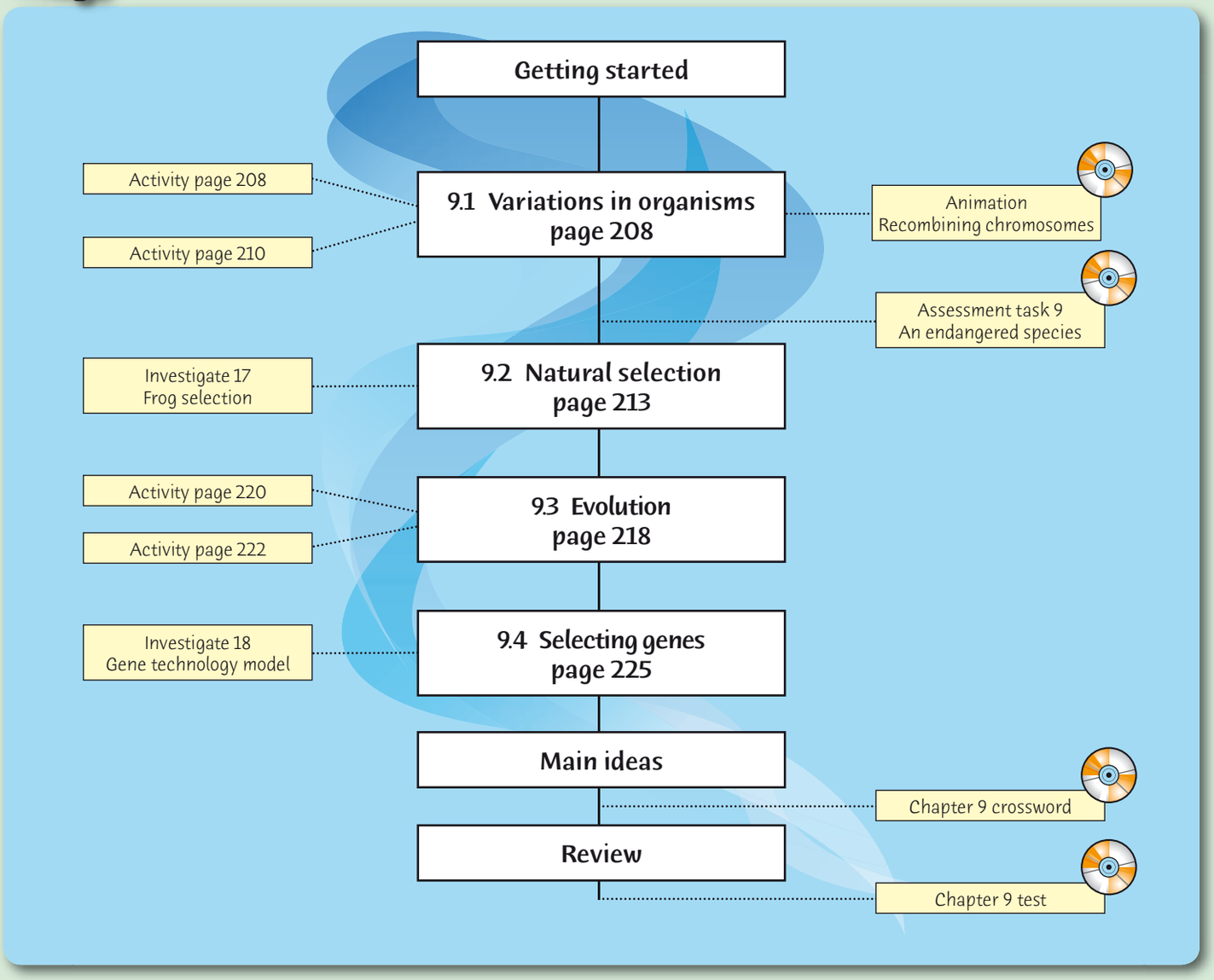
9 Species survival

Planning page



Essential Learnings for Chapter 9

Essential Learnings	References		
	Student book (page number)	Workbook (page number)	Teacher Edition CD (Assessment task)
Knowledge and understanding *Life and living* The diversity of plants and animals can be explained using the theory of evolution through natural selection	pp. 213–224	Exercise 3 p. 70 Exercise 5 pp. 72–73	Assessment task 9 An endangered species
Science as a human endeavour Responsible, ethical and informed decisions about social priorities often require the application of scientific understanding		pp. 67–68 p. 76	Assessment task 9 An endangered species
Ways of working Draw conclusions that summarise and explain patterns, and that are consistent with the data and respond to the question	Investigate 17 pp. 214–215 Science in action p. 216		
Evaluate data, information and evidence to identify connections, construct arguments and link results to theory	pp. 218–224	Challenge Exercise p. 72	
Reflect on learning, apply new understandings and justify future applications	pp. 229–232	pp. 67–68 p. 76	

QSA Science Essential Learnings by the end of Year 9

Vocabulary

artificial selection
biotechnology
cloning
comparative anatomy
complementary base
embryos
environmental
evolutionary
genetically modified
Gondwana
haemoglobin
independent assortment
ligases
offspring
pesticides
populations
recombinant DNA
sickle cell anaemia
species
transgenic

Focus for learning

Discuss variations in organisms, the work of Charles Darwin and endangered species (page 206).

Equipment and chemicals (per group)

Activity page 208	ruler or metre rule
Activity page 210	playdough (2 different colours)
Investigate 17 pages 214–215	three different colours of frog cards (20 red, 20 green and 20 yellow), a die
Investigate 18 page 228	about 100 coloured paper clips (4 colours—red, green, yellow and blue), strip of cardboard 7 cm × 50 cm, scissors

Special preparations

Investigate 17 pages 214–215 You will need A4 sheets of red, green and yellow card (about 120 gsm) which are available in newsagents. To prepare the frog cards, print the frog template from the teacher CD in the back of this book. Use these 24 frogs as your photocopy template, and copy enough frogs on red card for the whole class—these are the red frogs. Do the same for the green and yellow frogs.

9 Species survival

Getting Started

Form into a small group and discuss the following questions.

- Two orange trees were grown from cuttings so are genetically identical. The trees were planted in different areas many kilometres apart. One tree produced many kilograms of sweet oranges, the other tree produced a small number of small-sized fruit.
  If the trees have the same genes, why are they so different?
- Charles Darwin was a naturalist (biologist) on board the ship HMS *Beagle*. Between 1831 and 1836 the ship sailed along the coastline of South America and then across the Pacific. It docked in Sydney on 12 January 1836. Why is Darwin famous?
- The photo shows a Leadbeater's possum. It is a highly endangered species and the small population of possums is protected by law. It is found only in the Victorian central highlands, where it lives in hollow parts of trees in old growth forests.

What does *endanged species* mean? Why do you think the population of the possum is now very small?

Starting point

1 You could have students investigate the questions in Getting Started using the Placemat method of problem solving. (See Learning experience, page 105.) Allow sufficient research and preparation time. Once the groups have recorded their responses they should rotate around the room to view other groups' responses to the questions.

2 Students could create a mural using images of endangered organisms from their own photo collections, magazines or newspapers. The mural could be displayed in the classroom or a hallway. For each organism students should include its name, its habitat and where it is found. Set a challenge of adding a new organism to the mural for each science lesson during the chapter. This is a good task for fast-working students as they can do this when they have finished the set class work. Consider having a mural of only Australian endangered species. Remind students that plants can be endangered too.

3 What do students already know about this chapter? Familiarise yourself with the material students learned in *ScienceWorld 2* Chapter 11, and construct a pre-test using key ideas from it. After evaluating student responses, revise any necessary material.

4 Students could set some goals for this chapter. Goal setting is an important part of student progress. However, it is only useful if students are given time to reflect on their progress and modify their goals if necessary. Remind students that their goals do not have to be specific to this chapter—they can include goals for practical skills, teamwork, improving test grades and so on. A fun and useful way is getting students to use the step method. Students think about, plan for and document what they want to accomplish and how they are going to do it, then draw a visual diagram of steps/stairs to show their step-by-step process. Goals can be modified throughout the chapter and recorded.

9.1 Variations in organisms

You found out in the last chapter that genes control many of the characteristics in humans. Earlobe attachment, the ability to roll your tongue into a tube, and the colour of your hair, eyes and skin are some of these characteristics.

Earlobe attachment is controlled by one pair of genes. Therefore, this characteristic has two phenotypes—you have attached earlobes ot unattached earlobes.

Most other human characteristics such as height, weight, hair colour and skin colour are controlled by more than one pair of genes. This produces a range of phenotypes. For example, the colour of your eyes is controlled by at least three pairs of genes on different pairs of chromosomes. Some other genes may turn these genes off and on. So it is the way all of these genes combine that determines the exact colour of your eyes. And it is this combination that creates the wide range of variation in human eye colour.

Variation in hair colour and skin colour, and such characteristics as head and face shape, are also due to the interaction of many genes.

Fig 3 Hair colour is controlled by many genes.

Activity

In this activity you will need data from all the members of your class.

1 Find out how many people in the class can roll their tongue, and how many cannot.

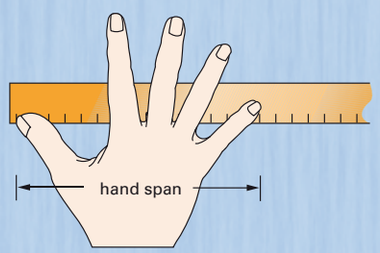
Record your results.

2 Measure the hand span of your right hand to the nearest 1 cm. To do this stretch your fingers out as wide as you can. Then place the tip of your thumb on the zero mark of a ruler and measure to the tip of your little finger.

Record your results.

3 Draw up a table to record the hand span data for the class. It is best to group the results in 5 cm intervals.

First, find out who in the class has the smallest hand span and who has the largest. Use these measurements to work out the range of your 5 cm intervals.



For example, if 160 cm is the smallest hand span and 219 cm is the largest, the first 5 cm interval will be 160–164, and the last will be 215–219 cm.

Draw a bar graph of the class data for tongue rolling. Then draw a bar graph for hand spans.

Suggest why the two bar graphs are different.

Hints and tips

Each person is unique. There are no two people exactly alike—even identical twins have differences. If one organism has the same genes as another, then what causes the differences? Have a discussion about variation in organisms and what can contribute to variations. If there are identical twins in the class, have students identify physical differences between them.

Activity notes

- It is worth explaining that the data collected for students being able to roll their tongue is categorical data—can or cannot roll tongue. The numerical data for hand width is usually graphed using class intervals, so a bar or column graph can be used, although a histogram is preferred, as the data is continuous.
- If graphs are drawn by hand, remind students to use rulers, use an appropriate scale and add labels.
- Using the tongue-rolling data, ask students to infer which characteristic is the dominant one and which is the recessive.

Research

Have students research variation in eye colour and find out which genes are responsible for it. Brown eyes are dominant over blue eyes. Hazel and black eyes are genetically considered brown, while green and grey eyes are considered blue. Kittens and puppies are often born with blue eyes, but later change. Is this the same for human babies? If so, explain what causes eye colour to change. Students could present their findings in the form of an informative poster or concept cartoon.

Learning experience

A good way to start new material is by having students construct a Y chart of their ideas about a topic. In each division of the chart they could answer the following: 'What I want to know', 'What I already know' and 'How I can find out more'.

The source of variations

The horticulturist in the photo below is taking cuttings from a geranium that produces good flowers. She knows that the cuttings from this plant will produce plants that produce exactly the same quality of flowers as the parent plant. This is an example of asexual reproduction. It does not produce variation in the offspring.

Fig 5 A horticulturist takes cuttings from the parent plant. These cuttings will grow into plants identical to the parent plant.

As you have seen in the last chapter, organisms that reproduce sexually produce variations in the offspring. There are three main ways that this occurs:

- *independent assortment* of chromosomes during cell division in the reproductive organs
- *recombination* of genes in chromosome pairs during sex cell division
- *mutations* in the DNA in the cells in the testes and ovaries.

1 Independent assortment

You found out earlier that a cell with three pairs of chromosomes could produce sex cells with eight different combinations of chromosomes.

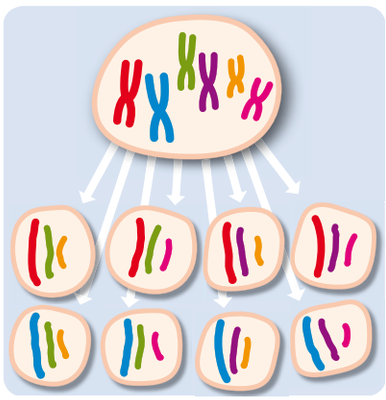


Fig 6 An organism with three pairs of chromosomes can produce eight different types of sex cells.

In humans with 23 pairs of chromosomes, there are about 8 million different possible combinations of chromosomes in the sex cells. This is why siblings look similar but not identical to each other and to their parents! The production of different arrangements of chromosomes in sex cells is called *independent assortment*.

extra for experts

The numbers game

A cell with two pairs of chromosomes can produce sex cells with four different arrangements of chromosomes. A cell with three pairs of chromosomes can produce sex cells with eight different arrangements of chromosomes. How many different types of sex cells can a fruit fly whose cells contain four pairs of chromosomes produce?

Use the data to work out a formula to calculate this. Then calculate the different types of sex cells an organism that has seven pairs of chromosomes can produce.

Learning experience

The genetics of hair colour is not yet fully understood. Different shades of hair colour occur because of the differing amounts of pigments (melanin). There are two kinds of melanin—eumelanin and phaeomelanin. If hair has a lot of eumelanin, it will be black. If it has only a little eumelanin, it will be blond. The amount of eumelanin in hair is determined by our genes. It is suggested that at least two gene pairs control human hair colour. One gene is a brown/blond pair and the second is for redness. It is often said that the brown/blond pair has a dominant brown allele (B) and a recessive blond allele (b). However, this doesn't account for various shades of hair colour.

It is better to consider the possibilities for these two genes as either *on* or *off*. When the genes are on, they make eumelanin; when they are off, they don't make anything. The more eumelanin genes that are on, the darker the hair will be. Suppose there are 4 eumelanin genes that determine hair colour. A person gets 4 copies of each gene from each parent, making a total of 8. If one of these hair colour genes is on, represent it as B; off is then represented by b. So someone with very dark brown hair (black) would be BBBBBBBB and someone with very blond hair would be bbbbbbbb.

Using this information, get students to explain how two brown-haired parents can produce a blond-haired child. Is it possible to have two blond-haired parents with a brown-haired child? Ask students to explain. What combinations of hair colour can be made?

