

Accreditation Period

Units 1 and 2

2016–2020

Units 3 and 4

2017–2021

Victorian Certificate of Education

BIOLOGY

STUDY DESIGN



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Important information

Accreditation period

Units 1 and 2: 1 January 2016 – 31 December 2020

Units 3 and 4: 1 January 2017 – 31 December 2021

Implementation for Units 1 and 2 of this study commences in January 2016.

Implementation for Units 3 and 4 of this study commences in January 2017.

Sources of information

The [VCAA Bulletin](#) is the only official source of changes to regulations and accredited studies. The *VCAA Bulletin* also regularly includes advice on VCE studies. It is the responsibility of each VCE teacher to refer to each issue of the *VCAA Bulletin*. The *VCAA Bulletin* is available as an e-newsletter via free subscription on the VCAA's website at: www.vcaa.vic.edu.au.

To assist teachers in developing courses, the VCAA publishes online the *Advice for teachers*, which includes teaching and learning activities for Units 1–4, and advice on assessment tasks and performance level descriptors for School-assessed Coursework in Units 3 and 4.

The current [VCE and VCAL Administrative Handbook](#) contains essential information on assessment processes and other procedures.

VCE providers

Throughout this study design the term 'school' is intended to include both schools and other VCE providers.

Copyright

VCE schools may reproduce parts of this study design for use by teachers. The full VCAA Copyright Policy is available at: www.vcaa.vic.edu.au/Footer/Pages/Copyright.aspx.

Introduction

Scope of study

Biology is a diverse and evolving science discipline that seeks to understand and explore the nature of life, past and present. Despite the diversity of organisms and their many adaptations for survival in various environments, all life forms share a degree of relatedness and a common origin. The study explores the dynamic relationships between organisms and their interactions with the non-living environment. It also explores the processes of life, from the molecular world of the cell to that of the whole organism, that maintain life and ensure its continuity. Students examine classical and contemporary research, models and theories to understand how knowledge in biology has evolved and continues to evolve in response to new evidence and discoveries. An understanding of the complexities and diversity of biology leads students to appreciate the interconnectedness of the content areas both within biology, and across biology and the other sciences.

An important feature of undertaking a VCE science study is the opportunity for students to engage in a range of inquiry tasks that may be self-designed, develop key science skills and interrogate the links between theory, knowledge and practice. In VCE Biology inquiry methodologies can include laboratory experimentation, fieldwork that may also involve use of technologies, surveys and sampling techniques, microscopy, local and remote data logging, simulations, animations, literature reviews and the use of global databases and bioinformatics tools. Students work collaboratively as well as independently on a range of tasks. They pose questions, formulate hypotheses and collect, analyse and critically interpret qualitative and quantitative data. They analyse the limitations of data, evaluate methodologies and results, justify conclusions, make recommendations and communicate their findings. Students investigate and evaluate issues, changes and alternative proposals by considering both shorter and longer term consequences for the individual, environment and society. Knowledge of the safety considerations and bioethical standards associated with biological investigations is integral to the study of VCE Biology.

As well as an increased understanding of scientific processes, students develop capacities that enable them to critically assess the strengths and limitations of science, respect evidence-based conclusions and gain an awareness of the ethical, social and political contexts of scientific endeavours.

Rationale

VCE Biology enables students to investigate the processes involved in sustaining life at cellular, system, species and ecosystem levels. In undertaking this study, students examine how life has evolved over time and understand that in the dynamic and interconnected system of life all change has a consequence that may affect an individual, a species or the collective biodiversity of Earth. The study gives students insights into how knowledge of molecular and evolutionary concepts underpin much of contemporary biology, and the applications used by society to resolve problems and make advancements.

In VCE Biology students develop a range of inquiry skills involving practical experimentation and research, analytical skills including critical and creative thinking, and communication skills. Students use scientific and cognitive skills and understanding to analyse contemporary biology-related issues, and communicate their views from an informed position.

VCE Biology provides for continuing study pathways within the discipline and leads to a range of careers. Branches of biology include botany, genetics, immunology, microbiology, pharmacology and zoology. In addition, biology is applied in many fields of endeavour including biotechnology, dentistry, ecology, education, food science, forestry, health care, horticulture, medicine, optometry, physiotherapy and veterinary science. Biologists also work in cross-disciplinary areas such as bushfire research, environmental management and conservation, forensic science, geology, medical research and sports science.

Aims

This study enables students to:

- develop knowledge and understanding of key biological models, theories and concepts, from the cell to the whole organism
- examine the interconnectedness of organisms, their relationship to their environmental context, and the consequences of biological change over time including the impact of human endeavours on the biological processes of species

and more broadly to:

- understand the cooperative, cumulative, evolutionary and interdisciplinary nature of science as a human endeavour, including its possibilities, limitations and political and sociocultural influences
- develop a range of individual and collaborative science investigation skills through experimental and inquiry tasks in the field and in the laboratory
- develop an informed perspective on contemporary science-based issues of local and global significance
- apply their scientific understanding to familiar and unfamiliar situations, including personal, social, environmental and technological contexts
- develop attitudes that include curiosity, open-mindedness, creativity, flexibility, integrity, attention to detail and respect for evidence-based conclusions
- understand and apply the research, ethical and safety principles that govern the study and practice of the discipline in the collection, analysis, critical evaluation and reporting of data
- communicate clearly and accurately an understanding of the discipline using appropriate terminology, conventions and formats.

Structure

The study is made up of four units.

Unit 1: How do living things stay alive?

Unit 2: How is continuity of life maintained?

Unit 3: How do cells maintain life?

Unit 4: How does life change and respond to challenges over time?

Each unit deals with specific content contained in areas of study and is designed to enable students to achieve a set of outcomes for that unit. Each outcome is described in terms of key knowledge and is complemented by a set of key science skills.

This study is structured under a series of curriculum framing questions that reflect the inquiry nature of the discipline.

Entry

There are no prerequisites for entry to Units 1, 2 and 3. Students must undertake Unit 3 prior to undertaking Unit 4. Students entering Unit 3 without Units 1 and/or 2 may be required to undertake additional preparation as prescribed by their teacher. Units 1 to 4 are designed to a standard equivalent to the final two years of secondary education. All VCE studies are benchmarked against comparable national and international curriculum.

Duration

Each unit involves at least 50 hours of scheduled classroom instruction over the duration of a semester.

Changes to the study design

During its period of accreditation minor changes to the study will be announced in the *VCAA Bulletin*. The *VCAA Bulletin* is the only source of changes to regulations and accredited studies. It is the responsibility of each VCE teacher to monitor changes and advice about VCE studies published in the *VCAA Bulletin*.

