached


long second toe


short second toe


can roll tongue


cannot roll tongue


left thumb on top of folded hands


right thumb on top of folded hands

Inheritance is not that simple!

Each of the characteristics in the activity above is inherited. However, explaining inheritance is not that simple. Very few characteristics in humans (or other organisms) are controlled by single genes. For example, the characteristic of widow's peak is dominant over straight hairline, but it may not be controlled by just one gene.

Single genes would generally produce either/or characteristics in a population. For example, if one gene controlled height, some people would be tall and others would be short. You would not see a range of heights.

Scientists have identified three genes that control eye colour in humans, but they suspect others are involved. This is why you see various shades of green, blue and brown eyes.

Fig 36 Eye colour in humans is controlled by at least three genes. This produces a variation in shades of blue, green and brown eyes.

Activity notes

Be aware of any student in the class who is adopted, fostered or experiencing a family trauma, as this activity may be stressful or awkward for them.

Extension

Encourage the students to go home and check with their parents to see who they inherited the characteristics in the activity from. Both parents may share the same characteristic. If possible, the students could extend their investigation to include other members of the family such as brothers, sisters and grandparents. They could draw a family tree to display the collected information. Refer to page 133 as a guide to drawing family trees (pedigrees).

Hints and tips

Personal learning and feeling-based questions focus on individuals and encourage them to think about their learning, their skills development and their own identity. Examples of personal learning questions you might ask the students are:

- How did you feel when you had to share your ideas with the class or a partner?
- What did you learn about yourself during this activity?

Feeling questions include:

- How do you feel about sharing the same characteristics as your parents?
- Do you feel happy that you are more like one parent than the other?

Learning experience

If students completed the Starting point task on page 112—completing a chart displaying features they have in common with their parents—refer back to it and have a class discussion about inherited features. Why isn't it possible to say for certain that they inherited a particular feature from their mother or father? Do they have features, such as eye colour, which seem different from either of their parents?

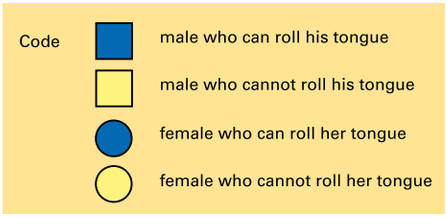
extra for experts

Human pedigrees

Scientists who study genetics and inheritance generally work with animals and plants that reproduce rapidly and in large numbers: for example, mice and guinea pigs. Information on humans comes from the study of family histories. Inherited characteristics can be traced through the generations on a family tree or **pedigree**.

The pedigree in Fig 37 shows the family members over three generations who can and cannot roll their tongue. It also shows that members 1 and 2 had two children, and members 3 and 4 had three children. Members 5 and 6 are siblings (sister and brother), and members 7, 8 and 9 are also siblings.

The code below explains the symbols used.



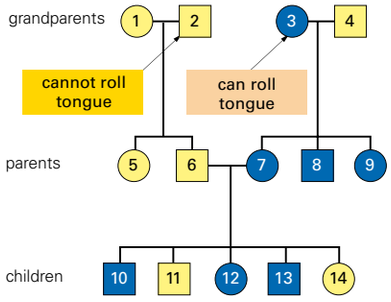


Fig 37 A pedigree. The individuals who can roll their tongue are shaded in blue.

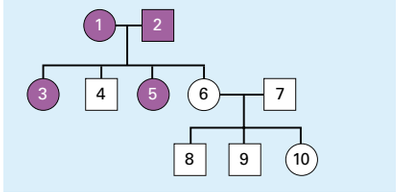
Suppose tongue rolling is controlled by a dominant gene. The pedigree shows that grandmother 3 could roll her tongue but grandfather 4 could not. All three of their children (7, 8 and 9) could roll their tongue.

For simple characteristics like tongue rolling, you can use pedigrees to work out the genes carried by individuals. For example, grandfather 4 could not roll his tongue, and we know that the gene that controls this characteristic is a recessive gene. Therefore he must have a pair of genes for non-tongue rolling.

The challenging part of the pedigree is to work out the genes carried by the tongue-rolling individuals such as 7, 8 and 9!

