Level

F	1	2	3	4	**5**	**6**	B6

*E*xplain the variation

Strand
Life and Living

Key concept
Evolutionary processes have given rise to a diversity of living things, which can be grouped according to their characteristics.

Purpose

Activities in this module are designed to help students understand the concepts of genetics and natural selection and to use them to explain how variation in living things leads to change in species over time. Students have opportunities to:

- create an analogy of cell division producing gametes;
- recognise the variety in genetic make-up that occurs in gametes;
- identify characteristics that are sex-linked;
- investigate the inheritance of characteristics or traits from one generation to the next;
- investigate the mechanism and consequences of natural selection.

Overview of activities

The following table shows the activities in this module and the way in which these are organised in **introductory**, **developmental** and **culminating** phases.

Introductory ►	Developmental ►	Culminating
What do you know?	Gamete production	Survival
	Issues of inheritance	
	Is it a boy or is it a girl?	
	Predictions	
	Simulation of natural selection	
	Species	

QUEENSLAND SCHOOL CURRICULUM COUNCIL

Core learning outcomes

This module focuses on the following core learning outcomes from the Years 1 to 10 Science Syllabus:

Life and Living

5.2 Students evaluate different processes and strategies of reproduction (including asexual reproduction and care of young) in terms of their relative efficiency in ensuring survival of offspring.

6.2 Students use scientific ideas (including concepts of genetics and natural selection) to explain how variation in living things leads to change in species over time.

Core content

This module incorporates the following core content from the syllabus:

Life and Living

Reproductive processes — sexual, asexual

Variation in species — sexual reproduction, mutation, genetics, evolution

Mendelian genetics — dominant/recessive, incomplete dominance, sex-linkage

Theory of evolution — natural selection, adaptation

Assessment strategy

Suggestions for gathering information about student learning are provided in each of the activities in this module. Once sufficient information has been collected, judgments can be made about students' demonstrations of outcomes. Typical demonstrations of this module's intended outcomes are provided here to indicate the pattern of behaviour to look for when making judgments.

Life and Living

5.2 Students evaluate different processes and strategies of reproduction (including asexual reproduction and care of young) in terms of their relative efficiency in ensuring survival of offspring.

Students may:

- illustrate and model the processes of mitosis and meiosis;
- compare the processes and products of meiosis and mitosis;
- evaluate the contribution of meiosis in producing variation in offspring;
- assess the variety of offspring arising from reproductive strategies.

Life and Living

6.2 Students use scientific ideas (including concepts of genetics and natural selection) to explain how variation in living things leads to change in species over time.

Students may:

- describe the differences between mitosis and meiosis and explain the role of each;
- evaluate the process of meiosis to determine the extent of gamete variation;
- predict and test using models how fertilisation produces variety in offspring;
- predict genotypes and phenotypes and probabilities of possible matings;
- explain sex-linkage of genes and its consequences;
- explain where mutation occurs and how it contributes to variation and speciation;
- describe processes and consequences of natural selection in various environmental conditions.

Background information

Current scientific conceptions

Individual organisms have characteristics that distinguish them from other organisms. These characteristics are coded into the genes contained in the nuclei of their cells. New organisms come into being from pre-existing organisms. The set of characteristics of an individual is determined by the genetic code that came from the pre-existing organism(s) that were involved in producing it.

All living things reproduce; large numbers of them rely on sexual reproduction for continuation of the species and asexual reproduction for growth and repair. Some organisms do not reproduce sexually — for example, bacteria reproduce by binary fission. Many plants can reproduce asexually (vegetatively) as well as sexually.

Processes of reproduction, including the mixing of genes and mutation, lead to variations in the characteristics of individuals within a population. Some individuals will have characteristics that enable them to survive more easily than the others. They are more likely to thrive, and to produce offspring that have the characteristics that enabled their parents to survive. This is known as 'natural selection'. Through successive generations, if the same characteristics continue to afford better chances of survival, more individuals in that population will have those characteristics. Because different characteristics afford better chances of survival in different circumstances, different populations of organisms in different locations may, in time, come to have different sets of characteristics from each other. This process is called divergent evolution. If these populations become so different that they are no longer reproductively compatible, speciation has occurred. Variations of characteristics can arise through mutations of particular genes. Mutations can also lead to different organisms with different characteristics developing similarities under similar environmental conditions — referred to as convergent evolution.

The genetic information of a species is carried on its chromosomes. The nuclei of cells may have a set of single chromosomes (haploid cells) or a set of paired chromosomes (diploid cells). Organisms that reproduce sexually will have a major life stage in which the cells of the organism are diploid with one of each pair of chromosomes coming from each of the parents. Diploid organisms will have sexually differentiated individuals (individual male and female organisms) or differentiated sexual organs (male and female parts, for example, parts of a flower). An organism that reproduces sexually will have a stage in its life cycle that produces haploid cells so that a single set of chromosomes from each parent can combine to create the diploid stage. Gametes (or sex cells) are haploid cells. Female gametes are usually referred to as ova or eggs, and male gametes as sperm. Fertilisation is the process of bringing gametes together. It provides the opportunity to mix the genetic material of the species giving rise to variation within the species.

The form of plants and animals commonly experienced by students is the diploid form. The diploid form possesses two sets of chromosomes and therefore two copies of a gene. The two copies may be of the same allele or different alleles for the same characteristic. Alleles are the different forms of a particular gene.

Alleles of a gene have different relationships with each other. Some alleles are dominant (for example, red colour in some flowers) in which case they will appear in the characteristics of the individual carrying them whether a pair of alleles is present or only one. Other alleles are recessive (for example, white flower colour). A pair of recessive alleles must be present before the flowers can be white. When alleles are incompletely dominant the individual has a characteristic which is a mixture of the two characteristics — in this example, pink. A description of the alleles of an organism and hence the possible characteristics that it might display is called the genotype. A description of the characteristics that an organism actually displays is called the phenotype.