Monitoring for quality

As part of ongoing monitoring and quality assurance, the VCAA will periodically undertake an audit of VCE Biology to ensure the study is being taught and assessed as accredited. The details of the audit procedures and requirements are published annually in the *VCE and VCAL Administrative Handbook*. Schools will be notified if they are required to submit material to be audited.

Safety and wellbeing

VCE Biology may involve the handling of potentially hazardous substances and the use of potentially hazardous equipment. 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 undertaking the study. Teachers and students should observe appropriate safety precautions when undertaking practical work. All laboratory work should be supervised by the teacher. It is the responsibility of schools to ensure that they comply with health and safety requirements.

Relevant acts and regulations include:

- *Occupational Health and Safety Act 2004*
- *Occupational Health and Safety Regulations 2007*
- *Occupational Health and Safety Management Systems (AS/NZ 4801)*
- *Dangerous Goods (Storage and Handling) Regulations 2012*
- *Dangerous Goods Storage and Handling Code of Practice 2000*
- *Hazardous Substances Code of Practice 2000*
- *Electrical Safety Act 1998*

Ethical conduct of experimental investigations

As part of this study teachers and students may be involved in teaching and learning activities that include experimental investigations using human subjects. Teachers and schools have a legal and moral responsibility to ensure that students follow ethical principles at all times when undertaking such investigations. Teachers should refer to the following documents for detailed advice:

- the National Statement on Ethical Conduct in Human Research (2007), issued by the National Health and Medical Research Council (NHMRC) in accordance with the *NHMRC Act 1992* (Cwlth), www.nhmrc.gov.au/publications/synopses/e72syn.htm
- the National Privacy Principles in the *Privacy Amendment (Private Sector) Act 2000* (Cwlth), www.privacy.gov.au/
- the Code of Ethics of the Australian Psychological Society (APS), www.psychology.org.au

It is not expected that animals will be used in the teaching of this study. If using animals in teaching, schools must comply with the current legislation including:

- the *Prevention of Cruelty to Animals Act 1986* and its Regulations 2008
- the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 2014* (8th edition), www.nhmrc.gov.au/guidelines/publications/ea28

Employability skills

This study offers a number of opportunities for students to develop employability skills. The *Advice for teachers* companion document provides specific examples of how students can develop employability skills during learning activities and assessment tasks.

Legislative compliance

When collecting and using information, the provisions of privacy and copyright legislation, such as the Victorian *Privacy and Data Protection Act 2014* and *Health Records Act 2001*, and the federal *Privacy Act 1988* and *Copyright Act 1968*, must be met.

Assessment and reporting

Satisfactory completion

The award of satisfactory completion for a unit is based on the teacher's decision that the student has demonstrated achievement of the set of outcomes specified for the unit. Demonstration of achievement of outcomes and satisfactory completion of a unit are determined by evidence gained through the assessment of a range of learning activities and tasks.

Teachers must develop courses that provide appropriate opportunities for students to demonstrate satisfactory achievement of outcomes.

The decision about satisfactory completion of a unit is distinct from the assessment of levels of achievement. Schools will report a student's result for each unit to the VCAA as S (Satisfactory) or N (Not Satisfactory).

Levels of achievement

Units 1 and 2

Procedures for the assessment of levels of achievement in Units 1 and 2 are a matter for school decision. Assessment of levels of achievement for these units will not be reported to the VCAA. Schools may choose to report levels of achievement using grades, descriptive statements or other indicators.

Units 3 and 4

The VCAA specifies the assessment procedures for students undertaking scored assessment in Units 3 and 4. Designated assessment tasks are provided in the details for each unit in the VCE study designs.

The student's level of achievement in Units 3 and 4 will be determined by School-assessed Coursework (SACs) and/or School-assessed Tasks (SATs) as specified in the VCE study designs, and external assessment.

The VCAA will report the student's level of achievement on each assessment component as a grade from A+ to E or UG (ungraded). To receive a study score the student must achieve two or more graded assessments and receive S for both Units 3 and 4. The study score is reported on a scale of 0–50; it is a measure of how well the student performed in relation to all others who took the study. Teachers should refer to the current [VCE and VCAL Administrative Handbook](#) for details on graded assessment and calculation of the study score. Percentage contributions to the study score in VCE Biology are as follows:

- Unit 3 School-assessed Coursework: 16 per cent
- Unit 4 School-assessed Coursework: 24 per cent
- End-of-year examination: 60 per cent.

Details of the assessment program are described in the sections on Units 3 and 4 in this study design.

Authentication

Work related to the outcomes of each unit will be accepted only if the teacher can attest that, to the best of their knowledge, all unacknowledged work is the student's own. Teachers need to refer to the current [VCE and VCAL Administrative Handbook](#) for authentication procedures.

Cross-study specifications

Units 1–4: Key science skills

The development of a set of key science skills is a core component of the study of VCE Biology and applies across Units 1 to 4 in all areas of study. In designing teaching and learning programs and in assessing student learning for each unit, teachers should ensure that students are given the opportunity to develop, use and demonstrate these skills in a variety of contexts when undertaking their own investigations and when evaluating the research of others. As the complexity of key knowledge increases from Units 1 to 4 and as opportunities are provided to undertake investigations, students should aim to demonstrate the key science skills at a progressively higher level.

The key science skills are common to all VCE science studies and have been contextualised in the following table for VCE Biology.

Key science skill	VCE Biology Units 1–4
Develop aims and questions, formulate hypotheses and make predictions	<ul style="list-style-type: none"> determine aims, hypotheses, questions and predictions that can be tested identify independent, dependent and controlled variables
Plan and undertake investigations	<ul style="list-style-type: none"> determine appropriate type of investigation: conduct experiments (including use of controls); solve a scientific or technological problem; use databases; perform simulations; access secondary data, including data sourced through the internet that would otherwise be difficult to source as raw or primary data through fieldwork, a laboratory or a classroom select and use equipment, materials and procedures appropriate to the investigation, taking into account potential sources of error and uncertainty
Comply with safety and ethical guidelines	<ul style="list-style-type: none"> apply ethical principles when undertaking and reporting investigations apply relevant occupational health and safety guidelines while undertaking practical investigations, including following relevant bioethical guidelines when handling live materials
Conduct investigations to collect and record data	<ul style="list-style-type: none"> work independently and collaboratively as appropriate and within identified research constraints systematically generate, collect, record and summarise both qualitative and quantitative data
Analyse and evaluate data, methods and scientific models	<ul style="list-style-type: none"> process quantitative data using appropriate mathematical relationships and units organise, present and interpret data using schematic diagrams and flow charts, tables, bar charts, line graphs, ratios, percentages and calculations of mean take a qualitative approach when identifying and analysing experimental data with reference to accuracy, precision, reliability, validity, uncertainty and errors (random and systematic) explain the merit of replicating procedures and the effects of sample sizes in obtaining reliable data evaluate investigative procedures and possible sources of bias, and suggest improvements explain how models are used to organise and understand observed phenomena and concepts related to biology, identifying limitations of the models