Hints and tips

- It might be necessary to have a refresher lesson on sexual and asexual reproduction.
- The mathematical formula for the number of different types of sex cells in an organism is 2^n, where n is the number of chromosome pairs (independent assortment). For humans it is $2^{23} = 8\,388\,608$ (over 8 million). This means there are over 8 million possible arrangements for both ovum and sperm cells.

Homework

Albinism is the inability to make melanin. It usually affects skin, hair and eye colour. The trait is recessive and can be represented by the allele **a**. Students could do a Punnett square for albinism, using **Aa** for a heterozygous male and female. For two heterozygous parents, what is the chance of having a child with albinism?

Learning experience

Write a fill-in-the-gaps worksheet for the students to complete using the information on pages 208–211. Add some higher order thinking questions for fast-working students, and make sure to assist those with language difficulties. It might be helpful to suggest students work in pairs and check each other's answers. Some examples of higher order thinking tasks are:

- If identical female twins become pregnant by sperm from the same male, will their children be exactly the same if they have the same sex offspring?
- Show mathematically how there are about 8 million different possible combinations of chromosomes in sex cells.

Hints and tips

Point out that the mutations that occur in body cells (other than sex cells) will not be inherited. Mutations that occur in sex cells, however, can be inherited.

Activity notes

A simple recipe for playdough is as follows.

- 2 cups plain flour
- 1 cup salt
- 2 tablespoons cooking oil
- 4 tablespoons cream of tartar
- 2 cups water
- food colouring as required.

Mix the ingredients together in a saucepan and stir over medium heat for 3–5 minutes until the mixture congeals. You will need to stir continuously and vigorously. Knead the mixture lightly and store in an airtight container, preferably in a fridge.

- Food colouring can be used to make different colours.
- Plasticine is an alternative to playdough.
- Give clear instructions and watch that students use the playdough or plasticine properly and do not put it into locks, power points, gas taps, etc.
- Another alternative to playdough is to use jelly snakes. Sections of snakes can be cut and pressed together, then eaten afterwards! Be sure to check for any students with food intolerances.

Learning experience

Students could grow some genetic barley that has a mistake in the chloroplast gene. Packets of 200 seeds can be obtained from the CSIRO but they are quite expensive, so use them efficiently. Each packet of seeds contains barley with approximately even numbers of GG, Gg and gg seeds. GG and Gg seeds produce green crops, while gg seeds produce white crops. Seeds can be grown in plastic petri dishes on moist cotton wool. Ask students to predict what the ratio of white shoots to green shoots is likely to be. Get students to draw some Punnett squares to show the inheritance of shoot colour if fertilisation took place between the plants.

2 Recombination

During the production of sex cells in the testes or ovaries, the pairs of chromosomes sometimes swap bits of each other, resulting in a different arrangement of genes on the chromosomes.

In the diagram below, the top section of the DNA on a pair of chromosomes exchanges. This process is called *crossing-over*, and it results in a **recombination** of genes in a pair of chromosomes.

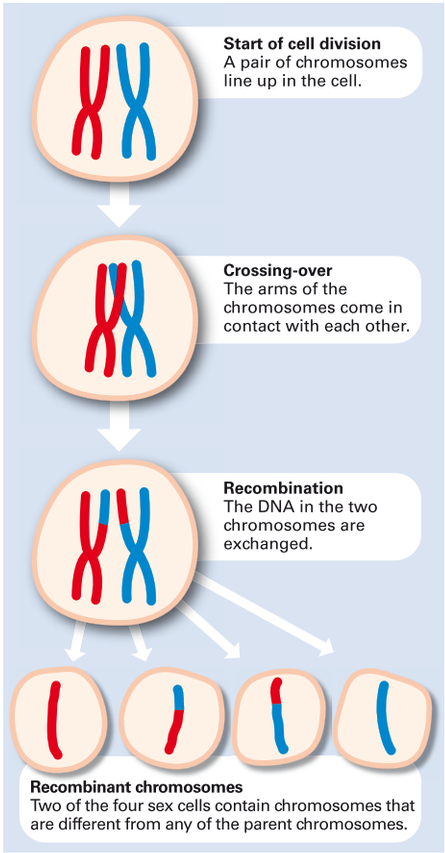


Fig 7 Crossing-over produces a different combination of genes in the chromosomes in the sex cells.

Activity

Recombining DNA

You will need two different colours of playdough for this activity. This is a simple hands-on activity to show you how chromosomes cross-over and result in a recombination of genes.

1. Using one colour of playdough, make two chromosomes the size of a pencil.
2. Lie them side by side and squeeze them together about halfway along their length so that they make a H shape.
3. Repeat Steps 1 and 2 using the other colour of playdough.
4. Use Fig 7 as a guide to show how the two chromosomes can cross-over and recombine.

Challenge: Use your model to show that if two genes are a long way apart on a chromosome, they have a greater chance of recombining by crossing-over.

To see how crossing-over creates a new assortment of genes on chromosomes, open the **Recombining chromosomes** animation on the CD. Working with technology

3 Mutations

When the base sequence in a gene is changed, it is highly likely that the proteins that are produced by this gene will be different from the original. The random changes to the DNA are called mutations.

Mutations in body cells cause little or no change to the organism, although cancerous tumours can develop from these mutations. However, if mutations occur in a sex cell, the changed DNA may be passed to the next generation when fertilisation occurs.

Learning experience

Writing reviews of media articles is one way students can do ongoing assessment. Have them scrapbook articles relating to this chapter and write reviews. Each entry should include the date of the entry, the article date, its source, a summary of the article in point form, possible effects on society now and in the future, and the student's viewpoint of the content of the article. You could make this a very simple ongoing homework activity as it promotes science literacy and can be used to initiate class discussions.

Hints and tips

It is important to give the students ongoing assessment. It is just as important to provide meaningful feedback that assists their learning and allows them to see improvement in their knowledge and understanding. One way is to give two similar tasks but at different times during the chapter, so that students can act on your feedback.

Effects of the environment

This mandarin tree is loaded with sweet, juicy mandarins. About 100 km away, mandarin trees bear very few, fairly dry fruit. Why is this, when all the mandarin trees came from the same stock? The juicy mandarins are grown in an area that has had good autumn rain; the other area has had very low rainfall. Cold weather occurred at the start of winter, which increased the sugar in the juicy mandarins. The other area has had unusually warm weather.

Even though the mandarin trees have the same genotype, the environmental conditions have produced different phenotypes. The trees have the same alleles, but they are expressed differently because of the different environments they are in.

The young boy in the photo below has grown up in a country ravaged by malnutrition and disease. His growth is stunted, his immunity to disease is poor and his mental development may be limited—all because of environmental conditions.

It is the combination of genetic and environmental factors that determines the characteristics of a population of organisms. The genes determine the potential phenotype of an organism, while a combination of the genes and the environment determines its actual phenotype.

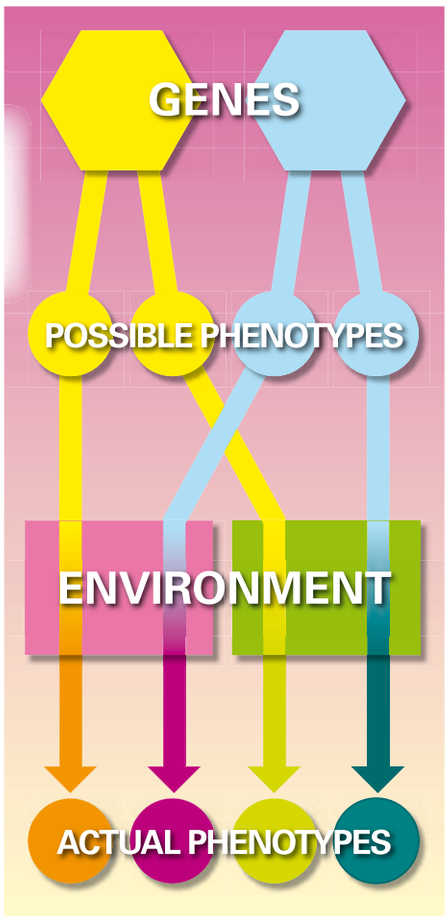


Fig 11 The characteristics of a population of organisms are determined by the environment as well as by the organism's genes.

Research

What does it mean to have a 'predisposition' to a medical disorder? Heart disease, melanoma and other cancers, and spina bifida are some conditions that a person may develop if triggered by environmental factors. In pairs, students could research a disorder which is due to a combination of genetic and environmental factors. Have them list the various factors and ways to avoid or reduce the effects of these factors (eg to avoid melanomas caused by ultraviolet radiation, cover up when in the sun). Students should also explain the disorder's symptoms, what treatment is available, any ongoing health issues as a result of the disorder, and if it is possible to genetically correct the disorder.

They could then present their work as an advertisement about the disorder, using simple explanations and neatly labelled diagrams so that a non-scientist can understand the information. Encourage students to work creatively. Visual learners could draw diagrams or cartoons, those whose preferred learning style is auditory might make a voice recording, and so on.

Learning experience

An activity students will find interesting is to do a height survey. (It is useful to do this before doing the theory, as it promotes thinking about the effects of the environment and genes.) In a table, students record the heights of each class member and the heights of each of their parents—it's a good idea to have students collect the data prior to this lesson. Make sure the sample size is greater than about 20.

On a graph, plot all three sets of data. What does the graph suggest? Is there a correlation between student height and parent height? Are these results a good representation of the world's population? Ask students to explain.

Have students investigate continuous and discontinuous variation. Height is a continuous variation characteristic. Characteristics such as albinism or tongue-rolling are examples of discontinuous variation. Is a person's height influenced by environmental factors? Discuss.

Learning experience

Students could take cuttings from geraniums or other plants that are easy to strike and fast growing. Allow the students to take care of the cuttings at home. After quite a few weeks, ask the students to bring the plants back to school for examination. Are the plants identical to each other? Have some grown faster than others? Does each plant have the same leaf shape? Compare and contrast the plants. How different are they from the parent plant? Their genetic composition may be the same but their appearance might be different because of different environmental influences.

A begonia plant can be grown from a cross-section of part of its leaf. Students find this quite fascinating and it is worth the effort to grow them. (Further information can be found in *ScienceWorld 1* page 201.) Consider doing the plant cuttings with the students earlier in the year so that they are ready for them to examine by the time you reach this chapter. Avoid telling the class the plant's ideal growing conditions because the purpose of this investigation is to see the effects of different environmental factors.

Check!

1 How do you account for the fact that some people have attached earlobes and others have unattached earlobes, while there is a wide range in the shapes and sizes of ears?

2 a Where does independent assortment occur in the body?
b What is the importance of the word *independent* in this process?
c Explain how this process produces variations in organisms.

3 What is crossing-over? Use a diagram to show how it is a source of variations in organisms.

4 Explain why a mutation in the cells in the skin does not affect the variation in future generations, whereas a mutation in the sex cells may.

5 Explain how variations in a population are caused by genetic factors as well as by environmental factors.

6 Explain, giving an example, how a particular environmental factor can affect the phenotype of an organism. (Do not use the examples in this book.)

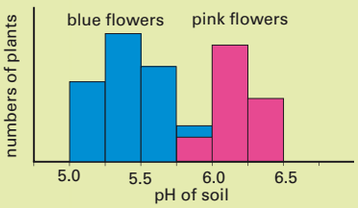
challenge

1 The particular type of Siamese cat in the photo has light fur on its body except on its face, ears, tail and legs. This cat carries a gene that makes a heat-sensitive version of the enzyme involved in making the dark colour (melanin) in the fur.

a Suggest why the extremities of the cat's body have darker fur.
b Do you think that the enzyme is turned off or turned on by high temperatures? Give a reason for your answer.
c When the cat was a kitten, a patch of fur from its back was removed and the skin kept warm until new fur grew. Would you expect this fur to be dark or light? Explain.

2 In biology books you often see the term *gene expression*.
a Suggest what this term means.
b Use biology books or the internet to find a definition of the term. In what ways is this definition different from yours?
c Use the example in Challenge 1 to explain how the environment can affect gene expression.

3 Hydrangea plants produce pink flowers and blue flowers depending on the acidity of the soil, as shown in the graph.



a Write a generalisation about the colour of flowers and the pH of the soil.
b What is the best soil pH for growing blue flowers? For growing pink flowers?

4 The colour of skin is controlled by three genes, each found on different chromosomes. The alleles for dark skin are M_1, M_2 and M_3, and they are dominant over the alleles for pale skin—m_1, m_2 and m_3. For example, a person with the darkest skin would have the alleles M_1M_1, M_2M_2 and M_3M_3.
a What genes would a person with the palest skin carry?
b How many combinations of skin colour are possible with these genes?
c Predict the shade of skin colour a person with the alleles M_1m_1, M_2m_2 and M_3m_3 might have.
d Is your prediction in **c** accurate? What other factors might affect the phenotype of this person?

Check! solutions

1 The reason is that one pair of genes will determine whether the lobes are attached or unattached. The other characteristics, such as the size and shape of ears, are controlled by more than one pair of genes.

2 a Independent assortment of the chromosomes occurs during meiosis in the sex organs of animals (testes and ovaries) and plants (anthers and ovaries). Meiosis results in the formation of new sex cells.
b It is independent because when the pairs of chromosomes separate to form two new sex cells, each new chromosome may go to one new cell or the other, independently of any other chromosome pairs.
c This independent assortment provides for many different combinations of chromosomes in the sex cells and therefore great genetic diversity. In humans there are approximately 8 million (2^{23}) different combinations in each cell.

3 Crossing-over occurs when the corresponding sections of the chromosome pairs break and rejoin, thereby exchanging genetic material and allowing for new combinations of alleles in the offspring. This is clearly shown in Fig 7 in the textbook.

4 A mutation in a skin cell, or any other tissue cell, cannot be transmitted to the next generation, whereas a mutation in a sperm or egg cell may be. If it is, then as the fertilised cell divides and an organism grows, all cells in the body will contain the mutated gene.

5 Variations in a population are caused by:
- genetic factors such as mutation, independent assortment and recombination
- environmental factors such as nutrition, disease, weather, temperature, pH and salinity.

6 The phenotype depends on the genotype but is also affected by environmental factors. Everyday examples include:

Your growth, which depends not just on the genes you have from your parents, but also nutrition and exercise and possibly serious injuries or disease that could occur during your life.