Students' prior understandings

Students' prior understandings may differ from current scientific conceptions in a range of ways:

Reproduction and inheritance

Some students may think that:

- gametes from an individual are all the same;
- characteristics are inherited by 'averaging of the parental characteristics';
- having a range of characteristics in offspring has no relevance to the survival of the species;
- a dominant gene is the one that is the most common.

Teachers can help students to refine their understanding through a variety of learning and teaching strategies. For example, teachers can facilitate discussion, provide and help students create models as well as develop hypothetical scenarios that challenge alternative conceptions and illustrate and clarify concepts.

Theories of evolution and natural selection

Some students may:

- think that species of organisms do not change;
- consider mutations to be mistakes;
- have beliefs that conflict with scientific explanations;
- think that organisms can always respond to the demands of their environment.

Teachers can provide students with a range of activities that explore characteristics of organisms and how they are inherited, population dynamics, natural selection and the scientific explanations associated with these phenomena.

Issues in this module

Some of the concepts to be explored in this module will raise questions for students about family background, physical characteristics, biological parents and genetic make-up. Teachers need to be prepared for a range of student responses to these issues. Teachers can model respect and sensitivity about these issues and expect the same sensitivity and respect for all people from students. Teachers can acknowledge the desirability of variation within a species and respect for the immense range displayed among the peoples of the world. It may be advisable to inform parents that these issues are going to form part of the students' discussions.

Terminology

Terms associated with genetics and natural selection are essential to the activities in this module — for example:

adaptation	evolution	maternal	phenotype
allele	fertilisation	meiosis	recessive
asexual	gamete	mitosis	sexual
binary fission	gene	mutation	sperm
chromosome	genotype	natural selection	survival
diploid	haploid	ovum	zygote
dominant	hybrid	paternal	

Students may already be familiar with some of these terms, and understand their meanings and use in scientific contexts. If so, the activities in this module will provide opportunities for them to evaluate current usage. If not, these activities will provide opportunities for students to develop their understandings.

School authority policies

Teachers need to be aware of and observe school authority policies that may be relevant to this module. It is essential that demonstrations and student activities are conducted according to procedures developed through appropriate risk assessments at the school.

Support materials and references

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Strahan, R. (ed.) 1983, *The Australian Museum Complete Book of Australian Mammals*, Angus & Robertson, Sydney. (This book is out of print. A revised edition, *The Mammals of Australia*, was published in 1998 by the Australian Museum and New Holland Publishers [Reed New Holland], Sydney.)

Tests for colour blindness

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Ishihara, S. 1979, *Tests for Colour Blindness — The Series of Plates*, Kanehara Shuppan, Japan.

ACTIVITY

What do you know?

Introductory

Focus

This activity provides opportunities for students to evaluate and clarify their current understanding of concepts related to the reproduction processes and location of genetic information in organisms.

Materials

No particular materials are required.

Teaching consideration

Be sensitive to the fact that many students, for a variety of reasons, may not live with their biological parents or relatives.

Working scientifically

Time: 40 minutes

Clarifying and challenging
Identifying
Reflecting
Creating diagrams
Exploring and elaborating ideas

▶ Led by the teacher, students discuss the variations in characteristics of people and identify the characteristics that lead them all to be grouped as the species *Homo sapiens*. They discuss their ideas about how variations in the characteristics of people have arisen.

▶ Working individually, students start with 'heredity' or 'inheritance' and create a list of all the words or ideas they associate with these terms. They then share their list with a peer and make a combined list. Working in groups of four, students then negotiate and collate their ideas to make a large concept map which shows their understanding of relationships between the ideas.

▶ Each group presents a concept map and explains the links they have made. Students seek clarification of ideas about which they are unsure.

▶ A list of terms from the concept maps that have specific meanings related to heredity and reproduction is collated for further investigation. Students reflect on what they know about heredity, what they need to know and what they might like to know (a source of extension activities).

▶ Students research the meaning of the words collated and write a glossary of terms before proceeding. Alternatively, they may collect information about the terms as they progress through the various activities.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions about similarities and differences within a species;
- students' concept maps of ideas about heredity;
- students' explanations of concept maps.

ACTIVITY

Gamete production

Developmental

Focus

This activity provides opportunities for students to use models to develop an understanding of events occurring in the cell nucleus during cell division.

Materials

For each group of students:

- 16 pipe-cleaners, wool strands or short strands of 'poppit' beads (four each of two shades of a colour, e.g. 4 light blue, 4 dark blue; 4 pink, 4 red)
- 3 large sheets of paper
- coloured pencils or pens the same colour as the pipe-cleaners, wools or poppit beads

Teaching considerations

Students should have some understanding of mitosis and meiosis before undertaking this activity. When students are discussing their understanding of chromosomes, lead the discussion towards the ideas that:

- an individual's chromosomes originally came from its parents — in the gametes that joined at fertilisation;
- half the genetic information in an individual comes from the male parent and the other half from the female parent;
- as the number of cells in an individual increases through cell division, copies must be made of the chromosomes so that the same type and amount of genetic information is found in most body cells.

Discuss with students how models can be used to explain complex ideas. Discuss also the limitations of the particular model being used and features of the model that may not correspond to the real situation. It is important that strategies used to explain or clarify one concept do not create misconceptions about others.

When modelling mitosis and meiosis use wool, pipe-cleaners or poppit beads of a particular family of colours for each cell. For example, give each pair of students two pink and two red strands of wool to represent two pairs of chromosomes. The other strands mentioned in the materials listed above will be needed to represent the replication of chromosomes during cell division.

Working scientifically

Time: 90 minutes

Collecting information
Exploring phenomena
Predicting
Constructing meaning
Creating analogies
Making links
Clarifying ideas and concepts

▶ Students share their ideas about chromosomes — what they are and where they are to be found. They collect information to clarify any ideas about which they are unsure. Questions to guide their thinking could include:

- What is the function of a chromosome?
- How many chromosomes are found in human cells?
- Where in cells are chromosomes found?
- Are chromosomes found in all cells of the human body? Explain.
- Where did the chromosomes in your cells come from originally?