Key science skill	VCE Biology Units 1–4
Draw evidence-based conclusions	<ul style="list-style-type: none">• determine to what extent evidence from an investigation supports the purpose of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation• draw conclusions consistent with evidence and relevant to the question under investigation• identify, describe and explain the limitations of conclusions, including identification of further evidence required• critically evaluate various types of information related to biology from journal articles, mass media and opinions presented in the public domain• discuss the implications of research findings and proposals
Communicate and explain scientific ideas	<ul style="list-style-type: none">• use appropriate biological terminology, representations and conventions, including standard abbreviations, graphing conventions and units of measurement• discuss relevant biological information, ideas, concepts, theories and models and the connections between them• identify and explain formal biological terminology about investigations and concepts• use clear, coherent and concise expression• acknowledge sources of information and use standard scientific referencing conventions

Scientific investigation

Students undertake scientific investigations across Units 1 to 4 of this study. Scientific investigations may be undertaken in groups, but all work for assessment must be completed individually. Students must maintain a logbook of practical activities in each unit of this study for recording, authentication and assessment purposes.

Students communicate findings for the practical investigation in Outcome 3, Unit 4 of this study in a scientific poster. The poster may be produced electronically or in hard copy format and should not exceed 1000 words. Students must select information carefully so that they meet the word limit. The production quality of the poster will not form part of the assessment.

The following template is to be used by students in the development of the scientific poster for the investigation undertaken.

Section	Content and activities
Title	Question under investigation is the title
Introduction	Explanation or reason for undertaking the investigation, including a clear aim, a hypothesis and/or prediction and relevant background biological concepts
Methodology	Summary that outlines the methodology used in the investigation and is authenticated by logbook entries Identification and management of relevant risks, including the relevant health, safety and ethical guidelines followed in the investigation
Results	Presentation of collected data/evidence in appropriate format to illustrate trends, patterns and/or relationships
Discussion	Analysis and evaluation of primary data Identification of outliers and their subsequent treatment Identification of limitations in data and methods, and suggested improvements Linking of results to relevant biological concepts
Conclusion	Conclusion that provides a response to the question
References and acknowledgments	Referencing and acknowledgment of all quotations and sourced content as they appear in the poster.

Unit 1: How do living things stay alive?

In this unit students are introduced to some of the challenges to an organism in sustaining life. Students examine the cell as the structural and functional unit of life, from the single celled to the multicellular organism, and the requirements for sustaining cellular processes in terms of inputs and outputs. They analyse types of adaptations that enhance the organism's survival in a particular environment and consider the role homeostatic mechanisms play in maintaining the internal environment. Students investigate how a diverse group of organisms form a living interconnected community that is adapted to, and utilises, the abiotic resources of its habitat. The role of a keystone species in maintaining the structure of an ecosystem is explored. Students consider how the planet's biodiversity is classified and the factors that affect the growth of a population.

A student practical investigation related to the survival of an organism or species is undertaken in Area of Study 3. The investigation draws on content from Area of Study 1 and/or Area of Study 2.

Area of study 1

How do organisms function?

In this area of study students examine the structure and functioning of cells and how the plasma membrane contributes to survival by controlling the movement of substances into and out of the cell. Although the internal structure of a cell varies, all cells require a relatively stable internal environment for optimal functioning. Whether life forms are unicellular or multicellular, or heterotrophic or autotrophic, whether they live in a deep ocean trench, a tropical rain forest, an arid desert or on the highest mountain peak, all individual organisms are faced with the challenge of obtaining nutrients and water, exchanging gases, sourcing energy and having a means of removal of waste products.

Outcome 1

On completion of this unit the student should be able to investigate and explain how cellular structures and systems function to sustain life.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 1 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

Cell size, structure and function

- cells as the basic structural feature of life on Earth, including the distinction between prokaryotic and eukaryotic cells
- surface area to volume ratio as an important factor in explaining the limitations of cell size and the need for internal compartments (organelles) with specific cellular functions
- the ultrastructure of plant and animal cells in terms of their organelles and identification of these organelles using the light microscope and electron micrographs.

Crossing the plasma membrane

- the characteristics of the plasma membrane as a semi-permeable boundary between the internal and external environments of a cell
- modes of transport of soluble substances across the plasma membrane including simple diffusion, facilitated diffusion, osmosis and active transport.

Energy transformations

- the distinction between photosynthetic autotrophs, chemosynthetic autotrophs and heterotrophs
- photosynthesis as a chemical process in which solar energy is captured and transformed to chemical energy by fixing carbon to produce a carbohydrate and releasing oxygen as a by-product
- cellular respiration as a chemical process that commonly uses glucose to produce energy for the cell in both autotrophs and heterotrophs.

Functioning systems

- a study of one selected vascular plant with reference to how its cells are specialised and organised (cells into tissues, and tissues into organs) for the intake, movement and loss of water from the plant
- a study of one selected mammalian system (circulatory, digestive, excretory or respiratory) with reference to how cells in the system are specialised and organised (cells into tissues, tissues into organs and organs into systems), how a specific malfunction can lead to biological consequences and how the system is interconnected to other systems for the survival of the organism.

Area of Study 2

How do living systems sustain life?

In this area of study students examine the structural, physiological and behavioural adaptations of a range of organisms that enable them to survive in a particular habitat and to maintain a viable population size over time. Students consider the distinction between the external and internal environment of an organism and examine how homeostatic mechanisms maintain the internal environment within a narrow range of values for factors including temperature, blood glucose and water balance. They explore the importance and implications of organising and maintaining biodiversity and examine the nature of an ecosystem in terms of the network of relationships within a community of diverse organisms. Students identify a keystone species, explore an organism's relationship to its habitat and evaluate the impact of abiotic factors on the distribution and abundance of organisms within the community. Factors affecting population size and growth are analysed.

Outcome 2

On completion of this unit the student should be able explain how various adaptations enhance the survival of an individual organism, investigate the relationships between organisms that form a living community and their habitat, and analyse the impacts of factors that affect population growth.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 2 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge**Survival through adaptations and regulation**

- the structural, physiological and behavioural adaptations that enhance an organism's survival and enable life to exist in a wide range of environments
- successful adaptations as models for biomimicry to solve human challenges
- how regulation of factors is needed to maintain a relatively constant internal environment, explained by the stimulus-response model and the use of homeostatic mechanisms including feedback loops
- factors regulated by homeostatic mechanisms in humans, including temperature, blood glucose and water balance
- malfunctions in homeostatic mechanisms that result in diseases, including Type 1 diabetes and hyperthyroidism in humans.