Questions

1 How many generations are shown in the pedigree in Fig 37?
2 How many children did parents 6 and 7 have?
3 If 3 is the mother of 7, what is the relationship of 3 to 6?
4 What is the relationship between 1 and 14?
5 What genes are carried by 5 and 6?
6 Use your answer to 2 to deduce the type of tongue-rolling genes carried by their parents.
7 Do you think that 14 could have inherited genes from 1? Explain.
8 In the pedigree below the shaded members are right handed and the unshaded members are left handed. The gene for right-handedness is dominant over the gene for left-handedness.



a How many generations are shown?
b If person 8 marries a left-handed person, can they have a right-handed child? Explain

Hints and tips

At the start of a lesson it is important to re-examine material covered from previous lessons. Give the class a quiz based on the material they have already learnt, to help you get an indication of whether any concepts need revising. It also helps the students consolidate their ideas. Ask them to write the answers only (no need for the questions).

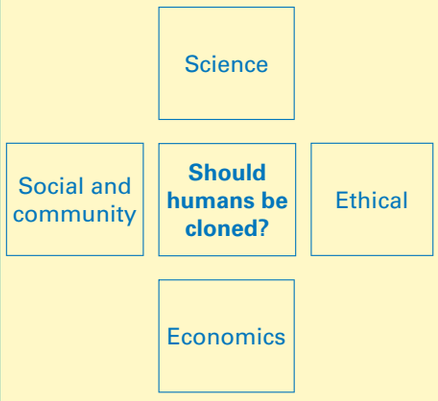
Issues

Issues map

As an extension task, the students could investigate an issue concerning genetics, such as cloning. First, discuss with the class questions such as:

- In the future, will it be possible to clone people?
- What happened to Dolly the sheep? Why wasn't she a perfect clone?

Then present an issue to the students about cloning and get them to investigate it using an issues map. An issues map can help identify the different dimensions of, or perspectives on, a particular event or issue. It is often helpful to phrase the issue as a question so it can be explored differently depending on the viewpoints held by different students. Students brainstorm the issue using the map. The responses can then be categorised as positive or negative. An example map template for the issue of cloning is below.



Learning experience

If the students haven't done the extension activity on the previous page (under 'Activity notes') they could attempt it now. Give them a large sheet of poster paper to draw their family pedigree. Remind them that a key is necessary for the pedigree.

Learning experience

Students who like animals could investigate a dog, cat, horse or other animal pedigree. What features make a good pedigree and what do breeders try to breed out of the pedigree?

Check!

1 Look at the table in Challenge 1 on page 127. How many chromosomes would there be in the ova of a female pigeon? Explain how you arrived at your answer.

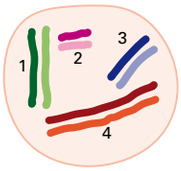
2 Human ova have 23 single chromosomes, all of the same type. However, human sperm have 23 chromosomes but the 23 can be different from those in the ova. Explain what this means.

3 When describing genes, what do the terms *dominant* and *recessive* mean? Write a sentence or two, using contrast linking words and include an example of each.

4 In cats, short hair is dominant over long hair.
- **a** Explain what this statement means so that it can be understood by a person with little knowledge of genes and inheritance.
- **b** Suppose a long-haired female cat has six kittens all with short hair. The father cat has short hair. Draw a diagram similar to the one in Fig 34 on page 131 to explain this.

5 A few characteristics in humans are controlled by a single gene, but most characteristics are controlled by many genes. Explain what this means, giving an example of each.

6 Suppose a body cell of an organism has four pairs of chromosomes as shown below.
- **a** Draw the different types of sex cells that could be made by this organism.
- **b** Is it possible for a sex cell to contain both chromosomes from pair 1?



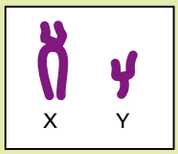
body cell

challenge

1 Mr and Mrs Brown have four children, three daughters and a son. The Browns would like another son. They think that because they have had three daughters, there is a greater chance that they will have another son.
- **a** Is this reasoning correct? Explain your answer.
- **b** Try to create a simple model to show the Brown's your answer to part **a**.

2 You get half your genes from your mother and half from your father. So why don't you get half your mother's features and half your father's features?

3 The human X chromosome is much longer than the human Y chromosome. Does this mean that a woman has more genes on her XX chromosomes than a man has on his XY?



