South Australian Certificate of Education
LEARNING AT THE PACE OF CHANGE

Government of South Australia

Biology

2021 Subject Outline | Stage 2

For teaching

- In Australian and SACE International schools from January 2021 to December 2021
- In SACE International schools only, from May/June 2021 to March 2022

Published by the SACE Board of South Australia,
60 Greenhill Road, Wayville, South Australia 5034

First published 2017
Published online November 2017, 2018, 2020
Revised November 2018
Reissued for 2020, 2021
ISBN 978 1 74102 809 6 (online Microsoft Word version)
ref: A906580

This subject outline is accredited for teaching at Stage 2 from 2018

CONTENTS

INTRODUCTION

SUBJECT DESCRIPTION

Biology is a 10-credit subject or a 20-credit subject at Stage 1 and a 20-credit subject at Stage 2.

The study of Biology is constructed around inquiry into and application of understanding the diversity of life as it has evolved, the structure and function of living things, and how they interact with their own and other species and their environments.

Students investigate biological systems and their interactions, from the perspectives of energy, control, structure and function, change, and exchange in microscopic cellular structures and processes, through to macroscopic ecosystem dynamics. These investigations allow students to extend the skills, knowledge, and understanding that enable them to explore and explain everyday observations, find solutions to biological issues and problems, and understand how biological science impacts on their lives, society, and the environment. They apply their understanding of the interconnectedness of biological systems to evaluate the impact of human activity on the natural world.

In their study of Biology, students inquire into and explain biological phenomena and draw evidence-based conclusions from their investigations into biology-related issues, developments, and innovations.

Students explore the dynamic nature of biological science and the complex ways in which science interacts with society, to think critically and creatively about possible scientific approaches to solving everyday and complex problems and challenges. They explore how biologists work with other scientists to develop new understanding and insights, and produce innovative solutions to problems and challenges in local, national, and global contexts, and apply their learning from these approaches to their own scientific thinking.

In Biology, students integrate and apply a range of understanding, inquiry, and scientific thinking skills that encourage and inspire them to contribute their own solutions to current and future problems and challenges. Students also pursue scientific pathways, for example, in medical research, veterinary science, food and marine sciences, agriculture, biotechnology, environmental rehabilitation, biosecurity, quarantine, conservation, and ecotourism.

CAPABILITIES

The capabilities connect student learning within and across subjects in a range of contexts. They include essential knowledge and skills that enable people to act in effective and successful ways.

The SACE identifies seven capabilities. They are:

- literacy
- numeracy
- information and communication technology (ICT) capability
- critical and creative thinking
- personal and social capability
- ethical understanding
- intercultural understanding.

Literacy

In this subject students extend and apply their literacy capability by, for example:

- interpreting the work of scientists across disciplines, using biological knowledge
- critically analysing and evaluating primary and secondary data
- extracting biological information presented in a variety of modes
- using a range of communication formats to express ideas logically and fluently, incorporating the terminology and conventions of biology
- synthesising evidence-based arguments
- communicating appropriately for specific purposes and audiences.

Numeracy

In this subject students extend and apply their numeracy capability by, for example:

- solving problems using calculations and critical thinking skills
- measuring with appropriate instruments
- recording, collating, representing, and analysing primary data
- accessing and interpreting secondary data
- identifying and interpreting trends and relationships
- calculating and predicting values by manipulating data and using appropriate scientific conventions.

Information and communication technology (ICT) capability

In this subject students extend and apply their ICT capability by, for example:

- locating and accessing information
- collecting, analysing, and representing data electronically
- modelling concepts and relationships
- using technologies to create new ways of thinking about science
- communicating biological ideas, processes, and information

- understanding the impact of ICT on the development of biology and its application in society
- evaluating the application of ICT to advance understanding and investigations in biology.

Critical and creative thinking

In this subject students extend and apply critical and creative thinking by, for example:

- analysing and interpreting problems from different perspectives
- deconstructing a problem to determine the most appropriate method for investigation
- constructing, reviewing, and revising hypotheses to design investigations
- interpreting and evaluating data and procedures to develop logical conclusions
- analysing interpretations and claims, for validity and reliability
- devising imaginative solutions and making reasonable predictions
- envisaging consequences and speculating on possible outcomes
- recognising the significance of creative thinking on the development of biological knowledge and applications.

Personal and social capability

In this subject students extend and apply their personal and social capability by, for example:

- understanding the importance of biological knowledge on health and well-being, both personally and globally
- making decisions and taking initiative while working independently and collaboratively
- planning effectively, managing time, following procedures effectively, and working safely
- sharing and discussing ideas about biological issues, developments, and innovations while respecting the perspectives of others
- recognising the role of their own beliefs and attitudes in gauging the impact of biology in society
- seeking, valuing, and acting on feedback.

Ethical understanding

In this subject students extend and apply their ethical understanding by, for example:

- considering the implications of their investigations on organisms and the environment
- making ethical decisions based on an understanding of biological principles
- using data and reporting the outcomes of investigations accurately and fairly
- acknowledging the need to plan for the future and to protect and sustain the biosphere
- recognising the importance of their responsible participation in social, political, economic, and legal decision-making.

Intercultural understanding

In this subject students extend and apply their intercultural understanding by, for example:

- recognising that science is a global endeavour with significant contributions from diverse cultures
- respecting and engaging with different cultural views and customs and exploring their interaction with scientific research and practices
- being open-minded and receptive to change in the light of scientific thinking based on new information
- understanding that the progress of biology influences and is influenced by cultural factors.

ABORIGINAL AND TORRES STRAIT ISLANDER KNOWLEDGE, CULTURES, AND PERSPECTIVES

In partnership with Aboriginal and Torres Strait Islander communities, and schools and school sectors, the SACE Board of South Australia supports the development of high-quality learning and assessment design that respects the diverse knowledge, cultures, and perspectives of Indigenous Australians.

The SACE Board encourages teachers to include Aboriginal and Torres Strait Islander knowledge and perspectives in the design, delivery, and assessment of teaching and learning programs by:

- providing opportunities in SACE subjects for students to learn about Aboriginal and Torres Strait Islander histories, cultures, and contemporary experiences
- recognising and respecting the significant contribution of Aboriginal and Torres Strait Islander peoples to Australian society
- drawing students' attention to the value of Aboriginal and Torres Strait Islander knowledge and perspectives from the past and the present
- promoting the use of culturally appropriate protocols when engaging with and learning from Aboriginal and Torres Strait Islander peoples and communities.

HEALTH AND SAFETY

The handling of live animals, pathogens, and a range of chemicals and equipment requires appropriate health, safety, and welfare procedures.

It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students and that school practices meet the requirements of the *Work Health and Safety Act 2012*, in addition to relevant state, territory, or national health and safety guidelines. Information about these procedures is available from the school sectors.

The following safety practices must be observed in all laboratory work:

- Use equipment only under the direction and supervision of a teacher or other qualified person.
- Follow safety procedures when preparing or manipulating apparatus.
- Use appropriate safety gear when preparing or manipulating apparatus.

Any teaching activities that involve the care and use of, or interaction with, animals must comply with the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes,* 8th edition, in addition to relevant state or territory guidelines.

Keeping live animals in an educational setting requires permission from the relevant Animal Ethics Committee. Permission to dissect animals must be obtained in writing from these committees.

For Department of Education and Child Development schools, information can be obtained from the DECD Intranet Animal Ethics webpage (https://myintranet.learnlink.sa.edu.au/educating/extra-curricular-activities/animal-ethics).

The Non Government Schools Animal Ethics Committee is a collaboration between Catholic Education South Australia and the Association of Independent Schools of South Australia (www.ais.sa.edu.au/home/general-information/animal-ethics).

LEARNING SCOPE AND REQUIREMENTS

LEARNING REQUIREMENTS

The learning requirements summarise the knowledge, skills, and understanding that students are expected to develop and demonstrate through their learning in Stage 2 Biology.

In this subject, students are expected to:

1. apply science inquiry skills to deconstruct a problem and design and conduct biological investigations, using appropriate procedures and safe, ethical working practices
2. obtain, record, represent, analyse, and interpret the results of biological investigations
3. evaluate procedures and results, and analyse evidence to formulate and justify conclusions
4. develop and apply knowledge and understanding of biological concepts in new and familiar contexts
5. explore and understand science as a human endeavour
6. communicate knowledge and understanding of biological concepts and information, using appropriate terms, conventions, and representations.