Organising biodiversity

- classification of biodiversity, past and present, into taxonomic groups based on shared morphological and molecular characteristics, and naming using binomial nomenclature
- strategies for managing Earth's biodiversity to support the conservation of species and as a reservoir for the bio-prospecting of new food sources and medicinal drugs.

Relationships between organisms within an ecosystem

- the beneficial, harmful and benign relationships between species including amensalism, commensalism, mutualism, parasitism and predation
- interdependencies between species as represented by food webs, including impact of changes to keystone species
- the distribution, density and size of a population of a particular species within an ecosystem and the impacts of factors including available resources, predation, competition, disease, chance environmental events, births, deaths and migration.

Area of Study 3

Practical investigation

Survival requires control and regulation of factors within an individual and often outside the individual. In this area of study students design and conduct a practical investigation into the survival of an individual or a species.

The investigation requires the student to develop a question, plan a course of action to answer the question, undertake an investigation to collect the appropriate primary qualitative and/or quantitative data, organise and interpret the data and reach a conclusion in response to the question. The investigation is to be related to knowledge and skills developed in Areas of Study 1 and/or 2 and is conducted by the student through laboratory work, fieldwork and/or observational studies.

Outcome 3

On completion of this unit the student should be able to design and undertake an investigation related to the survival of an organism or species, and draw conclusions based on evidence from collected data.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 3 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

- the biological concepts specific to the investigation and their significance, including definitions of key terms, and biological representations
- the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the investigation: laboratory work (microscopy), fieldwork (quadrats, transects and field guides) and/or observational studies of animal behavior; precision, accuracy, reliability and validity of data; and minimisation of experimental bias
- ethics and issues of research including identification and application of relevant health, safety and bioethical guidelines
- methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and limitations of data and methodologies
- observations and experiments that are consistent with, or challenge, current biological models or theories
- the nature of evidence that supports or refutes a hypothesis, model or theory

- options, strategies or solutions to issues related to organism or species survival
- the key findings of the selected investigation and their relationship to cytological and/or ecological concepts
- the conventions of scientific report writing including biological terminology and representations, standard abbreviations and units of measurement.

Assessment

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks that provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study, including the key knowledge and key skills listed for the outcomes, should be used for course design and the development of learning activities and assessment tasks. Assessment must be a part of the regular teaching and learning program and should be completed mainly in class and within a limited timeframe.

All assessments at Units 1 and 2 are school-based. Procedures for assessment of levels of achievement in Units 1 and 2 are a matter for school decision.

For this unit students are required to demonstrate achievement of three outcomes. As a set these outcomes encompass all areas of study in the unit.

Suitable tasks for assessment may be selected from the following:

For Outcomes 1 and 2

- a report of a fieldwork activity
- annotations of a practical work folio of activities or investigations
- a bioinformatics exercise
- media response
- data analysis
- problem solving involving biological concepts, skills and/or issues
- a reflective learning journal/blog related to selected activities or in response to an issue
- a test comprising multiple choice and/or short answer and/or extended response.

For Outcome 3

- a report of a student-designed or adapted investigation related to the survival of an organism or a species using an appropriate format, for example a scientific poster, practical report, oral communication or digital presentation.

Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

Practical work is a central component of learning and assessment. As a guide, between 3½ and 5 hours of class time should be devoted to student practical work and investigations for each of Areas of Study 1 and 2. For Area of Study 3, between 6 and 8 hours of class time should be devoted to undertaking the investigation and communicating findings.

Unit 2: How is continuity of life maintained?

In this unit students focus on cell reproduction and the transmission of biological information from generation to generation. Students learn that all cells are derived from pre-existing cells through the cell cycle. They examine the process of DNA replication and compare cell division in both prokaryotic and eukaryotic organisms. Students explore the mechanisms of asexual and sexual reproductive strategies, and consider the advantages and disadvantages of these two types of reproduction. The role of stem cells in the differentiation, growth, repair and replacement of cells in humans is examined, and their potential use in medical therapies is considered.

Students use chromosome theory and terminology from classical genetics to explain the inheritance of characteristics, analyse patterns of inheritance, interpret pedigree charts and predict outcomes of genetic crosses. They explore the relationship between genes, the environment and the regulation of genes in giving rise to phenotypes. They consider the role of genetic knowledge in decision making about the inheritance of autosomal dominant, autosomal recessive and sex-linked genetic conditions. In this context the uses of genetic screening and its social and ethical issues are examined.

A student-directed research investigation into, and communication of, an issue related to genetics and/or reproductive science is to be undertaken in Area of Study 3. The investigation draws on content from Area of Study 1 and/or Area of Study 2.

Area of Study 1

How does reproduction maintain the continuity of life?

In this area of study students consider the need for the cells of multicellular organisms to multiply for growth, repair and replacement. They examine the main events of the cell cycle in prokaryotic and eukaryotic cells. Students become familiar with the key events in the phases of the cell cycle, and focus on the importance of the processes involved in a cell's preparation for cell division. Students investigate and use visualisations and modelling to describe the characteristics of each of the phases in mitosis. Cytokinesis is explained for both plant and animal cells. Students describe the production of gametes in sexual reproduction through the key events in meiosis and explain the differences between asexual and sexual reproduction in terms of the genetic makeup of daughter cells. Students consider the role and nature of stem cells, their differentiation and the consequences for human prenatal development and their potential use to treat injury and disease.

Outcome 1

On completion of this unit the student should be able to compare the advantages and disadvantages of asexual and sexual reproduction, explain how changes within the cell cycle may have an impact on cellular or tissue system function and identify the role of stem cells in cell growth and cell differentiation and in medical therapies.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 1 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

The cell cycle

- derivation of all cells from pre-existing cells through completion of the cell cycle
- the rapid procession of prokaryotic cells through their cell cycle by binary fission
- the key events in the phases (G1, S, G2, M and C) of the eukaryotic cell cycle, including the characteristics of the sub-phases of mitosis (prophase, metaphase, anaphase and telophase) and cytokinesis in plant and animal cells.

Asexual reproduction

- the types of asexual reproduction including fission, budding, vegetative propagation and spore formation
- the biological advantages and disadvantages of asexual reproduction
- emerging issues associated with cloning, including applications in agriculture and horticulture.

Sexual reproduction

- how an offspring from two parents has a unique genetic identity
- the key events in meiosis that result in the production of gametes from somatic cells including the significance of crossing over of chromatids between homologous chromosomes in Prophase 1 and the non-dividing of the centromere in Metaphase 1
- the biological advantage of sexual reproduction, specifically the genetic diversity in offspring.