The growth of plants, which will depend on factors such as availability of water and the fertility of the soil.

Challenge solutions

1 a It is most likely that the extremities of the cat's body are a darker colour because they are generally at a lower temperature than other parts of its body. If so, this will change the activity of the enzyme that makes the coloured pigment.
b If this idea is correct the enzyme will work better at lower temperatures.
c If this experiment was done you would expect the fur to be light-coloured, because the enzyme would not be activated.

2 a You probably thought that 'gene expression' refers to the way that a gene works and this can usually be seen in the phenotype of an organism.
b If so, you were right!
c In the example above, the expression of the gene that makes the colour in the cat's fur is affected by the temperature of the cat's skin.

3 a Generally it can be said that in acidic soil (pH of 5–5.5), the colour of the flowers is blue, and in less acidic (pH 6–6.5) soils, the colour is pink.
b The best way to grow blue flowers is to add chemicals to the soil to make it more acidic. The best way to grow pink flowers is to make sure the soil is only slightly acidic.

9.2 Natural selection

Most organisms produce many more offspring than their habitat can support. If these offspring are produced by sexual reproduction, they will show variations of characteristics. Some of these characteristics will give the offspring a better chance of survival than others. Individuals with these particular characteristics are said to be better *adapted* to the environment. Individuals with unfavourable characteristics will usually die before they are able to reproduce.

Biologists say that the environment has selected certain characteristics for survival. This process is called **natural selection**, and is sometimes refered to as *survival of the fittest*. This means that the best adapted individuals will survive in a particular environment. It does not always mean that the largest, most muscular and physically fit individuals survive. In some cases smaller or slower organisms may be better suited to a particular environment. For example, shrubs that grow close to the ground and have small leaves will be better suited to a windy environment than tall, large-leaved trees.

Selection agents in the environment

The factors in an organism's environment which affect its survival are called *selection agents*. These agents can be divided into two groups:

- biotic agents, including predators, disease, competition between members of the same species, and availability of food
- abiotic agents, including heat, cold and wind, availability of oxygen and water, pH of soil and water, and availability of living space.

The 'fittest' organisms are those which can reduce the effects of these selection agents.

In the investigation on the next page you can use a model to help you understand how natural selection works.

Fig 14 The flowers on this plant will produce more seeds than can survive. The seeds have slightly different genotypes and only the ones best adapted to this environment will survive.

Fig 15 The plants that grow successfully on sand dunes can survive on very little water and withstand the damaging effects of salt spray, strong sunlight and strong winds.

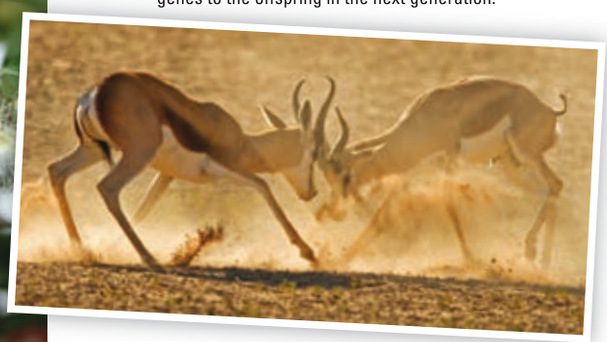
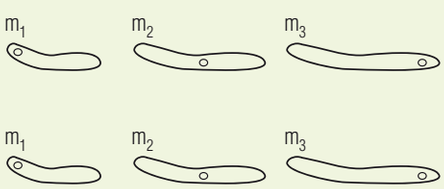


Fig 16 Male antelopes often compete for the breeding females in a herd at mating time. The male that wins passes his favourable genes to the offspring in the next generation.

4 a The person with the palest skin would carry all 'm' genes (i.e. m_1m_1, m_2m_2, m_3m_3), as shown below:



b There are three possible genotypes for each set of genes (eg M_1M_1, M_1m_1 and m_1m_1). Therefore, there are $3 \times 3 \times 3 = 27$ possible genotypes for skin colour. However, there are only 4 possible phenotypes depending on whether an individual has 0, 1, 2 or 3 of the dominant genes.

c This person will have the darkest possible skin because they have 3 dominant genes.

d The prediction might not be accurate because of environmental factors, eg amount of sunlight and diet.

Hints and tips

- You could revise the material taught so far by giving the class a quick quiz. This will identify any concepts that need to be revised. Ask the students to write the answers only (no need for the questions). Make sure to ask some questions that test understanding rather than just remembering.
- Reinforce the difference between biotic and abiotic factors.

Homework

Polar bears have black skin, thick white fur coats and small ears. Ask students to try to explain how these adaptations allow them to live in their icy habitat.

Learning experience

Prepare and show a slide show of different organisms. Ask students to list possible adaptations that each organism may have to help it survive. Adaptations can be functional, structural and behavioural. Get students to find out what characterises each type of adaptation. Show the slide show again; this time, discuss the different *types* of adaptations.

Learning experience

Develop a class chart with the students, listing the factors/influences which contribute to the survival of organisms. The chart can then be added to progressively. Divide the chart into three groups: 'Functional', 'Structural' and 'Behavioural'. Pin the chart up in the room or save the document for future use if it is done electronically.

Lab notes

This activity is rather complex but works very well. It may take several lessons to complete with the tables, graphs and questions. It is best done in pairs or groups of three.

Part A

- Prepare the frog cards prior to the investigation.
- There is a frog template on the teacher CD in the back of the book. Photocopy the template onto A4 sheets of red, green and yellow card and then carefully cut them. Make sure you have a complete set of frog cards.
- It is a good idea to read through the method with the class before they start, and spend time answering any student questions.

Investigate

17 FROG SELECTION

Aim

To use a model to show how natural selection affects two populations of frogs.

Materials

- three different colours of frog cards—20 red, 20 green and 20 yellow (for preparation see the Teacher note)
- a dice

Teacher note: You will need A4 sheets of red, green and yellow card (about 120 gsm) which are available in newsagents. To prepare the frog cards, photocopy the frogs below so that you have 24 frogs on a sheet of white paper. Photocopy enough frogs on red card for the whole class—these are the red frogs. Do the same for the green and yellow frogs. There are also frog templates in the Teacher Resource Book.

Planning and Safety Check

- It is important you know exactly what to do before you proceed. Carefully read through the investigation. Then test your knowledge by telling your partner what you have to do and what you have to record.
- Prepare data tables for your results for the POND and the FOREST before you start.

Background

You will be investigating the process of natural selection in two different and separate environments—a pond and a rainforest. The pond is surrounded by reeds and rushes which are yellowish in colour, while the forest has much leafy green vegetation.

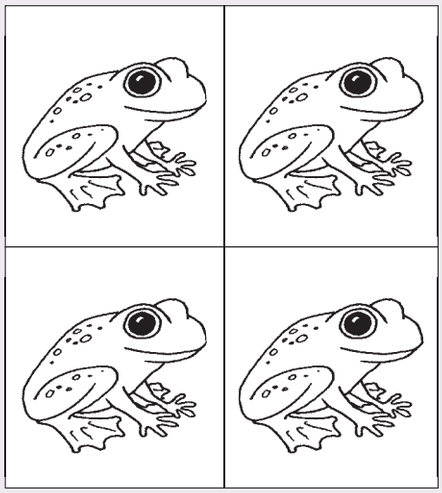
You will look at only two organisms in these environments—a frog which occurs in three colours, red, green and yellow, and a snake which is a predator of the frog.

In this model, for simplicity, assume that each pair of frogs produces one offspring each year, and that snakes eat 15 frogs each year.

PART A
The frog population

Method

1. Write POND on a sticky label and FOREST on another. Then stick them apart on a table. These labels represent the location of the two environments.
2. Count out 10 red frogs, 10 green frogs and 10 yellow frogs and place them in one of the two environments. Shuffle the cards thoroughly and place them at *random* into 15 pairs.
3. Repeat Step 2 for the other environment.
4. Each pair of frogs produces *one* offspring a year. To work out the colour of the offspring use Table 1 and Table 2. Then add the correct coloured frog to each pair.



Notes

1 The three different colours of frogs are the same species and can interbreed and produce different coloured offspring.

2 If the parents in Table 1 produce more than one colour of offspring, throw a dice and use Table 2 to work out the colour.

Table 1

Colour of parents		Colour of offspring
red x red	=	red
yellow x yellow	=	yellow
red x yellow	=	green
red x green	=	some red, some green—see Table 2
green x green	=	some red, some green, some yellow—see Table 2
green x yellow	=	some green, some yellow—see Table 2

Table 2

Number on dice	Colour of offspring		
	red x green parents	green x green parents	green x yellow parents
1	red	red	green
2	red	red	green
3	red	green	green
4	green	green	yellow
5	green	yellow	yellow
6	green	yellow	yellow

PART B
Predation by snakes

Method

1 Around the pond, the red frogs are the most likely to be eaten and the yellow frogs the least. In the forest the yellow frogs are most likely to be eaten and the green frogs the least.

2 Mix all the frog cards for the POND, throw a dice and use Table 3 to decide which 15 frogs are eaten. Remove an appropriately coloured frog each throw. (Note: If there are no frogs of a particular colour left, roll the dice again.) Do the same for the FOREST.

3 After the 15th frog has been removed from each environment, tally the numbers. Record the numbers in the Year 2 row in the data tables you have prepared. (The POND data table is shown as an example.)

4 Repeat Parts A and B for 10 years or until all the frogs are the same colour.

Table 3

Number on dice	Pond	Forest
1	red	yellow
2	red	yellow
3	red	yellow
4	green	red
5	green	red
6	yellow	green

Results: Pond

Year	Red frogs	Green frogs	Yellow frogs
1	10	10	10
2			
3			
4			
5			

Discussion

1 Suggest why the red frogs around the pond are most likely to be eaten by snakes. Why are the yellow frogs most likely to be eaten in the forest?

2 Draw a fully labelled line graph of the changes in the numbers of the different coloured frogs around the pond over 10 years. Do the same for the forest.

3 Compare your results with those from other groups. Why are the results similar? Why are there some differences?

4 Write a conclusion for this experiment. Use the words *model* and *natural selection*.

Lab notes

Part B

- Data tables could be prepared with the class and drawn in their prac books, or photocopied sheets could be given, ready to be filled in.
- An alternative activity, if there are enough students in the class, is to repeat the investigation using students as frogs. Divide the class into three groups with an even number of students, so that when the groups are combined, pairs can be formed. Assign the students different frog colours—students who are red frogs are given a red frog card and so on. Any leftover students can be dice-rollers or snakes.

  Modify the number of frogs eaten by snakes to suit the initial frog population—if you have 20 frogs then only 10 frogs are eaten by snakes each year. Have the two different frog environments on opposite sides of the room.

  This activity is fun but requires a lot of teacher/student coordination. (For class sizes of less than 20 students it is not very successful.)

Science in action

Sickle cell anaemia

Sickle cell anaemia is a blood condition caused by a mutated gene. The allele produces an abnormal type of haemoglobin (the red pigment found in red blood cells) which turns the normally concave disc-shaped red blood cells into sickle shaped cells.

The abnormal haemoglobin allele is recessive to the allele that codes for normal haemoglobin.

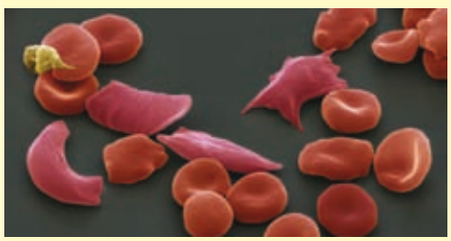


Fig 19 Normal red blood cells are rounded, in contrast with the distorted sickle-shaped cells (pink).

The sickle red blood cells are much less efficient at carrying oxygen than the normal cells. They also have a 'sticky' surface and the cells tend to stick together, causing blockages in blood vessels. This causes painful and sometimes fatal conditions such as heart attacks.

Most people who carry both abnormal haemoglobin alleles die in childhood. However, because the alleles are *co-dominant* (like human blood types on page 200) some of the blood cells of heterozygous people contain abnormal haemoglobin.

If sickle cell anaemia is fatal why then does the allele still exist in the human population?

Sickle cell anaemia and malaria

Sickle cell anaemia is much more common in Africa, India and parts of the Middle East than elsewhere in the world. Fig 20 shows the percentage of people in the population with the allele for abnormal haemoglobin.

Fig 21 shows the areas affected by malaria. The parasite that causes malaria lives in red blood cells and eventually destroys them, causing the death of the infected person. The parasite for some reason cannot live in cells that contain abnormal haemoglobin.

Questions

1 What does co-dominance mean?
2 What alleles would a person carry if they were homozygous for normal haemoglobin?
3 If sickle cell anaemia is fatal how does the allele stay in the population?
4 Why is it an advantage for people who are heterozygous for sickle cell anaemia to live in areas where malaria is common?
5 Suggest how *survival of the fittest* might apply to people with sickle cell anaemia.
6 Suggest how sickle cell anaemia might have originated in the human population.

Fig 20 The percentage of people carrying the sickle cell allele

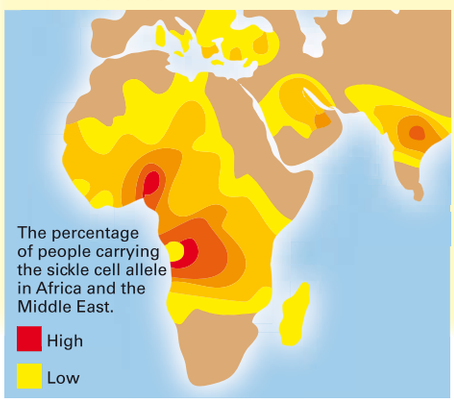


Fig 21 Areas in Africa, India and the Middle East where malaria is prevalent

Hints and tips

Students could Think/Pair/Share their answers to the questions. Make sure you go through each question with the class to check that they understand it.

Learning experience

Gifted and talented students might like to investigate other genetic disorders that appear to be regional, affect one ethnicity more than another or are highly influenced by environmental factors. For example, Tay-Sachs disorder is an interesting condition: about 1 in 25 Ashkenazi Jewish Australians (descendants of central and eastern European Jews) are genetic carriers. The inheritance pattern is described as autosomal recessive inheritance, meaning it is a recessive condition. Students could investigate the following questions:

- If only one parent is a carrier of the recessive gene, what are the chances that their offspring will inherit the disorder?
- What if both parents have the recessive gene?
- Why do you think this disorder has affected this particular group of people?

Check!