CONTENT

Stage 2 Biology is a 20-credit subject.

The topics in Stage 2 Biology provide the framework for developing integrated programs of learning through which students extend their skills, knowledge, and understanding of the three strands of science.

The three strands of science to be integrated throughout student learning are:

- science inquiry skills
- science as a human endeavour
- science understanding.

The topics for Stage 2 Biology are:

- Topic 1: DNA and proteins
- Topic 2: Cells as the basis of life
- Topic 3: Homeostasis
- Topic 4: Evolution

Students study all four topics. The topics can be sequenced and structured to suit individual groups of students.

The following pages describe in more detail:

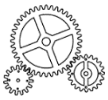
- science inquiry skills
- science as a human endeavour
- the topics for science understanding.

The descriptions of the science inquiry skills and the topics are structured in two columns: the left-hand column sets out the science inquiry skills or science understanding and the right-hand column sets out possible contexts.

Together with science as a human endeavour, the science inquiry skills and science understanding form the basis of teaching, learning, and assessment in this subject.

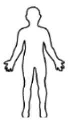
The possible contexts are suggestions for potential inquiry approaches, and are neither comprehensive nor exclusive. Teachers may select from these and are encouraged to consider other inquiry approaches according to local needs and interests.

Within the topic descriptions, the following symbols are used in the possible contexts to show how a strand of science can be integrated:



indicates a possible teaching and learning strategy for science understanding

indicates a possible science inquiry activity



indicates a possible focus on science as a human endeavour.

Science Inquiry Skills

In Biology, investigation is an integral part of the learning and understanding of concepts, using scientific methods to test ideas and develop new knowledge.

Practical investigations must involve a range of both individual and collaborative activities, during which students extend the science inquiry skills described in the table that follows.

Practical activities may take a range of forms, such as developing or using models and simulations that enable students to develop a better understanding of particular concepts. The activities include laboratory and field studies during which students develop investigable questions and/or testable hypotheses, and select and use equipment appropriately to collect data. The data may be observations, measurements, or other information obtained during the investigation. Students represent and analyse the data they have collected; evaluate procedures, and describe the limitations of the data and procedures; consider explanations for their observations; and present and justify conclusions appropriate to the initial question or hypothesis.

It is recommended that a minimum of 16–20 hours of class time involves practical activities.

Science inquiry skills are fundamental to students investigating the social, ethical, and environmental impacts and influences of the development of scientific understanding and the applications, possibilities, and limitations of science. These skills enable students to critically consider the evidence they obtain so that they can present and justify conclusions.

Science Inquiry Skills	Possible contexts
Scientific methods enable systematic investigation to obtain measurable evidence. • Deconstruct a problem to determine and justify the most appropriate method for investigation. • Design investigations, including: ◆ a hypothesis or inquiry question ◆ types of variables – dependent – independent – factors held constant (how and why they are controlled) – factors that may not be able to be controlled (and why not) ◆ materials required ◆ the method to be followed ◆ the type and amount of data to be collected ◆ identification of ethical and safety considerations.	Develop inquiry skills by, for example: • designing investigations that require investigable questions and imaginative solutions (with or without implementation) • critiquing proposed investigations • using the conclusion of one investigation to propose subsequent experiments • changing an independent variable in a given procedure and adapting the method • researching, developing, and trialling a method • improving an existing procedure • identifying options for measuring the dependent variable • researching hazards related to the use and disposal of chemicals and/or biological materials • developing safety audits • identifying relevant ethical and/or legal considerations in different contexts.

<table>
<tr><th>Science Inquiry Skills</th><th>Possible contexts</th></tr>
<tr><td>Obtaining meaningful data depends on conducting investigations using appropriate procedures and safe, ethical working practices.
• Conduct investigations, including:
◆ selection and safe use of appropriate materials, apparatus, and equipment
◆ collection of appropriate primary and/or secondary data (numerical, visual, descriptive)
◆ individual and collaborative work.</td><td>Develop inquiry skills by, for example:
• identifying equipment, materials, or instruments fit for purpose
• practising techniques and safe use of apparatus
• comparing resolution of different measuring tools
• distinguishing between, and using, primary and secondary data.</td></tr>
<tr><td>Results of investigations are represented in a well-organised way to allow them to be interpreted.
• Represent results of investigations in appropriate ways, including:
◆ use of appropriate SI units, symbols
◆ construction of appropriately labelled tables
◆ drawing of graphs, including lines or curves of best fit as appropriate
◆ use of significant figures.</td><td>Develop inquiry skills by, for example:
• practising constructing tables to tabulate data, including column and row labels with units
• identifying the appropriate representations to graph different data sets
• selecting appropriate axes and scales to graph data
• clarifying understanding of significant figures using, for example:
www.astro.yale.edu/astro120/SigFig.pdf
www.hccfl.edu/media/43516/sigfigs.pdf
www.physics.uoguelph.ca/tutorials/sig_fig/SIG_dig.htm
• comparing data from different sources to describe as quantitative or qualitative.</td></tr>
<tr><td>Scientific information can be presented using different types of symbols and representations.
• Select, use, and interpret appropriate representations, including:
◆ mathematical relationships, such as ratios
◆ diagrams
◆ equations
to explain concepts, solve problems, and make predictions.</td><td>Develop inquiry skills by, for example:
• writing chemical equations
• drawing and labelling diagrams
• recording images
• constructing flow diagrams.</td></tr>
</table>

<table>
<tr><th>Science Inquiry Skills</th><th>Possible contexts</th></tr>
<tr><td>Analysis of the results of investigations allows them to be interpreted in a meaningful way.
• Analyse data, including:
◆ identification and discussion of trends, patterns, and relationships
◆ interpolation/extrapolation where appropriate.</td><td>Develop inquiry skills by, for example:
• analysing data sets to identify trends and patterns
• determining relationships between independent and dependent variables
• using graphs from different sources (e.g. CSIRO or the Australian Bureau of Statistics (ABS)) to predict values other than plotted points
• calculating mean values and rates of reaction, where appropriate.</td></tr>
<tr><td>Critical evaluation of procedures and data can determine the meaningfulness of the results.
• Identify sources of uncertainty, including:
◆ random and systematic errors
◆ uncontrolled factors.
• Evaluate reliability, accuracy, and validity of results, by discussing factors including:
◆ sample size
◆ precision
◆ resolution of equipment
◆ random error
◆ systematic error
◆ factors that cannot be controlled.</td><td>Develop inquiry skills by, for example:
• discussing how the repeating of an investigation with different materials/equipment may detect a systematic error
• using an example of an investigation report to develop report-writing skills.
Useful website:
www.biologyjunction.com/sample%20ap%20lab%20reports.htm</td></tr>
<tr><td>Conclusions can be formulated that relate to the hypothesis or inquiry question.
• Select and use evidence and scientific understanding to make and justify conclusions.
• Recognise the limitations of conclusions.
• Recognise that the results of some investigations may not lead to definitive conclusions.</td><td>Develop inquiry skills by, for example:
• evaluating procedures and data sets provided by the teacher to determine and hence comment on the limitations of possible conclusions
• using data sets to discuss the limitations of the data in relation to the range of possible conclusions that could be made.</td></tr>
<tr><td>Effective scientific communication is clear and concise.
• Communicate to specific audiences and for specific purposes using:
◆ appropriate language
◆ terminology
◆ conventions.</td><td>Develop inquiry skills by, for example:
• reviewing scientific articles or presentations to recognise conventions
• developing skills in referencing and/or footnoting
• distinguishing between reference lists and bibliographies
• practising scientific communication in written, oral, and multimodal formats (e.g. presenting a podcast or writing a blog).</td></tr>
</table>

Science as a Human Endeavour

The science as a human endeavour strand highlights the development of science as a way of knowing and doing, and explores the purpose, use, and influence of science in society.

By exploring science as a human endeavour, students develop and apply their understanding of the complex ways in which science interacts with society, and investigate the dynamic nature of biological science. They explore how biologists develop new understanding and insights, and produce innovative solutions to everyday and complex problems and challenges in local, national, and global contexts. In this way, students are encouraged to think scientifically and make connections between the work of others and their own learning. This enables them to explore their own solutions to current and future problems and challenges.