Constructing and using models
Creating diagrams
Discussing thinking

- What happens to the zygote (the first cell of a new individual) as the individual grows and develops?
- If the number of chromosomes in most cells is the same, what must happen to the chromosomes as the number of cells increases?

Mitosis

▶ Students watch as the teacher models mitosis and ask questions to clarify their understanding of the process. In groups, they model the process for themselves and record in diagrams and words the significant parts of the process.

▶ Students discuss where the process of mitosis might be taking place in their bodies, in bodies of other animals and in plants.

Meiosis

▶ Students formulate and elaborate ideas on what would happen if gametes were produced by mitosis. They review evidence that fertilisation does not lead to continued doubling of genetic material, but that chromosome pairs must be halved when gametes are produced.

▶ Students watch as the teacher models meiosis and ask questions to clarify their understanding of the process. In groups, they model the process for themselves and record in diagrams and words the significant parts of the process.

▶ Students then model fertilisation and compare the genetic information in the two parents with that in the offspring.

▶ Students compare mitosis and meiosis identifying where the processes are similar, where they are different and the significance of the differences. They make links between the processes of mitosis and meiosis, and the differences between asexual and sexual reproduction.

Additional learning

▶ Students extend the modelling of fertilisation through a number of generations recognising the increasing variation of the individuals produced. They also consider the number of different types of gametes that could be produced by an individual as the number of chromosomes in the cell is increased.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' recording of the process of mitosis;
- students' recording of the process of meiosis;
- students' comparison of mitosis and meiosis.

ACTIVITY

Issues of inheritance

Developmental

Focus

This activity provides opportunities for students to observe characteristics within a family group and make deductions about the nature of the genetic influences.

Materials

- Resource Sheet 1, 'A matter of inheritance'

Teaching considerations

Be sensitive to the fact that many students, for a variety of reasons, may not live with their biological parents or relatives. Information about inherited traits may be collected from Resource Sheet 1 or from reference material as well as from students' own families.

When students are clarifying their understandings of patterns of inheritance, they should develop an understanding of 'dominant/recessive inheritance' and 'incomplete dominance'. They should also become aware of the terms 'genotype' and 'phenotype'.

Working scientifically

Time: 60 minutes (and research time)

Clarifying and challenging
Collecting information
Looking for patterns and meanings
Seeking reasons
Applying ideas and concepts
Constructing meaning
Drawing conclusions
Interpreting data
Using ideas, theories and principles
Creating presentations
Illustrating

▶ Students discuss their thinking about the ways in which people describe family likenesses. Discussion questions could include:

- What sorts of features do people usually compare when discussing family likenesses?
- Do you think inherited traits (characteristics) are confined to the physical features of a person? Explain.
- What do you think people mean when they say that a characteristic has 'skipped a generation'?
- What do you think is happening (in terms of genetic information) when 'skipping of generations' occurs?
- What do you think is happening when a child appears to have a characteristic half way between that of the two parents?

▶ Students collect information (from their own families or from resource material) about the inheritance of specific traits and hypothesise about different patterns of inheritance. They record their ideas in their notebooks. In groups, students discuss their ideas and formulate questions to help clarify their understandings. They find answers to their questions, collate their information and report it to the class.

▶ Students decide which of the traits they have identified are dominant, which are recessive and which show incomplete dominance.

Resource Sheet 1

▶ In groups, students collect information about the work of Gregor Mendel and the ratios of genotypes and phenotypes he predicted for offspring in crosses involving dominant/recessive and incompletely dominant traits. They record this information in their notebooks. Students use the examples on Resource Sheet 1 and for one characteristic show the phenotype of each individual and their possible genotypes.

▶ Students research genetic traits such as dwarfism, cystic fibrosis, albinism, sickle-cell anaemia or thalassemia. They describe the pattern of inheritance, its occurrence in the population and the effects it has on individuals with the trait. In small groups, students create a presentation of their research for the class.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' reports on ways in which genetic traits may be inherited;
- students' notes on the work of Gregor Mendel;
- students' presentations on a genetic trait.

ACTIVITY

Is it a boy or is it a girl?

Developmental

Focus

This activity provides opportunities for students to explore the concept that characteristics of organisms can be sex-linked and examine evidence supporting this concept.

Materials

- Shinobu Ishihara's *Tests for Colour Blindness — The Series of Plates*

Teaching considerations

Some students may know that in humans the pairs of XX and XY chromosomes determine whether an individual will be male or female. They may not be aware that the X chromosome is much bigger than the Y chromosome and therefore carries more genetic information. Females, with two X chromosomes, may have a recessive characteristic on one of the X chromosomes which will not be apparent in the phenotype. However, that characteristic may be passed on to any children. Males, who have only one X chromosome, will have a phenotype that reflects any recessive characteristic found on that X chromosome. Therefore, some characteristics are found more commonly in males than in females and are called 'sex-linked'. Examples of sex-linked characteristics are Duchenne muscular dystrophy, red/green colour blindness and haemophilia.

When carrying out the test for colour blindness, be sensitive to the fact that some students may have been tested and are therefore aware of their colour perception abilities, while others will not be aware. In addition, only some students may be able to check family histories. The tests for colour blindness will have more meaning in a co-education environment than in single-sex schools. In the general population, one in 12 males are colourblind. The ratio for females is one in 165.

Ensure that students are aware that there are various forms of colour blindness and that the book of plates tests only one form.

Tests for colour blindness can be found on the web at URL: http://www.bareket.org.il/colourblind/test.html.

Gather sufficient copies of the test for colour blindness to make the activity practical.

Working scientifically

Time: 60 minutes

Accessing resources
Clarifying and challenging
Exploring phenomena
Formulating questions
Looking for patterns and meanings
Applying ideas and concepts
Constructing meaning

▶ Students discuss their understanding of how information carried on chromosomes determines whether an individual will be male or female. They formulate questions to assist clarification of their understandings and gather information to answer their questions.

▶ Students discuss the effect on the phenotype of an individual of having two or only one X chromosome. Questions to guide their thinking could include:

- If a girl's mother has a recessive characteristic on one of her X chromosomes, could the girl also have that characteristic and would it be evident in her phenotype? Explain.