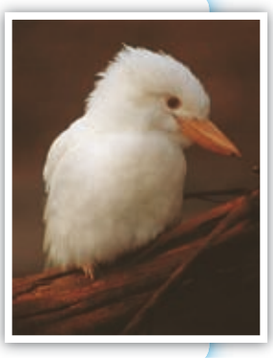
1 In your own words describe what is meant by the term *natural selection*.

2 A spider has spun a large web between two trees. Describe the selection agents which might affect the spider's survival.

3 What does *survival of the fittest* mean? Give two examples of where this could apply.

4 How does 'survival of the fittest' apply to the people in the malaria regions of West Africa? Describe the selection agents in this case.

5 The albino kookaburra in the photo is in a wildlife sanctuary. Why do you think that an animal with this phenotype would have little chance of survival in the wild?



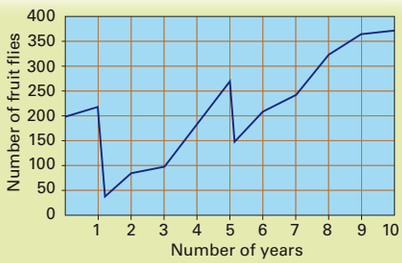
challenge

1 Explain why natural selection works only if:
- **a** there is variation of characteristics within the species
- **b** characteristics are inherited.

2 About 65 million years ago, the Earth was inhabited by many species of dinosaurs. Some of them were herbivores but others were very efficient predators. Why did these enormously strong animals become extinct if they were such powerful and efficient predators?

3 The dodo was a flightless bird found on the island of Mauritius in the Indian Ocean off the coast of Africa. It laid one large egg in a nest on the ground. The dodo has been extinct since about 1680. Europeans who came to the island 100 years before this brought cats which ate the young chicks and pigs which ate the eggs.
- **a** Suggest why the dodo survived for so long prior to European settlement, and then became extinct so quickly.
- **b** Describe the selection agents in this case.

4 The graph is for a population of fruit flies that was sprayed with an insecticide.
- **a** How many times were the fruit flies sprayed with insecticide?
- **b** Why didn't all the fruit flies die after the first spraying?
- **c** How many fruit flies died after each spraying? Suggest reasons for the difference in the numbers.



- **d** What is the selection agent in this study?
- **e** Predict what might happen if the fruit flies were sprayed with a different insecticide after 10 years.

5 The butterfly in the photo has eye spots on its wings. When the butterfly rests on plants, it folds its wings so that the eye spots are not visible. However, when disturbed by a predator the butterfly opens its wings and displays the large eye spots.

- **a** How do the eye spots help the survival of this type of butterfly?
- **b** Can you think of any situations where this characteristic might be a problem for the butterfly?

Check! solutions

1 Natural selection is the process in which nature selects those organisms that are best suited to conditions. In other words, in nature, some live and most die.

2 The purpose of the web is to trap small animals, which the spider then eats as food. Any factors that destroy the web will threaten the survival of the spider.

Biotic factors, such as humans, other large animals (eg kangaroos) or birds, might destroy the web or part of it.

Abiotic factors, such as strong wind or rain, or very hot, dry conditions, might also destroy the web.

3 Survival of the fittest does not necessarily mean the biggest and strongest. For example, the smallest hummingbird with the longest beak will be best suited to extracting nectar from flowers. Also, the flower that is coloured most brightly and has the sweetest nectar will attract the hummingbirds.

4 In West Africa there is a genetic disease called sickle cell anaemia that causes the red blood cells to be a different shape. Although this means the people are ill and lethargic, it provides protection from a parasite that causes malaria and possibly death. As a result, the frequency of people with anaemia is high. In this case the 'fittest' people are those with the anaemia.

5 In the wild, most animals have coats or feathers that are of a similar colour to their surroundings. This is called camouflage. This helps them avoid detection by predators and may also help them if they are preying on other animals. The albino kookaburra would be easily seen in the wild and would probably starve to death or be eaten by another animal while it was still young.

Challenge solutions

1 a During natural selection only those organisms with favourable characteristics survive and reproduce. If there is no variation within the species then it is likely that they will all live or all die when facing a change in the environment.

b Those organisms that survive and reproduce pass on their successful genes to their offspring. This means that the next generation will, on the whole, be better adapted to the environment.

2 The extinction of dinosaurs is a good example of what happens when natural selection and evolution do not happen as quickly as environmental change. It may be that a comet hit the Earth and the dust blocked the Sun and caused an ice age, or it may be something else that led to extinction. Such changes might have killed the dinosaurs directly or might have caused the death of the plants and animals they ate.

3 a The dodo survived for so long because it was well adapted to its environment. It had a good supply of food, an effective method of reproduction and no (or few) natural predators. New species introduced by the Europeans were predators of the dodos' chicks and eggs and rapidly caused its extinction.

b The selection agents were the cats and pigs introduced by the Europeans.

4 a The fruit flies were sprayed twice with the insecticide. These are the points where the graph dips suddenly.

b About 20% of the flies were naturally resistant to the first spray and survived.

c After the first spraying approximately 180 flies were killed. After the second spraying approximately 120 flies were killed.

Continued on next page

After the second spraying about 60% of the fruit flies were naturally resistant and survived. This occurred because they had been bred from the flies that survived the first spraying 4 years earlier.

d The selection agent in this study is the insecticide.

e If a different insecticide was used after 10 years it is likely that it would kill a large proportion of the flies. However, those that remained would breed and the same pattern would be observed as that seen with the first insecticide.

5 a Eye spots are a structural adaptation that assists survival by deterring a predator. When the wings are open, the eye spots look like the eyes of a much larger animal.

b They could be a disadvantage if the predator is a large animal (such as a cat) that can easily see the butterfly and is not deterred.

Hints and tips

Students could write down a paragraph about what they have learned so far and share it with the person next to them. Have them write down an area they found challenging and if they would like it reviewed, and what they feel they have grasped or understood. Collect their responses and evaluate what they have written.

Homework

Get students to construct a dot-point summary of the chapter so far. Remind them that the simpler their sentences are, the more likely they are to remember the information. The summary can be added to progressively and used later as a revision tool.

Learning experience

Ask the class to predict what plant and animal life might exist 1000 years from now, and explain their choices scientifically. They should explain which species they think will survive or become extinct, and if any new species might evolve. A good way to tackle this task is to get students to compile a list of factors which might cause a species to die out or to increase in numbers.

9.3 Evolution

The best adapted organisms are those that survive environmental changes and pass on favourable characteristics to their offspring. But changes to the environment also affect the types of organisms that live there.

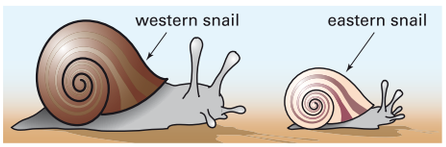
- Changed weather patterns cause short-term effects such as droughts, floods or cyclones, or long-term effects such as atmospheric warming and a rise in sea levels.
- Forces inside the Earth cause earthquakes and volcanoes, and the movement of Earth plates causes changes over millions of years.

Formation of new species

A population of land snails lives in moist areas on the forest floor throughout a wide valley many kilometres wide and in the hills on either side of the valley. The snails show a wide variation of colour and banding on their shells.

Over thousands of years the climate changes. The creeks and wet areas in the valley dry up and the snails are no longer able to travel from one side of the valley to the other. The forest on the eastern side of the valley becomes drier than the forest on the western side. The eastern forest also contains lizards which eat snails. These predators are not found on the western side.

The two populations of snails become isolated and as a result they cannot mix and interbreed. Because of the different conditions in the two habitats, the phenotypes of the two snail populations eventually become distinctly different. The eastern snail is generally smaller and has a thicker shell with many bands. These features help the snail to avoid water loss, and protect and camouflage it against predators. The western snail, on the other hand, is generally larger and has few bands on its relatively thin shell.



A **species** is defined as a population of organisms that normally interbreed. The eastern and western snails are said to be different species because they have different mating seasons and behaviours, and do not interbreed.

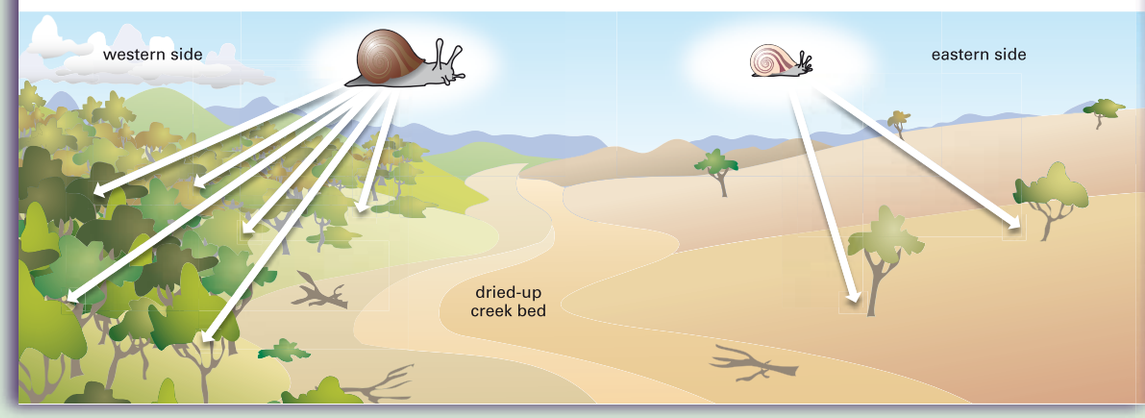


Fig 27 After many years of dry weather the creek and vegetation in the valley disappear.

Learning experience

In small groups, students could design a new species from an existing one. Have them list its survival features, draw a detailed diagram of it and make a model. Where would it live (location and habitat)? Why did it evolve into a new species? How is it different from the original species? Does it have a better chance of survival than the original species? Ask them to explain. Students' predictions could be presented in the form of a booklet designed for a wildlife park or zoo information centre.

Learning experience

Ask the class to come up with a list of questions they would like to investigate in relation to species survival. For example, why is variation in a species a good feature? Are we likely to end up with little or more variation in the human population over time? Ask the students to predict what the human race might look like 1000 years from now and explain their answers. (If there is very little genetic variation among a species, it is more likely to become extinct.)

Gene pools

A population of any organism contains all the genes that produce the variations of characteristics in its individuals. The sum of all these genes is called the **gene pool**. For example, the gene pool of the original snail population contained all the genes that produced the range of shell patterns and colours.

The gene pool of a population can change by mutations and by natural selection. Mutations add new genes to the gene pool, and selection removes genes. For example, the eastern snail population has a thick shell which is an advantage against predators and water loss. The gene for this characteristic may have been added to the gene pool from a mutation in the snails' chromosomes. The gene for thin shells may have been removed from the gene pool because all snails with thin shells were eaten or dried out and died.

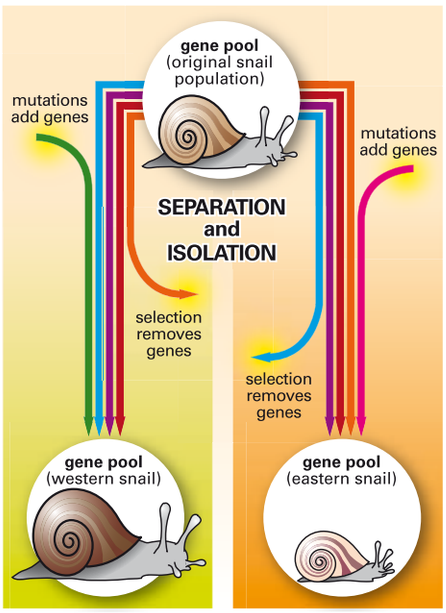


Fig 28 New species can be formed by separation and isolation of the gene pool.

Evolution—inferences and theories

In his famous book called *The Origin of Species*, published in 1859, Charles Darwin suggested that natural selection was the process in which species change over time and develop into new species. This process is now called **evolution**. His ideas created a lot of controversy because they conflicted with the accepted Biblical belief that all organisms were created at the same time.

Although Darwin was not the first person to suggest that currently living organisms evolved from earlier types of organisms, he was the first to argue that the change was brought about by the process of natural selection or 'survival of the fittest'. Darwin and his contemporaries had no knowledge of genetics and could not explain the cause of the variations and the way they are inherited.

To construct a theory explaining how species form, biologists made inferences from data obtained from the relationships between currently living species and those species that were previously living (fossils). These inferences were used to construct the *theory of evolution*. Biologists believe that this theory is useful for explaining how different species can form from a common ancestor. The changes to organisms usually occur over a very long period of time, very much longer than one human lifetime. Consequently, it is usually impossible for biologists to directly observe species formation and to test their inferences.

The evidence that is used to make inferences about evolution is gathered by many different people using many different techniques. As new discoveries and inferences are made the theory of evolution is modified accordingly. Only the future will show whether the current ideas about evolution are correct.

Hints and tips

- It is particularly important to reinforce the difference between scientific facts and inferences/ theories for this section.
- Be sensitive towards and encourage tolerance from the students about other class members' viewpoints on the evolution theory. Allow time for students to express their views and explain why they have them. It may initiate an interesting class discussion. Be mindful that, as educators, we are not there to give our own viewpoint, but to explore all viewpoints so that the students can form their own opinions.

Issues

What is 'intelligent design' or creationism?

- Because of the complexity of organisms and DNA replication, some people have suggested that natural selection cannot take place so that a new species evolves (macroevolution). However, natural selection taking place within a species (microevolution) has been observed.
- Ask students to think of and explore the issues surrounding the idea of intelligent design. Could an 'intelligent designer' be responsible for the complexity of organisms? Could an intelligent designer be responsible for the mechanism of Darwin's evolution theory? How can fossil evidence be used to support evolution and intelligent design?
- The DOVE method of brainstorming could be used by the students to examine the theory of intelligent design (see Learning experience, page 77.) This method works best in small groups. Each group can then share their findings with the class. Students should be able to recognise the value of fellow students' viewpoints. Ask them why they came up with those points and what they learned from this activity.

Learning experience

Students could construct a sunshine wheel about evolution, with 'rays' radiating out from a central word. This activity doesn't have to be limited to theoretical concepts. Emotions, viewpoints and thoughts about the topic could also be explored. The wheel can be used as a progressive summary of the topic and added to each lesson. Alternatively, a spider map could be developed. At the ends of each leg, students could comment on whether the idea is a fact or an inference.