Students understand that the development of science concepts, models, and theories is a dynamic process that involves analysis of evidence and sometimes produces ambiguity and uncertainty. They consider how and why science concepts, models, and theories are continually reviewed and reassessed as new evidence is obtained and emerging technologies enable new avenues of investigation. They understand that scientific advancement involves a diverse range of individual scientists and teams of scientists working within an increasingly global community of practice.

Students explore how scientific progress and discoveries are influenced and shaped by a wide range of social, economic, ethical, and cultural factors. They investigate ways in which the application of science may provide great benefits to individuals, the community, and the environment, but may also pose risks and have unexpected outcomes. They understand how decision-making about socio-scientific issues often involves consideration of multiple lines of evidence and a range of needs and values. As critical thinkers, they appreciate science as an ever-evolving body of knowledge that frequently informs public debate, but is not always able to provide definitive answers.

The key concepts of science as a human endeavour underpin the contexts, approaches, and activities in this subject, and must be integrated into all teaching and learning programs.

The key concepts of science as a human endeavour, with elaborations that are neither comprehensive nor exclusive, in the study of Biology are:

Communication and Collaboration

- Science is a global enterprise that relies on clear communication, international conventions, and review and verification of results.
- Collaboration between scientists, governments, and other agencies is often required in scientific research and enterprise.

Development

- Development of complex scientific models and/or theories often requires a wide range of evidence from many sources and across disciplines.
- New technologies improve the efficiency of scientific procedures and data collection and analysis. This can reveal new evidence that may modify or replace models, theories, and processes.

Influence

- Advances in scientific understanding in one field can influence and be influenced by other areas of science, technology, engineering, and mathematics.
- The acceptance and use of scientific knowledge can be influenced by social, economic, cultural, and ethical considerations.

Application and Limitation

- Scientific knowledge, understanding, and inquiry can enable scientists to develop solutions, make discoveries, design action for sustainability, evaluate economic, social, cultural, and environmental impacts, offer valid explanations, and make reliable predictions.
- The use of scientific knowledge may have beneficial or unexpected consequences; this requires monitoring, assessment, and evaluation of risk, and provides opportunities for innovation.
- Science informs public debate and is in turn influenced by public debate; at times, there may be complex, unanticipated variables or insufficient data that may limit possible conclusions.

Topic 1: DNA and proteins

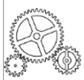
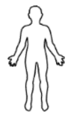
Heredity is an important biological principle as it explains why new cells or offspring resemble their parent cell or parent organism. Some organisms require cellular division and differentiation for growth, development, repair, and sexual reproduction. Students investigate the structure of DNA and processes involved in the transmission of genetic material to the next generation of cells and to offspring. They also develop an understanding of how genetic information is expressed in cells and organisms, and how this understanding has changed in the light of new technology and new evidence. They study how interactions between genes and environmental conditions influence an organism's characteristics.

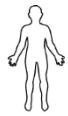
Students relate gene expression to protein production and explore some of the many roles that proteins have in a functioning cell and organism. They speculate on the possible outcomes of gene modification and discuss the associated ethical implications and consequences. Students develop an understanding of the increased capacity of technology to acquire and process genetic data, and explore some of the social, environmental, and economic impacts of scientific research in this area as they continue to develop their social and personal capability.

Science Understanding	Possible contexts	
DNA stores and transmits genetic information; it functions in the same way in all living things. DNA is a helical double-stranded molecule. In eukaryotes, DNA is bound to proteins in linear chromosomes, which are found in the nucleus. DNA is unbound and circular in the cytosol of prokaryotes and in the mitochondria and chloroplasts of eukaryotes. • Compare chromosomes in prokaryotes and eukaryotes. Replication of DNA allows for genetic information to be inherited. Base-pairing rules and method of DNA replication are universal. • Describe the structural properties of the DNA molecule, including: ◆ nucleotide composition and pairing ◆ the weak bonds between strands of DNA that allow for replication. • Explain the importance of complementary base pairing (A–T and C–G). • Describe and represent the process of semi-conservative replication of DNA.	Review prokaryotic and eukaryotic cells. Construct and use models of DNA replication, to communicate conceptual understanding, solve problems, and make predictions. View the following website: www.phet.colorado.edu/en/simulation/stretching-dna	
	Extract DNA (e.g. from peas or bananas). Model the mechanism of semi-conservative replication showing complementary base-pairing.	
	Explore how the work of Watson, Crick, Franklin, and Wilkins exemplifies some of the ways in which a range of evidence from many sources contributed to developing the model of the structure of DNA.	
A gene consists of a unique sequence of nucleotides that codes for a functional protein or an RNA molecule. • Distinguish between exons and introns as coding and non-coding segments of DNA found in genes in eukaryotes. • Describe how both exons and introns are transcribed but only the information contained in exons is translated to form a polypeptide in eukaryotes.	Note that most prokaryotic cells do not have introns. Discuss the end products of genes including functional proteins, tRNA, rRNA, and microRNA.	

Science Understanding	Possible contexts	
Protein synthesis involves transcription of a gene into messenger RNA (mRNA), and translation of mRNA into an amino acid sequence at the ribosomes. In eukaryotic cells, transcription occurs in the nucleus. • Describe and illustrate the role of DNA, mRNA, transfer RNA (tRNA), and ribosomal RNA (rRNA) in transcription and translation. • Describe the relationship between DNA codons, RNA codons, anticodons, and amino acids. • Distinguish between coding (gene) and template strands of DNA.	Construct and use appropriate representations, including models of transcription and translation, to communicate conceptual understanding of the roles of mRNA, tRNA, and ribosomes.	
The folding of a polypeptide to form a protein with a unique three-dimensional shape is determined by its sequence of amino acids. • Describe the factors that determine the primary, secondary, tertiary, and quaternary structure of proteins.	Illustrate, using examples, how the primary and secondary structure of a protein determines its tertiary (three-dimensional) structure. Discuss examples of proteins that combine into a quaternary structure (e.g. haemoglobin, DNA polymerase).	
	Explore the significance of the collaborative work of Nobel prize winners and the contribution of their ideas to understanding the catalytic properties of RNA-ribozymes.	
Proteins are essential to cell structure and function. Examples of proteins with specific shapes include enzymes, some hormones, receptor proteins, and antibodies. • Explain why the three-dimensional shape of a protein is critical to its function. Enzymes are specific for their substrate and increase reaction rates by lowering activation energy. • Describe the induced-fit model of enzyme–substrate binding.	Discuss examples of proteins whose three-dimensional structure can facilitate the recognition and binding of specific molecules, including enzymes and substrates, and cell membrane receptors and hormones. Use examples to emphasise enzyme specificity and reinforce the importance of the three-dimensional shape of proteins.	
	Investigate the effect that conditions such as temperature, pH, substrate concentration, product concentration, and chemical inhibitors can have on enzyme activity.	

Science Understanding	Possible contexts	
Enzymes have specific functions and are affected by factors including: – temperature – pH – presence of inhibitors. The rate of an enzyme-controlled reaction is affected by: – concentrations of reactants – concentration of the enzyme.	Research ways in which an understanding of enzyme inhibitors enables scientists to develop solutions to health and environmental problems. Identify beneficial outcomes or unexpected consequences. Examples include: • pesticides (e.g. glyphosate) • drugs (e.g. ritonavir) • some types of chemotherapy. Investigate how knowledge of the specificity of antibodies enables the development of medical procedures and diagnostic tools. Examples include blood transfusions and the ELISA assay.	
The phenotypic expression of genes depends on factors controlling transcription and translation. These include the products of other genes and the environment. Cellular differentiation associated with tissue growth and development is controlled by gene expression. • Recognise that cytosine nucleotides in DNA can be methylated and this alters gene expression. Epigenetic changes can lead to phenotypic differences between identical siblings, phenotypic differences between clones, and may cause human diseases. • Explain how epigenetic modifications in genes that control cell division, such as changes in DNA methylation, can lead to cancer.	*Note the link with Stage 1, Topic 3: Multicellular organisms.* Revise the concept of cell differentiation. Discuss DNA methylation. Explore some example of diseases caused by epigenetics such as Fragile X syndrome and Rett syndrome.	
Changes in the DNA sequence are called 'mutations'. Mutations in genes and chromosomes can result from errors in DNA replication or cell division, or from damage by physical or chemical factors in the environment. Mutation rate can be increased by: – ionising radiation – mutagenic chemicals – viruses.	*Note the link with Stage 2, Topic 4: Evolution.* Describe the effect of mutations such as point, frameshift, or involving parts of or whole chromosomes on the genetic code and overall protein formation. Discuss examples of the impacts of mutations (e.g. genetic diseases).	
	Debate the use of gene therapy to prevent or correct the expression of genes that result in genetic diseases (e.g. cancer or cystic fibrosis). Discuss the limitations, social impacts, and ethical issues involved.	