4 There are two types of twins—fraternal twins and identical twins. Use the internet to find out how these types of twins form. Find out why identical twins have to be the same sex and have the same characteristics.

5 Polydactyly (POL-ee-DACT-ill-ee) describes the inherited characteristic of having more than 5 digits on the hands or feet. It is controlled by a dominant gene. A man with 6 fingers on each hand has the extra finger surgically removed. He now believes that none of his children will have polydactyly. Is he correct? Explain.

6 Find out more about polydactyly and the famous people who had this gene. Go to www.scienceworld.net.au and follow the links to **Polydactyly**.

7 The gene for short hair in cats is dominant over the gene for long hair. A long-haired female mates with a male that carries a pair of genes for short hair. They produce 5 short-haired kittens. When the kittens reach adulthood, one female mates with a long-haired male. They have 3 short-haired and 3 long-haired kittens. Draw a pedigree (see previous page) for this information.

Check! solutions

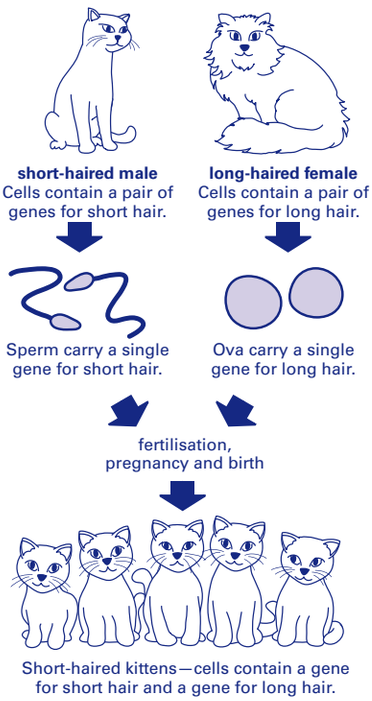
1 The body cells of a pigeon have 80 chromosomes and the ova cells will contain half of this number, which is 40. The reason is that if this ovum combines with a pigeon sperm cell it will form a new cell (zygote) with the full number of 80 chromosomes.

2 In human males, each sperm cell contains 23 single chromosomes, made up of 22 chromosomes plus an X chromosome or 22 plus a Y chromosome. So there can be two different types of sperm cell. In human females, each ovum has 22 chromosomes plus an X chromosome. So there is only one type of ovum.

3 Genes often work in pairs. Both genes for a particular characteristic are normally present in an organism *but* only one characteristic will be seen. This characteristic is dominant and the gene is called the dominant gene (for example, the gene for tongue-rolling), *whereas* the one that is hidden is recessive (for example, the gene for non-tongue-rolling).

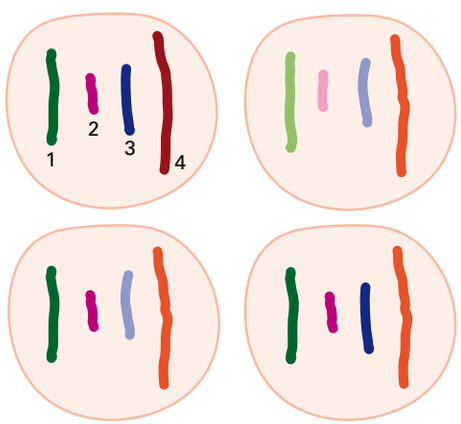
4 **a** This means that if a short-haired cat (with two genes for short hair) mates with a long-haired cat, all of the kittens in the litter will be short-haired. This is because the gene for short hair is dominant and completely masks the gene for long hair, which is called the recessive gene.

b



5 In humans, a few characteristics are thought to depend on the inheritance of a single gene. For example, widow's peak and ear-lobe attachment are inherited this way. Often genes act together to produce a particular characteristic. For example, height is thought to be controlled by several genes which helps to explain why there is such a range of heights in the human population.

6 **a** Each sex cell must contain one chromosome from each pair, for example a dark green one from pair 1, a dark purple one from pair 2, a dark blue one from pair 3 and a dark brown one from pair 4. Only four of the 16 possible combinations are shown here.



MAIN IDEAS

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

1 Cells can be seen only with a _____. Cell dimensions are usually measured in _____ (μm).

2 _____ occurs for growth in young organisms, and to replace cells that are dead or no longer of use.