Research

There is much debate surrounding the ideas of macroevolution and microevolution. Ask the students to do some research and come up with their own conclusions. The following simplistic definition could be given to the class:

Microevolution is the adaptations and changes within a species, while macroevolution is the addition of new traits or a transition to a new species. Microevolution is a fact that is observable throughout nature. Macroevolution is a theory that has not been observed.

Evidence for evolution

Fossil evidence

Fossils are the remains of once-living organisms, and are important pieces of evidence for the theory that life has evolved on Earth. The fact that many of these fossils are not like present-day organisms suggests that major changes have taken place on the Earth.

You learnt in your previous studies that most fossils form in sedimentary rock, and that usually only the hard parts of organisms become fossilised. Scientists can use various radioactive dating techniques to find the age of the surrounding rocks and then make inferences about the age of the fossils. It appears that not all fossils lived on Earth at the same time. Because of this it is likely that the various species evolved from earlier ones, and that many living organisms have common ancestors.

Even though the fossil record shows only a very small fraction of the organisms that have lived on the Earth, biologists have been able to suggest possible evolutionary changes that have taken place.

Fig 30 Dinosaur fossils are evidence that the types of organisms on Earth have changed over a long period of time.

Activity

The fossil record below shows the types of organisms that were alive at various times over the last 600 million years. Use this to answer the following questions.

- How long ago did the first fish appear?
- When did coal deposits form? What does this suggest about the environmental conditions at that time?
- How long have mammals been on Earth?
- What age are the oldest winged insects?
- Suggest inferences about how different organisms have appeared and disappeared on Earth at different times.

Age of rocks (millions of years)	Fossils found in rocks	
2	first true humans	
15	first apes	
45	first primates	
70	mass extinction of many species, including dinosaurs	first flowering plants
150	first birds	first conifers
200	first mammals	
250	first dinosaurs	
	first winged insects	
	first reptiles	coal deposits formed
360	first amphibians	first ferns
	first fish	
410	first land arthropods	first land plants
	first marine vertebrates	
500	marine molluscs and arthropods	marine algae
570	bacteria and protists	

Hints and tips

Review students' media article scrapbooks (see Learning experience, page 210). Ask some students to read one of their articles and their review. Discuss some of the main features of each article and check that students understand the content.

Activity notes

If the science department has any fossil specimens, take them into class for students to view and touch. See if they can infer which time period each one could have come from.

Homework

Is there another alternative to the theories of evolution and creationism? (The steady-state theory is an alternative theory which suggests that life did not have a 'beginning' but has always existed.) Have students write a script or perform a mini-film outlining the main points about one of the theories. Try to ensure that students do not convey any prejudices but explain the theory's ideas with sensitivity.

Learning experience

Students could write a creative story about the life of a giant wombat, marsupial lion or another extinct creature from Australia's geological past. They could be quite imaginative and write diary entries for the animal.

- What story would it tell about its environment?
- How did it live?
- What did it look like?
- Which other creatures coexisted with it?
- What was its diet like?
- What might have caused it to become extinct?

Although the story is to be creative, students still need to be as scientifically accurate as possible. They could present their work as a written response, role play, script, video, podcast or illustrated storybook.

Biogeography

Biogeography is the study of the distribution of organisms. For example, marsupials are mainly found in Australia and include kangaroos, wallabies, koalas, wombats, possums and bandicoots. These mammals have pouches and give birth to immature young. Only two other types of marsupials live outside Australia—the possums and pouched shrews from South America. Fossil marsupials have been found in North America, South America and Australia, but none has ever been found in Africa or Europe. The present distribution of these animals gives clues to their evolution.

Scientists have inferred that millions of years ago Australia, Antarctica, South America and Africa formed the supercontinent Gondwana. Africa separated from this land mass about 100 million years ago and left the other continents joined. Marsupials were distributed widely over this remaining land mass. Then the plates that contain these continents started to separate. The South American plate separated first, and then about 55 million years ago, Australia separated from Antarctica, and drifted northwards towards the equator.

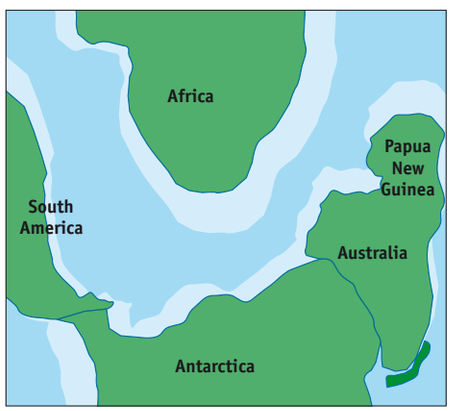


Fig 32 Part of the supercontinent Gondwana about 85 million years ago, which allowed organisms to spread over the now separated continents.

During the slow drift northwards the climate of Australia became progressively drier. Fossil records show that during this time marsupials became even more numerous and many different types evolved. In South America, however, the marsupials decreased in number and diversity, probably due to the competition from placental mammals such as the ancestors of jaguars. The very long period of isolation of Australia from other land masses has meant that many different marsupial species evolved.

By studying the distribution of the different types of living organisms and fossils, inferences have been made to show how the various types of organisms may have evolved.

Comparing embryos

When the embryos of different animals are studied, similarities can be seen. This is particularly evident when studying the embryos of vertebrates. The similarities, particularly in the very early stages, suggest that the genes that control the early growth of vertebrates may have come from common ancestors. The differences the embryos show as they develop further are due to other genes which are unique to each type of vertebrate.

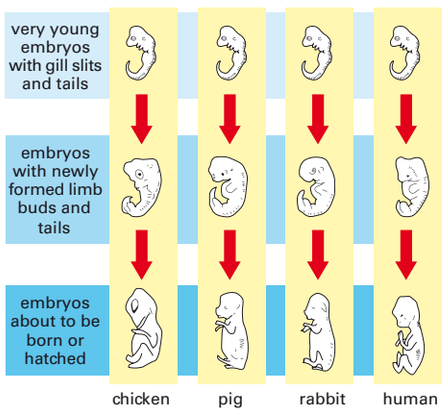


Fig 33 These vertebrate embryos are very similar at an early stage, suggesting that they might share a common ancestor.

Hints and tips

Colourful posters and flow diagrams are always a good way to summarise and simplify information. Get the class to make posters to display around the room using information from this chapter.

Learning experience

Have students choose a fossilised creature, construct a scale model of it and explain what it probably looked like. To do this, they need to research its measurements and inferred appearance. Alternatively, students could choose a prehistoric period of time and make a diorama of what Australia's environment may have looked like.

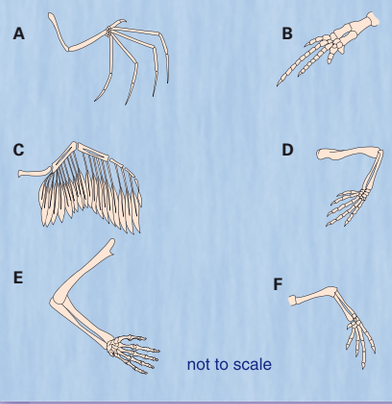
Learning experience

Number the students from 1 to 5, and write five different thinking questions on the board. The students numbered 1 should answer question 1, and so on, up to 5. When students have individually answered their question, have them work in groups categorised by their number to discuss the question further. Each group should write a final conclusion and present it to the class. Ask questions such as the following:

- If dinosaurs still roamed the earth, what might the world be like now?
- How might a population of bacteria become resistant to antibiotics? Methicillin-resistant *Staphylococcus aureus* (MRSA) is resistant to penicillin. How can this be explained in terms of the theory of natural selection?
- What factors will determine whether Leadbeater's possum or the bilby will survive in the future?
- Natural selection acts on populations, not on individuals. What does this mean?
- For a theory to be considered scientific, what criteria does it have to fulfil?

Activity

The forelimbs shown below are from six different vertebrates. They show a number of similarities. This suggests that they share a common ancestor. However, they are each modified to suit a particular type of environment.



1 Match the name of the vertebrate in the list to its forelimb in the diagram.

bat whale bird
frog human lizard

Discuss how you arrived at your answers.

2 Make a list of the similarities of the forelimbs.

3 Suggest the specific function of each forelimb.

4 The study of the shapes and sizes of the bodies of different organisms is called comparative anatomy. Apart from forelimbs, which other parts of vertebrates could be useful for comparison?

Comparative DNA studies

Until the last 30 years, most of the studies that show evolutionary links between organisms relied on *comparative anatomy* (used in the activity above), and evidence from fossils and biogeographical distribution. Now, however, the DNA in living species and that found in fossils can be analysed and compared.

A particular species is different from another species in the number and types of genes it contains. In comparative DNA tests, single strands of DNA from two different species are mixed together. If the two pieces of DNA are similar, the bases on each strand will bind strongly. The greater the difference between the DNA, the less tightly the strands will bind.

DNA studies have shown that the percentage similarity of DNA strands from humans and chimpanzees is 98.5%, while the similarity between humans and orang-utans is 96.5%. This shows that there is a close evolutionary link between these animals.

Using DNA tests we can establish evolutionary links between various organisms and construct an evolutionary tree to show these links.

Fig 35 Strands of DNA from humans, apes and chimpanzees show a great degree of similarity, suggesting that these animals may have a common ancestor.

Hints and tips

Sometimes students find summarising written material challenging. A useful technique is to get them to read each paragraph and then write down a summary of that paragraph. This summary should be only one or two sentences long. Such summaries are especially useful for those who experience language difficulties.

Learning experience

Have students develop a set of summary cards for this chapter. Encourage them to draw diagrams to help explain key points. ESL students could write them in their native language.

Learning experience

A particular species is different from another species in the number and type of genes it contains. Comparative DNA tests how similar two pieces of DNA are. For example, how similar is the genetic make-up of mice to that of humans? Why are mice often used for medical testing before the techniques or drugs are used on humans? What examples are there of this? How ethical is it to use mice for these purposes?

This could be turned into a Round Table or Pass-it-on activity. A Pass-it-on activity is where students, in groups, answer part of a series of questions, write their answers onto a sheet of paper and pass it on to the next group. This group then reads what has been written, adds to the response and continues the passing on process, until all groups have contributed.

Science in action

How theories change

If Charles Darwin was alive today and studied modern evolutionary theory he would see many differences from the theory he proposed in 1859.

Scientific models and theories are constantly modified as new discoveries are made. For example, the platypus is an egg-laying mammal called a monotreme. Together with its relative the echidna, these mammals are the only living monotremes. No ancestral forms had been found, and this led biologists to believe that these families of monotremes evolved separately from a common ancestor in Australia. However, in 1991 fossilised teeth found in sediments in South America were identified as very similar to fossil platypus teeth found in Australia. As a result of this discovery, biologists may have to modify their ideas about the ancestor of the platypus and its distribution.

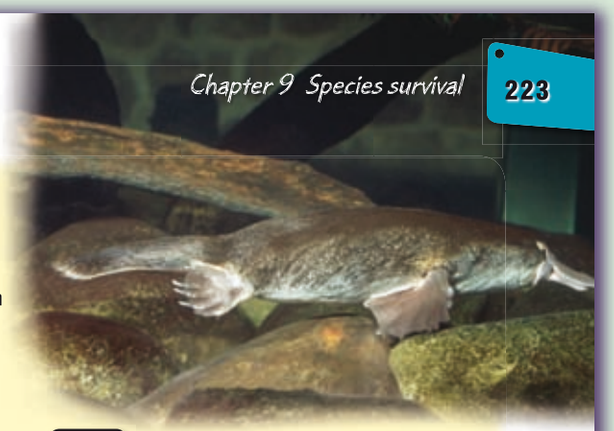


Fig 36 The platypus was once thought to have lived in Australia only. Recent fossil evidence suggests that it may have lived in other continents as well.

Theories develop as inferences are suggested and evidence is collected to support or dispute them. This is why theories have to be treated as tentative—likely to change. In the future, new fossil discoveries and advanced technology will undoubtedly change some of the ideas that form the current theory of evolution.

Check!

1 **a** What is a gene pool?
b How do gene pools change over time?

2 Parrot A lives in forests and feeds on nectar and pollen. It has a repeating, high-pitched call, and breeds between May and August each year. Parrot B lives in the same habitat as Parrot A and also feeds on nectar and pollen. It has a similar call to Parrot A but breeds between September and November. Would you consider Parrot A and Parrot B to be the same species? Explain.

3 **a** What do you understand by the term evolution?
b Use the snail story on page 218 and explain how it is an example of the process of evolution.
c List the selection agents that acted on the snail populations over the period of time in the story.

4 What is the fossil record? How is it used as evidence for the evolution of organisms?

5 A particular type of tree called the Antarctic beech grows in small areas of Papua New Guinea, Australia's east coast, New Zealand and the far south of South America. Fossil beech trees have been found in these countries as well as in Antarctica. How do you account for the distribution of the Antarctic beech?

6 Apart from fossils and the distribution of organisms, what other evidence is used by biologists to support the theory that organisms have evolved on Earth?

7 Suggest why evolutionary changes to organisms that reproduce many times a year are more rapid than those in organisms that reproduce only once a year.

8 The theory of evolution has changed since the time of Charles Darwin. Give reasons why this might have occurred.

9 Suggest why comparing DNA is a more powerful tool in establishing evolutionary links than comparing embryos.

Check! solutions

1 **a** A gene pool consists of all of the genes in a breeding population.
b Gene pools change over time because new genes may be added by mutation and some are removed by selection.

2 You would not consider these two types of parrots to be the same species because they do not breed together. Members of the same species interbreed. Their calls and diet may not be important in deciding whether they are the same species or not.

3 **a** Evolution is the process by which groups of organisms change over time and may develop into new species.
b The original snail population showed some differences in the patterns and thickness of their shells and in other ways as well. When conditions changed the population was split in two. These two groups lived in different environments and, over time, natural selection occurred so that they could be easily distinguished from each other. When these differences were so great that they prevented mating, you could say that a new species had been formed. This is a very good example of evolution.
c The selection agents that acted on the snails included differences in rainfall, the presence of lizards as predators, and different vegetation.

4 The fossil record is the remains of organisms that are preserved in rocks. These fossils are used as evidence of evolution because they can be studied and compared to other fossils and present-day organisms. They can also be 'dated' and used to infer relationships to other organisms that are extinct or alive.

5 These observations can be explained by inferring that these land masses were once joined together, or were at least much closer than they are now. This would mean that seeds could be spread around more easily. When the land masses moved further apart, the small groups of trees on each continent survived and perhaps are slowly evolving into new species.