Making comparisons
Clarifying ideas and concepts
Creating presentations
Discussing thinking
Exploring and elaborating ideas
Summarising and reporting

- If a boy's mother has a recessive characteristic on one of her X chromosomes, could the boy also have that characteristic and would it be evident in his phenotype? Explain.
- If a girl's father has a recessive characteristic on his X chromosome, could the girl also have that characteristic and would it be evident in her phenotype? Explain.
- If a boy's father has a recessive characteristic on his X chromosome, could the boy also have that characteristic and would it be evident in his phenotype? Explain.
- Could a sex-linked characteristic be present in a number of generations of a family without it becoming apparent? Explain.

▶ In groups, students explore the phenomenon of sex-linkage, identify characteristics that are inherited in this way, and create a presentation explaining the effect on an individual of one of these characteristics.

▶ Students test each other for colour blindness using the colour plates in the book and record their diagnosis. The results for the class are collated in a table like the one down below. The percentage of students in each category is calculated. The class results are compared with global results. These can be found by searching on the Internet using 'colour blindness' as the key words. Students write a paragraph explaining the relationship between the class results and global results.

Class results of tests for colour blindness

	Normal vision male	Normal vision female	Red/green colourblind male	Red/green colourblind female
Tally				
Total				
Class percentage				
Global percentage				

Additional learning

▶ Students investigate how sex is determined in other animals. They describe the significance for the species of any differences.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' questions and answers;
- students' presentations on sex-linked characteristics;
- students' paragraphs on the results of tests for colour blindness.

ACTIVITY

Predictions

Developmental

Focus

This activity provides opportunities for students to explore the use of models to predict patterns of inheritance.

Materials

For each group of students:

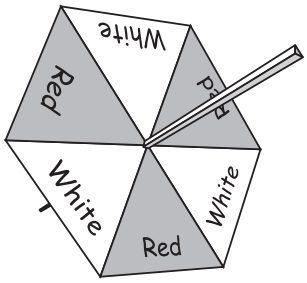
- 2 coins, dice or spinning tops

Teaching considerations

Models can be used to predict the likelihood of an event occurring. Small numbers of events may not appear to follow the predictions. However, the greater the number of events occurring, the closer reality approaches the prediction.

The probability of events involving spinning tops, dice and coins can be used to represent the probabilities associated with inheritance of specific characteristics. The process of meiosis results in one chromosome from each pair going into each gamete. Therefore, a gamete contains the genetic information of either one chromosome or the other. If, for example, one chromosome of a pair had the characteristic 'red' and the other 'white', then the gametes would contain either the 'red' characteristic or the 'white' characteristic. This could be represented by:

- heads = red and tails = white on a coin;
- odds = red and evens = white on a die;
- the words 'red' and 'white' written on a simple spinning top like the one shown in the diagram below.



Tossing two coins, throwing two dice or spinning two tops could represent the two parents and the characteristics in the gametes that come together at fertilisation (the genotype). Depending on the type of inheritance (dominant/recessive, incomplete dominance or sex-linked), the phenotype can then be determined.

Groups of students could investigate different patterns of inheritance.

Be sensitive to the fact that due to religious or cultural reasons some students cannot be involved in activities that use dice or coins because of their link with gambling.

Working scientifically

Time: 60 minutes

Clarifying and challenging
Designing and performing investigations
Exploring phenomena
Looking for patterns and meanings
Predicting
Applying ideas and concepts
Creating analogies
Using ideas, theories and principles
Constructing and using models
Discussing thinking
Illustrating
Summarising and reporting

▶ As a class, students predict how many times heads (or tails) would occur if a coin were tossed ten times. They record their predictions then, working in pairs, test their predictions by tossing a coin. Each pair records the results and shares them with the rest of the class. Students discuss how many groups had results that matched their predictions and suggest reasons for any variations.

▶ Students then collate results for the whole class. They compare the collated results with the predictions and suggest reasons for any change in the match between the predictions and the results from a larger sample.

▶ Students create an analogy between the coin tossing activity and inheritance of characteristics. Questions to guide their thinking could include:

- What are the chances that heads will come up when a coin is tossed?
- If heads comes up the first time, what are the chances that it will come up the next time?
- If heads comes up the first nine times, what are the chances that heads will come up on the tenth throw?
- When a child is conceived what are the chances it will be a boy (or girl)?
- If the first child in a family is a girl (or boy) what are the chances that the next child will be a boy (or girl)?
- A flowering plant has one pair of chromosomes with information determining flower colour. On one chromosome the information determines red flowers. On the other chromosome the information determines white flowers. What percentage of the gametes produced by the plant would carry the information for red flowers?

▶ Students discuss ways in which the coin tossing activity could be used to model gamete formation and inheritance of specific characteristics. They suggest other ways of modelling these processes.

▶ Students use the models they have devised to test their responses to the earlier questions. They compare the results collected with their predictions and suggest reasons for the differences.

▶ Students prepare a summary of their investigations and report their findings to the class. In their reports, they discuss any suggested improvements to their investigations.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' reports to the class.

ACTIVITY

Simulation of natural selection

Developmental

Focus

This activity provides opportunities for students to investigate the mechanism and effects of natural selection.

Materials

- Resource Sheet 2, 'Simulation of natural selection'
- materials listed on Resource Sheet 2

Teaching consideration

Discuss with students how models or simulations can be used to explain complex ideas. Discuss also the limitations of the particular model being used and features of the model that may not correspond to the real situation. It is important that strategies used to explain or clarify one concept do not create misconceptions about others.

Working scientifically

Time: 50 minutes

Identifying variables
Applying ideas and concepts
Judging credibility
Constructing and using models
Creating tables and graphs

▶ Students discuss relationships between an organism, its characteristics and its ability to survive in an environment.

▶ Students discuss the structure of the simulation described on Resource Sheet 2 and make predictions about what will happen to the populations of species as the simulation is completed.

Resource Sheet 2

▶ Students carry out the simulation in small groups, record and graph their results and write an explanation of what happened. They share their results with the rest of the class.