3 _____ occurs when cells divide rapidly and uncontrollably. This usually occurs in parts of the body where cells are dividing.

4 During cell division, or _____, sausage-shaped objects called _____ become visible in the nucleus.

5 Chromosomes are made of _____, which is in the shape of a _____.

6 A _____ is a section of DNA containing a sequence of _____.

7 In humans, body cells contain 23 _____ of chromosomes while the sex cells (_____ and _____) contain 23 single chromosomes.

8 For many inherited characteristics, the _____ form of the gene completly masks the recessive form.

9 Very few human inherited characteristics are controlled by _____ genes. Most, like _____, are controlled by more than one gene.

bases
cancer
cell division
chromosomes
DNA
dominant
double helix
gene
height
microscope
micrometres
mitosis
ova
pairs
single
sperm

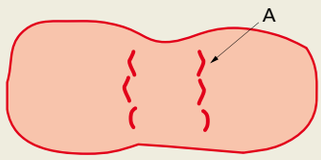
Try doing the Chapter 6 crossword on the CD. Working with technology

REVIEW

1 The following are observations about cells. Which one is *false*?
- **A** They are the units of which all organisms are made.
- **B** They are not visible to the naked eye.
- **C** They are all brick shaped.
- **D** They all contain a nucleus and a cell membrane.

2 The field of view in a microscope with a ×10 eyepiece and a ×4 objective lens is 4.5 mm.
- **a** What is the field of view in micrometres?
- **b** What is the field of view when a ×10 objective lens is used with the same eyepiece lens?

3 The diagram below shows a cell from the growing region of the skin.
- **a** What are the objects labelled A?
- **b** Why are there two sets of these objects?
- **c** If you take cells from other areas of the skin, you will not see these objects. Why not?



Solutions for Review 1–3 are on the next page.

In earlier printings, Main ideas 3 and 4 were incorrectly numbered.

Main ideas solutions

1 microscope, micrometres
2 cell division
3 cancer
4 mitosis, chromosomes
5 DNA, double helix
6 gene, bases
7 pairs, ova, sperm
8 dominant
9 single, height

that some characteristics are always seen (because the gene is dominant) and others are not often seen (because the gene is recessive).

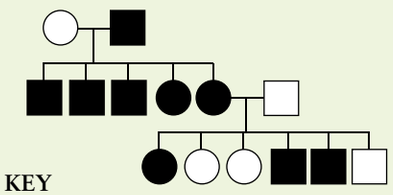
3 The answer is yes. The X chromosome is larger than the Y chromosome and since chromosomes are made of DNA, there would be more genes on an X chromosome than a Y chromosome.

4 Fraternal twins are non-identical and are formed when two eggs from the mother are fertilised by two sperm from the father. Identical twins, in contrast, are formed when one egg is fertilised by one sperm and then splits to form two identical cells that grow to become genetically identical (including gender and all characteristics).

5 Polydactyly is caused by a single gene. An operation to remove the extra digit will not change the gene concerned and therefore it is still possible that some of his children will inherit this characteristic.

6 This link will take you to Wikipedia where you will find out more interesting information, eg there are different types of polydactyly, it occurs in about 1 in every 500 live births, and it occurs in other animals as well. Some people who have had this condition are Hrithik Roshan (a Bollywood star), Ann Boleyn (one of Henry VIII's wives) and Fabinho (a Brazilian footballer).

7



KEY
- ■ short-haired male cat
- □ long-haired male cat
- ● short-haired female cat
- ○ long-haired female cat

b No. When the sex cells are being made in the testes or the ovaries, each of the 23 pairs of chromosomes separates. This means a sex cell will contain 23 single chromosomes—a single chromosome from each pair.

Challenge solutions

1 a Their reasoning is incorrect. Each fertilisation of a sperm and an egg is a separate or independent event with a 50/50 chance of a son or a daughter.

b A good model is the tossing of a coin and the equal chance of heads or tails. If you toss three heads in a row it does not mean that the next toss is more likely to be a tail. It is still 50/50. The more times you toss the coin the closer the ratio will become to 50/50.