Cell growth and cell differentiation

- the types and function of stem cells in human development, including the distinction between embryonic and adult stem cells and their potential use in the development of medical therapies
- the consequences of stem cell differentiation in human prenatal development including the development of germ layers, types of tissues formed from germ layers and the distinction between embryo and foetus
- the disruption of the regulation of the cell cycle through genetic predisposition or the action of mutagens that gives rise to uncontrolled cell division including cancer and abnormal embryonic development.

Area of Study 2

How is inheritance explained?

In this area of study students build on their understanding of the nature of genes and the use of genetic language to read and interpret patterns of inheritance and predict outcomes of genetic crosses. They gain an understanding that a characteristic or trait can be due solely to one gene and its alleles, or due to many genes acting together, or is the outcome of genes interacting with external environmental or epigenetic factors. Students apply their genetic knowledge to consider the social and ethical implications of genetic applications in society including genetic screening and decision making regarding the inheritance of autosomal and sex-linked conditions.

Outcome 2

On completion of this unit the student should be able to apply an understanding of genetics to describe patterns of inheritance, analyse pedigree charts, predict outcomes of genetic crosses and identify the implications of the uses of genetic screening and decision making related to inheritance.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 2 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge**Genomes, genes and alleles**

- the distinction between a genome, gene and allele
- the genome as the sum total of an organism's DNA measured in the number of base pairs contained in a haploid set of chromosomes
- the role of genomic research since the Human Genome Project, with reference to the sequencing of the genes of many organisms, comparing relatedness between species, determining gene function and genomic applications for the early detection and diagnosis of human diseases.

Chromosomes

- the role of chromosomes as structures that package DNA, their variability in terms of size and the number of genes they carry in different organisms, the distinction between an autosome and a sex chromosome and the nature of a homologous pair of chromosomes (one maternal and one paternal) as carrying the same gene loci
- presentation of an organism's set of chromosomes as a karyotype that can be used to identify chromosome number abnormalities including Down's, Klinefelter's and Turner's syndromes in humans.

Genotypes and phenotypes

- the use of symbols in the writing of the genotypes for the alleles present at a particular gene locus
- the distinction between a dominant and recessive phenotype
- the relative influences of genetic material, environmental factors and interactions of DNA with other molecules (epigenetic factors) on phenotypes
- qualitative treatment of polygenic inheritance as contributing to continuous variation in a population, illustrated by the determination of human skin colour through the genes involved in melanin production or by variation in height.

Pedigree charts, genetic cross outcomes and genetic decision-making

- pedigree charts and patterns of inheritance including autosomal dominant, autosomal recessive, X-linked and Y-linked traits
- the determination of genotypes and prediction of the outcomes of genetic crosses including monohybrid crosses, and monohybrid test crosses
- the inheritance of two characteristics as either independent or linked, and the biological consequence of crossing over for linked genes
- the nature and uses of genetic testing for screening of embryos and adults, and its social and ethical implications.

Area of Study 3

Investigation of an issue

The increasing uses and applications of genetics knowledge and reproductive science in society both provide benefits for individuals and populations and raise social, economic, legal and ethical questions. Human cloning, genetic modification of organisms, the use of forensic DNA databanks, assisted reproductive technologies and prenatal and predictive genetic testing challenge social and ethical norms. In this area of study students apply and extend their knowledge and skills developed in Areas of Study 1 and/or 2 to investigate an issue involving reproduction and/or inheritance.

They communicate the findings of their investigation and explain the biological concepts, identify different opinions, outline the legal, social and ethical implications for the individual and/or species and justify their conclusions. Material for the investigation can be gathered from laboratory work, computer simulations and modelling, literature searches, global databases and interviews with experts.

Outcome 3

On completion of this unit the student should be able to investigate and communicate a substantiated response to a question related to an issue in genetics and/or reproductive science.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 3 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

- the characteristics of effective science communication: accuracy of biological information; clarity of explanation of biological concepts, ideas and models; contextual clarity with reference to importance and implications of findings; conciseness and coherence; and appropriateness for purpose and audience
- the biological concepts specific to the investigation: definitions of key terms; use of appropriate biological terminology, conventions and representations
- the use of data representations, models and theories in organising and explaining observed phenomena and biological concepts, and their limitations
- the nature of evidence and information: distinction between opinion, anecdote and evidence, weak and strong evidence, and scientific and non-scientific ideas; and validity, reliability and authority of data including sources of possible errors or bias
- the influence of social, economic, legal and ethical factors relevant to the selected biological issue.

Assessment

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks that provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study, including the key knowledge and key skills listed for the outcomes, should be used for course design and the development of learning activities and assessment tasks. Assessment must be a part of the regular teaching and learning program and should be completed mainly in class and within a limited timeframe.

All assessments at Units 1 and 2 are school-based. Procedures for assessment of levels of achievement in Units 1 and 2 are a matter for school decision.

For this unit students are required to demonstrate achievement of three outcomes. As a set these outcomes encompass all areas of study.

Suitable tasks for assessment may be selected from the following:

For Outcomes 1 and 2

- a report of a fieldwork activity
- annotations of a practical work folio of activities or investigations
- a bioinformatics exercise
- media response
- data analysis
- problem solving involving biological concepts, skills and/or issues
- a reflective learning journal/blog related to selected activities or in response to an issue
- a test comprising multiple choice and/or short answer and/or extended response.

For Outcome 3

- a report of an investigation into genetics and/or reproductive science using an appropriate format, for example, digital presentation, oral communication or written report.

Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

Practical work is a central component of learning and assessment. As a guide, between 3½ and 5 hours of class time should be devoted to student practical work and investigations for each of Areas of Study 1 and 2. For Area of Study 3, between 6 and 8 hours of class time should be devoted to undertaking the investigation and communicating findings.

Unit 3: How do cells maintain life?

The cell is a dynamic system of interacting molecules that define life. An understanding of the workings of the cell enables an appreciation of both the capabilities and the limitations of living organisms whether animal, plant, fungus or microorganism. The convergence of cytology, genetics and biochemistry makes cell biology one of the most rapidly evolving disciplines in contemporary biology.

In this unit students investigate the workings of the cell from several perspectives. They explore the importance of the insolubility of the plasma membrane in water and its differential permeability to specific solutes in defining the cell, its internal spaces and the control of the movement of molecules and ions in and out of such spaces. Students consider base pairing specificity, the binding of enzymes and substrates, the response of receptors to signalling molecules and reactions between antigens and antibodies to highlight the importance of molecular interactions based on the complementary nature of specific molecules.

Students study the synthesis, structure and function of nucleic acids and proteins as key molecules in cellular processes. They explore the chemistry of cells by examining the nature of biochemical pathways, their components and energy transformations. Cells communicate with each other using a variety of signalling molecules. Students consider the types of signals, the transduction of information within the cell and cellular responses. At this molecular level students study the human immune system and the interactions between its components to provide immunity to a specific antigen.

