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Important information

Accreditation period

Units 1–4: 1 January 2022 – 31 December 2026

Implementation of this study commences in 2022.

Other sources of information

The [*VCAA Bulletin*](https://www.vcaa.vic.edu.au/news-and-events/bulletins-and-updates/bulletin/Pages/index.aspx) is the only official source of changes to regulations and accredited studies. The Bulletin also regularly includes advice on VCE studies. It is the responsibility of each VCE teacher to refer to each issue of the Bulletin. The Bulletin is available as an e-newsletter via [free subscription](https://www.vcaa.vic.edu.au/Footer/Pages/Subscribe.aspx) on the VCAA’s website.

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*](https://www.vcaa.vic.edu.au/administration/vce-vcal-handbook/Pages/index.aspx) 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](https://www.vcaa.vic.edu.au/Footer/Pages/Copyright.aspx) is available on the VCAA website.

Introduction

Scope of study

The study of Biology explores the diversity of life as it has evolved and changed over time, and considers how living organisms function and interact. It explores the processes of life, from the molecular world of the cell to that of the whole organism, and examines how life forms maintain and ensure their continuity. Students study contemporary research, models and theories to understand how knowledge in biology has developed and how this knowledge continues to change in response to new evidence and discoveries. An understanding of the complexities and diversity of biology provides students with the opportunity to appreciate the interconnectedness of concepts and 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 scientific investigation methodologies, to develop key science skills, and to interrogate the links between knowledge, theory and practice. Students work collaboratively as well as independently on a range of scientific investigations involving controlled experiments, fieldwork, case studies, correlational studies, classification and identification, modelling, simulations, literature reviews, and the development of a product, process or system. Knowledge and application of the safety and ethical guidelines associated with biological investigations is integral to the study of VCE Biology.

As well as increasing their understanding of scientific processes, students develop insights into how knowledge in biology has changed, and continues to change, in response to new evidence, discoveries and thinking. They 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 contexts of scientific endeavours. Students consider how science is connected to innovation in addressing contemporary biological challenges.

Rationale

VCE Biology enables students to investigate the processes involved in sustaining life at cellular, system and species levels. In undertaking this study, students develop an understanding that, in the dynamic and interconnected system of life, all change has consequences that may affect an individual, a species or the collective biodiversity of Earth. Students gain insights into how molecular and evolutionary concepts and key science skills underpin much of contemporary biology, and how society applies such skills and concepts to resolve problems and make scientific advancements.

In VCE Biology, students develop and enhance a range of inquiry skills including practical experimentation, research and analytical skills, problem-solving skills including critical and creative thinking, and communication skills. Students pose questions, formulate hypotheses, conduct investigations, and analyse and critically interpret qualitative and quantitative data. They assess   
the limitations of data, evaluate methodologies and results, justify their conclusions, make recommendations and communicate their findings. Students use biological knowledge, scientific skills and ethical understanding to investigate and analyse contemporary bioethical issues and communicate their views from an informed position.

VCE Biology provides for continuing study pathways within the discipline and can lead 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 human endeavour including bioethics, biotechnology, dentistry, ecology, education, food science, forestry, health care, horticulture, medicine, optometry, physiotherapy and veterinary science. Biologists 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, concepts and issues from the individual cell to species level
* develop knowledge and understanding of organisms, their relationship to their environment, and the consequences of biological change over time, including the impact of human endeavours on biological processes and the survival of species

and more broadly to:

* develop attitudes that include curiosity, open-mindedness, creativity, flexibility, integrity, attention to detail and respect for evidence-based conclusions
* develop an understanding of the cooperative, cumulative, iterative and interdisciplinary nature of science as a human endeavour, including its possibilities, limitations and sociocultural, economic, political and legal influences and consequences
* develop a range of individual and collaborative science inquiry skills through a variety of investigation methodologies in the laboratory and field, refining investigations to improve data quality
* understand the research, ethical and safety guidelines that govern the study and practice of the discipline and apply these guidelines to generate, collate, analyse, critically evaluate and report data
* analyse and interpret qualitative and quantitative data to provide evidence, recognising patterns, relationships and limitations of data
* develop an informed and critical perspective, as local and global citizens, on contemporary science-based issues
* develop knowledge and understanding of key models, concepts, theories and laws of science to explain scientific processes and phenomena, and apply this understanding in familiar and unfamiliar situations, including personal, sociocultural, environmental and technological contexts
* communicate clearly and accurately an understanding of the discipline using appropriate terminology, conventions and formats.

Structure

The study is made up of four units, structured as a series of curriculum-framing questions that reflect the inquiry nature of the discipline.

Unit 1: How do organisms regulate their functions?

Unit 2: How does inheritance impact on diversity?

Unit 3: How do cells maintain life?

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

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.

Entry

There are no prerequisites for entry to Units 1, 2 and 3. Students must undertake Unit 3 and   
Unit 4 as a sequence. 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.

Changes to the study design

During its period of accreditation minor changes to the study will be announced in the [*VCAA Bulletin*](https://www.vcaa.vic.edu.au/news-and-events/bulletins-and-updates/bulletin/Pages/index.aspx). The Bulletin is the only source of changes to regulations and accredited studies. It is the responsibility of each VCE teacher to monitor changes or advice about VCE studies published in the 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*](https://www.vcaa.vic.edu.au/administration/vce-vcal-handbook/Pages/index.aspx). Schools will be notified if they are required to submit material to be audited.

Safety and wellbeing

The study 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 activities. 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 2017*
* *Occupational Health and Safety Management Systems (AS/NZ 4801)*
* *Dangerous Goods (Storage and Handling) Regulations 2012*
* *Dangerous Goods Storage and Handing Code of Practice 2000*
* *Hazardous Substances Code of Practice 2000*
* *Electrical Safety Act 1998*

Ethical conduct of scientific investigations

As part of this study, teachers and students may be involved in teaching and learning activities that include scientific investigations using human subjects. Teachers and schools have a legal and moral responsibility to ensure that students demonstrate ethical conduct 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) – Updated 2018*, issued by the National Health and Medical Research Council (NHMRC) in accordance with the *NHMRC Act 1992* (Cwlth), [www.nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018](http://www.nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018)
* the *Australian Privacy Principles* *from the Privacy Amendment (Enhancing Privacy Protection) Act 2012*, [www.oaic.gov.au/individuals/privacy-fact-sheets/general/privacy-fact-sheet-17-australian-privacy-principles](http://www.oaic.gov.au/individuals/privacy-fact-sheets/general/privacy-fact-sheet-17-australian-privacy-principles)
* the *Australian Psychological Society* (APS) *Code of Ethics*, [www.psychology.org.au/About-Us/What-we-do/ethics-and-practice-standards/APS-Code-of-Ethics](http://www.psychology.org.au/About-Us/What-we-do/ethics-and-practice-standards/APS-Code-of-Ethics)

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 *Extension Regulations 2018*
* the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 2013* (8th edition), [www.nhmrc.gov.au/about-us/publications/australian-code-care-and-use-animals-scientific-purposes](http://www.nhmrc.gov.au/about-us/publications/australian-code-care-and-use-animals-scientific-purposes)

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 VCE study designs.