Science Understanding	Possible contexts	
• Compare the different potential consequences of mutations in germ cells and somatic cells. • Explain how inheritable mutations can lead to changes in the characteristics of the descendants.		
DNA can be extracted from cells. Modern techniques can be used to analyse even small amounts of DNA. Segments of DNA can be multiplied using the polymerase chain reaction (PCR). • Describe PCR, including the roles of – heating and cooling – primers – free nucleotides – heat-resistant enzymes. The base sequence of DNA can be determined by electrophoresis. • Describe electrophoresis. The results of electrophoresis may be displayed in an electropherogram. • Interpret electropherograms that illustrate DNA sequences. DNA sequencing enables mapping of species' genomes. The results of electrophoresis can be used to construct DNA profiles. They may be displayed in an electropherogram or in a table of data. DNA profiling identifies the unique genetic makeup of individuals. • Interpret electropherograms and tables of data that illustrate DNA profiles. • Explain how differences in DNA fragments, identified by DNA profiling, can be used; for example, in forensic science. • Discuss the ethical, economic, and cultural issues related to the collection of genetic information.	Discuss the use of polymerase chain reaction (PCR), short tandem repeats, and fluorescent labelling for DNA profiling.	
	Explore the potential of databases and search engines such as BLAST at the National Center for Biotechnology Information. Practise interpreting different types of electropherograms.	
	Investigate using RFLPs and VNTRs in forensic science and explore the social, ethical, and economic impacts. Research how the development and refinement of PCR has revolutionised the efficiency of data collection and analysis, including gene cloning, genome sequencing, and DNA-based diagnostics, such as Low Template DNA analysis. Inquire into the work of the Australian Centre for Ancient DNA (ACAD). Explore the social and ethical issues of direct to consumer (DCT) genetic testing and array CGH (comparative genomic hybridisation).	

Science Understanding	Possible contexts	
Biotechnology can involve the use of plasmids and viruses as vectors, bacterial enzymes, and yeasts. Techniques include bacterial transformations, electroporation, and microinjection. • Describe how particular genes can be selected using probes and removed using restriction enzymes. • Describe how selected genes can be transferred between species. • Describe how CRISPR can be used to edit and/or transfer genes. • Discuss the design of new proteins and their uses.	Investigate examples of transgenic organisms and their uses that may have beneficial or unexpected consequences requiring monitoring, assessment, and evaluation of risk. Examples include the production of food and human hormones. Deliberate the social and ethical advantages and consequences of the manipulation of DNA. Explore bioethical issues of using CRISPR and implications in particular scenarios. Investigate and assess applications of scientific knowledge that have enabled scientists to design and manufacture proteins for scientific/medicinal use. Examples include biochips, biomaterials, diagnostics, and targeted chemotherapy.	

Topic 2: Cells as the basis of life

The cell is the basic unit of life. All cells possess some common features: all prokaryotic and eukaryotic cells need to exchange materials with their immediate external environment in order to maintain the chemical processes vital for cell functioning. In this topic, students examine the cell theory, the structure and function of the cell membrane, the exchange of materials, and processes required for cell survival. Students investigate the importance of enzymes in cell metabolism and ways in which energy is transformed and transferred in the biochemical processes of photosynthesis and respiration.

Students investigate events that occur during binary fission and mitotic cell division, and how they determine the degree of similarity between parent cells and daughter cells. They also consider the importance of culturing cells, and chemicals that interfere with cell metabolism.

Students explain how the evolution of cells from simpler to more complex structures and functions may have occurred.

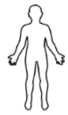
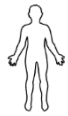
In this topic, students expand their scientific literacy skills by using appropriate biological terminology. They extend their numeracy skills through investigating the importance of the microscopic nature of cells.

Science Understanding	Possible contexts	
The cell theory unifies all living things. The cell membrane separates the cell cytoplasm from its surroundings and controls the exchange of materials, including nutrients and wastes, between the cell and its environment. • Describe and represent the fluid mosaic model of the cell membrane.	Illustrate the structure of the cell membrane.	
	Observe cells using a microscope.	
	Explore how cell theory has been modified in the light of new evidence.	
The major types of cell are – prokaryotic – eukaryotic. Prokaryotic and eukaryotic cells have many features in common, which is a reflection of their common evolutionary past. • Compare prokaryotic and eukaryotic cells with respect to their: – size – internal organisation – shape and location of chromosomes. Prokaryotes only exist as single cells.	Use animations or video clips to highlight the differences between prokaryotes and eukaryotes. View the following website: www.ck12.org/biology/Prokaryotic-and-Eukaryotic-Cells/lesson/Prokaryotic-and-Eukaryotic-Cells/	
	Evaluate the significance of discoveries such as stromatolites in Western Australia and how they contribute to understanding of the origin of life.	
Eukaryotic cells have specialised organelles which facilitate biochemical processes. • Represent the structure and describe the function of: – nucleus – nucleolus – mitochondrion – chloroplast – vacuole/vesicle – Golgi body – endoplasmic reticulum (rough and smooth) – ribosome – lysosome – cytoskeleton. • Compare the structures of plant and animal cells.	Use electron photomicrographs to recognise organelles such as Golgi body, endoplasmic reticulum, mitochondria, chloroplasts, ribosomes.	

Science Understanding	Possible contexts	
Cells require inputs of suitable forms of energy, including light energy or chemical energy in complex molecules. • Distinguish between autotrophs and heterotrophs. The sun is the main source of energy for life. • Recognise that photosynthesis is important in the conversion of light energy into chemical energy, as illustrated by the following equation: $6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2$ carbon dioxide + water $\xrightarrow[\text{chlorophyll}]{\text{light}}$ glucose + oxygen Energy transformations occur within all living cells. • Explain how most autotrophs and heterotrophs transform chemical energy for use through aerobic respiration, as illustrated by the following equation: $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ glucose + oxygen $\longrightarrow$ carbon dioxide + water • Explain that fermentation is an anaerobic alternative to aerobic respiration: – in plants and yeast: $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$ glucose $\longrightarrow$ ethanol + carbon dioxide – in animals: $C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3$ glucose $\longrightarrow$ lactic acid • Compare the amount of energy released through aerobic respiration and fermentation (anaerobic respiration). • Recognise that energy is required to break chemical bonds and energy is released when new bonds are formed. • Describe the formation of ATP from ADP and P_i. • Describe the conversion of ATP to ADP and P_i which releases energy for some metabolic reactions.	Discuss the importance of light and chemical energy (photosynthesis and respiration). Consider lactic acid fermentation by some bacteria.	
	Investigate limiting factors that affect photosynthesis (e.g. using leaf discs). Investigate factors affecting anaerobic respiration using yeast in solution or in a bread dough mix.	
	Evaluate the ways in which scientists use knowledge of factors affecting photosynthesis to make predictions and recommendations about suitable habitats for crop production (e.g. in the light of climate change).	
In order to survive, cells require an input of matter, including gases, simple nutrients, and ions, and the removal of wastes. • Compare the inputs and outputs of autotrophs and heterotrophs.	*Link this with Stage 1, Topic 1: Cells and microorganisms.*	