▶ Students compare the results from all the groups. Explanations are suggested for similarities and differences. Discussion questions and ideas could include:

- What happened to the species of prey that were highly visible in the environment?
- What happened to the species that were well camouflaged?
- What would be the long-term effect of this pattern on the survival of some species in an area? If not all the class groups found this pattern in their results, suggest explanations for the differences.
- Compare what happened in the simulation with what would happen in a natural environment.
- Suggest ways in which the simulation could be improved.

If time and resources permit, students could undertake their own simulations and report on these to the class.

▶ Students discuss their thinking on how populations of a single species showing significant variation could change with time if, for example:

- climatic conditions change;
- new predators come into an area;
- predators leave an area;
- new food sources become available in an area;
- existing food sources are depleted;
- insecticides or herbicides are used frequently in their habitat.

▶ Students use their understanding of the previous simulation to develop a simulation to test their ideas. They carry out the simulation and report their findings to the class.

Additional learning

▶ Students gather information about the changes to the populations of Peppered Moths (*Biston betularia*) in England over the last 250 years. A search on the Internet using 'Biston+betularia' or 'peppered+moth' will provide information.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' tabulation, graphing and reporting on the results of the simulations;
- students' simulations.

ACTIVITY

Species

Developmental

Focus

This activity provides opportunities for students to explore ideas about the variation within and between species, and scientific explanations of variation and change.

Materials

For the class:

- dictionaries, biology reference books with glossaries and encyclopedias

For the teacher:

- Resource Sheet 3, 'Meanings of terms'
- Resource Sheet 4, 'Rosellas'
- Resource Sheet 5, 'Quolls'

Teaching considerations

Have students find definitions of 'species', 'mutation' and 'adaptation' before the activity begins. A range of definitions is provided on Resource Sheet 3.

Discuss with students in general terms how a small change in genetic code is a mutation and causes some change in the individual organism which may be advantageous, deleterious or neutral. The change could isolate it reproductively or lead to isolation after a number of generations.

Revisit issues related to efficiency of reproduction and survival of offspring during discussion where appropriate.

Specific references which could be used to extend this activity include: *The Nature of Biology: Book 2*; *Biology: An Australian Perspective*; *Encyclopaedia Botanica*; *The Graham Pizzey and Frank Knight Field Guide to the Birds of Australia*; *Year 12 Biology 1997 Student Resource and Activity Manual*; *The Australian Museum Complete Book of Australian Mammals* (revised and reprinted as *The Mammals of Australia*); 'Quoll on the run' in *Australian Geographic*, no. 54 (contains information from the previous reference); *Macquarie Study Dictionary*. See 'Support materials and references' for full details.

Working scientifically

Time: Part 1, 20 minutes; Part 2, 30 minutes; Part 3, 20 minutes

Collecting information
Looking for patterns and meanings
Seeking reasons
Inferring from data
Making comparisons
Preparing scenarios
Arguing a position
Supporting decisions

Part 1

▶ Students share definitions and explanations they have found for the terms 'species', 'mutation' and 'adaptation'. Led by the teacher, they:

- research the various definitions and explanations of the terms;
- suggest why there is more than one definition or explanation;
- decide on one definition or explanation to be used by the class.

▶ Students consider how creating a definition clarifies communication but also sets artificial boundaries that are not reflected in the natural world. Students might discuss the notion that defining an entity affects the way people view it and this can lead to misconceptions. They also consider how extending the scope of a definition to include all possible instances or to increase precision will most likely make the definition more complicated and less useful.

Resource Sheet 4

▶ Students consider the information 'The formation of a new species' on Resource Sheet 4 and then draw a diagram to represent the process of speciation described there. They consider the implications of the various definitions of species and compare them with current ideas about speciation.

Part 2

▶ Students read the descriptions of the different rosellas on Resource Sheet 4. They identify the shaded areas on the map which describe the ranges of the Crimson Rosella (*Platycercus elegans elegans*), the Northern Crimson Rosella (*Platycercus elegans nigrescens*), the Adelaide Rosella (*Platycercus elegans adelaidae*), the Yellow Rosella (*Platycercus elegans flaveolus*), and the Green Rosella (*Platycercus caledonicus*).

▶ Students use the information provided to make a comparison of species and subspecies. They show ways in which the forms are similar and ways in which they are different. Students create scenarios to suggest:

- how the differences arose;
- why they have been maintained;
- which differences would be the most likely cause of a separation into four separate subspecies;
- events that would have to occur for speciation to happen;
- how the Green Rosella became a separate species.

Part 3

Resource Sheet 5

▶ Students read and consider the information about the quoll on Resource Sheet 5. They supplement the information provided with their own research, then develop a hypothesis for how speciation might have occurred and argue their case.

Additional learning

▶ Students research and reflect upon the variations, and the mechanisms by which they have been achieved, in the genus *Euphorbia* which have made it so successful in so many countries and climates across the world.

▶ Students investigate and explain the variations and similarities in species of gymnosperms across the world.

▶ Students investigate and explain, in terms of natural selection:

- homologous structures such as wings of birds and bats, fins of fish and flippers in seals or whales;
- similarity of structure of the forelimbs of humans, dogs, bats and whales.

Gathering information about student learning

Sources of information may include:

- students' contributions to discussions;
- students' comparisons and scenarios;
- students' hypotheses.

ACTIVITY

Survival

Culminating

Focus

This activity provides opportunities for students to demonstrate their understanding of the role of variation in populations as their habitat changes significantly.

Materials

No particular materials are required.

Teaching consideration

Although no particular materials are required, it may be useful to have access to a variety of resources to enable students to clarify ideas and to stimulate thinking. Videos showing the after-effects of volcanic eruptions, simulations of the effects of meteor impacts or previous ice ages could also be useful.

Working scientifically

Time: 60–90 minutes

Engaging with problems
Exploring phenomena
Forecasting and backcasting
Predicting
Dealing in an orderly manner with the parts of a complex whole
Formulating and elaborating ideas
Judging credibility
Selecting and justifying
Clarifying ideas and concepts
Creating presentations
Supporting decisions

▶ Students brainstorm a list of events that could cause major and relatively long-term changes to the habitat of living things — for example:

- volcanic eruption;
- meteor impact;
- global cooling or warming caused by natural forces or human impact.