6 Other evidence that supports the theory of evolution is comparative anatomy, whereby present organisms are compared to fossils and, more recently, DNA studies. By analysing DNA samples from many organisms you can calculate the percentage similarity and, from this, construct a 'tree' that shows likely relationships.

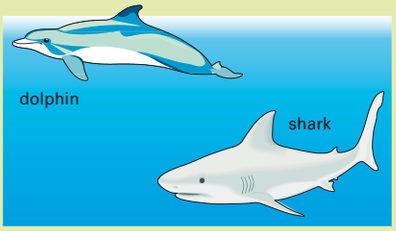
7 Every generation of an organism provides an opportunity for the selection of more successful phenotypes to take place. This explains why reproducing many times a year will allow more change than once every year.

8 Every valid scientific theory must accommodate new evidence, even if it is necessary to change it to do so. This has been the case with Darwin's theory because it was based on his own observations as a naturalist. Since his death there have been many more observations and discoveries about genetics and DNA. These have enabled biologists to attempt to explain how evolution has occurred.

9 The study of embryos provides some structural evidence from which inferences can be made about possible relationships. A technique called DNA hybridisation can show the percentage similarity between the DNA of different species (see page 222). However, direct comparisons can reveal just how many bases in a particular segment of DNA are different between different species. This can be used as a fairly direct measure of time, since they evolved from a common ancestor.

challenge

1 The shark is a fish and the dolphin is a mammal, but these two animals have the same basic body shape and structure. Suggest how natural selection might have caused this similarity.



2 The Tasmanian tiger (thylacine) was last seen in the wild in 1932. However, fossils show that it lived throughout Tasmania and mainland Australia. Biologists now think that this marsupial is extinct.

a What does extinct mean? Use the term *gene pool* in your answer.

b Some people think that endangered species should be protected and breeding programs established. Others think that it is simply natural selection at work and that the fittest species will survive. Outline your views on this and then discuss your views with others.

3 The map shows the distribution of Fletcher's frog. It is found in rainforests and breeds in small pools and creeks.

a Suggest why this species of frog is found in two locations that are widely separated.

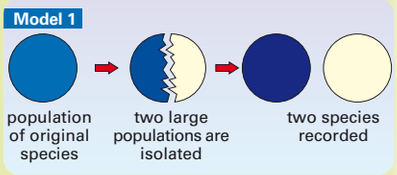
b Suggest what could happen to the frog populations in the two different locations over a period of time.

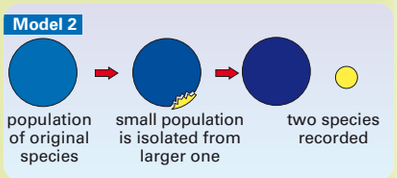
c Biologists say that distribution maps like this are only tentative and may change in years to come. Suggest factors which you think may cause this map to change.

4 Do you think that organisms stop evolving in environments that change very little over long periods of time? Explain your answer.

5 The models below show two ways in which the gene pools of an original species can be separated and isolated over a long period of time.

In Model 2 only a very small number of organisms are isolated from the larger population. Biologists suggest that this model accounts for those species that change very quickly from the original one. Give reasons why biologists suggest this.





WEBwatch

Use the internet to find out how the work and theories of Jean Baptiste Lamarck and Alfred Wallace contributed to the modern theory of evolution. Compare and contrast the theories of both of these biologists to that put forward by Darwin.

Suggest why Darwin is more well-known than Lamarck or Wallace.

Challenge solutions

1 Although they have significant structural and functional differences, the dolphin and shark have similar adaptations to their environment. In both cases natural selection has favoured a streamlined shape, powerful fins and light underside colouring. In other words, the similarities have come about because they are adapted to the same environment.

2 **a** Extinct means that the last member of a species has died. There are no more genes in the *gene pool*, which you can say has 'dried up'.

b Here are some arguments. You may have thought of others.

Arguments for protection and breeding:

- The animals are endangered because of the effects of humans and not natural selection.
- The species may have unique genes which would otherwise be lost to the planet.
- The species may be able to help humans in some way (eg providing medicines).

Arguments against protection and breeding:

- So many species have become extinct in the past few hundred years—what does another one matter?
- Too much time and effort is required.
- There are more important projects that biologists should be working on (eg conserving the Great Barrier Reef).
- Humans should not interfere with nature.

3 **a** One suggestion is that long ago this species of frog was spread right along the eastern coast, but because the environment changed they died out in the central area.

b There are biotic and abiotic factors that would affect the two populations. Examples of biotic factors are predators and food supply, and examples of abiotic factors include the supply of water, temperature variations and humidity.

c Distribution maps like the one shown can change, because if conditions change the species can move to find a more suitable environment. The species may also become extinct in some areas.

4 Even if changes in a particular environment occur slowly, the same laws of natural selection still apply and some of the species will live and some will die. Even very small changes in the environment (which may not even be noticed by humans) will favour the survival of some organisms rather than others.

5 A small population has a smaller gene pool, which can be changed much more easily by random events. Such random events include mutations and natural disasters such as floods. In such cases, the frequencies of certain genes in the population can be changed within a few generations. This accounts for the rapid change in genotype and phenotype compared with the original population.

9.4 Selecting genes

The fantail goldfish in the photo cannot swim very well, has vision problems and probably will not live as long as those in the wild. However, to a collector of fish it is worth hundreds of times the value of a wild form of goldfish.

Fig 40 A selectively bred fantail

Artificial selection

Artificial selection or *selective breeding* is the process in which *humans* select those phenotypes in organisms that have a value or serve a purpose.

For example, the particular features of the goldfish are valued by certain people, so fish breeders select fish with unusual phenotypes and try to produce offspring with the same features.

Dogs are the oldest domestic animals and may have been selectively bred by humans for more than 10 000 years. At the time Europeans landed in North America, the indigenous American people had selectively bred more than 20 breeds of dogs.

The grey wolf is thought to be the ancestor of the dog, and many of the characteristics of the wolf are present in some dog breeds. For example, wolves tend to guard the den which houses their young. This feature has been selected in certain breeds of dogs, namely German shepherds and Doberman pinschers, which are used as guard or watch dogs. The hunting characteristic in the wolf has been selected in such breeds as the hounds and spaniels (for trailing after prey), retrievers (for finding and retrieving prey), and terriers (for attacking prey).

However, the selective breeding of dogs has also brought with it some genetic problems. For example, German shepherds have hip problems and suffer endocrine gland problems. Pugs and bulldogs suffer from breathing and teeth problems due to the odd shape of their jaws.

Fig 41 The pug, like the bulldog, was bred for its sporting and fighting ability but has inherited breathing and teeth problems due to the shape of its jaws.

Fig 42 Cocker spaniels have been bred for their ability to find prey. However, they often suffer ear infections because of their large floppy ears.

Hints and tips

You could ask some reflective questions at various points throughout the chapter. Questions should be focused on students' understanding and thinking, interpersonal development and personal learning. Questions could be 'What did you learn?', 'How do you know that you have learned it?' and 'How will you use that learning again?'

Learning experience

Pedigree or show animals, such as cats and dogs, are often selectively bred. Ask students to find out what some of the desired features of these different breeds are. Does selective breeding result in any undesirable features?

Learning experience

Ask the students to investigate selective breeding of farm animals. What is it, and what are its outcomes? Form them into small groups and get each group to present their information from the point of view of a geneticist, economist, farmer or bioethics expert. They could give an oral or multimedia presentation.

Biotechnology

Biotechnology is a field of science that uses organisms to produce materials for people to use, for example food, clothing and medicines. Most of the work in modern biotechnology is at the molecular level and involves the manipulation of genes in organisms. This is commonly called **genetic engineering** or *recombinant DNA technology* and is the technique of inserting desired genes from one species into the chromosomes of another species.

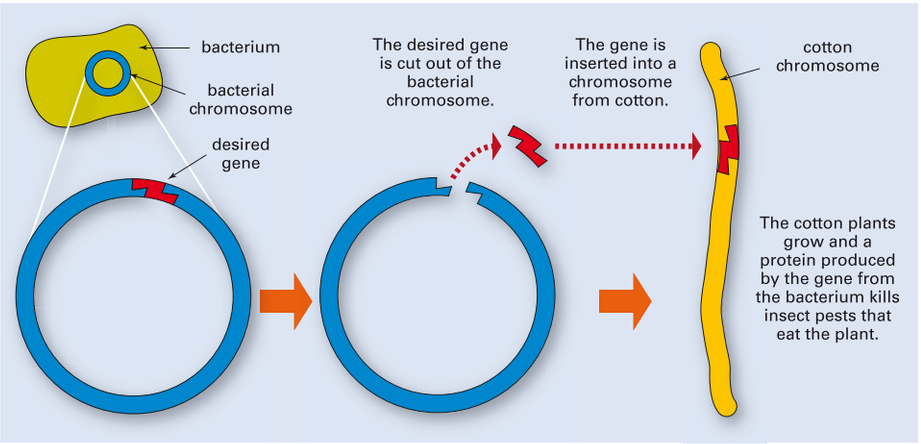
The photo above shows the caterpillar of the moth (cotton bollworm) that causes severe damage to cotton crops. Traditionally, farmers have used pesticides to control the caterpillars and to stop damage to crops. However, over the years the insect has become resistant to the pesticides. Consequently farmers have to use more concentrated pesticide solutions to have any effect on the caterpillars.

A particular species of bacterium called *Bacillus thuringiensis* or Bt naturally produces a protein that kills caterpillars. In plant nurseries you can buy packets of Bt which you mix with water and spray onto vegetable crops. The bacteria infect the caterpillars on the plants and cause them to die.

Scientists have found that a gene in the Bt chromosome is responsible for making the protein that kills caterpillars. They have inserted this gene into the chromosomes of cotton cells, so that as the cotton plant grows it makes the special protein. When the caterpillar eats the plant, it takes in the protein and dies. Using this technology the farmers enjoy a double benefit—they are able to reduce quite dramatically the amount of pesticide used and also increase their yields of cotton from the crop.

Transferring a gene between two unrelated species, like the bacterium and the cotton plant, produces a transgenic organism.

Fig 44 Transferring a gene from a bacterium to a chromosome in a cotton plant



Hints and tips

Review concepts covered so far in this chapter. Ask each student to write down about five questions, with answers, on a piece of paper for you to collect. Allow only a few minutes to do this. Once you have collected the papers, run a short quiz. You may need to be selective with your questions. Spend no more than about 15 minutes on this activity.

Homework

Have students compile a set of 'Did you know' facts about biotechnology, with a record of the source of their facts. Web pages or poster displays are good presentation formats. You could start them off with this fact: in May 2008 it was reported that a gene from a Tasmanian tiger had been inserted into a mouse embryo. The resulting transgenic organism was a mouse with the bone structure of a Tasmanian tiger. (It was an attempt at cloning the tiger.)

Learning experience

Ask students to consider if it is right to alter an organism's genes for some purpose, and if it is wise to change the organism's genes when we don't know if it is safe to do so.

Present the following scenarios to the class, then have students construct a PMI chart and write their viewpoints on one or more of these scenarios. Ask them to research to see if any of the scenarios are already happening.

- Instead of dyeing silk, silkworms could be genetically modified so that they produce silk of any colour of the rainbow.
- Instead of vaccinating people in developing countries for various diseases, geneticists are developing bananas that contain the necessary drugs so that eating the fruit will give people immunity.
- Protein-enriched potato or rice could be distributed in poor countries, such as India, and given to children who don't get enough protein in their usual diet.
- Genetically modified plants could be used to produce plastic and human blood proteins.

Finally, have students come up with their own scenario, evaluate it using a PMI chart and research to see if it is already happening.

Cutting and recombining genes

DNA normally consists of two strands and is called double-stranded DNA. Each base on one strand is paired to a *complementary base* on the other strand. You can see in the diagram below that A bonds only to T, and G only to C. So A is the complementary base to T.

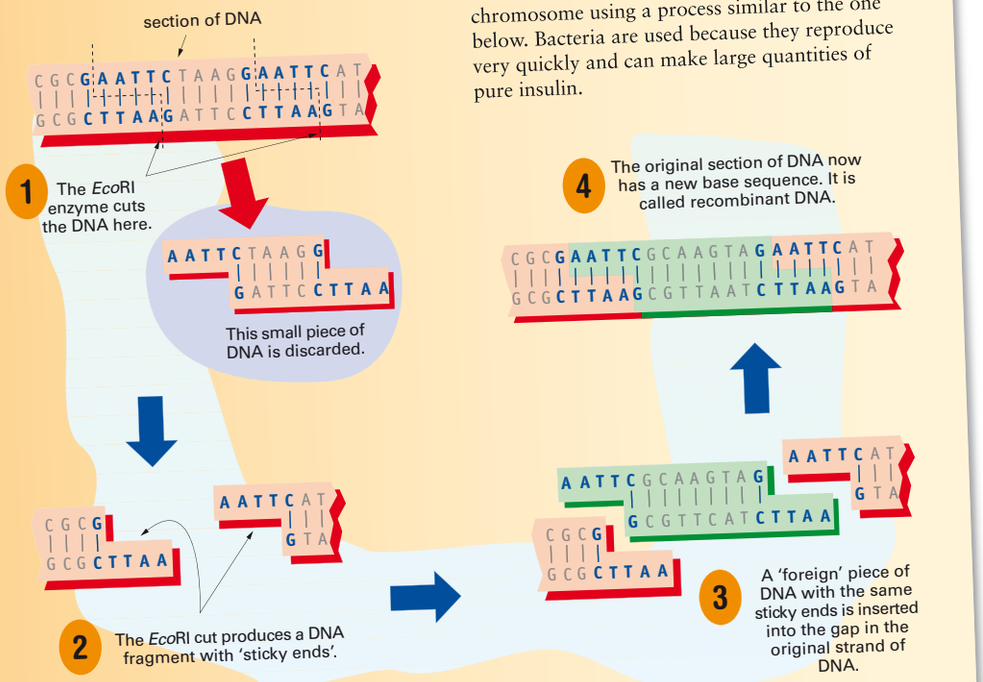
To cut DNA, biologists use special enzymes called restriction enzymes. These cut the DNA at particular places along the sequence of bases. There are several hundred restriction enzymes, each able to cut the DNA at a particular place. For example, the restriction enzyme *Eco*RI recognises the base sequence GAATTC and cuts the DNA after the G in this sequence, leaving a tail or 'sticky end'. In the diagram below the *Eco*RI enzyme has found and cut two GAATTC sequences out of the piece of DNA.