The student’s level of achievement in Units 3 and 4 will be determined by School-assessed Coursework (SAC) as specified in the VCE study design, 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 completed the study. Teachers should refer to the current [*VCE and VCAL Administrative Handbook*](https://www.vcaa.vic.edu.au/administration/vce-vcal-handbook/Pages/index.aspx) 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: 20 per cent
* Unit 4 School-assessed Coursework: 30 per cent
* End-of-year examination: 50 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*](https://www.vcaa.vic.edu.au/administration/vce-vcal-handbook/Pages/index.aspx) for authentication procedures.

Cross-study specifications

Key science skills

The key science skills are a core component of the study of VCE Biology and apply across Units 1 to 4 in all areas of study. In designing teaching and learning programs for each unit and in assessing student learning for each outcome, teachers should ensure that students are given the opportunity to develop, use and demonstrate these skills in a variety of contexts, including when undertaking their own investigations and when evaluating the research of others. As the complexity of key knowledge increases from Unit 1 to 4, and as opportunities are provided to undertake scientific 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 | * identify, research and construct aims and questions for investigation * identify independent, dependent and controlled variables in controlled experiments * formulate hypotheses to focus investigation * predict possible outcomes |
| Plan and conduct investigations | * determine appropriate investigation methodology: case study; classification and identification; controlled experiment; correlational study; fieldwork; literature review; modelling; product, process or system development; simulation * design and conduct investigations; select and use methods appropriate to the investigation, including consideration of sampling technique and size, equipment and procedures, taking into account potential sources of error and uncertainty; determine the type and amount of qualitative and/or quantitative data to be generated or collated * work independently and collaboratively as appropriate and within identified research constraints, adapting or extending processes as required and recording such modifications |
| Comply with safety and ethical guidelines | * demonstrate safe laboratory practices when planning and conducting investigations by using risk assessments that are informed by safety data sheets (SDS), and accounting for risks * apply relevant occupational health and safety guidelines while undertaking practical investigations * demonstrate ethical conduct when undertaking and reporting investigations |
| Generate, collate and record data | * systematically generate and record primary data, and collate secondary data, appropriate to the investigation, including use  of databases and reputable online data sources * record and summarise both qualitative and quantitative data, including use of a logbook as an authentication of generated or collated data * organise and present data in useful and meaningful ways, including schematic diagrams, flow charts, tables, bar charts and line graphs * plot graphs involving two variables that show linear and non-linear relationships |
| Analyse and evaluate data and investigation methods | * process quantitative data using appropriate mathematical relationships and units, including calculations of ratios, percentages, percentage change and mean * identify and analyse experimental data qualitatively, handing where appropriate concepts of: accuracy, precision, repeatability, reproducibility and validity of measurements; errors (random and systematic); and certainty in data, including effects of sample size in obtaining reliable data * identify outliers, and contradictory or provisional data * repeat experiments to ensure findings are robust * evaluate investigation methods and possible sources of personal errors/mistakes or bias, and suggest improvements to increase accuracy and precision, and to reduce the likelihood of errors |
| Construct evidence-based arguments and draw conclusions | * distinguish between opinion, anecdote and evidence, and scientific and non-scientific ideas * evaluate data to determine the degree to which the evidence supports the aim of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation * evaluate data to determine the degree to which the evidence supports or refutes the initial prediction or hypothesis * use reasoning to construct scientific arguments, and to draw and justify conclusions consistent with the evidence and relevant to the question under investigation * identify, describe and explain the limitations of conclusions, including identification of further evidence required * discuss the implications of research findings and proposals |
| Analyse, evaluate and communicate scientific ideas | * 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 * analyse and explain how models and theories are used to organise and understand observed phenomena and concepts related to biology, identifying limitations of selected models/theories * critically evaluate and interpret a range of scientific and media texts (including journal articles, mass media communications and opinions in the public domain), processes, claims and conclusions related to biology by considering the quality of available evidence * analyse and evaluate bioethical issues using relevant approaches to bioethics and ethical concepts, including the influence of social, economic, legal and political factors relevant to the selected issue * use clear, coherent and concise expression to communicate to specific audiences and for specific purposes in appropriate scientific genres, including scientific reports and posters * acknowledge sources of information and assistance, 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.

All VCE science studies include scientific investigations that are student-designed. In approving student-designed investigation topics, teachers and schools must ensure that an investigation proposed by a student for a VCE Biology assessment task is not able to be presented as an assessment task in another VCE study at the school.

Scientific investigation methodologies

Scientific investigations can be undertaken in a variety of ways depending on the aim of the investigation and the question under investigation. For the purposes of VCE Biology, the planning and conducting of scientific investigations will require consideration of the following scientific investigation methodologies:

* **Case study:** An investigation of a particular activity, behaviour, event or problem that contains a real or hypothetical situation and includes the complexities that would be encountered in the real world. Case studies can take various forms: historical, involving the analysis of causes and consequences, and discussion of knowledge learned from the situation; a real situation or a role-play of an imagined situation, where plausible recommendations are to be made; or problem-solving, where developing a new design, methodology or method is required.
* **Classification and identification:** Classification is the arrangement of phenomena, objects or events into manageable sets, whereas identification is a process of recognition of phenomena as belonging to particular sets or possibly being part of a new or unique set.
* **Controlled experiment:** An experimental investigation of the relationship between an independent variable and a dependent variable, controlling all other variables.
* **Correlational study:** Planned observation and recording of events and behaviours that have not been manipulated or controlled to understand the relationships/associations that exist between variables, to identify which factors may be of greater importance, and to make predictions.
* **Fieldwork:** Based on inquiry or the investigation of an issue, fieldwork involves observing and interacting with a selected environment beyond the classroom, usually in an attempt to determine correlation, rather than a causal relationship. It may be conducted through direct qualitative and/or quantitative observations and sampling, participant observation, interviews and questionnaires.
* **Literature review:** Involves the collation and analysis of secondary data related to other people’s scientific findings and/or viewpoints in order to answer a question or provide background information to help explain observed events, or as preparation for an investigation to generate primary data.
* **Modelling:** Involves the construction of: a physical model, such as a small- or large-scale representation of an object; a conceptual model, which represents a system involving concepts that help people know, understand or simulate the system; or a mathematical model, which describes a system using mathematical equations that involve relationships between variables and that can be used to make predictions.
* **Product, process or system development:** Design of an artefact, process or system to meet a human need, which may involve technological applications in addition to scientific knowledge and procedures.
* **Simulation:** A process of using a model to study the behaviour of a real or theoretical system. The modelling and manipulation of variables in a real system is useful because often the variables cannot be controlled as the system may be too complex, too large or small, too fast or slow, not accessible or too dangerous.

Logbooks

The use of a logbook reflects standard scientific practice. Students undertaking this study must maintain a logbook of practical activities in each of Units 1 to 4 for recording, authentication and assessment purposes. All items in the logbook must be dated and clearly documented.

The logbook is submitted as a requirement for satisfactory completion in each of Units 1 to 4. Teachers must regularly sight and monitor the logbook, particularly for the student-designed practical and/or research investigations in Outcome 3 of Units 1 and 2, and Outcome 3 of Unit 4.

The logbook may be maintained in hard copy or electronic form. However, to avoid falsification and/or alteration of results, for assessment tasks it is recommended that students maintain a hard copy, as is commonly the practice in scientific research.