▶ Groups of students select one change from the list. They formulate and elaborate ideas about the effects that the change would have on various groups of living things (for example, producers, consumers, decomposers, omnivores, herbivores, carnivores) normally found in an ecosystem.

▶ Students suggest characteristics a living thing would require if it were to survive in the changed environment. They focus their discussion on the individual organism initially, then extend their consideration to the species as a whole. They consider the long-term effects on the species and other species with which it interacts in a community. Some questions to guide students as they deal with the parts of this complex situation could include:

- What environmental conditions are necessary for survival?
- Which of these conditions have changed? How have they changed? What are the immediate short- and long-term consequences of the changes?
- What effect will genetic variation have on survival of particular groups of organisms? Will some groups of organisms benefit from having more (or less) variation? Justify answers to this question.
- What potential effects on survival will there be of:
  - producing different numbers of offspring?
  - having longer or shorter life cycles?
  - being more (or less) specialised in terms of living places and feeding requirements?

▶ Students apply their ideas and create a presentation that represents, with justification, the new environment that they think could result. The presentation would include information about, for example:

- the groups of living things present;
- the relative numbers of the different groups;
- the characteristics of the groups (or particular species) of living things;
- how stable the new ecosystem would be;
- how much variation there would be in the new populations.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' presentations.

A matter of inheritance

Resource Sheet 1 *(continued)*

Table 1: Family traits

Trait	Maternal grandmother	Maternal grandfather	Mother	Paternal grandmother	Paternal grandfather	Father	Daughter	Son
eye colour	blue	grey	blue	brown	blue	hazel	hazel	blue-grey
hair colour	brown	dark brown	brown	auburn	brown	auburn	black	brown
hair type	curly	straight	wavy	straight	straight	straight	wavy	wavy
ear lobe	unattached	unattached	unattached	attached	unattached	attached	attached	attached
chin	smooth	smooth	smooth	smooth	smooth	smooth	smooth	smooth
tongue	rolling	non-rolling	rolling	non-rolling	rolling	rolling	rolling	rolling
nose shape	tilted	convex	tilted	tilted	tilted	tilted	tilted	tilted
blood type	unknown	unknown	A+	unknown	unknown	unknown	unknown	A+
colour blindness	no	no	no	no	no	no	no	yes

A matter of inheritance *(continued)*

Resource Sheet 1

Table 2: Dominant and recessive traits

Trait		Dominant	Recessive	Notes
eye colour		brown, hazel	blue, grey, green	Eye colour is not a simple dominant/recessive relationship. There are numerous factors interacting. Do not infer any relationship within the groups without research.
hair type				The alleles for straight and curly hair display incomplete dominance.
ear lobe		unattached	attached	
chin		cleft	smooth	
tongue		rolling	non-rolling	
blood type	Rh factor	+	–	
	blood group	A, B	O	Blood groups A and B are codominant; when they occur together they produce type AB.
colour blindness		normal vision	colourblind	Colour blindness is sex-linked. The gene occurs on the X chromosome only.

Simulation of natural selection

Resource Sheet 2

In this simulation, a large sheet of paper represents an environment. Small squares of paper represent prey animals living in that environment, with different-coloured squares representing different prey species. The students represent predators of the animals and 'capture' the prey animals under controlled conditions.

Each group of students will need:

- large sheet of multi-coloured paper (e.g. gift wrapping paper)
- a large number of small squares (10 x 10 mm) of paper of the same colour as the large sheet of paper and of at least two other colours
- stopwatch or watch/clock with a second hand

1. Work in groups of two to four. For each simulation, one student acts as a predator and another acts as the time-keeper; a third could record the results, and a fourth could keep the 'prey animals' organised.

2. Count out equal numbers of squares of each coloured paper (at least 20 of each colour). Record your results in the table 'Simulation of natural selection — Results table'. Assign a colour to each section of the table (Prey 1, 2 or 3). Record the starting number of prey of each colour.

Roles of the group members

- *Predator*: Turn around or close your eyes until the time-keeper says 'go' then face the paper or open your eyes, and start to 'capture' the prey by picking up the small squares of paper. Pick them up; do not just push them to one side. Stop hunting as soon as the time-keeper says 'stop'.
- *Time-keeper*: Allow the predator exactly 10 seconds to capture the 'prey'. Start the time by saying 'go'; end it by saying 'stop'.
- *Other students*: Spread the small squares of paper evenly over the large, multi-coloured sheet of paper.

Recording the results of the first predation

1. Sort the captured prey by colour. Record results for one prey species at a time.

2. Count the number of prey that have been taken. Record this number in the second column of the table — 'number taken'.

3. Subtract the 'number taken' from the 'starting number' to calculate the number of prey remaining. Record this in the third column of the table — 'number remaining'.

4. Each of the prey remaining is able to have one offspring. Record this number in the 'offspring added' column.

(continued)

Simulation of natural selection *(continued)*

5. The sum of the 'number remaining' and the 'offspring added' becomes the 'total' for the last column. This number then becomes the 'starting number' for the second predation.

6. Repeat this recording process for the other two prey species.

An example of the recording process is shown below.

Prey 1

	starting number	number taken	number remaining	offspring added	total
First predation	20	15	5	5	10
Second predation	10				

More predation

1. Add the 'offspring' to the 'environment'. Ensure that you are starting with the correct number of coloured squares representing each prey species.

2. Repeat the complete process another four times, making a total of five episodes of predation altogether.

3. Draw a graph to demonstrate the changes in number of each of the prey. The graph would include the starting number for each of the prey at the beginning of the simulation and the total at the end of the fifth predation.