Science Understanding	Possible contexts	
Substances move in and out of cells by processes such as: – diffusion – facilitated diffusion – osmosis – active transport – endocytosis – exocytosis. • Explain how the structure of a membrane facilitates different processes of movement through it. • Explain the roles of transport proteins, including channel proteins (such as aquaporins), and carrier proteins. • Explain how the exchange of materials across membranes is affected by factors including: – surface-area-to-volume ratio of the cell – concentration gradients – the physical and chemical nature of the materials being exchanged.	Review the role of the cell membrane. (*Link this with Stage 1, Topic 1: Cells and microorganisms.*) Explain why composition of and conditions within the cell are important and need to be maintained. Use effects of osmosis to illustrate the need to regulate cellular composition. Investigate the role of aquaporins.	
	Use agar cubes, or cellulose tubing, starch, and iodine solutions to investigate diffusion. Investigate factors affecting the rate of osmosis — for example, in rhubarb epidermal cells.	
	Explore how the development of the complex fluid-mosaic model of membrane structure has required a range of evidence from many sources and input from across disciplines.	
Cell metabolism is critical to the survival of cells. Biochemical processes in the cell are influenced by the nature and arrangement of internal membranes and the presence of specific enzymes. • Explain how the structure of internal membranes of mitochondria and chloroplasts facilitates some biochemical processes. • Explain that in a metabolic pathway: – there are many regulated steps – each step loses some energy as heat – some steps produce intermediate compounds – specific enzymes are required at each step. Biochemical processes in the cell are influenced by environmental factors.	Use examples, such as glycolysis, Krebs cycle, and photosynthesis, to introduce metabolic pathways, including an explanation of the need for regulation. Review the effect of conditions such as temperature, pH, substrate concentration, product concentration, and chemical inhibitors on enzyme activity. (*Link this with Stage 2, Topic 1: DNA and proteins.*) Discuss folded internal membranes such as cristae in mitochondria and lamellae in chloroplasts. Use examples to emphasise enzyme specificity and reinforce the importance of the three-dimensional shape of proteins. Review the effect of environmental factors such as temperature, pH, substrate concentration, product concentration, and chemical inhibitors on enzyme activity. (*Link this with Stage 2, Topic 1: DNA and proteins.*)	

Chemicals can interfere with cell metabolism. • Discuss possible benefits and/or harmful effects of chemicals that human beings use.	Discuss examples of chemicals that interfere with metabolism, such as cyanide, antibiotics, herbicides, and insecticides.	
	Investigate ways in which new technologies can potentially be used for therapeutic drug design, and discuss related ethical considerations.	
Cells arise from pre-existing cells, and cell division leads to an increase in cell number. Cell division in somatic cells is different from the cell division that produces gametes from germ-line cells. Continuity of life requires the replication of genetic material and its transfer to the next generation through processes including binary fission, mitosis, meiosis, and fertilisation. • Explain why the amount of DNA in a cell doubles before division.	Review the semi-conservative replication of DNA. (*Link this with Stage 2, Topic 1: DNA and proteins*.)	
The products of binary fission and mitotic division have the same number and type of chromosomes as the parent. • Recognise, describe, and represent the process of binary fission in prokaryotic cells. • Recognise, describe, and represent the process of mitosis in eukaryotic cells. • Compare the products of binary fission and mitotic division.	View animations to show the process of binary fission.	
	Examine the stages of mitosis in onion root tip cells. Use models to represent the arrangement and movement of chromosomes during mitosis.	
Diploid cells contain pairs of homologous chromosomes. Haploid cells have one chromosome from each homologous pair. • Recognise, describe, and represent the process of meiosis in eukaryotic cells. • Explain why the products of meiosis are haploid cells and contain a single set of chromosomes. • Explain the importance of crossing over and independent assortment in meiosis. • Explain that fertilisation restores the diploid number. • Compare the products of mitotic and meiotic cell division. • Compare the sources and degree of genetic variation of the products of asexual and sexual reproduction.	Use models to represent the arrangement and movement of chromosomes during meiosis. Use models to demonstrate how the processes of crossing over, independent assortment, and fertilisation contribute to genetic variation. Construct and use diagrams to show the difference between haploid and diploid cells.	
	Discuss the potential social, cultural, and economic impacts and ethical considerations of the genetic manipulation of somatic and germline cells.	

Science Understanding	Possible contexts	
Cell division may be regulated by internal and external factors. The cell produces gene products that regulate the cell cycle. • Describe the stages in the cell cycle (including checkpoints). • Explain that hormones may regulate cell division. Carcinogens upset the normal controls of cell division by causing mutations in key regulatory genes.	Review the link between genes and their products. Provide examples of hormones that regulate cell division, such as human growth hormone.	
	Investigate examples of carcinogens: components of tobacco smoke, some dioxins, asbestos. Discuss their health, social, and economic impacts.	
Human beings culture cells for a variety of purposes. • Describe techniques of cell culture, and discuss the applications and limitations of contemporary examples.	Review the requirements (nutritional and environmental) of cells and their need to eliminate waste products in the context of cell culture.	
	Investigate the applications and limitations of cell and tissue cultures such as: HeLa cells, human skin replacement, cultures to produce vaccines, plant tissue culture, yeast cultures.	

Topic 3: Homeostasis

In this topic, students examine some of the body systems, including the nervous, endocrine (hormonal), and excretory systems that play interdependent roles in the regulation of body processes such as body temperature, blood glucose levels, carbon dioxide levels in blood, and water balance. They relate the structure of the cells, tissues, and organs of these systems to their function.

Students develop an understanding of how homeostasis is the whole set of responses that occur in multicellular organisms, which enable their survival in their environment. They examine how the cells in an organism work efficiently within tolerance limits that determine the optimal conditions for growth and survival.

Students develop an understanding of how homeostasis is maintained through the stimulus–response model and may involve negative feedback responses. By comparing the nervous and endocrine (hormonal) systems and examining their modes of action, they understand how these systems operate together to maintain homeostasis for a number of regulated processes.

Students examine how biotechnology has contributed to advances in the treatment of the malfunctioning of the nervous and endocrine systems.

In this context, students use pathway/flow diagrams to communicate for specific purposes. They extend their scientific vocabulary through using biological terms accurately. They further develop their critical thinking skills by interpreting and evaluating data to construct logical conclusions and make reasonable predictions.

Science Understanding	Possible contexts	
Organisms survive most effectively within their tolerance limits. Factors for which organisms have tolerance limits include: – body temperature – water availability – blood glucose level – carbon dioxide concentration in the blood and tissues. There are impacts on an organism when conditions fall outside its tolerance limits.	Discuss Liebig's Law of the Minimum: the impact of limiting factors in biological systems.	
	Model the effects of tolerance limits by investigating the effect of salinity, pH, temperature, or other factors on seedlings.	
	Examine the tolerance limits of organisms that exist in extreme environmental conditions. Consider how these can be used to design action for sustainability and minimise the impact of climate change. View the following video: *Science Nation: Extreme Microbes* (US-NSF Video) https://www.youtube.com/watch?v=pdq_JoNoOGs *Note link to Stage 2, Earth and Environmental Science, Topic 4: Climate change.*	
Organisms detect and respond to changes in the internal and external environment. Homeostasis is the maintenance of a relatively constant internal environment. This ensures the optimum conditions for the body to function. In human beings, homeostasis depends on the functioning of the nervous and endocrine systems. Homeostasis involves a stimulus–response and negative feedback model. • Describe the role of sensory receptors. • Describe the role of effectors. • Explain the stimulus–response model. • Recognise that in negative feedback the response inhibits the initial stimulus.	Use examples to describe homeostatic processes and explain how these processes help body systems respond to a change in environment.	