Unit 4 Scientific poster

In Unit 4, Area of Study 3, students demonstrate their science communication skills by presenting the findings of a student-designed scientific investigation and the significance of these findings to both technical and non-technical audiences. The poster may be produced electronically or in hard-copy format and should not exceed 600 words.

Students will use the following scientific poster format when reporting on their investigation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Title Student name | |  |
| Introduction  Methodology and methods  Results | Communication statement reporting the key finding  of the investigation as a one-sentence summary | Discussion  Conclusion | |
| References and acknowledgements | | | |

The centre of the poster will occupy between 20 to 25 per cent of the poster space and will be a one-sentence summary of the major finding of the investigation that answers the investigation question.

The presentation format of the poster will include the following sections:

|  |  |  |
| --- | --- | --- |
| **Poster section** | **Content** | |
| Title | Question under investigation | |
| Introduction | Brief explanation or reason for undertaking the investigation, including a clear aim, a hypothesis and/or prediction and relevant background biological concepts | |
| Methodology and methods | Brief outline of the selected methodology used to address the investigation question | |
| Summary of data generation method/s and data analysis method/s | |
| Results | Presentation of generated data/evidence in appropriate format to illustrate trends, patterns and/or relationships | |
| Discussion | Interpretation and evaluation of analysed primary data | |
| Identification of limitations in data and methods, and suggested improvements | |
| Cross-referencing of results to relevant biological concepts | |
| Linking of results to investigation question and to the aim to explain whether or not the investigation data and findings support the hypothesis | |
| Implications of the investigation and/or suggestions as to further investigations that may be undertaken | |
| Conclusion | | Conclusion that provides a response to the investigation question |
| Identification of the extent to which the analysis has answered the investigation question, with no new information being introduced |
| References and acknowledgements | | Referencing and acknowledgement of all quotations and sourced content relevant to the investigation |

Students record in their logbooks all elements of their investigation planning, comprising identification and management of relevant risks, recording of raw data, and preliminary analysis and evaluation of results, including identification of outliers and their subsequent treatment. Both the students’ poster and logbook entries are assessed as part of Unit 4, Area of Study 3.

Critical and creative thinking

Critical and creative thinking are embedded in the key science skills and applied across the VCE Sciences during learning experiences where students develop questions and hypotheses, design and undertake investigations, make reasoned predictions, generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and consequences, make evidence-based decisions, devise real or imagined solutions and solve problems.

Students may engage in scientific investigations involving both primary and secondary data after they identify an aim and methodology, and develop a specific investigation method that includes consideration of participants, sampling technique and size, equipment and procedure. A commitment to accuracy, precision and integrity in observation is an important precursor to critical thinking when generating primary data.

Problem solving of any kind requires initial deconstruction to identify an appropriate methodology, followed by consideration of potential risks, and perseverance in adopting different strategies to develop a solution or to reach a conclusion.

In VCE Biology, students also consider how critical and creative thinking has been applied by others in the development of knowledge and applications related to addressing biological challenges.

Ethical understanding

Ethical understanding is applied across Units 1 to 4 of the VCE Sciences. Students apply ethical understanding when they undertake their own investigations, analyse their own and others’ data, and identify and investigate issues relating to the application of scientific knowledge in society. Applying the knowledge and skills of ethical understanding enables students to:

* consider the implications of their own and others’ investigations of living things and the environment
* apply integrity when recording and reporting the outcomes of their own investigations, and when using their own and others’ data
* reach a position about science-related ethical issues based on an understanding of ethical concepts and scientific knowledge and skills, considering current and future needs
* recognise the importance of values, and social, economic, political and legal factors in responsible science-related decision-making.

The application of ethical understanding in the context of VCE Biology involves the demonstration and application of approaches to bioethics and ethical concepts. Further explanation of these terms can be found in the ‘Terms used in this study’ section on [pages 16 and 17](#ethics).

Individual and collaborative scientific endeavour

Scientific endeavour is commonly a collaborative, and often global, undertaking that draws on the knowledge and skills of individuals. Units 1 to 4 of VCE Biology provides students with opportunities to manage their time effectively, work safely, make responsible decisions and constructively handle challenging situations.

When working with others, students are expected to actively participate, share ideas, and offer viewpoints and suggestions while respecting the perspectives of others. In group work, students should identify collective goals and make use of strategies to work effectively as a group member to complete tasks and solve problems.

Students learn to seek, value and act on feedback when undertaking both individual and collaborative endeavours.

Aboriginal and Torres Strait Islander knowledge, cultures and history

Aboriginal and Torres Strait Islander peoples have diverse cultures, social structures and a history of unique, complex knowledge systems. In VCE Biology, students consider how scientific thinking can be informed and enhanced by considering how Aboriginal and Torres Strait Islander peoples have developed and refined their own knowledge about the world through: observation, using all the senses; prediction and hypothesis testing, including trial-and-error; and making generalisations within specific contexts including their connection to Country and Place, use of plants as medicine, and adaptations and diversity within ecosystems.

Teachers are encouraged to include Aboriginal and Torres Strait Islander knowledge and perspectives in the design and delivery of teaching and learning programs related to VCE Biology. Many local Aboriginal and Torres Strait Islander communities have protocols that they have developed in relation to education. The Victorian Koorie community-preferred education model enables teachers to focus inclusively on supporting students to consider Victorian Koorie education matters, and systematically support students to learn about local, regional, state and national Indigenous perspectives. VCE studies involve a focused extension of this model and include a broader application of national and international perspectives.

*Protocols for Koorie education in Victorian schools*, developed through the Yalca policy, and other resources relating to the inclusion of Aboriginal and Torres Strait Islander knowledge and perspectives may be accessed at [www.vaeai.org.au/documents/](http://www.vaeai.org.au/documents/)

Terms used in this study

For the purposes of this study design and associated assessment, the following definitions will apply. The *Advice for teachers* provides additional information and should be used in conjunction with this study design.

Aboriginal and Torres Strait Islander knowledge, cultures and history

Inclusion of Aboriginal and Torres Strait Islander knowledge, cultures and history in Units 1 to 4 will require consideration of the following:

**Aboriginal and Torres Strait Islander Peoples:** Aboriginal Peoples are the first peoples of Australia and are represented by over 250 language groups, each associated with a particular Country or territory. Torres Strait Islander Peoples whose island territories to the north east of Australia were annexed to Queensland in 1879 are also Indigenous Australians and are represented by five cultural groups.

An Aboriginal and/or Torres Strait Islander person is someone who:

* is of Aboriginal and/or Torres Strait Islander descent
* identifies as an Aboriginal person and/or Torres Strait Islander person, and
* is accepted as such by the Aboriginal and/or Torres Strait Islander community in which they live.

**Country:** An area that is traditionally owned and looked after by an Aboriginal language group or community, or by certain people within that group. The term may indicate more than simply a geographical area – it is also a concept that can encompass the spiritual meaning and feelings of deep connection and attachment associated with that area.

**Place:** A space mapped out by physical or intangible boundaries that individuals or groups of Torres Strait Islander Peoples occupy and regard as their own. Places are spaces that have varying degrees of spirituality.