A student practical investigation related to cellular processes and/or biological change and continuity over time is undertaken in either Unit 3 or Unit 4, or across both Units 3 and 4, and is assessed in Unit 4, Outcome 3. The findings of the investigation are presented in a scientific poster format as outlined in the template on [page 12](#).

Area of Study 1

How do cellular processes work?

In this area of study students focus on the cell as a complex chemical system. They examine the chemical nature of the plasma membrane to compare how hydrophilic and hydrophobic substances move across it. They model the formation of DNA and proteins from their respective subunits. The expression of the information encoded in a sequence of DNA to form a protein is explored and the nature of the genetic code outlined. Students use the *lac* operon to explain prokaryotic gene regulation in terms of the 'switching on' and 'switching off' of genes.

Students learn why the chemistry of the cell usually takes place at relatively low, and within a narrow range of, temperatures. They examine how reactions, including photosynthesis and cellular respiration, are made up of many steps that are controlled by enzymes and assisted by coenzymes. Students explain the mode of action of enzymes and the role of coenzymes in the reactions of the cell and investigate the factors that affect the rate of cellular reactions.

Outcome 1

On completion of this unit the student should be able to explain the dynamic nature of the cell in terms of key cellular processes including regulation, photosynthesis and cellular respiration, and analyse factors that affect the rate of biochemical reactions.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 1 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

Plasma membranes

- the fluid mosaic model of the structure of the plasma membrane and the movement of hydrophilic and hydrophobic substances across it based on their size and polarity
- the role of different organelles including ribosomes, endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of a protein product from the cell through exocytosis
- cellular engulfment of material by endocytosis.

Nucleic acids and proteins

- nucleic acids as information molecules that encode instructions for the synthesis of proteins in cells
- protein functional diversity and the nature of the proteome
- the functional importance of the four hierarchical levels of protein structure
- the synthesis of a polypeptide chain from amino acid monomers by condensation polymerisation
- the structure of DNA and the three forms of RNA including similarities and differences in their subunits, and their synthesis by condensation polymerisation
- the genetic code as a degenerate triplet code and the steps in gene expression including transcription, RNA processing in eukaryotic cells and translation.

Gene structure and regulation

- the functional distinction between structural genes and regulatory genes
- the structure of genes in eukaryotic cells including stop and start instructions, promoter regions, exons and introns
- use of the *lac* operon as a simple prokaryotic model that illustrates the switching off and on of genes by proteins (transcriptional factors) expressed by regulatory genes.

Structure and regulation of biochemical pathways

- the role of enzymes as protein catalysts in biochemical pathways
- the mode of action of enzymes including reversible and irreversible inhibition of their action due to chemical competitors at the active site, and by factors including temperature, concentration and pH
- the cycling of coenzymes (ATP, NADH, and NADPH) as loaded and unloaded forms to move energy, protons and electrons between reactions in the cell.

Photosynthesis

- the purpose of photosynthesis
- chloroplasts as the site of photosynthesis, an overview of their structure and evidence of their bacterial origins
- inputs and outputs of the light dependent and light independent (Calvin cycle) stages of photosynthesis in C₃ plants (details of the biochemical pathway mechanisms are not required)
- factors that affect the rate of photosynthesis, including light, temperature and carbon dioxide concentration.

Cellular respiration

- the purpose of cellular respiration
- the location of, and the inputs and outputs of, glycolysis including ATP yield (details of the biochemical pathway mechanisms are not required)
- mitochondria as the site of aerobic cellular respiration, an overview of their structure and evidence of their bacterial origins
- the main inputs and outputs of the Krebs (citric acid) cycle and electron transport chain including ATP yield (details of the biochemical pathway mechanisms are not required)

- the location of anaerobic cellular respiration, its inputs and the difference in outputs between animals and yeasts including ATP yield
- factors that affect the rate of cellular respiration, including temperature, glucose availability and oxygen concentration.

Area of Study 2

How do cells communicate?

In this area of study students focus on how cells receive specific signals that elicit a particular response. Students apply the stimulus-response model to the cell in terms of the types of signals, the position of receptors, and the transduction of the information across the cell to an effector that then initiates a response. Students examine unique molecules called antigens and how they elicit an immune response, the nature of immunity and the role of vaccinations in providing immunity. They explain how malfunctions in signalling pathways cause various disorders in the human population and how new technologies assist in managing such disorders.

Outcome 2

On completion of this unit the student should be able to apply a stimulus-response model to explain how cells communicate with each other, outline immune responses to invading pathogens, distinguish between the different ways that immunity may be acquired, and explain how malfunctions of the immune system cause disease.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 2 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

Cellular signals

- the sources and mode of transmission of various signalling molecules to their target cell, including plant and animal hormones, neurotransmitters, cytokines and pheromones
- the stimulus-response model when applied to the cell in terms of signal transduction as a three-step process involving reception, transduction and cellular response
- difference in signal transduction for hydrophilic and hydrophobic signals in terms of the position of receptors (on the membrane and in the cytosol) and initiation of transduction (details of specific chemicals, names of second messengers, G protein pathways, reaction mechanisms or cascade reactions are not required)
- apoptosis as a natural, regulatory process of programmed cell death, initiated after a cell receives a signal from inside (mitochondrial pathway) or from outside (death receptor pathway) the cell resulting in the removal of cells that are no longer needed or that may be a threat to an organism, mediated by enzymes (caspases) that cleave specific proteins in the cytoplasm or nucleus (details of specific cytoplasmic or nuclear proteins are not required)
- malfunctions in apoptosis that result in deviant cell behaviour leading to diseases including cancer.

Responding to antigens

- an antigen as a unique molecule or part of a molecule that initiates an immune response including the distinction between non-self antigens, self-antigens and allergens
- invading cellular and non-cellular pathogens as a source of non-self antigens, and preventative strategies including physical, chemical and microbiological barriers in animals and plants that keep them out
- the characteristics and roles of components (macrophages, neutrophils, mast cells, dendritic cells, complement proteins) of the innate (non-specific) immune response to an antigen including the steps in the inflammatory response

- the role of the lymphatic system in the immune response including the role of secondary lymphoid tissue (with reference to lymph nodes) as the site of antigen recognition by lymphocytes, and as a transport system for antigen presenting cells including dendritic cells
- the characteristics and roles of components of the adaptive (specific) immune response including the actions of B lymphocytes and their antibodies (including antibody structure) in humoral immunity, and the actions of T helper and T cytotoxic cells in cell-mediated immunity.

Immunity

- the difference between natural and artificial immunity, and active and passive strategies for acquiring immunity
- vaccination programs and their role in maintaining herd immunity for a particular disease in the human population
- the deficiencies and malfunctions of the immune system as a cause of human diseases including autoimmune diseases (illustrated by multiple sclerosis), immune deficiency diseases (illustrated by HIV) and allergic reactions (illustrated by reactions to pollen)
- the use of monoclonal antibodies in treating cancer.