To join the fragments of DNA, other enzymes called *ligases* (LYE-gay-zes) are used. These enzymes occur in the cells of most organisms and are used to repair pieces of DNA that have been broken or damaged. In the laboratory, ligases are used to recombine the fragments of DNA that have been cut.

Using gene technology to make insulin

People suffering from diabetes have low blood levels of the hormone insulin. Diabetics can lead normal lives by having daily injections of insulin. The insulin was traditionally obtained from pigs and cattle. However, it differs slightly from human insulin, and can contain impurities that cause an allergic reaction in some people.

To overcome this problem, biologists have added the human insulin gene to a bacterial chromosome using a process similar to the one below. Bacteria are used because they reproduce very quickly and can make large quantities of pure insulin.



Hints and tips

- Reinforce with students that A bonds only to T, and G only to C (see Chapter 8).
- Also remind students how enzymes work.

Research

Biotechnology and its uses is a controversial topic. Negative issues surrounding this technology are largely due to ethics and concerns about transgenic organisms. Have students research the use of biotechnology in a particular area. They should spend time brainstorming and could use tools such as an advantage/disadvantage chart, PMI chart or issues circle. A series of questions about the technology should be developed and researched. It is important that they explore not only the science surrounding this technology but also any ethical implications. Topics could include:

- gene technology for cloning
- biotechnology for medicines
- biotechnology for plants and animals
- gene cell therapy.

Their target audience is the general public. Information should include the type of technology, its purpose, its pros and cons, and ethical considerations. Students should use appropriate language outlined in this chapter and present their work as an information poster, booklet, pamphlet or web page. Encourage students to choose a format that they have not previously used.

Lab notes

- For step 3, get students to write down their DNA sequence for both strands so that they can successfully compare their recombined DNA (step 7) with their original (step 3).
- When swapping DNA fragments it is easier to swap using a rotation method. This avoids group arguments and each group has someone nearby to swap with.
- Note that Fig 19 on page 189 shows the DNA triplets and not the RNA codons, which are complementary.

Erratum

In earlier printings there was an error in the Planning and Safety Check: page references were incorrect. Check that students know the references are the activity on page 188 and the table on page 189.

Investigate

18 GENE TECHNOLOGY MODEL

Aim

To use a model to show how genes are cut from chromosomes and recombined into other chromosomes.

Materials

- about 100 coloured paper clips (4 colours —red, green, yellow and blue)
- strip of cardboard 7 cm x 50 cm
- scissors

Planning and Safety Check

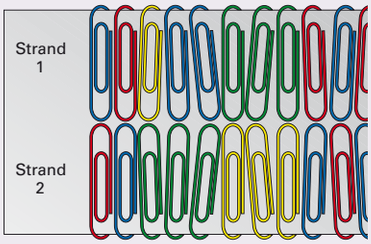
- In the activity on page 188 you made a model DNA using coloured paper clips. The same model is used in this investigation. The four colours of the paper clips represent the four types of bases in DNA. Blue = A, red = T, yellow = G and green = C.
- Read through the Method carefully. You will need to refer to the table on page 189 to work out your amino acid sequence.

Method

1 On one side of the strip of cardboard place about 50 paper clips in random order side by side. Make sure the total number can be divided by three. Label this Strand 1.

2 Make sure you have two sets of the base sequence GAATTC somewhere along the chain of paper clips.

3 On the other side of the cardboard strip place paper clips which represent the complementary bases to those on Strand 1.



Remember, A bonds only to T, and G only to C. So if the first five bases on Strand 1 are ATGAA, the complementary bases in Strand 2 will be TACTT. This is your model of double-stranded DNA.

Use the code for amino acids in the table on page 189 to work out the sequence of amino acids that is coded by Strand 1.

4 Look for the first base sequence GAATTC in Strand 1 and cut through both strands as shown in the diagram on the previous page.

5 Locate the second sequence GAATTC and cut through both strands. You should now have three fragments of double-stranded DNA.

6 Keep the two end fragments of the double-stranded DNA and swap the middle fragment with another group.

7 Join the new middle fragment between the end fragments. Does it fit? Why?

Work out the amino acid sequence on your recombinant piece of DNA. Compare this one to the original sequence in Step 3.

Discussion

1 Write a conclusion for this experiment. Use the term *recombinant DNA technology*.

2 What is the complementary base sequence to the sequence CTTAAG? Read the complementary sequence back-to-front. What do you notice? What is the importance of this in the DNA molecule?

science bits

Genetically modified foods

Transgenic organisms are being bred to produce foods or ingredients for foods. These foods are called *genetically modified foods* or *GM foods*.

GM foods are usually defined as those foods that contain genetically modified ingredients. Sometimes the whole of the food is genetically modified, for example soybeans and corn. Other foods that are considered GM foods contain varying amounts of GM ingredients. For example, 10% of the mass of a doughnut may be GM soybean meal. Other foods might contain smaller amounts of GM ingredients such as food preservatives or additives.

What are the advantages of GM foods?

The GM foods currently available in Australia contain mostly soybeans, canola, corn, potato or sugar beet. In the USA, more than 70% of the foods in supermarkets contain some GM foods.

Some of the GM crops have been modified to protect them against either insect or virus attack. This means that farmers can reduce the amount of pesticides they spray on their crops. Other GM crops such as soybeans can withstand the effect of herbicides, which means that they can be sprayed with herbicides that kill weeds but not the crop.

Currently, scientists are experimenting to produce GM foods with greater amounts of vitamins and proteins, and ones that are free from the proteins which cause allergic reactions in some people.

Animals are also used to produce GM foods. Transgenic technology is being used to produce faster-growing and leaner pigs that use food more efficiently and are resistant to common diseases. This technique is also used to breed fish, sheep and poultry.

Concerns about GM foods

In 1992 scientists working for a multinational seed company produced a transgenic soybean containing a gene from a Brazil nut. The gene produces a protein rich in a particular amino acid which is found in small amounts in normal soybeans. Before being released the soybean was given to a test group of people. Some of the people allergic to Brazil nuts became allergic to the soybeans. Because of this the GM soybeans were withdrawn and never released.

Some scientists are concerned about the use of GM crop plants. It has been estimated that 20% of crop plants escape from farms and establish wild populations. It is likely that the wild crops could crossbreed with weeds to produce plants that are herbicide and pesticide resistant, or drought, cold or salt tolerant. Also GM plants which are poisonous to insects kill both the 'pest' as well as beneficial insects. Then the insects may become resistant to the GM plants and farmers will again have to spray the crops with poisons.

Discussion and debate

The questions below deal with a number of GM food issues. To help in your discussion, search the internet under *genetically modified foods*, *transgenic animals* or *biotechnology*.

1. The Food Standard 1.5.2, which came into effect in December 2001, requires labelling of GM foods. Go to www.scienceworld.net.au and follow the links to the **ANZFA** website to find out more about this requirement.
2. Do a supermarket survey to find out how many products contain GM foods.
3. Prepare a questionnaire to find out how much people in your neighbourhood know about the benefits and risks of GM foods.
4. The genes of some animals, for example pigs, have been added to plants that are grown for food. Should genes be allowed to be swapped between animals and plants? What are some of the consequences for people of certain religions or for vegetarians if this occurs?
5. What are the benefits of using GM crops that are resistant to pests and certain climatic conditions? What are the possible problems?
6. Prepare for and against cases about GM foods and transgenics. Your teacher might organise you into groups for a class debate.

Hints and tips

The 'Discussion and debate' questions could be investigated individually or in groups. Get students to read through each question and decide if the question is better tackled individually, as a group or by the whole class. Genetically modified foods could be explored further, as outlined below.

Issues

What are the issues involved in genetically modified (GM) foods? Why are some foods genetically modified? Why is there a difference of opinion in the community as to whether or not to accept such foods? Should all GM foods be labelled as such? Are there ethical dilemmas with this issue?

Assign one half of the class to investigate the positive aspects of GM foods and the other half the negative aspects. Students could draw up a PMI chart to help research the issue. The issue could be:

- debated in class
- presented in the form of a letter or email to the government, urging them to review their stance on genetically modified foods
- written as an advertisement persuading the public to change their viewpoint.

Science in action

Cloning

In 1997, the world's first cloned mammal was born. 'Dolly' the lamb was developed from the single body cell of a ewe (female sheep). In this process the cell developed without being fertilised by a sperm.

Since Dolly, many improvements have been made to this cloning technique which is often called *nuclear transfer*. The diagram shows the technique used to produce Australia's first cloned pigs in 2001.

The nuclear transfer technique allows the production of a large number of identical animals, called **clones**, all from the one cell grown in a culture. This could mean that herds of identical farm animals could be produced. For example, the best milk-producing cows could be cloned, and then smaller herds could produce large quantities of milk for less food and lower production costs.

Cloning is also important for future human organ transplants. For example, cloned pigs could be used as a source of transplant organs, namely the heart, lungs, liver and kidneys.

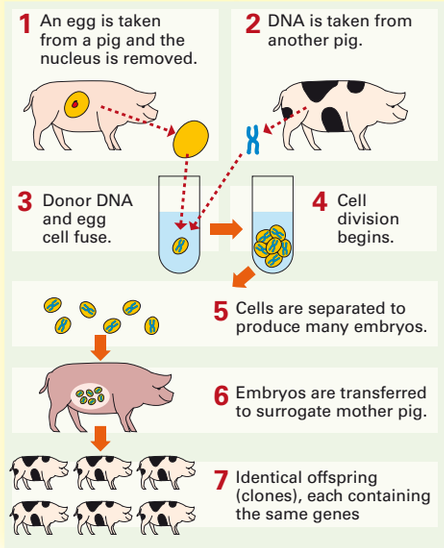


Fig 49 This baby gaur, a wild ox from India, was born in 2001 and was the first endangered animal to be cloned. The baby gaur, called Noah, died from an infection (unrelated to the procedure) two days after its birth.

Goodbye Dolly

Dolly the sheep died in February 2003, six years after her birth was headlined in newspapers around the world.

Dolly died from a lung infection which is fairly common in sheep. She also had arthritis in her back legs. However scientists are uncertain if her premature death was a result of the cloning procedure or just a natural occurrence.

Before developing arthritis, Dolly had given birth to six healthy lambs as a result of natural mating.

WEBwatch

For more information on cloning go to www.scienceworld.net.au and follow the links to the websites below.

Cloning fact sheet

How cloning works

Hints and tips

Discuss with the class the advantages and disadvantages of cloning. Consider giving the students the scenario of Australia having herds of cloned dairy cows. These cows produce more milk and, being all the same size, fit the milking machines perfectly. What are the advantages for Australia to have such cows? What are the risks of having cloned herds? Remind students that if there is very little genetic variation among a species, it is more likely to become extinct. How does this relate to cloned animals?

Homework

The Science in action and Webwatch activities are good for 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 (in italics/underlined), the URL of the site, and the date it was last updated.

Learning experience

Dolly the sheep made headline news in 1997. What was the name of the first Australian sheep to be cloned, and how long did she live? What was her cause of death? Ask students to find out more about cloned animals and what the purpose of their cloning is. What other animals have been cloned in Australia? Information can be presented in a variety of formats, including fact sheets posted around the room, pages on the school intranet, a series of 'Did you know' sheets or descriptive cartoons.

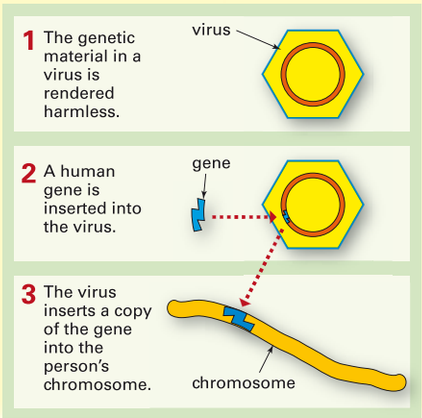
Science in action

Human gene therapy

Human gene therapy is an experimental area of biotechnology which treats people with genetic diseases. It involves introducing a piece of DNA which carries a 'normal' dominant gene into a person who has a genetic disease. The 'normal' gene replaces the disease-causing gene in the body cells of the sick person. Currently only diseases that are caused by a single recessive gene are treatable. These include cystic fibrosis and thalassaemia.

How does the new gene get into body cells?

At present the most successful way to insert a gene into a person's chromosomes is to use another organism—a virus. When viruses infect people they insert their genetic material into the person's chromosomes. Scientists render the virus's own genes harmless, and insert the human gene into the chromosome. The viruses are then injected or inhaled and invade the body cells, inserting the dominant gene into the affected person's chromosomes. This gene masks the recessive gene which is causing the disease.



Germ-line gene therapy—creating designer people?

Instead of inserting the gene into a person's body cells, it is possible to insert it into the cells of an embryo and allow the normal cell division and growth to occur. This is called *germ-line therapy* and is currently prohibited in Australia and in most other countries.

The main concern with this technology is that it could be used to create designer babies. For example, a woman could have an egg fertilised by sperm and cultured in the laboratory. Before it is placed into her uterus, the embryo's genes could be scanned for potential diseases and replaced if necessary. However, other 'selected' genes could also be inserted in the embryo at this stage.

Questions

1 Draw a simple flow chart to show how a virus can be used to insert a gene into chromosomes in a lung cell of a person suffering from cystic fibrosis.
2 Why do you think germ-line therapy is prohibited by most governments?
3 Use the internet to search under *human gene therapy* and *germ-line therapy*. Use the information to prepare a for and against discussion.

Check!

1 How does artificial selection differ from natural selection?

2 Genetic engineering is called recombinant DNA technology. Explain in simple language why these terms are interchangeable. (Hint: refer to page 226.)

3 The greatest advantage of gene technology is that it can be used to make large amounts of substances needed by humans (eg hormones) by placing human genes into bacteria.
   a Why are bacteria used in this process?
   b At present many of these substances are extracted from other mammals. Suggest why there are problems with this.

Hints and tips

Get the students to revise the goals they set at the beginning of this chapter (page 207). How many have they accomplished? Were their goals achievable? Do they need to improve further in a particular area? What do they think they did well? Ask students to write a self-evaluation.

Issues

What is a designer baby? Are there any recorded cases of designer babies? What are the issues surrounding this question? Ensure students consider social and ethical implications. They will probably find surfing the internet the quickest research method, but remember that not all the information on websites is reliable.