Data and measurement

A major aim of science is to develop explanations that are supported by evidence for natural phenomena and events. This involves considering the quality and quantity of evidence and, before conclusions are drawn from data, considering questions such as: ‘Can I rely on the data I have generated when drawing conclusions?’ and ‘Does the difference between one measurement and another indicate a real change in what is being measured?’.

When analysing and discussing investigations of a quantitative nature, the following terms require consideration:

* **Accuracy:** the accuracy of a measurement relates to how close it is to the ‘true’ value of the quantity being measured.
* **Precision:** refers to how closely a set of measurement values agree with each other. Precision gives no indication of how close the measurements are to the true value and is therefore a separate consideration to accuracy.
* **Repeatability:** the closeness of the agreement between the results of successive measurements of the same quantity being measured, carried out under the same conditions of measurement. These conditions include the same measurement procedure, the same observer, the same measuring instrument used under the same conditions, the same location, and repetition over a short period of time.
* **Reproducibility:** the closeness of the agreement between the results of measurements of the same quantity being measured, carried out under changed conditions of measurement. These different conditions include a different method of measurement, different observer, different measuring instrument, different location, different conditions of use, and different time.
* **True value:** the value, or range of values, that would be found if the quantity could be measured perfectly.
* **Validity:** a measurement is said to be valid if it measures what it is supposed to be measuring.   
  An experiment is said to be valid if it investigates what it sets out and/or claims to investigate.

Ethical approaches and concepts

VCE Biology requires consideration of:

1. Approaches to bioethics

There are three major approaches to resolving ethical issues that support students to identify bioethical issues, explore these bioethical issues in context, consider different perspectives on bioethical issues, reflect on courses of action, and choose a position or course of action on the basis of reasoning and reflection.

Depending on the bioethical issue being explored, one or more of the following approaches could be applied and/or considered:

* **Consequences-based** approach places central importance on the consideration of the consequences of an action (the ends), with the aim to achieve maximisation of positive outcomes and minimisation of negative effects.
* **Duty- and/or rule-based** approach is concerned with how people act (the means) and places central importance on the idea that people have a duty to act in a particular way, and/or that certain ethical rules must be followed, regardless of the consequences that may be produced.
* **Virtues-based** approach is person- rather than action-based. Consideration is given to the virtue or moral character of the person carrying out the action, providing guidance about the characteristics and behaviours a good person would seek to achieve to then be able to act in the right way.

2. Ethical concepts

Consideration of ethical concepts supports students in exploring bioethical issues. The concepts may be useful as standalone ways of exploring a bioethical issue under consideration or be used in conjunction with a particular ethical approach. Ethical concepts are general in nature and commonly used to inform any Codes of Ethics and ethical guidelines that apply when undertaking research involving human and non-human participants. They can also be used when identifying a bioethical issue and when deciding the extent to which the outcome of a particular course of action (the effect) or the action itself (the cause) is ethically acceptable.

While there are many ethical concepts that can support the investigation of bioethical issues, one or more of the following principles should be applied:

* **Integrity:** the commitment to searching for knowledge and understanding and the honest reporting of all sources of information and communication of results, whether favourable or unfavourable, in ways that permit scrutiny and contribute to public knowledge and understanding.
* **Justice:** the moral obligation to ensure that there is fair consideration of competing claims; that there is no unfair burden on a particular group from an action; and that there is fair distribution and access to the benefits of an action.
* **Beneficence:** the commitment to maximising benefits and minimising the risks and harms involved in taking a particular position or course of action.
* **Non-maleficence:** involves avoiding the causations of harm. However, as positions or courses of actions in scientific research may involve some degree of harm, the concept of non-maleficence implies that the harm resulting from any position or course of action should not be disproportionate to the benefits from any position or course of action.
* **Respect:** involves consideration of the extent to which living things have an intrinsic value and/or instrumental value; giving due regard to the welfare, liberty and autonomy, beliefs, perceptions, customs and cultural heritage of both the individual and the collective; consideration of the capacity of living things to make their own decisions; and when living things have diminished capacity to make their own decisions ensuring that they are empowered where possible and protected as necessary.

Errors, uncertainty and outliers

It is important not to confuse the terms measurement error and personal error. Error, from a scientific measurement perspective, is the difference between the measured value and the true value of what is being measured. For the purposes of VCE Biology, two types of measurement error should be considered when evaluating the quality of data: systematic errors and random errors. Personal errors should be eliminated by performing the experiment again correctly the next time, and therefore do not form part of an analysis of data quality.

* **Personal errors:** include mistakes or miscalculations.
* **Random errors:** affect the precision of a measurement and are present in all measurements except for measurements involving counting. Random errors are unpredictable variations in the measurement process and result in a spread of readings. The effect of random errors can be reduced by making more or repeated measurements and calculating a new mean and/or by refining the measurement method or technique.
* **Systematic errors:** affect the accuracy of a measurement. Systematic errors cause readings to differ from the true value by a consistent amount each time a measurement is made, so that all the readings are shifted in one direction from the true value. The accuracy of measurements subject to systematic errors cannot be improved by repeating those measurements.

It is also important not to confuse the terms ‘error’ and ‘uncertainty’, which are not synonyms. Outliers in data are a separate consideration, and must be further analysed and accounted for, rather than being automatically dismissed.

* **Uncertainty:** The uncertainty of the result of a measurement reflects the lack of exact knowledge of the value of the quantity being measured. VCE Biologyrequires only a qualitative treatment of uncertainty. When evaluating personally sourced or provided data, students should be able to identify contradictory, provisional and incomplete data including possible sources of bias.
* **Outliers:** Readings that lie a long way from other results are sometimes called outliers. Repeating readings may be useful in further examining an outlier.

Unit 1: How do organisms regulate their functions?

In this unit students examine the cell as the structural and functional unit of life, from the single celled to the multicellular organism, including the requirements for sustaining cellular processes. Students focus on cell growth, replacement and death and the role of stem cells in differentiation, specialisation and renewal of cells. They explore how systems function through cell specialisation in vascular plants and animals, and consider the role homeostatic mechanisms play in maintaining an animal’s internal environment.

A student-adapted or student-designed scientific investigation is undertaken in Area of Study 3. The investigation involves the generation of primary data and is related to the function and/or the regulation of cells or systems. The investigation draws on the key science skills and key knowledge from Area of Study 1 and/or Area of Study 2.

Area of Study 1

How do cells function?

In this area of study students examine the structure and functioning of prokaryotic and eukaryotic cells, and how the plasma membrane contributes to survival by controlling the movement of substances into and out of the cell. Students explore cellular growth, replacement and death. They become familiar with the key events and regulation of the cell cycle and the processes for cell division, including disruptions to the cell cycle and deviant cell behaviour. Students consider the properties of stem cells and their role in differentiation, specialisation and renewal of cells and tissues.

Outcome 1

On completion of this unit the student should be able to explain and compare cellular structure and function and analyse the cell cycle and cell growth, death and differentiation.

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 7–9](#skills) of the study design.