School-based assessment

Satisfactory completion

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of assessment tasks to provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study and key knowledge and key skills listed for the outcomes should be used for course design and the development of learning activities and assessment tasks.

Assessment of levels of achievement

The student's level of achievement in Unit 3 will be determined by School-assessed Coursework. School-assessed Coursework tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe.

Where teachers provide a range of options for the same School-assessed Coursework task, they should ensure that the options are of comparable scope and demand.

The types and range of forms of School-assessed Coursework for the outcomes are prescribed within the study design. The VCAA publishes *Advice for teachers* for this study, which includes advice on the design of assessment tasks and the assessment of student work for a level of achievement

Teachers will provide to the VCAA a numerical score representing an assessment of the student's level of achievement. The score must be based on the teacher's assessment of the performance of each student on the tasks set out in the following table.

Contribution to final assessment

School-assessed Coursework for Unit 3 will contribute 16 per cent to the study score.

Outcomes	Marks allocated*	Assessment tasks
<p>Outcome 1 Explain the dynamic nature of the cell in terms of key cellular processes including regulation, photosynthesis and cellular respiration, and analyse factors that affect the rate of biochemical reactions.</p>	50	<p>A report related to at least two practical activities from a logbook of practical activities.</p> <p>The assessment task may be written or multimodal. (approximately 50 minutes or not exceeding 1000 words)</p>
<p>Outcome 2 Apply a stimulus-response model to explain how cells communicate with each other, outline immune responses to invading pathogens, distinguish between the different ways that immunity may be acquired, and explain how malfunctions of the immune system cause disease.</p>	50	<p>At least one task selected from:</p> <ul style="list-style-type: none"> • a report of a practical activity • annotations of activities or investigations from a logbook of practical activities • a graphic organiser • a bioinformatics exercise • an evaluation of research • media response • data analysis • a response to a set of structured questions • problem solving involving biological concepts, skills and/or issues • a reflective learning journal/blog related to selected activities or in response to an issue. <p>The assessment task/s may be written or multimodal. (approximately 50 minutes or not exceeding 1000 words for each task)</p>
Total marks	100	

*School-assessed Coursework for Unit 3 contributes 16 per cent.

Practical work and assessment

Practical work is a central component of learning and assessment. As a guide, between 3½ and 5 hours of class time should be devoted to student practical work and investigations for each of Areas of Study 1 and 2.

External assessment

The level of achievement for Units 3 and 4 is also assessed by an end-of-year examination, which will contribute 60 per cent to the study score.

Unit 4: How does life change and respond to challenges over time?

In this unit students consider the continual change and challenges to which life on Earth has been subjected. They investigate the relatedness between species and the impact of various change events on a population's gene pool. The accumulation of changes over time is considered as a mechanism for biological evolution by natural selection that leads to the rise of new species. Students examine change in life forms using evidence from palaeontology, biogeography, developmental biology and structural morphology. They explore how technological developments in the fields of comparative genomics, molecular homology and bioinformatics have resulted in evidence of change through measurements of relatedness between species.

Students examine the structural and cognitive trends in the human fossil record and the interrelationships between human biological and cultural evolution. The biological consequences, and social and ethical implications, of manipulating the DNA molecule and applying biotechnologies is explored for both the individual and the species.

A student practical investigation related to cellular processes and/or biological change and continuity over time is undertaken in either Unit 3 or Unit 4, or across both Units 3 and 4, and is assessed in Unit 4, Outcome 3. The findings of the investigation are presented in a scientific poster format as outlined in the template on [page 12](#).

Area of Study 1

How are species related?

In this area of study students focus on changes to genetic material over time and the evidence for biological evolution. They investigate how changes to genetic material lead to new species through the process of natural selection as a mechanism for evolution. Students examine how evolutionary biology and the relatedness of species is based upon the accumulation of evidence. They learn how interpretations of evidence can change in the light of new evidence as a result of technological advances, particularly in molecular biology. The human fossil record is explored to identify the major biological and cognitive trends that have led to a complex interrelationship between biology and culture.

Outcome 1

On completion of this unit the student should be able to analyse evidence for evolutionary change, explain how relatedness between species is determined, and elaborate on the consequences of biological change in human evolution.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 1 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

Changes in the genetic makeup of a population

- the qualitative treatment of the causes of changing allele frequencies in a population's gene pool including types of mutations (point, frameshift, block) as a source of new alleles, chromosomal abnormalities (aneuploidy and polyploidy), environmental selection pressures on phenotypes as the mechanism for natural selection, gene flow, and genetic drift (bottleneck and founder effects) and the biological consequences of such changes in terms of increased or reduced genetic diversity
- processes of evolution including through the action of mutations and different selection pressures on a fragmented population and subsequent isolating mechanisms (allopatric speciation) that prevent gene flow
- the manipulation of gene pools through selective breeding programs.

Changes in biodiversity over time

- significant changes in life forms in Earth's geological history including the rise of multicellular organisms, animals on land, the first flowering plants and mammals
- evidence of biological change over time including from palaeontology (the fossil record, the relative and absolute dating of fossils, types of fossils and the steps in fossilisation), biogeography, developmental biology and structural morphology
- patterns of biological change over geological time including divergent evolution, convergent evolution and mass extinctions.

Determining relatedness between species

- molecular homology as evidence of relatedness between species including DNA and amino acid sequences, mtDNA (the molecular clock) and the DNA hybridisation technique
- the use of phylogenetic trees to show relatedness between species
- the evolution of novel phenotypes arising from chance events within genomes, specifically sets of genes that regulate developmental processes and lead to changes in the expression of a few master genes found across the animal phyla, as demonstrated by the expression of gene BMP4 in beak formation of the Galapagos finches and jaw formation of cichlid fish in Africa.

Human change over time

- shared characteristics that define primates, hominoids and hominins
- major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo* including structural, functional and cognitive changes and the consequences for cultural evolution
- the human fossil record as an example of a classification scheme that is open to interpretations that are contested, refined or replaced when new evidence challenges them or when a new model has greater explanatory power, including whether *Homo sapiens* and *Homo neanderthalensis* interbred and the placement of the *Denisovans* into the *Homo* evolutionary tree.

Area of Study 2

How do humans impact on biological processes?

In this area of study students examine the impact of human culture and technological applications on biological processes. They apply their knowledge of the structure and function of the DNA molecule to examine how molecular tools and techniques can be used to manipulate the molecule for a particular purpose. Students describe gene technologies used to address human issues and consider their social and ethical implications. Scientific knowledge can both challenge and be challenged by society. Students examine biological challenges that illustrate how the reception of scientific knowledge is influenced by social, economic and cultural factors.