Science Understanding	Possible contexts	
The nervous system is composed of the central nervous system and the peripheral nervous system. • Compare the structure and function of sensory neurons, interneurons, and motor neurons. • Describe the structure of a nerve pathway from receptor to effector. • Describe the role of synapses and neurotransmitters. • Describe the role and pathway of reflex responses.	Discuss the importance of sensory receptors that detect changes in the internal and external environment, (e.g. olfactory receptors, proprioceptors, taste receptors, receptors in the skin, pain receptors). Discuss different neurotransmitters (e.g. norepinephrine, acetylcholine, cholinesterase, dopamine, serotonin). Use examples to illustrate the function of reflex arcs (e.g. the patellar reflex, the pupillary reflex, or hand on hot plate).	
	Investigate the stimulus–response model using plant hormones, light, or gravity.	
	Discuss how the development of anaesthetics and other drugs and chemicals, both natural and synthetic, may have beneficial or unexpected consequences. Discuss how an understanding of the biological basis of neurological diseases such as Alzheimer's or Parkinson's disease can enable scientists to develop methods of detection and treatment. Explore nerve damage that may lead, for example, to paralysis and paraplegia. Investigate innovative technologies for treatment (e.g. cochlear implants, artificial eyes).	
The endocrine system releases hormones that are amino acid derivatives, peptides, proteins, or steroids. Hormones travel to target sites via the blood. Hormones can alter the metabolism of target cells, tissues, or organs. • Compare the action of insulin and glucagon in blood sugar regulation. • Describe how diabetes mellitus can result from a hormonal imbalance. • Describe the action of thyroid stimulating hormone and thyroxine in metabolism. • Describe the role of antidiuretic hormone (ADH) in osmoregulation. • Discuss the links between osmoregulation, blood volume, and blood pressure.	Discuss examples of endocrine glands and the hormones they release, for example: • hypothalamus/pituitary complex • thyroid • parathyroid • adrenal glands • islet cells of the pancreas.	
	Assess the unintended consequences of using chemotherapy, hormone replacement therapy (HRT), or other hormones such as growth hormone or thyroid hormones. Evaluate how the growing need for treatment of diseases such as diabetes may influence scientific research.	

Science Understanding	Possible contexts	
Hormonal responses can be stimulated by either the nervous system or other hormonal messages. • Describe the role of adrenaline in the ‘fight or flight’ response. Describe the role of thyroid-stimulating hormone in the production of thyroxine.		
The nervous system and endocrine system function independently or together to achieve homeostasis. • Compare the action of the nervous and endocrine systems. • Explain how the nervous and endocrine systems work independently or together to: – control body temperature – enable osmoregulation – maintain blood sugar level – monitor pH in the brain to maintain a constant carbon dioxide level in the blood.	Illustrate the effect of ADH on the nephron. Use a flow diagram to represent the components of the stimulus–response model based on, for example, the control of body temperature.	
	Investigate the effects of exercise, coffee, and/or chocolate on heart rate, breathing rate, body temperature, or volume of urine.	

Topic 4: Evolution

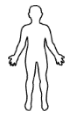
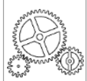
Students examine the biological evidence that forms the basis for understanding the changes in species described in the theory of evolution by natural selection. In this topic, students investigate the genetic basis for the theory of evolution by natural selection through constructing, using, and evaluating explanatory and predictive models for gene pool diversity of populations. They explore genetic variation in gene pools, selection pressures, and isolation effects in order to explain speciation and extinction events and make predictions about future changes to populations.

Through the investigation of appropriate contexts, students explore ways in which models and theories have developed over time. This includes changes in the understanding of natural selection, evolution, and population genetics, and the technologies used to investigate them. They discuss the influences and impacts of social, cultural, economic, and ethical considerations of habitat change.

Students investigate ways in which science contributes to contemporary debate about local, regional, and global issues, including evaluation of risk and action for sustainability. Students also recognise the limitations of science to provide definitive answers in different contexts.

Students use science inquiry skills to design and conduct investigations into how different factors affect processes in gene pools. They further enhance their scientific literacy by creating and using models to analyse the data gathered, and continue to develop their critical thinking skills by constructing plausible predictions and valid and reliable conclusions.

Science Understanding	Possible contexts	
Evidence shows that life has existed on Earth for around 3.5 billion years, during which time it has diversified.	Define the characteristics of all known life forms and list the features that they share, including nucleic acids and a cell membrane.	
Existing cells are the products of evolution. Membranes may have formed spontaneously and the first simple cells may have used RNA as genetic information. Ribozymes may have played a role in this development. • Describe the possible roles of RNA and ribozymes in the first simple cells. There is evidence that prokaryotic cells existed before eukaryotic cells. • Describe this evidence, including fossil evidence. • Explain how the ancestry of most existing eukaryotic cells probably involved endosymbiotic events.	Discuss the evidence to illustrate the existence of life on Earth for around 3.5 billion years, including microfossils and geochemical evidence. http://exploringorigins.org/index.html Review the structure and function of mitochondria and chloroplasts.	
	Discuss the significant, collaborative work of Nobel prize winners in the field of evolutionary biology and its application to current theories. http://www.bbc.com/earth/story/20161026-the-secret-of-how-life-on-earth-began	
Comparative genomics provides evidence for evolution and helps establish the likely evolutionary relationship between different species. • Describe the technique of DNA-DNA hybridisation. • Describe how evidence from the following techniques may be used: – sequencing of common proteins (e.g. cytochromes) – DNA–DNA hybridisation – DNA sequencing – rRNA gene sequencing. Phylogenetic tree diagrams represent evolutionary relationships. • Draw and analyse simple phylogenetic tree diagrams to represent evolutionary relationships. Mutations accumulate over time. If the mutation rate is known, it can be used as a 'clock'. More closely related species have fewer differences in their DNA sequences and have separated more recently from a	Describe modern techniques used to compare the likely evolutionary relatedness of species. Compare known sequences of DNA in different species. Develop a timeline for biological change (e.g. Nuffield activity), using websites such as: www.nuffieldfoundation.org/practical-biology/mapping-change-over-time www.wellcometreeoflife.org/video/	
	Extract DNA from common sources (e.g. fruit, vegetables, liver). Useful sources: www.nuffieldfoundation.org/practical-biology/dna www.eurovolvox.org/Protocols/PDFs/DNAnecklace02_UK_eng.pdf Use gel electrophoresis to isolate DNA segments. Use known sequences of DNA or known sequences of amino acids to suggest phylogenetic relationships.	

Science Understanding	Possible contexts	
common ancestor than distantly related species.	Assess the impact of the use of new technology on the study of comparative genomics and discuss the ethical, social, cultural, and economic impacts. Examples include: • DNA databases (forensic & medical) such as BLAST • commercial DNA testing and what it can offer • the human genome project • mitochondrial DNA comparisons • identification of human remains by mtDNA (e.g. King Richard III of England, Tut-ankh-amun's family, or natural disaster victims). Explore the advantages and disadvantages of next generation sequencing (NGS).	
Different criteria are used to define a species depending on the mode of reproduction. A species that reproduces sexually can be defined by the ability of its members to actually or potentially interbreed to produce fertile offspring. Other criteria used to define a species include: – morphological similarity – biochemical similarity – sharing a common gene pool. Reproductive isolating mechanisms act to maintain distinct species. • Describe pre-zygotic mechanisms (prevention of zygote formation) including: – temporal isolation – behavioural isolation – mechanical isolation – gamete isolation. • Describe post-zygotic mechanisms (prevention of fertile hybrids) including: – hybrid inviability – hybrid sterility.	Review the differences between a species, population, community, and an ecosystem. (*Link to Stage 1, Topic 4: Biodiversity and ecosystem dynamics*.) Discuss the limitations of different criteria used to define a species. Give examples of how pre- and post-zygotic isolating mechanisms maintain distinct species. Examples include courtship rituals, breeding seasons, and hybrids (liger, zebronkey).	

Science Understanding	Possible contexts	
Mutation is a permanent change in the sequence of DNA nucleotides and is the ultimate source of genetic variation in a species. In a species that reproduces sexually there are additional sources of genetic variation. • Explain the sources of genetic variation in a species that reproduces sexually.	*Link to Stage 2, Topic 1: DNA and proteins and Stage 2, Topic 2: Cells.* Review the structure and function of DNA and sources of variation. Recognise that the selection pressure may determine whether the mutation may be lethal, disadvantageous (but not lethal), neutral, or beneficial to an organism. Explain why many mutations will not be detected or will have no effect. Discuss why sickle-cell anaemia may be advantageous in malaria-prone environments.	
	Simulations and other resources include: http://www.biologyjunction.com/Monstrous%20Mutations.doc comes from http://www.biologyjunction.com www.yourgenome.org/activities/kras-cancer-mutation http://geneed.nlm.nih.gov/topic_subtopic.php?tid=142&sid=145	
	Investigate examples of mutagenic factors in the environment, such as: • nicotine, tar, benzene, and other polycyclic hydrocarbons • some elements (As, Cd, Br) • some viruses, e.g. retroviruses (HIV) • X-rays, γ-rays, cosmic rays. • shorter wavelengths of UV (UV B) Make predictions about the potential for increase or decrease in their frequency.	