Key knowledge

Cellular 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 the limitations of cell size and the need for internal compartments (organelles) with specific cellular functions
* the structure and specialisation of plant and animal cell organelles for distinct functions, including chloroplasts and mitochondria
* the structure and function of the plasma membrane in the passage of water, hydrophilic and hydrophobic substances via osmosis, facilitated diffusion and active transport

The cell cycle and cell growth, death and differentiation

* binary fission in prokaryotic cells
* the eukaryotic cell cycle, including the characteristics of each of the sub-phases of mitosis and cytokinesis in plant and animal cells
* apoptosis as a regulated process of programmed cell death
* disruption to the regulation of the cell cycle and malfunctions in apoptosis that may result in deviant cell behaviour: cancer and the characteristics of cancer cells
* properties of stem cells that allow for differentiation, specialisation and renewal of cells and tissues, including the concepts of pluripotency and totipotency.

Area of Study 2

How do plant and animal systems function?

In this area of study students explore how systems function through cell specialisation in vascular plants and in digestive, endocrine and excretory systems in animals, focusing on regulation of water balance in plants, and temperature, blood glucose and water balance in animals. Students examine how homeostatic mechanisms in animals help maintain their internal environment within a narrow range of tolerance levels, and consider malfunctions in homeostatic mechanisms.

Outcome 2

On completion of this unit the student should be able to explain and compare how cells are specialised and organised in plants and animals, and analyse how specific systems in plants and animals are regulated.

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 7–9](#skills) of the study design.

Key knowledge

Functioning systems

* specialisation and organisation of plant cells into tissues for specific functions in vascular plants, including intake, movement and loss of water
* specialisation and organisation of animal cells into tissues, organs and systems with specific functions: digestive, endocrine and excretory

Regulation of systems

* regulation of water balance in vascular plants
* regulation of body temperature, blood glucose and water balance in animals by homeostatic mechanisms, including stimulus-response models, feedback loops and associated organ structures
* malfunctions in homeostatic mechanisms: type 1 diabetes, hypoglycaemia, hyperthyroidism.

Area of Study 3

How do scientific investigations develop understanding of how organisms regulate their functions?

Survival of organisms requires control and regulation of factors within an organism and often outside an organism. Different types of cells and adaptations enhance an organism’s survival   
in a particular environment, while homeostatic mechanisms maintain the internal environment.

In this area of study students adapt or design and then conduct a scientific investigation to generate appropriate qualitative and/or quantitative data, organise and interpret the data, and reach a conclusion in response to the research question.

The student-adapted or student-designed scientific investigation relates to knowledge and skills developed in Area of Study 1 and/or Area of Study 2.

Outcome 3

On completion of this unit the student should be able to adapt or design and then conduct a scientific investigation related to function and/or regulation of cells or systems, and draw a conclusion based on evidence from generated primary 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 7–9](#skills) of the study design.

Key knowledge

Investigation design

* biological science concepts specific to the selected scientific investigation and their significance, including the definition of key terms
* scientific methodology relevant to the selected scientific investigation, selected from: classification and identification; controlled experiment; correlational study; fieldwork; modelling; product, process or system development; or simulation
* techniques of primary qualitative and quantitative data generation relevant to the investigation
* accuracy, precision, reproducibility, repeatability and validity of measurements in relation to the investigation
* health, safety and ethical guidelines relevant to the selected scientific investigation

Scientific evidence

* the distinction between an aim, a hypothesis, a model, a theory and a law
* observations and investigations that are consistent with, or challenge, current scientific models or theories
* the characteristics of primary data
* ways of organising, analysing and evaluating generated primary data to identify patterns and relationships including sources of error
* use of a logbook to authenticate generated primary data
* the limitations of investigation methodologies and methods, and of data generation and/or analysis

Science communication

* the conventions of scientific report writing including scientific terminology and representations, standard abbreviations and units of measurement
* ways of presenting key findings and implications of the selected scientific investigation.

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 science skills and key knowledge in the outcomes.

The areas of study, including the key science skills and key knowledge 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 three outcomes. As a set these outcomes encompass the areas of study in the unit.

Suitable tasks for assessment in this unit may be selected from the list below.

For *Outcomes 1 and 2*

For each outcome, at least one task selected from:

* a case study analysis
* a bioinformatics exercise
* a data analysis of generated primary and/or collated secondary data
* reflective annotations of a logbook of practical activities
* media analysis of two or more media sources
* a modelling or simulation activity
* problem-solving involving biological concepts and/or skills
* a response to a bioethical issue
* a report of a laboratory or fieldwork activity including the generation of primary data
* a scientific poster.

If multiple tasks are selected for Outcome 1 and/or Outcome 2, they must be different. The same task cannot be selected more than once across Outcomes 1 and 2.

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

For *Outcome 3*

* a report of a student-adapted or student-designed scientific investigation using a selected format such as a scientific poster, an article for a scientific publication, a practical report, an oral presentation, a multimedia presentation or a visual representation.

Practical work

Practical work is a central component of learning and assessment and may include activities such as laboratory experiments, fieldwork, simulations, modelling and other direct experiences as described in the scientific investigation methodologies on [pages 9 and 10.](#methodologies) A minimum of ten hours of class time should be devoted to student practical activities and scientific investigations across Areas of Study 1 and 2. For Area of Study 3, a minimum of seven hours of class time should be devoted to undertaking, and communicating findings of, the student-adapted or student-designed scientific investigation.

Unit 2: How does inheritance impact on diversity?

In this unit students explore reproduction and the transmission of biological information from generation to generation and the impact this has on species diversity. They apply their understanding of chromosomes to explain the process of meiosis. Students consider how the relationship between genes, and the environment and epigenetic factors influence phenotypic expression. They explain the inheritance of characteristics, analyse patterns of inheritance, interpret pedigree charts and predict outcomes of genetic crosses.

Students analyse the advantages and disadvantages of asexual and sexual reproductive strategies, including the use of reproductive cloning technologies. They study structural, physiological and behavioural adaptations that enhance an organism’s survival. Students explore interdependences between species, focusing on how keystone species and top predators structure and maintain the distribution, density and size of a population. They also consider the contributions of Aboriginal and Torres Strait Islander knowledge and perspectives in understanding the survival of organisms in Australian ecosystems.

A student-directed research investigation into a contemporary ethical issue is to be undertaken in Area of Study 3. The investigation relates to the application of genetic knowledge, reproductive science, inheritance or adaptations and interdependencies beneficial for survival. The investigation draws on key knowledge and key science skills from Area of Study 1 and/or Area of Study 2.

Area of Study 1

How is inheritance explained?

In this area of study students describe the production of gametes in sexual reproduction through the key events in meiosis. They explore the nature of chromosomes and the use of genetic language to read and interpret patterns of inheritance and predict outcomes of genetic crosses.

Students explain how a characteristic or trait can be influenced by one gene, many genes acting together, and genes interacting with external environmental or epigenetic factors. They apply their genetic knowledge to analyse pedigree charts, determine patterns of inheritance and predict outcomes of genetic crosses.

Outcome 1

On completion of this unit the student should be able to explain and compare chromosomes, genomes, genotypes and phenotypes, and analyse and predict patterns of inheritance.

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 7–9](#skills) of the study design.