To help students with their investigation, a cause and effect wheel (concentric circles) or an issues map could be used. These methods help students to identify the different dimensions of, or perspectives on, a particular event or issue. For the cause and effect wheel, students begin the process by drawing a circle on a large sheet of paper and writing in the issue to be explored. Then they expand the wheel by drawing further circles around the issue. Each of the circles allows students to explore the effects in greater detail. Students could also consider relationships between ideas not directly connected, or reflect on what might happen if the links were reversed.

Check! solutions

1 Artificial selection is carried out by humans, whereas natural selection does not and occurs in nature.

2 'Genetic engineering' is the original term and implies making and then manipulating the genetic components. 'Recombinant DNA technology' means the same thing because it means recombining sections of DNA (genes), often from different species. It is now the more common term.

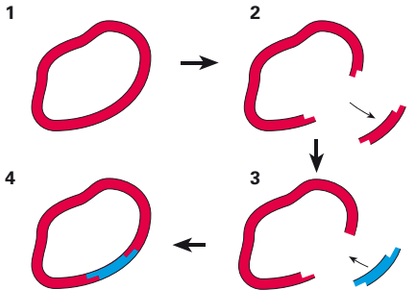
3 a Bacteria are usually used in this process because they pose no ethical problems, grow quickly and produce large amounts of the hormones quickly and cheaply.

b The problems are that hormones that are extracted from animals are slightly different and can cause an allergic reaction. They are also difficult and expensive to purify.

4 Restriction enzymes have sometimes been called gene shears. What does the word 'shears' mean? If you are unsure find the meaning in a dictionary. Why do you think this term describes the role of restriction enzymes?

5 **a** Describe what a clone is.
b Why is cloning called nuclear transfer?
c Suppose a farmer had a herd of 30 cloned sheep. What would be the advantages and disadvantages of a cloned herd compared with a normal herd?

6 The diagram on the right shows foreign DNA being placed into a bacterial chromosome.
a Copy the diagram in your notebook and add these labels: bacterial chromosome containing donor DNA, deleted section of bacterial DNA, donor DNA, bacterial chromosome.
b In which steps are restriction enzymes and ligase enzymes used? Explain your answer.

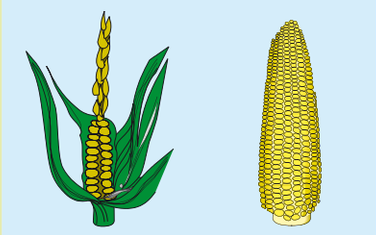


c Why is the same type of restriction enzyme used for the bacterial DNA as for the donor DNA?

7 The cotton plant in the photo on page 226 is called a transgenic organism.
a What does the word transgenic mean?
b Why are some people worried about the effect of GM crops like this cotton on the environment?

challenge

1 The diagram below shows an ear of modern corn and an ancestor of modern corn.



a Unlike the ancestral corn, the seeds (or kernels) of modern corn cannot come away from the stem and therefore cannot self seed. Suggest why this characteristic would have been selectively bred in corn. Could modern corn survive in the wild?

b Many biologists argue that the wild forms of plants like corn should not be allowed to become extinct. Suggest why.

2 Consider the following cloning scenario. Suppose a woman suffers from a severe genetic disorder. She and her husband want a child and are opposed to abortion and egg donation from another woman. Doctors say that the husband's DNA can be fused into one of his wife's eggs whose nucleus has been removed.
a Use the diagram on page 230 as a guide to explain how this might be done.
b What other technique in biotechnology could possibly be used in this case?

3 A CSIRO researcher found a gene which makes plants destroy their own seeds. Discuss the pros and cons of adding this gene to plants that supply our fruit and vegetables.

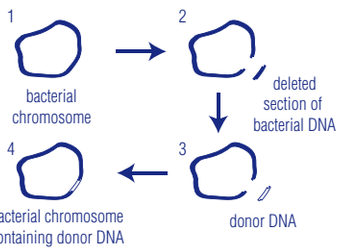
4 Selective breeding is just one technique used in what is now called traditional biotechnology. Find out about other techniques. Then make a list of the techniques in traditional and modern biotechnology. Beside each technique list its benefits and risks to our society.

Check! solutions

4 The word 'shears' is defined as a 'clipping instrument'. It is appropriate because 'gene shears' are restriction enzymes that clip or cut out a section of DNA or gene, which can then be inserted into another chromosome in another organism.

5 **a** A clone is an identical twin born at a later time. It is produced by growing an organism using the chromosomes from another organism. A clone has identical characteristics to the donor because it has the identical genes (genotype) of the donor.
b The technique is called nuclear transfer because that is part of the process—the nucleus of the donor cell is placed into an 'empty' egg cell. These 'fertilised' cells are then implanted into a uterus or several 'surrogate' uteri for the pregnancy and birth.
c The advantages would be that they would all have the same desired characteristics (eg producing very fine wool). A disadvantage would be that because they are genetically identical they would all be equally affected by any disease or parasite. This could mean that all of the flock might die suddenly as a result of the same disease, whereas this would not happen in a flock of genetically different animals. Another disadvantage is that the DNA is 'old' DNA and likely to carry mutations that would cause damage to the offspring.

6 **a**



b Restriction enzymes are used in step 2 to remove a section of bacterial DNA. Ligase enzymes are used in step 4 to insert the donor DNA into the bacterial chromosome.
c The reason is that the DNA in bacteria is the same as that of all other organisms and will be affected by the enzymes in the same way. The same enzymes will cut the different DNA in the same way so that the ends will fit together.

7 **a** The word transgenic means that genes from one species have been incorporated into a chromosome of another species.
b Some people are worried because there is a fear that these genes may 'escape' from the cotton or other species and get into other native species and confer undesirable characteristics (eg insecticide production). If so, this might interfere with the survival and reproduction of native animals and plants.

Challenge solutions

1 **a** This characteristic has been selected for in modern corn so that it can be used as a food. If the kernels fell away from the stem it would not provide as much food per ear. Modern corn could not survive in the wild because it does not drop its seeds, so it cannot germinate to form new plants.
b Wild corn has a wider variety of genes than the modern version. It could therefore be useful in future when trying to breed other forms of corn. If the wild corn became extinct these genes would be lost forever.

MAIN IDEAS

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

artificial selection
competition
environmental
evolution
gene pool
genes
genetic engineeering
independent assortment
mutations
natural selection
phenotypes
population
selection agents
variations

1 There are three ways in which variations in a genotype occurs: _____ of chromosomes as well as recombination of DNA during sex cell division, and _____ in the chromosomes in sex cells.

2 The _____ of phenotypes in a population occur as a result of genetic factors and _____ factors such as nutrition and health.

3 _____ is the process in which individuals with favourable _____ have a better chance of surviving in a particular environment than other individuals.

4 The factors in an organism's environment which affect its survival are called _____. These include _____ and predation from other organisms, heat and cold, and the availability of soil and water.

5 A _____ is the sum of all the genes in a particular _____ of organisms.

6 _____ is the process in which species change over time and may develop into new species.

7 _____ or selective breeding by humans has changed the phenotypes of many types of organisms.

8 _____ describes the process in which _____ from one organism are inserted into the DNA of another organism.

Try doing the Chapter 9 crossword on the CD. Working with technology

REVIEW

1 Which is the best definition of a gene pool?
- **A** the type of gene in a population
- **B** the sum of all the genes in a population
- **C** the number of combinations of genes possible
- **D** the genes carried by the parents of a particular offspring

2 Which of the following factors would least influence natural selection?
- **A** natural death
- **B** competition from other species
- **C** mutation
- **D** interbreeding

3 Which statement about natural selection is *incorrect*?
- **A** It indicates how new species may form.
- **B** It relies upon the fact that characteristics are inherited.
- **C** It suggests that only the largest and most physically fit organisms survive.
- **D** It suggests that the biotic and abiotic factors may favour some individuals and not others.

4 The domestic dog has over 100 different breeds, yet wild dogs have very few variations (eg jackal, wolf, dingo). How can you explain this?

5 An organism's genotype is not the only factor that determines its characteristics (phenotype). The environment also plays an important part in how the organism's genes are expressed. Explain, giving an example, what this statement means.

Main ideas solutions

1 independent assortment, mutations
2 variations, environmental
3 natural selection, phenotypes
4 selection agents, competition
5 gene pool, population
6 evolution
7 artificial selection
8 genetic engineering, genes

Review solutions

1 B—see page 219
2 A
3 C
4 The ancestors of the domestic dog were selectively bred (artificially selected) by humans to produce breeds with the required characteristics. For example, the greyhound was bred for speed while the golden retriever was bred for hunting.
5 Two plants from the same stock have the same genotypes. However, if they are planted in different areas where the climate is different, then the environmental conditions will produce different characteristics (phenotypes).

2 a The technique would involve taking an egg from the mother and removing the nucleus. A cell could then be removed from the father and inserted into the egg. This will then form an embryo, which can then be implanted into the mother's uterus, and a normal pregnancy and birth should follow. In this case, the child will be a clone of his father.

b It is possible that not all the woman's eggs contain the defective gene. In this case the eggs, or the zygotes which are formed by fertilisation of the eggs with sperm, can be screened and those with the defective gene discarded. Another possibility is to replace the defective gene with the normal gene in an egg or zygote, and then implant it and allow the pregnancy to proceed. There are bioethical concerns with both of these possibilities.

3 Arguments in favour of this technique would include:
- more tasty fruit without the nuisance of removing seeds
- easier processing, for example, in making jams or tinned fruit.

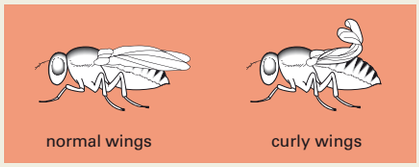
You may have thought of some others. Arguments against this technique include:
- the difficulty in propagating this species because there are no seeds
- the possibility that this gene could get into another species and cause them to destroy their seeds

You may have thought of some others.

4 Biotechnology is a huge area that includes any application of technology to biology, which are too numerous to list here. The two main areas of biology are medicine and agriculture. Some traditional areas of biotechnology include grafting plants, artificial insemination of animals, brewing and IVF. Some modern areas of biotechnology include DNA analysis, genetic screening, genetic fingerprinting, genome mapping and nanotechnology. (Look at <www.csiro.au/science/biotechnology.html> for some more examples.)

REVIEW

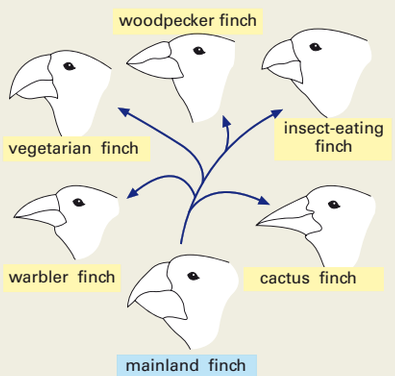
6 The diagram below shows a fruit fly with normal wings and one with curly wings. Flies with curly wings cannot fly. The gene for this characteristic occurs as a natural mutation. Suggest why very few adult fruit flies with this phenotype are found in nature.



7 In which of the following activities are humans least likely to influence the evolution of other organisms? Justify your answer.

A spraying gardens with pesticides
B breeding frost-resistant oranges
C recycling wastes from cities
D using antibiotics in the control of bacteria

8 The diagram below shows the five species of finches that Charles Darwin observed when he visited the Galapagos Islands. It also shows the finch that lived on the mainland of South America, which Darwin inferred was the ancestor of the Galapagos Islands finches. Suggest how modern DNA testing techniques could be used to support Darwin's inference.

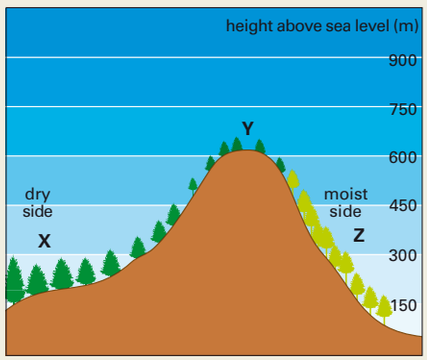


9 A human gene that is responsible for the manufacture of a growth hormone in humans can be produced in the laboratory by genetically modified bacteria. Using simple labelled diagrams explain how this procedure works.

10 A particular species of moth exists in two forms, a light-coloured form and a dark-coloured form. These moths rest on the bark of trees in the daytime. When a bird catches a moth, it swallows the body and rejects the wings.

Suppose you had 100 of each type of moth. Design a test to show that birds are selection agents of this moth.

11 A species of forest tree has spread over a mountain from the dry side to the moist side. The three populations show different characteristics: the trees at X are drought-resistant, those at Y are frost-resistant, while those at Z need high humidity.



a List the selection agents in this situation.
b Explain why the populations of trees in each location are different.
c Suggest why the trees at X are more likely than the trees at Y to form a different species from the trees at Z.

Check your answers on page 337.

6 Fruit flies born with curly wings cannot fly. Hence, they would die of starvation or would be easy prey for predators.

7 C—The other alternatives could change the gene pools and hence the characteristics of the organisms. For example in A most insects would die, but the naturally resistant ones would survive and hence the gene pool might change.

8 If the mainland finch was the ancestor of the Galapagos finches, then the DNA of each finch would be very similar. The higher the percentage similarity, the more Darwin's inference is supported.

9 See the diagram in Exercise 6 on page 232. Instead of the foreign DNA you would use the gene for human growth hormone.

10 Here is one suggestion for an experiment, although you may have a different design. If so, ask your teacher to check it.

In a very large cage (aviary), place a number of model tree trunks—all made from dark-coloured material (dark bark). Release 50 dark-coloured moths and 50 light-coloured ones. Also release a small number of birds. After a number of hours, remove the birds and record the number and colour of the wings of moths that have been eaten.

Repeat the experiment this time using light-coloured model tree trunks, the same number of moths and the same number of birds.

By tabulating the number and colour of the moths' wings in each case, you should be able to see whether birds act as selection agents by eating light-coloured moths on the dark bark, or the dark-coloured moths on the light bark.

11 **a** The selection agents are temperature and availability of water.

b Over a long period of time, the trees have spread over both sides of the mountain, but only those trees best suited to the conditions in each of the locations have survived and reproduced.

c The trees at X are separated from the trees at Z by the cold conditions on the high parts of the mountain, and it is unlikely that trees at X and Z would interbreed. Therefore, if the gene pools of each group are isolated from each other for a long period of time, trees at X and Z could form two different species. On the other hand, trees at Y are not totally isolated from the trees at Z and might still interbreed.