(continued)

Simulation of natural selection *(continued)*

Results table

Prey 1

	starting number	number taken	number remaining	offspring added	total
First predation	20				
Second predation					
Third predation					
Fourth predation					
Fifth predation					

Prey 2

	starting number	number taken	number remaining	offspring added	total
First predation	20				
Second predation					
Third predation					
Fourth predation					
Fifth predation					

Prey 3

	starting number	number taken	number remaining	offspring added	total
First predation	20				
Second predation					
Third predation					
Fourth predation					
Fifth predation					

Meanings of terms

These definitions may be a useful starting point for your work.

Adaptation

An adaptation is a feature that appears to equip an organism for survival in a particular habitat.

(Kinnear, J. & Martin, M. 1993, *The Nature of Biology: Book 2*, The Jacaranda Press, Milton, Q)

An adaptation is a feature of an organism which enhanced its ability to survive and reproduce in a particular habitat.

(Huxley, L. & Walter, M. 1998, *Biology: An Australian Perspective*, Oxford University Press, Melbourne)

An adaptation is a characteristic of an organism that improves its chances of survival in a particular habitat.

(*Macquarie Study Dictionary* 1998, Jacaranda Wiley, Milton, Q)

Mutation

A mutation is a change in chromosome or gene composition.

(Huxley, L. & Walter, M. 1998, *Biology: An Australian Perspective*, Oxford University Press, Melbourne)

A mutation with respect to a gene is a change from one form to another resulting in a change in the genotype of an organism or an individual cell. Mutations can occur spontaneously as a result of the normal cell process or can be induced by certain chemicals and types of radiation.

(*Macquarie Study Dictionary* 1998, Jacaranda Wiley, Milton, Q)

Mutation, in relation to a gene, is a sudden and unpredictable alteration of the nucleotide sequence in the gene and, as a consequence, changes the instructions for an organism's functioning that are encoded in the gene. It may involve the addition, replacement or deletion of one or more bases in the DNA sequence.

(Kinnear, J. & Martin, M. 1993, *The Nature of Biology: Book 2*, The Jacaranda Press, Milton, Q)

Species

A species (in sexually reproducing organisms) is a group of individuals that is able to interbreed to produce fertile offspring. This group of organisms is reproductively isolated from all other such groups. The species is the lowest rank in the taxonomic classification of organisms with similar and related species grouped into genera.

(*Macquarie Study Dictionary* 1998, Jacaranda Wiley, Milton, Q)

A species is a taxonomic unit consisting of organisms capable of mating and producing viable and fertile offspring.

(Kinnear, J. & Martin, M. 1993, *The Nature of Biology: Book 2*, The Jacaranda Press, Milton, Q)

A species is a group of actually or potentially interbreeding natural populations that is reproductively isolated from other such groups.

(Proposed by Ernst Mayr)

Rosellas

The formation of a new species

When two separate populations of a species in an area develop some genetic variations, they may interbreed less than they originally did. They may develop into separate races with noticeable variations. This variation may further isolate the species so that there is less interbreeding at which time the group becomes a subspecies. Once the variation excludes interbreeding, the group is considered a separate species.

Biologists studying rosellas think that the Crimson Rosella was, in the past, widespread throughout eastern Australia. Now distinct groups are recognised. The Green Rosella is regarded as a separate species. The Adelaide, Yellow, Northern Crimson and Crimson are classified as subspecies.

Crimson Rosella (*Platycercus elegans elegans*)

Common Australian parrot, 32 to 37 cm in length, mainly crimson with blue cheeks, shoulders and tail. The wings and back are mottled black.

The juveniles are golden olive with patchy crimson colour on the forehead, throat and under-wing coverlets. Juveniles also have blue cheeks and shoulders and some blue and white on the edges of the tail. The juveniles in northern New South Wales and southern Queensland are very similar to the adults in colouring except that they have green fringes to some feathers.

The rosellas associate in pairs and small flocks feeding on the ground, mainly on grass seeds. Their diet also includes fruits, flowers, insects and their larvae. Their habitat includes rainforest, tall open forest and wetter open forest. Those found in rainforests tend to live in areas that abut the open forest, roads or cultivated land.

They breed between September and January, laying five to eight white eggs in holes high up in trees or in building cavities. They disperse during autumn and winter to lowlands and urban areas.

Yellow Rosella *(Platycercus elegans flaveolus)*

Between 30 and 34 cm in length, this parrot is predominantly pale yellow with red and blue cheeks and shoulders. The back and wing feathers are mottled black. Juveniles are a 'washed' olive green.

They congregate in pairs and small flocks, feeding on the ground, mainly on grass seed. Their diet also includes fruits, flowers, insects and their larvae. Their habitat is forests along rivers and their tributaries.

They breed between August and January, laying four to five white eggs in hollows in tall trees standing in or near water. In the Morgan–Mannum area of South Australia, there is interbreeding between the Yellow and Adelaide Rosellas.

(continued)

Rosellas *(continued)*

Northern Crimson Rosella (*Platycercus elegans nigrescens*)

This subspecies is found in northern Queensland. They are smaller and darker than the Crimson Rosella but otherwise have the same habits and habitat.

Adelaide Rosella (*Platycercus elegans adelaidae*)

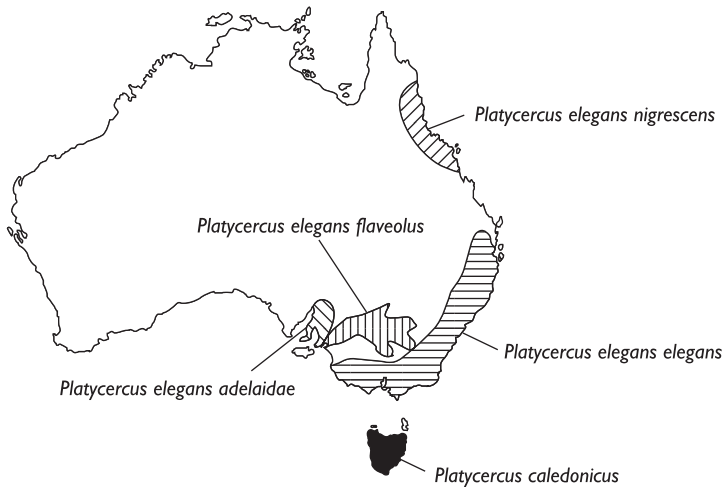
This parrot is 34 to 36 cm long and has variable colouring. Some are reddish-yellow with blue cheeks, shoulders and tail edges; others are red on the mantle turning to yellow over the neck and rump. Juveniles are olive green with red on the forehead, throat and under-tail covers.