Key knowledge

From chromosomes to genomes

* the distinction between genes, alleles and a genome
* the nature of a pair of homologous chromosomes carrying the same gene loci and the distinction between autosomes and sex chromosomes
* variability of chromosomes in terms of size and number in different organisms
* karyotypes as a visual representation that can be used to identify chromosome abnormalities
* the production of haploid gametes from diploid cells by meiosis, including the significance of crossing over of chromatids and independent assortment for genetic diversity

Genotypes and phenotypes

* the use of symbols in the writing of genotypes for the alleles present at a particular gene locus
* the expression of dominant and recessive phenotypes, including codominance and incomplete dominance
* proportionate influences of genetic material, and environmental and epigenetic factors, on phenotypes

Patterns of inheritance

* pedigree charts and patterns of inheritance, including autosomal and sex-linked inheritance
* predicted genetic outcomes for a monohybrid cross and a monohybrid test cross
* predicted genetic outcomes for two genes that are either linked or assort independently.

Area of Study 2

How do inherited adaptations impact on diversity?

In this area of study students analyse the advantages and disadvantages of asexual and sexual reproduction and investigate the use and application of reproductive cloning technologies. Students explore the biological importance of genetic diversity and the structural, physiological and behavioural adaptations that enable species to survive in an ecosystem.

Students explore the interdependencies between species, including the importance and impact of keystone species and top predators. They consider the contributions of Aboriginal and Torres Strait Islander knowledge and perspectives to the understanding of the adaptations of, and interdependencies between, species in Australian ecosystems.

Outcome 2

On completion of this unit the student should be able to analyse advantages and disadvantages of reproductive strategies, and evaluate how adaptations and interdependencies enhance survival of species within an ecosystem.

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 7–9](#skills) of the study design.

Key knowledge

Reproductive strategies

* biological advantages and disadvantages of asexual reproduction
* biological advantages of sexual reproduction in terms of genetic diversity of offspring
* the process and application of reproductive cloning technologies

Adaptations and diversity

* the biological importance of genetic diversity within a species or population
* structural, physiological and behavioural adaptations that enhance an organism’s survival and enable life to exist in a wide range of environments
* survival through interdependencies between species, including impact of changes to keystone species and predators and their ecological roles in structuring and maintaining the distribution, density and size of a population in an ecosystem
* the contribution of Aboriginal and Torres Strait Islander peoples’ knowledge and perspectives in understanding adaptations of, and interdependencies between, species in Australian ecosystems.

Area of Study 3

How do humans use science to explore and communicate contemporary bioethical issues?

In this area of study students explore a contemporary bioethical issue relating to the application of genetic knowledge, reproductive science, inheritance or adaptations and interdependencies beneficial for survival.

Examples of investigation topics include, but are not limited to: genomic and epigenetic research; cloning for agriculture, horticulture or other purposes; assisted reproductive technologies; prenatal and predictive genetic testing; strategies for maintaining genetic diversity within a species or population; the impact of introduced species; changes to specific keystone species on populations and ecosystems; or the use of biomimicry to solve human challenges or biopiracy of Indigenous knowledge.

Students may develop a research question related to the applications included above or, in conjunction with their teacher, they may develop their own research question related to Area of Study 1 and/or Area of Study 2. Possible starting points when developing a research question may include stimulus material such as announcements of recent discoveries, an expert’s published point of view, a TED talk or a YouTube presentation, an article from a scientific publication, public concern about an issue, changes in government funding or new government initiatives.

Analysing and synthesising secondary data, students demonstrate and apply their knowledge and relevant key science skills to: explain the biological concepts specific to the identified bioethical issue; consider different perspectives; outline social, economic, legal and/or political factors relevant to the selected issue; choose a position or course of action on the basis of reasoning and reflection; and communicate their findings.

The application of ethical understanding in VCE Biology involves the consideration of approaches to bioethics and ethical concepts. Further explanation of these terms can be found in the ‘Terms used in this study’ section [on pages 16 and 17](#ethics).

Outcome 3

On completion of this unit the student should be able to identify, analyse and evaluate a bioethical issue in genetics, reproductive science or adaptations beneficial for survival.

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 7–9](#skills) of the study design.

Key knowledge

Scientific evidence

* the distinction between primary and secondary data
* the nature of evidence and information: distinction between opinion, anecdote and evidence, and scientific and non-scientific ideas
* the quality of evidence, including validity and authority of data and sources of possible errors or bias
* methods of organising, analysing and evaluating secondary data
* the use of a logbook to authenticate collated secondary data

Scientific communication

* biological concepts specific to the investigation: definitions of key terms; use of appropriate biological terminology, conventions and representations
* 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 use of data representations, models and theories in organising and explaining observed phenomena and biological concepts, and their limitations
* the influence of social, economic, legal and political factors relevant to the selected research question
* conventions for referencing and acknowledging sources of information

Analysis and evaluation of bioethical issues

* ways of identifying bioethical issues
* characteristics of effective analysis of bioethical issues
* approaches to bioethics and ethical concepts as they apply to the bioethical issue being investigated.

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 science skills and key knowledge in the outcomes.

The areas of study, including the key science skills and key knowledge 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 three outcomes. As a set these outcomes encompass the areas of study in the unit.

Suitable tasks for assessment in this unit may be selected from the list below.

For *Outcomes 1 and 2*

For each outcome, at least one task selected from:

* a case study analysis
* a bioinformatics exercise
* a data analysis of generated primary and/or collated secondary data
* reflective annotations of a logbook of practical activities
* media analysis of two or more media sources
* a modelling or simulation activity
* problem-solving involving biological concepts and/or skills
* a response to an issue
* a report of a laboratory or fieldwork activity including the generation of primary data
* a scientific poster

If multiple tasks are selected for Outcome 1 and/or Outcome 2, they must be different. The same task cannot be selected more than once across Outcomes 1 and 2.

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

For *Outcome 3*

* a response to an investigation into a bioethical issue relating to genetics or reproductive science or adaptations beneficial to survival

Practical work

Practical work is a central component of learning and assessment and may include activities such as laboratory experiments, fieldwork, simulations, modelling and other direct experiences as described in the scientific investigation methodologies on [pages 9 and 10](#methodologies). A minimum of ten hours of class time should be devoted to student practical activities and investigations across Areas of Study 1 and 2. For Area of Study 3, a minimum of seven hours of class time should be devoted to undertaking the investigation and communicating findings.

Unit 3: How do cells maintain life?

In this unit students investigate the workings of the cell from several perspectives. They explore the relationship between nucleic acids and proteins as key molecules in cellular processes. Students analyse the structure and function of nucleic acids as information molecules, gene structure and expression in prokaryotic and eukaryotic cells and proteins as a diverse group of functional molecules. They examine the biological consequences of manipulating the DNA molecule and applying biotechnologies.

Students explore the structure, regulation and rate of biochemical pathways, with reference to photosynthesis and cellular respiration. They explore how the application of biotechnologies to biochemical pathways could lead to improvements in agricultural practices.

Students apply their knowledge of cellular processes through investigation of a selected case study, data analysis and/or a bioethical issue. Examples of investigation topics include, but are not limited to: discovery and development of the model of the structure of DNA; proteomic research applications; transgenic organism use in agriculture; use, research and regulation of gene technologies, including CRISPR-Cas9; outcomes and unexpected consequences of the use of enzyme inhibitors such as pesticides and drugs; research into increasing efficiency of photosynthesis or cellular respiration or impact of poisons on the cellular respiration pathway.