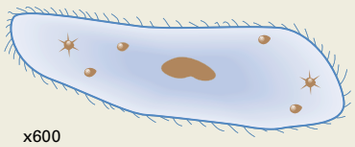
2 The simple reason is that often there is more than one set of genes for each characteristic, eg height. Another reason is

REVIEW

4 A gene is:
- **A** a molecule of DNA
- **B** one of the four types of bases on a molecule of DNA
- **C** a sequence of bases on DNA that determines a particular characteristic
- **D** another name for DNA

5 Which one of the following statements is *incorrect*? Change the statement to make it correct.
- **A** There are four types of bases in DNA.
- **B** A human sperm cell contains 23 pairs of chromosomes.
- **C** A human sperm cell can contain either an X chromosome or a Y chromosome.
- **D** Fertilisation occurs when the nucleus of a sperm fuses with the nucleus of an ovum.

6 The protist below has been magnified 600 times. Use a ruler to calculate the length and width of the protist in micrometres.



x600

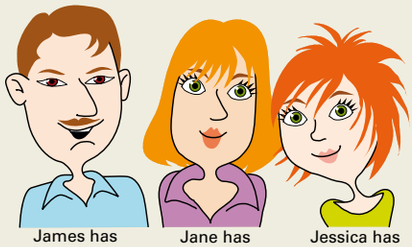
7 The simplified diagram below shows a small section of a strand of DNA.

- **a** What does the heavy black horizontal line represent?
- **b** What do the capital letters represent?
- **c** How many amino acids does this small section of DNA code for?

8 The following questions are about mitosis.
- **a** What is the purpose of mitosis?
- **b** Why do the chromosomes duplicate?
- **c** Why would you find cells undergoing mitosis in the skin but not in the brain or heart?

9 Almond eye shape in humans has a gene that is recessive to the dominant gene which codes for round eyes.

James has almond-shaped eyes but his wife Jane and their daughter Jessica have round eyes.



- **a** Explain what a recessive gene is.
- **b** Why doesn't Jessica have almond-shaped eyes?

10 The diagram below shows the DNA fingerprints from two people.
- **a** What do the bands represent?
- **b** Could person 2 be related to person 1? Give reasons for your answer.
- **c** How could a DNA fingerprint be used to free a person who has been wrongly accused of a crime?

Check your answers on pages 320–321.

Review solutions

1 **C**—see page 113.

2 **a** 4.5 mm = 4.5 × 1000 µm
= 4500 µm

b If you use a ×10 objective lens instead of a ×4 lens, the magnifying power will increase 2.5 times. However, the field of view will decrease by the same amount. That is,

$4500\ \mu m \times \frac{4}{10} = 1800\ \mu m$

3 **a** chromosomes

b The cell is in the process of dividing and the chromosomes in the cell have duplicated themselves.

c Cells in other areas of the skin do not divide, therefore you will not see chromosomes.

4 **C**

5 **B** A human sperm cell contains 23 single chromosomes.

6 The protist measures about 60 mm × 20 mm. The actual size of the protist is therefore 83 µm × 33 µm.

$\frac{60\ mm}{600} = 0.01\ mm = 100\ \mu m$

$\frac{20\ mm}{600} = 0.033\ mm = 30\ \mu m$ (approx)

7 **a** The sugar-phosphate strand

b The four types of bases

c There are three bases in a triplet code that codes for one amino acid. Therefore, this section of 9 bases codes for three amino acids.

8 **a** Mitosis occurs when cells divide to produce new cells for growth or replacement of dead cells

b The chromosomes duplicate in mitosis so that the two daughter cells have the same number of chromosomes as the original cell.

c Certain cells in the skin divide to replace dead skin cells. However, cells in the heart or brain cannot divide and so dead cells are not replaced.

9 **a** A recessive gene is one that is masked or hidden when a dominant gene is present.

b Jessica received a gene for almond eyes (recessive) from her father and a gene for round eyes (dominant) from her mother. The gene for almond eyes is masked by the gene for round eyes.

10 **a** The bands represent fragments of DNA.

b Person 2 is probably not related to person 1 because most of the bars in the two fingerprints do not line up (match).

c A person's DNA would have to be obtained and fingerprinted. DNA found at the crime scene would also have to be fingerprinted. If there is no matching of the bands, the suspect is probably not the criminal.