They congregate in pairs and small flocks and are often seen foraging in tall trees, on the ground or near waterholes. They feed mainly on grass seeds; however, their diet also includes fruits, flowers, insects and their larvae. Their habitat is wooded valleys, open woodland and forests along major waterways. They breed from November to February and interbreed with the Yellow Rosella near the Morgan–Mannum area of South Australia.

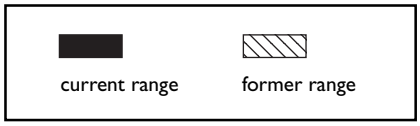
Green Rosella (*Platycercus caledonicus*)

About 37 cm long, the Green Rosella is predominantly greenish-yellow to yellow with blue patches on its cheek, a red forehead and black edges to the feathers of the upper back and shoulders. The juveniles are duller and generally washed with green.

They congregate in pairs and small flocks, feeding on the ground, mainly on grass seed. However, their diet also includes fruits, flowers, insects and their larvae. Their habitat is open forest, open woodland and heathland. They breed between November and February, laying four to five eggs in holes in trees or crevices of buildings.

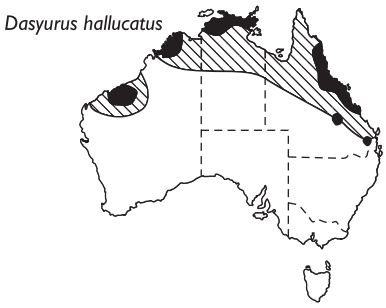


Quolls



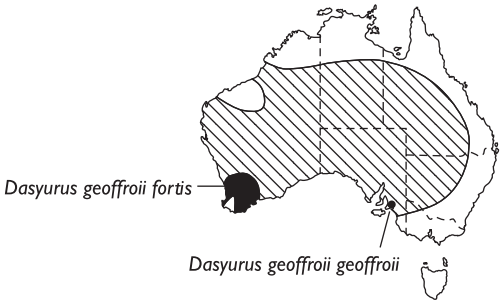
Dasyurus hallucatus (Little northern native cat)

Once found along much of the northern coastline of Australia but now restricted to pockets in treed locations and broken rocky areas. It has five toes and a striated hind foot for climbing over smooth rock surfaces. The little northern native cat is an aggressive carnivore. It has a varied diet which includes mammals, insects and some fruits.



Dasyurus geoffroii (rare)

Once found in any habitat ranging from forest to desert in most of non-arid Australia, particularly Western and central Australia. It is active mostly around dusk and dawn, eating a range of meat, carrion and possibly eggs. Now restricted to south-west Western Australia. The reason for its endangered status is not evident.

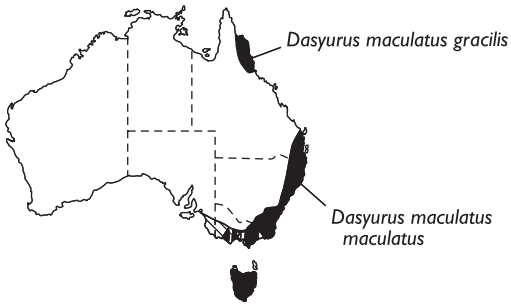


(continued)

Quolls *(continued)*

Dasyurus maculatus gracilis

Found in both rainforest and coastal heathland of tropical Queensland east of the ranges from Townsville to Princess Charlotte Bay. Its habitat has been diminished by land clearing. Epidemics, competition and predation have further contributed to a decline in its numbers. It is carnivorous and nocturnal but will scavenge farm carcasses, bask in the sun and feed opportunistically during the day.

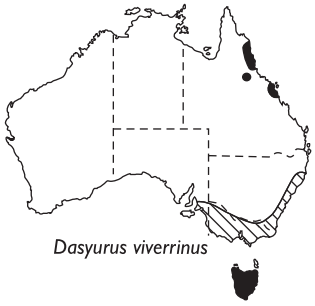


Dasyurus maculatus maculatus (*Spotted tailed quoll*)

Found in wetter coastal regions, both forest and heathland of south eastern Australia (Queensland, New South Wales, Victoria) including Tasmania. Its habitat has been diminished by land clearing. Epidemics, competition and predation have further contributed to a decline in numbers. It is no longer found in South Australia and parts of western Victoria. It is carnivorous and nocturnal but will scavenge farm carcasses, bask in the sun and feed opportunistically during the day.

Dasyurus viverrinus (*Eastern quoll*)

Once found in Queensland, New South Wales, Victoria, eastern South Australia and Tasmania in dry forest, scrub, heathland, grassland and farming areas. It is now limited to Tasmania and pockets of coastal north Queensland. Predation by foxes, habitat loss and disease were the main reasons that the numbers of eastern quolls reduced on the mainland. The absence of foxes in Tasmania may have enabled the quoll to survive there. It is nocturnal, favours a mix of forest and farmland, and is an opportunistic carnivore feeding on birds, small mammals and insects. It also eats grass and berries.



Source: Based on information courtesy the Australian Museum. (From *The Australian Museum Complete Book of Australian Mammals,* Angus & Robertson, 1983; publication currently revised and reprinted as *The Mammals of Australia*, New Holland, 1998.)

Acknowledgments

This module includes material developed by Joan Benham in association with the Queensland School Curriculum Council.

Grateful acknowledgment is made to the following organisation for granting permission to use copyright material:

Australian Museum for material from *The Australian Museum Complete Book of Australian Mammals*, 1983.

This sourcebook module should be read in conjunction with the following Queensland School Curriculum Council materials:

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Years 1 to 10 Science Sourcebook: Guidelines

Science Initial In-service Materials

ISBN 0 7345 2047 6

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PIP 99313