The application of ethical understanding in VCE Biology involves the consideration of approaches to bioethics and ethical concepts. Further explanation of these terms can be found in the ‘Terms used in this study’ section on [pages 16 and 17.](#ethics)

A student-designed scientific investigation related to cellular processes and/or responses to challenges 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 design, analysis and findings of the investigation are presented in a scientific poster format as outlined on [pages 11 and 12](#poster).

Area of Study 1

What is the role of nucleic acids and proteins in maintaining life?

In this area of study students explore the expression of the information encoded in a sequence of DNA to form a protein and outline the nature of the genetic code and the proteome. They apply their knowledge to 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 compare gene technologies used to address human and agricultural issues and consider the ethical implications of their use.

Outcome 1

On completion of this unit the student should be able to analyse the relationship between nucleic acids and proteins, and evaluate how tools and techniques can be used and applied in the manipulation of DNA.

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 7–9](#skills) of the study design.

Key knowledge

The relationship between nucleic acids and proteins

* nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides
* the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes
* the structure of genes: exons, introns and promoter and operator regions
* the basic elements of gene regulation: prokaryotic *trp* operon as a simplified example of a regulatory process
* amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein
* proteins as a diverse group of molecules that collectively make an organism’s proteome, including enzymes as catalysts in biochemical pathways
* the role of rough endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of proteins from a cell via the protein secretory pathway

DNA manipulation techniques and applications

* the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA
* the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism’s genome
* amplification of DNA using polymerase chain reaction and the use of gel electrophoresis in sorting DNA fragments, including the interpretation of gel runs for DNA profiling
* the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin
* the use of genetically modified and transgenic organisms in agriculture to increase crop productivity and to provide resistance to disease.

Area of Study 2

How are biochemical pathways regulated?

In this area of study students focus on the structure and regulation of biochemical pathways. They examine how biochemical pathways, specifically photosynthesis and cellular respiration, involve many steps that are controlled by enzymes and assisted by coenzymes. Students investigate factors that affect the rate of cellular reactions and explore applications of biotechnology that focus on the regulation of biochemical pathways.

Outcome 2

On completion of this unit the student should be able to analyse the structure and regulation of biochemical pathways in photosynthesis and cellular respiration, and evaluate how biotechnology can be used to solve problems related to the regulation of biochemical pathways.

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 7–9](#skills) of the study design.

Key knowledge

Regulation of biochemical pathways in photosynthesis and cellular respiration

* the general structure of the biochemical pathways in photosynthesis and cellular respiration from initial reactant to final product
* the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration
* the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors

Photosynthesis as an example of biochemical pathways

* inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C3 plants (details of biochemical pathway mechanisms are not required)
* the role of Rubisco in photosynthesis, including adaptations of C3, C4 and CAM plants to maximise the efficiency of photosynthesis
* the factors that affect the rate of photosynthesis: light availability, water availability, temperature and carbon dioxide concentration

Cellular respiration as an example of biochemical pathways

* the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required)
* the location, inputs and the difference in outputs of anaerobic fermentation in animals and yeasts
* the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration

Biotechnological applications of biochemical pathways

* potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields
* uses and applications of anaerobic fermentation of biomass for biofuel production.

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 learning activities and assessment tasks to provide a range of opportunities for students to demonstrate the key science skills and key knowledge in the outcomes.

The areas of study and key knowledge and relevant key science 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 20 per cent to the study score.

|  |  |  |
| --- | --- | --- |
| **Outcomes** | **Marks allocated** | **Assessment tasks** |
| **Outcome 1**  Analyse the relationship between nucleic acids and proteins, and evaluate how tools and techniques can be used and applied in the manipulation of DNA. | 40 | *For Outcomes 1 and 2*  For each outcome, one task selected from:  analysis and evaluation of a selected biological case study  analysis and evaluation of generated primary and/or collated secondary data  comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities  analysis and evaluation of a contemporary bioethical issue.  Each task type can only be selected once across Units 3 and 4.  For each task the time allocated should be approximately 50–70 minutes for a written response and 10 minutes for a multimodal or oral presentation. |
| **Outcome 2**  Analyse the structure and regulation of biochemical pathways in photosynthesis and cellular respiration, and evaluate how biotechnology can be used to solve problems related to the regulation of biochemical pathways. | 40 |
|  |  |
| **Total marks** | **80** |  |

Practical work

Practical work is a central component of learning and assessment and may include activities such as laboratory experiments, fieldwork, simulations and other direct experiences as described in the scientific investigation methodologies on [pages 9 and 10](#methodologies). A minimum of ten hours of class time should be devoted to student practical activities and investigations across 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 50 per cent to the study score.

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

In this unit students consider the continual change and challenges to which life on Earth has been, and continues to be, subjected to. They study the human immune system and the interactions between its components to provide immunity to a specific pathogen. Students consider how the application of biological knowledge can be used to respond to bioethical issues and challenges related to disease.

Students consider how evolutionary biology is based on the accumulation of evidence over time. They investigate the impact of various change events on a population’s gene pool and the biological consequences of changes in allele frequencies. Students examine the evidence for relatedness between species and change in life forms over time using evidence from paleontology, structural morphology, molecular homology and comparative genomics. Students examine the evidence for structural trends in the human fossil record, recognising that interpretations can be contested, refined or replaced when challenged by new evidence.

Students demonstrate and apply their knowledge of how life changes and responds to challenges through investigation of a selected case study, data analysis and/or bioethical issue. Examples of investigation topics include, but are not limited to: deviant cell behaviour and links to disease; autoimmune diseases; allergic reactions; development of immunotherapy strategies; use and application of bacteriophage therapy; prevention and eradication of disease; vaccinations; bioprospecting for new medical treatments; trends, patterns and evidence for evolutionary relationships; population and species changes over time in non-animal communities such as forests and microbiota; monitoring of gene pools for conservation planning; role of selective breeding programs in conservation of endangered species; or impact of new technologies on the study of evolutionary biology.

The application of ethical understanding in VCE Biology involves the consideration of approaches to bioethics and ethical concepts. Further explanation of these terms can be found in the ‘Terms used in this study’ section on [pages 16 and 17](#ethics).

A student-designed scientific investigation involving the generation of primary data related to cellular processes and/or how life changes and responds to challenges 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 design, analysis and findings of the investigation are presented in a scientific poster format as outlined on [pages 11 and 12](#poster).

Area of Study 1

How do organisms respond to pathogens?

In this area of study students focus on the immune response of organisms to specific pathogens. Students examine unique molecules called antigens and how they illicit an immune response, the nature of immunity and the role of vaccinations in providing immunity. They explain how technological advances assist in managing immune system disorders and how immunotherapies can be applied to the treatment of other diseases.

Students consider that in a globally connected world there are biological challenges that can be mediated by identification of pathogens, the prevention of spread and the development of treatments for diseases.

Outcome 1

On completion of this unit the student should be able to analyse the immune response to specific antigens, compare the different ways that immunity may be acquired and evaluate challenges and strategies in the treatment of disease.

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 7–9](#skills) of the study design.