Science Understanding	Possible contexts	
A gene pool comprises all the genetic information in a population. • Recognise that a large gene pool indicates considerable genetic diversity and is found in populations that are more likely to survive selection pressures. Natural selection is a process in which organisms that are better adapted to their environment are more likely to survive and produce offspring. • Explain how natural selection results in evolution by causing a change in the frequency of alleles in a population.	Illustrate how the environmental selection pressures will determine the success of a group, rather than the group 'adapting' to the conditions. Describe the concepts of gene flow and genetic drift. Explain how genetic drift and natural selection may have influences on different populations. Investigate the concepts of gene flow and genetic drift to show how gene (allele) frequency can change rapidly in some cases. Discuss the industrial melanism in peppered moths (*Biston betularia*).	
Evolutionary changes are affected by other factors besides selection, including: – sexual reproduction – genetic drift.	Model natural selection using coloured counters or beads. Investigate the 'predation' of spaghetti worms: www.eurovolvox.org/Protocols/PDFs/BirdWorms_UK_1.1.pdf	
	Discuss how some scientists collaborate and others work independently to establish new theories such as the theory of evolution.	
Speciation may result from an accumulation of genetic changes influenced by different selection pressures or genetic drift in geographically isolated populations. • Describe the process of speciation due to physical separation (allopatric speciation). • Compare allopatric and sympatric speciation.	Describe how different selection pressures on isolated populations of a species may lead to natural selection producing different species that are related by a common ancestor.	
	Investigate the study of rapid evolution on the Galapagos Islands in the late 20th century and predict future evolutionary rates. https://www.evolving-science.com/environment/rapid-evolution-galapagos-islands-leads-new-species-finch-00501	
Similar selection pressures on unrelated species may lead to convergent evolution. • Recognise and give examples of convergent evolution.	Discuss examples of independent evolution (e.g. eyes, placental and marsupial mammals, dugongs and whales).	

Science Understanding	Possible contexts	
When new niches become available to a species, for example as a result of succession or following an environmental change, different selection pressures may lead to divergent evolution or adaptive radiation. • Recognise and give examples of adaptive radiation. • Describe the process of succession.	Investigate adaptive radiation in Darwin's finches, plants such as Brassicas, or Australian marsupials. Explore New Zealand's native species that exhibit divergent evolution and adaptive radiation. Compare primary and secondary succession.	
Species or populations that have a reduced genetic diversity have a higher risk of extinction. • Give examples of species with low genetic diversity.	Discuss the significance of examples of populations with reduced genetic diversity, including cheetahs and Tasmanian devils.	
Human activities can create new and significant selection pressures on a gene pool, leading to species extinction. • Describe how these activities have caused or may threaten the extinction of species. • Give examples of human activities that lead to climate or environmental change.	(*Note link to Stage 2, Earth and Environmental Science, Topic 4: Climate change.*) Investigate local, national, or global human activities that have had (or are having) a significant effect on species, including activities such as habitat destruction and the introduction of non-native species. Debate the points of view for the logging of native forests in different states of Australia including the social, economic, and environmental impacts. Make predictions depending on the possible outcomes. Investigate how the influences of humans may have contributed to the extinction of Australian native species in pre- and post-European colonisation times.	
Maintaining biodiversity is an ethical issue with long-term biological and/or environmental consequences. • Recognise that humans have an obligation to prevent species extinction.	Investigate strategies that can be used to maintain biodiversity. (*Review Stage 1, Topic 4: Biodiversity and ecosystem dynamics.*) Explore the ethical, social, and economic reasons behind quarantine laws in protecting native species. Research the impact of local, national, and global initiatives and organisations that focus on the preservation of biodiversity. Suggest how the initiatives may be maintained into the future.	

ASSESSMENT SCOPE AND REQUIREMENTS

All Stage 2 subjects have a school assessment component and an external assessment component.

EVIDENCE OF LEARNING

The following assessment types enable students to demonstrate their learning in Stage 2 Biology:

School assessment (70%)

- Assessment Type 1: Investigations Folio (30%)
- Assessment Type 2: Skills and Applications Tasks (40%).

External assessment (30%)

- Assessment Type 3: Examination (30%).

Students provide evidence of their learning through eight assessments, including the external assessment component. Students complete:

- at least two practical investigations
- one investigation with a focus on science as a human endeavour
- at least three skills and applications tasks
- one examination.

At least one investigation or skills and applications task should involve collaborative work.

ASSESSMENT DESIGN CRITERIA

The assessment design criteria are based on the learning requirements and are used by:

- teachers to clarify for the student what they need to learn
- teachers and assessors to design opportunities for the student to provide evidence of their learning at the highest possible level of achievement.

The assessment design criteria consist of specific features that:

- students should demonstrate in their learning
- teachers and assessors look for as evidence that students have met the learning requirements.

For this subject the assessment design criteria are:

- investigation, analysis, and evaluation
- knowledge and application.

The specific features of these criteria are described below.

The set of assessments, as a whole, must give students opportunities to demonstrate each of the specific features by the completion of study of the subject.

Investigation, Analysis, and Evaluation

The specific features are as follows:

IAE1 Deconstruction of a problem and design of a biological investigation.

IAE2 Obtaining, recording, and representation of data, using appropriate conventions and formats.

IAE3 Analysis and interpretation of data and other evidence to formulate and justify conclusions.

IAE4 Evaluation of procedures and their effect on data.

Knowledge and Application

The specific features are as follows:

KA1 Demonstration of knowledge and understanding of biological concepts.

KA2 Application of biological concepts in new and familiar contexts.

KA3 Exploration and understanding of the interaction between science and society.

KA4 Communication of knowledge and understanding of biological concepts and information, using appropriate terms, conventions, and representations.

SCHOOL ASSESSMENT

Assessment Type 1: Investigations Folio (30%)

Students undertake at least two practical investigations and one investigation with a focus on science as a human endeavour. Students may undertake more than two practical investigations within the maximum number of assessments allowed. They inquire into aspects of biology through practical discovery and data analysis, and/or by selecting, analysing, and interpreting information.

Practical Investigations

As students design and safely carry out investigations, they demonstrate their science inquiry skills by:

- deconstructing a problem to determine the most appropriate method for investigation
- formulating investigable questions and hypotheses
- selecting and using appropriate equipment, apparatus, and techniques
- identifying variables
- collecting, representing, analysing, and interpreting data
- evaluating procedures and considering their impact on results
- drawing conclusions
- communicating knowledge and understanding of concepts.

As a set, practical investigations should enable students to:

- work both individually or collaboratively
- investigate a question or hypothesis for which the outcome is uncertain.
- investigate a question or hypothesis linked to one of the topics in Stage 2 Biology
- individually deconstruct a problem to design their own method and justify their plan of action.

For each investigation, students present an individual report.

Evidence of deconstruction (where applicable) should outline the deconstruction process, the method designed as most appropriate, and a justification of the plan of action, to a maximum of 4 sides of an A4 page. This evidence must be attached to the practical report.

Suggested formats for this evidence include flow charts, concept maps, tables, or notes.

In order to manage the implementation of an investigation efficiently, students could individually design investigations and then conduct one of these as a group, or design hypothetical investigations at the end of a practical activity.

A practical report must include:

- introduction with relevant biological concepts, and either a hypothesis and variables, or an investigable question
- materials/apparatus
- the method that was implemented
- identification and management of safety and/or ethical risks
- results, including table(s) and/or graph(s)
- analysis of results, including identifying trends and linking results to concepts
- evaluation of procedures and their effect on data, and identifying sources of uncertainty
- conclusion, with justification.

The report should be a maximum of 1500 words if written, or a maximum of 10 minutes for an oral presentation, or the equivalent in multimodal form.

Only the following sections of the report are included in the word count:

- introduction
- analysis of results
- evaluation of procedures
- conclusion and justification.

Suggested formats for presentation of a practical investigation report include:

- a written report
- an oral presentation
- a multimodal product.