Outcome 2

On completion of this unit the student should be able to describe how tools and techniques can be used to manipulate DNA, explain how biological knowledge is applied to biotechnical applications, and analyse the interrelationship between scientific knowledge and its applications in society.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 2 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

DNA manipulation

- the use of enzymes including endonucleases (restriction enzymes), ligases and polymerases
- amplification of DNA using the polymerase chain reaction
- the use of gel electrophoresis in sorting DNA fragments, including interpretation of gel runs
- the use of recombinant plasmids as vectors to transform bacterial cells.

Biological knowledge and society

- techniques that apply DNA knowledge (specifically gene cloning, genetic screening and DNA profiling) including social and ethical implications and issues
- the distinction between genetically modified and transgenic organisms, their use in agriculture to increase crop productivity and to provide resistance to insect predation and/or disease, and the biological, social and ethical implications that are raised by their use
- strategies that deal with the emergence of new diseases in a globally connected world, including the distinction between epidemics and pandemics, the use of scientific knowledge to identify the pathogen, and the types of treatments
- the concept of rational drug design in terms of the complementary nature (shape and charge) of small molecules that are designed to bind tightly to target biomolecules (limited to enzymes) resulting in the enzyme's inhibition and giving rise to a consequential therapeutic benefit, illustrated by the Australian development of the antiviral drug Relenza as a neuraminidase inhibitor
- the use of chemical agents against pathogens including the distinction between antibiotics and antiviral drugs with reference to their mode of action and biological effectiveness.

Area of Study 3

Practical investigation

A student-designed or adapted investigation related to cellular processes and/or biological change and continuity over time is undertaken in either Unit 3 or Unit 4, or across both Units 3 and 4. The investigation is to relate to knowledge and skills developed across Units 3 and 4 and may be undertaken by the student through laboratory work and/or fieldwork.

The investigation requires the student to identify an aim, develop a question, formulate a hypothesis and plan a course of action to answer the question and that complies with safety and ethical guidelines. The student then undertakes an experiment that involves the collection of primary qualitative and/or quantitative data, analyses and evaluates the data, identifies limitations of data and methods, links experimental results to science ideas, reaches a conclusion in response to the question and suggests further investigations which may be undertaken. The results of the investigation are presented in a scientific poster format according to the template provided on [page 12](#). A logbook of practical activities must be maintained by the student for record, authentication and assessment purposes.

Outcome 3

On the completion of this unit the student should be able to design and undertake a practical investigation related to cellular processes and/or biological change and continuity over time, and present methodologies, findings and conclusions in a scientific poster.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 3 and the related key science skills on [pages 10 and 11](#) of the study design.

Key knowledge

- independent, dependent and controlled variables
- the biological concepts specific to the investigation and their significance, including definitions of key terms, and biological representations
- the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation, including laboratory work (biochemistry, cytology, immunology) and/or fieldwork (geomorphology); precision, accuracy, reliability and validity of data; and minimisation of experimental bias
- ethics and issues of research including identification and application of relevant health, safety and bioethical guidelines
- methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and limitations of data and methodologies
- models, theories and classification keys, and their use in organising and explaining observed phenomena and biological concepts including their limitations
- the nature of evidence that supports or refutes a hypothesis, model or theory
- the key findings of the selected investigation and their relationship to cytological, biochemical and/or evolutionary concepts
- the conventions of scientific report writing and scientific poster presentation including biological terminology and representations, standard abbreviations, units of measurement and acknowledgment of references.

School-based assessment

Satisfactory completion

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of assessment tasks to provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study and key knowledge and key skills listed for the outcomes should be used for course design and the development of learning activities and assessment tasks.

Assessment of levels of achievement

The student's level of achievement in Unit 4 will be determined by School-assessed Coursework. School-assessed Coursework tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe.

Where teachers provide a range of options for the same School-assessed Coursework task, they should ensure that the options are of comparable scope and demand.

The types and range of forms of School-assessed Coursework for the outcomes are prescribed within the study design. The VCAA publishes *Advice for teachers* for this study, which includes advice on the design of assessment tasks and the assessment of student work for a level of achievement.

Teachers will provide to the VCAA a numerical score representing an assessment of the student's level of achievement. The score must be based on the teacher's assessment of the performance of each student on the tasks set out in the following table.

Contribution to final assessment

School-assessed Coursework for Unit 4 will contribute 24 per cent to the study score.

Outcomes	Marks allocated*	Assessment tasks
Outcome 1 Analyse evidence for evolutionary change, explain how relatedness between species is determined, and elaborate on the consequences of biological change in human evolution.	30	A report using primary or secondary data. The assessment task may be written or multimodal. (approximately 50 minutes or not exceeding 1000 words)
Outcome 2 Describe how tools and techniques can be used to manipulate DNA, explain how biological knowledge is applied to biotechnical applications, and analyse the interrelationship between scientific knowledge and its applications in society.	30	A response to an issue OR A report of a laboratory investigation The assessment task may be written or multimodal. (approximately 50 minutes or not exceeding 1000 words)
Outcome 3 Design and undertake a practical investigation related to cellular processes and/or biological change and continuity over time, and present methodologies, findings and conclusions in a scientific poster.	30	A structured scientific poster according to the VCAA template (not exceeding 1000 words)
Total marks	90	

*School-assessed Coursework for Unit 4 contributes 24 per cent.

Practical work and assessment

Practical work is a central component of learning and assessment. As a guide, between 3½ and 5 hours of class time should be devoted to student practical work and investigations for each of Areas of Study 1 and 2. In Area of Study 3, between 7 and 10 hours of class time should be devoted to the investigation to be undertaken in either Unit 3 or Unit 4, or across both Units 3 and 4, including the writing of the sections of the scientific poster.

External assessment

The level of achievement for Units 3 and 4 is also assessed by an end-of-year examination.

Contribution to final assessment

The examination will contribute 60 per cent.

End-of-year examination

Description

The examination will be set by a panel appointed by the VCAA. All the key knowledge that underpins the outcomes in Units 3 and 4 and the cross-study key science skills are examinable.

Conditions

The examination will be completed under the following conditions:

- Duration: 2.5 hours.
- Date: end-of-year, on a date to be published annually by the VCAA.
- VCAA examination rules will apply. Details of these rules are published annually in the VCE and [VCAL Administrative Handbook](#).
- The examination will be marked by assessors appointed by the VCAA.

Further advice

The VCAA publishes specifications for all VCE examinations on the VCAA website. Examination specifications include details about the sections of the examination, their weighting, the question format/s and any other essential information. The specifications are published in the first year of implementation of the revised Units 3 and 4 sequence together with any sample material.