Key knowledge

Responding to antigens

* physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in animals and plants
* the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins and interferons
* initiation of an immune response, including antigen presentation, the distinction between self-antigens and non-self antigens, cellular and non-cellular pathogens and allergens

Acquiring immunity

* the role of the lymphatic system in the immune response as a transport network and the role of lymph nodes as sites for antigen recognition by T and B lymphocytes
* the characteristics and roles of the components of the adaptive immune response against both extracellular and intracellular threats, including the actions of B lymphocytes and their antibodies, helper T and cytotoxic T cells
* the difference between natural and artificial immunity and active and passive strategies for acquiring immunity

Disease challenges and strategies

* the emergence of new pathogens and re-emergence of known pathogens in a globally connected world, including the impact of European arrival on Aboriginal and Torres Strait Islander peoples
* scientific and social strategies employed to identify and control the spread of pathogens, including identification of the pathogen and host, modes of transmission and measures to control transmission
* vaccination programs and their role in maintaining herd immunity for a specific disease in a human population
* the development of immunotherapy strategies, including the use of monoclonal antibodies for the treatment of autoimmune diseases and cancer.

Area of Study 2

How are species related over time?

In this area of study students focus on changes to genetic material over time and the evidence for biological evolution. They consider how the field of evolutionary biology is based upon the accumulation of evidence over time and develop an understanding of how interpretations of evidence can change in the light of new evidence as a result of technological advances, particularly in molecular biology. Students consider the biological consequences of changes in allele frequencies and how isolation and divergence are required elements for speciation. They consider the evidence for determining the relatedness between species and examine the evidence for major trends in hominin evolution, including the migration of modern human populations around the world.

Outcome 2

On completion of this unit the student should be able to analyse the evidence for genetic changes in populations and changes in species over time, analyse the evidence for relatedness between species, and evaluate the evidence for human change over time.

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 7–9](#skills) of the study design.

Key knowledge

Genetic changes in a population over time

* causes of changing allele frequencies in a population’s gene pool, including environmental selection pressures, genetic drift and gene flow; and mutations as the source of new alleles
* biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity
* manipulation of gene pools through selective breeding programs
* consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens

Changes in species over time

* changes in species over geological time as evidenced from the fossil record: faunal (fossil) succession, index and transitional fossils, relative and absolute dating of fossils
* evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and *Howea* palms on Lord Howe Island as an example of sympatric speciation

Determining the relatedness of species

* evidence of relatedness between species: structural morphology – homologous and vestigial structures; and molecular homology – DNA and amino acid sequences
* the use and interpretation of phylogenetic trees as evidence for the relatedness between species

Human change over time

* the shared characteristics that define mammals, primates, hominoids and hominins
* evidence for major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo*: changes in brain size and limb structure
* the human fossil record as an example of a classification scheme that is open to differing interpretations that are contested, refined or replaced when challenged by new evidence, including evidence for interbreeding between *Homo sapiens* and *Homo neanderthalensis* and evidence of new putative *Homo* species
* ways of using fossil and DNA evidence (mtDNA and whole genomes) to explain the migration of modern human populations around the world, including the migration of Aboriginal and Torres Strait Islander populations and their connection to Country and Place.

Area of Study 3

How is scientific inquiry used to investigate cellular processes and/or biological change?

Students undertake a student-designed scientific investigation in either Unit 3 or Unit 4, or across both Units 3 and 4. The investigation involves the generation of primary data relating to cellular processes and/or how life changes and responds to challenges. The investigation draws on knowledge and related key science skills developed across Units 3 and 4 and is undertaken by students in the laboratory and/or in the field.

When undertaking the investigation students are required to apply the key science skills to develop a question, state an aim, formulate a hypothesis and plan a course of action to answer the question, while complying with safety and ethical guidelines. Students then undertake an investigation to generate primary quantitative data, analyse and evaluate the data, identify limitations of data and methods, link experimental results to scientific ideas, discuss implications of the results, and draw a conclusion in response to the question. The presentation format for the investigation is a scientific poster constructed according to the structure outlined on [pages 11 and 12](#poster). A logbook is maintained by students for record, assessment and authentication purposes.

Outcome 3

On completion of this unit the student should be able to design and conduct a scientific investigation related to cellular processes and/or how life changes and responds to challenges,   
and present an aim, methodology and methods, results, discussion and a conclusion 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 7–9](#skills) of the study design.

Key knowledge

Investigation design

* biological concepts specific to the selected scientific investigation and their significance, including definitions of key terms
* characteristics of the selected scientific methodology and method, and appropriateness of the use of independent, dependent and controlled variables in the selected scientific investigation
* techniques of primary quantitative data generation relevant to the selected scientific investigation
* the accuracy, precision, reproducibility, repeatability and validity of measurements
* the health, safety and ethical guidelines relevant to the selected scientific investigation

Scientific evidence

* the nature of evidence that supports or refutes a hypothesis, model or theory
* ways of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and uncertainty
* authentication of generated primary data through the use of a logbook
* assumptions and limitations of investigation methodology and/or data generation and/or analysis methods

Science communication

* conventions of science communication: scientific terminology and representations, symbols, formulas, standard abbreviations and units of measurement
* conventions of scientific poster presentation, including succinct communication of the selected scientific investigation and acknowledgements and references
* the key findings and implications of the selected scientific investigation.

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 learning activities and assessment tasks to provide a range of opportunities for students to demonstrate the key science skills and key knowledge in the outcomes.

The areas of study and key knowledge and relevant key science 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 30 per cent to the study score.

|  |  |  |
| --- | --- | --- |
| **Outcomes** | **Marks allocated** | **Assessment tasks** |
| **Outcome 1**  Analyse the immune response to specific antigens, compare the different ways that immunity may be acquired and evaluate challenges and strategies in the treatment of disease. | 40 | *For Outcomes 1 and 2*  For each outcome, one task selected from:  analysis and evaluation of a selected biological case study  analysis and evaluation of generated primary and/or collated secondary data  comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities  analysis and evaluation of a contemporary bioethical issue.  Each task type can only be selected once across Units 3 and 4.  For each task the time allocated should be approximately 50–70 minutes for a written response and 10 minutes for a multimodal or oral presentation. |
| **Outcome 2**  Analyse the evidence for genetic changes in populations and changes in species over time, analyse the evidence for relatedness between species, and evaluate the evidence for human change over time. | 40 |
| **Outcome 3**  Design and conduct a scientific investigation related to cellular processes and/or how life changes and responds to challenges, and present an aim, methodology and method, results, discussion and a conclusion in a scientific poster. | 40 | *For Outcome 3*  Communication of the design, analysis and findings of a student-designed and student-conducted scientific investigation through a structured scientific poster and logbook entries.  The poster should not exceed 600 words. |
| **Total marks** | **120** |  |

Practical work

Practical work is a central component of learning and assessment and may include activities such as laboratory experiments, fieldwork, simulations and other direct experiences as described in the scientific investigation methodologies on [pages 9 and 10](#methodologies). A minimum of ten hours of class time should be devoted to student practical activities and investigations across Areas of Study 1 and 2. For Area of Study 3, a minimum of ten hours of class time should be devoted to designing and undertaking the student-designed scientific investigation and communicating findings.

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 50 per cent to the study score.

End-of-year examination

Description

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

Conditions

The examination will be completed under the following conditions:

* Duration: two and a half 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*](https://www.vcaa.vic.edu.au/administration/vce-vcal-handbook/Pages/index.aspx).
* 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 year prior to implementation of the revised Unit 3 and 4 sequence together with any sample material.