Science as a Human Endeavour Investigation

Students investigate a contemporary example of how science interacts with society. This may focus on one or more of the key concepts of science as a human endeavour described on pages 11 and 12, and may draw on a context suggested in the topics or relate to a new context.

Students select and explore a recent discovery, innovation, issue, or advance linked to one of the topics in Stage 2 Biology. They analyse and synthesise information from different sources to explain the science relevant to the focus of their investigation, show its connections to science as a human endeavour, and develop a conclusion.

Possible starting points for the investigation could include, for example:

- the announcement of a discovery in the field of biological science
- an expert's point of view on a controversial innovation
- a TED talk based on a biological development
- an article from a scientific publication (e.g. *Cosmos*)
- public concern about an issue that has environmental, social, economic, or political implications
- changes in government funding for biology-related purposes, e.g. for scientific research into biotechnology, conservation planning, hormone use in food production, safe disposal of nuclear waste, biosecurity, water quality, energy supplies, disease control, health
- innovative directions in research.

Based on their investigation, students prepare a scientific report, which must include the use of scientific terminology and:

- an introduction to identify the focus of the investigation and the key concept(s) of science as a human endeavour that it links to
- relevant biology concepts or background
- an explanation of how the focus of the investigation illustrates the interaction between science and society, including a discussion of the potential impact of the focus of the investigation, e.g. further development, effect on quality of life, environmental implications, economic impact, intrinsic interest
- a conclusion
- citations and referencing.

The report should be a maximum of 1500 words if written, or a maximum of 10 minutes for an oral presentation, or the equivalent in multimodal form.

This report could take the form of, for example:

- an article for a scientific publication
- an oral or multimodal scientific presentation.

For this assessment type, students provide evidence of their learning in relation to the following assessment design criteria:

- investigation, analysis, and evaluation
- knowledge and application.

Assessment Type 2: Skills and Applications Tasks (40%)

Students undertake at least three skills and applications tasks. Students may undertake more than three skills and applications tasks within the maximum number of assessments allowed in the school assessment component, but at least three should be under the direct supervision of the teacher. The supervised setting should be appropriate to the task. Each supervised task should be a maximum of 90 minutes of class time, excluding reading time.

Skills and applications tasks allow students to provide evidence of their learning in tasks that may:

- be applied, analytical, and/or interpretative
- pose problems in new and familiar contexts
- involve individual or collaborative assessments, depending on task design.

A skills and applications task may involve, for example:

- solving problems
- designing an investigation to test a hypothesis or investigable question
- considering different scenarios in which to apply knowledge and understanding
- graphing, tabulating, and/or analysing data
- evaluating procedures and identifying their limitations
- formulating and justifying conclusions
- representing information diagrammatically or graphically
- using biological terms, conventions, and notations.

As a set, skills and applications tasks should be designed to enable students to apply their science inquiry skills, demonstrate knowledge and understanding of key biological concepts and learning, and explain connections with science as a human endeavour. Problems and scenarios should be set in a relevant context, which may be practical, social, or environmental.

Skills and applications tasks may include, for example:

- developing simulations
- practical and/or graphical skills
- a multimodal product
- an oral presentation
- participation in a debate
- an extended response
- responses to short-answer questions
- a response to science in the media.

For this assessment type, students provide evidence of their learning in relation to the following assessment design criteria:

- investigation, analysis, and evaluation
- knowledge and application.

EXTERNAL ASSESSMENT

Assessment Type 3: Examination (30%)

Students undertake a 130-minute examination.

Stage 2 science inquiry skills and science understanding from all Stage 2 Biology topics may be assessed.

Questions:

- will be of different types
- may require students to show an understanding of science as a human endeavour
- may require students to apply their science understanding from more than one topic.

All specific features of the assessment design criteria for this subject may be assessed in the external examination.

PERFORMANCE STANDARDS

The performance standards describe five levels of achievement, A to E.

Each level of achievement describes the knowledge, skills, and understanding that teachers and assessors refer to in deciding how well students have demonstrated their learning on the basis of the evidence provided.

During the teaching and learning program the teacher gives students feedback on their learning, with reference to the performance standards.

At the student's completion of study of each school assessment type, the teacher makes a decision about the quality of the student's learning by:

- referring to the performance standards
- assigning a grade between A+ and E– for the assessment type.

The student's school assessment and external assessment are combined for a final result, which is reported as a grade between A+ and E–.

Performance Standards for Stage 2 Biology

	Investigation, Analysis, and Evaluation	Knowledge and Application
A	Critically deconstructs a problem and designs a logical, coherent, and detailed biological investigation. Obtains, records, and represents data, using appropriate conventions and formats accurately and highly effectively. Systematically analyses and interprets data and evidence to formulate logical conclusions with detailed justification. Critically and logically evaluates procedures and their effect on data.	Demonstrates deep and broad knowledge and understanding of a range of biological concepts. Applies biological concepts highly effectively in new and familiar contexts. Critically explores and understands in depth the interaction between science and society. Communicates knowledge and understanding of biology coherently, with highly effective use of appropriate terms, conventions, and representations.
B	Logically deconstructs a problem and designs a well-considered and clear biological investigation. Obtains, records, and represents data, using appropriate conventions and formats mostly accurately and effectively. Logically analyses and interprets data and evidence to formulate suitable conclusions with reasonable justification. Logically evaluates procedures and their effect on data.	Demonstrates some depth and breadth of knowledge and understanding of a range of biological concepts. Applies biological concepts mostly effectively in new and familiar contexts. Logically explores and understands in some depth the interaction between science and society. Communicates knowledge and understanding of biology mostly coherently, with effective use of appropriate terms, conventions, and representations.
C	Deconstructs a problem and designs a considered and generally clear biological investigation. Obtains, records, and represents data, using generally appropriate conventions and formats, with some errors but generally accurately and effectively. Undertakes some analysis and interpretation of data and evidence to formulate generally appropriate conclusions with some justification. Evaluates procedures and some of their effect on data.	Demonstrates knowledge and understanding of a general range of biological concepts. Applies biological concepts generally effectively in new or familiar contexts. Explores and understands aspects of the interaction between science and society. Communicates knowledge and understanding of biology generally effectively, using some appropriate terms, conventions, and representations.
D	Prepares a basic deconstruction of a problem and an outline of a biological investigation. Obtains, records, and represents data, using conventions and formats inconsistently, with occasional accuracy and effectiveness. Describes data and undertakes some basic interpretation to formulate a basic conclusion. Attempts to evaluate procedures or suggest an effect on data.	Demonstrates some basic knowledge and partial understanding of biological concepts. Applies some biological concepts in familiar contexts. Partially explores and recognises aspects of the interaction between science and society. Communicates basic biological information, using some appropriate terms, conventions, and/or representations.
E	Attempts a simple deconstruction of a problem and a procedure for a biological investigation. Attempts to record and represent some data, with limited accuracy or effectiveness. Attempts to describe results and/or interpret data to formulate a basic conclusion. Acknowledges that procedures affect data.	Demonstrates limited recognition and awareness of biological concepts. Attempts to apply biological concepts in familiar contexts. Attempts to explore and identify an aspect of the interaction between science and society. Attempts to communicate information about biology.

ASSESSMENT INTEGRITY

The SACE Assuring Assessment Integrity Policy outlines the principles and processes that teachers and assessors follow to assure the integrity of student assessments. This policy is available on the SACE website (www.sace.sa.edu.au) as part of the SACE Policy Framework.

The SACE Board uses a range of quality assurance processes so that the grades awarded for student achievement, in both the school assessment and the external assessment, are applied consistently and fairly against the performance standards for a subject, and are comparable across all schools.

Information and guidelines on quality assurance in assessment at Stage 2 are available on the SACE website (www.sace.sa.edu.au).

SUPPORT MATERIALS

SUBJECT-SPECIFIC ADVICE

Online support materials are provided for each subject and updated regularly on the SACE website (www.sace.sa.edu.au). Examples of support materials are sample learning and assessment plans, annotated assessment tasks, annotated student responses, and recommended resource materials.

ADVICE ON ETHICAL STUDY AND RESEARCH

Advice for students and teachers on ethical study and research practices is available in the guidelines on the ethical conduct of research in the SACE on the SACE website (www.sace.sa.edu.au).