Biology 2025 v1.2

General senior syllabus

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Queensland Government

Queensland Curriculum & Assessment Authority

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Queensland syllabuses for senior subjects

In Queensland, a syllabus for a senior subject is an official 'map' of a senior school subject. A syllabus's function is to support schools in delivering the Queensland Certificate of Education (QCE) system through high-quality and high-equity curriculum and assessment.

Syllabuses are based on design principles developed from independent international research about how excellence and equity are promoted in the documents teachers use to develop and enliven the curriculum.

Syllabuses for senior subjects build on student learning in the Prep to Year 10 Australian Curriculum and include General, General (Extension), Senior External Examination (SEE), Applied, Applied (Essential) and Short Course syllabuses.

More information about syllabuses for senior subjects is available at www.qcaa.qld.edu.au/senior/senior-subjects and in the 'Queensland curriculum' section of the *QCE and QCIA policy and procedures handbook*.

Teaching, learning and assessment resources will support the implementation of a syllabus for a senior subject. More information about professional resources for senior syllabuses is available on the QCAA website and via the QCAA Portal.

Course overview

Rationale

At the core of all scientific endeavour is the inquiry into the nature of the universe. Science uses a systematic way of thinking, involving creative and critical reasoning, in order to acquire better and more reliable knowledge. Scientists recognise that knowledge is not fixed, but is fallible and open to challenge. As such, scientific endeavour is never conducted in isolation, but builds on and challenges an existing body of knowledge in the pursuit of more reliable knowledge. This collaborative process, whereby new knowledge is gained, is essential to the cooperative advancement of science, technology, health and society in the 21st century.

Tertiary study in any field will be aided by the transferable skills developed in this senior Science subject. It is expected that an appreciation of, and respect for, evidence-based conclusions and the processes required to gather, scrutinise and use evidence will be carried forward into all aspects of life beyond the classroom.

The purpose of senior Science subjects in Queensland is to introduce students to a scientific discipline. Students will be required to learn and apply aspects of the knowledge and skill of the discipline (thinking, experimentation, problem-solving and research skills), understand how it works and how it may impact society.

Upon completion of the course, students will have an appreciation for a body of scientific knowledge and the process that is undertaken to acquire this knowledge. They will be able to distinguish between claims and evidence, opinion and fact, and conjecture and conclusions.

In each of the senior Science subjects, students will develop:

- a deep understanding of a core body of discipline knowledge
- aspects of the skills used by scientists to develop new knowledge, as well as the opportunity to refine these skills through practical activities
- the ability to coordinate their understandings of the knowledge and skills associated with the discipline to refine experiments, verify known scientific relationships, explain phenomena with justification and evaluate claims by finding evidence to support or refute the claims.

Biology provides opportunities for students to engage with living systems. In Unit 1, students develop their understanding of cells and multicellular organisms. In Unit 2, they engage with the concept of maintaining the internal environment. In Unit 3, students study biodiversity and the interconnectedness of life. This knowledge is linked in Unit 4 with the concepts of heredity and the continuity of life.

Students will learn valuable skills required for the scientific investigation of questions. In addition, they will become citizens who are better informed about the world around them and who have the critical skills to evaluate and make evidence-based decisions about current scientific issues.

Biology aims to develop students':

- sense of wonder and curiosity about life
- respect for all living things and the environment
- understanding of how biological systems interact and are interrelated, the flow of matter and energy through and between these systems, and the processes by which they persist and change
- understanding of major biological concepts, theories and models related to biological systems at all scales, from subcellular processes to ecosystem dynamics
- appreciation of how biological knowledge has developed over time and continues to develop; how scientists use biology in a wide range of applications; and how biological knowledge influences society in local, regional and global contexts
- ability to plan and carry out fieldwork, laboratory and other research investigations, including the collection and analysis of qualitative and quantitative data and the interpretation of evidence
- ability to use sound, evidence-based arguments creatively and analytically when evaluating claims and applying biological knowledge
- ability to communicate biological understanding, findings, arguments and conclusions using appropriate representations, modes and genres.

Syllabus objectives

The syllabus objectives outline what students have the opportunity to learn.

1. **Describe ideas and findings.**

   Students use scientific representations and language in appropriate genres to give a detailed account of scientific phenomena, concepts, theories, models and systems.

2. **Apply understanding.**

   Students use scientific concepts, theories, models and systems within their limitations. They use algebraic, visual and graphical representations of scientific relationships and data to determine unknown scientific quantities or features. They explain phenomena, concepts, theories, models, systems and modifications to methodologies.

3. **Analyse data.**

   Students consider scientific information from primary and secondary sources to identify trends, patterns, relationships, limitations and uncertainty. In qualitative data, they identify the essential elements, features or components. In quantitative data, they use mathematical processes and algorithms. They identify data to support ideas, conclusions or decisions.

4. **Interpret evidence.**

   Students use their understanding of scientific concepts, theories, models and systems and their limitations to draw conclusions and develop scientific arguments. They deduce, extrapolate, infer, justify and make predictions based on their analysis of data.

5. **Evaluate conclusions, claims and processes.**

   Students critically reflect on the available evidence and make judgments about its application to research questions. They extrapolate findings to support or refute claims. They use the quality of the evidence to evaluate the validity and reliability of inquiry processes and suggest improvements and extensions for further investigation.

6. **Investigate phenomena.**

   Students develop rationales and research questions for experiments and investigations. They modify methodologies to collect primary data and select secondary sources. They manage risks, environmental and ethical issues and acknowledge sources of information.

Designing a course of study in Biology

Syllabuses are designed for teachers to make professional decisions to tailor curriculum and assessment design and delivery to suit their school context and the goals, aspirations and abilities of their students within the parameters of Queensland's senior phase of learning.

The syllabus is used by teachers to develop curriculum for their school context. The term *course of study* describes the unique curriculum and assessment that students engage with in each school context. A course of study is the product of a series of decisions made by a school to select, organise and contextualise subject matter, integrate complementary and important learning, and create assessment tasks in accordance with syllabus specifications.

It is encouraged that, where possible, a course of study is designed such that teaching, learning and assessment activities are integrated and enlivened in an authentic setting.

Course structure

Biology is a General senior syllabus. It contains four QCAA-developed units from which schools develop their course of study.

Each unit has been developed with a notional time of 55 hours of teaching and learning, including assessment.

Students should complete Unit 1 and Unit 2 before beginning Units 3 and 4. Units 3 and 4 are studied as a pair.

More information about the requirements for administering senior syllabuses is available in the 'Queensland curriculum' section of the *QCE and QCIA policy and procedures handbook*.

Curriculum

Senior syllabuses set out only what is essential while being flexible so teachers can make curriculum decisions to suit their students, school context, resources and expertise.

Within the requirements set out in this syllabus and the *QCE and QCIA policy and procedures handbook*, schools have autonomy to decide:

- how and when subject matter is delivered
- how, when and why learning experiences are developed, and the context in which learning occurs
- how opportunities are provided in the course of study for explicit and integrated teaching and learning of complementary skills.

These decisions allow teachers to develop a course of study that is rich, engaging and relevant for their students.

Assessment

Senior syllabuses set out only what is essential while being flexible so teachers can make assessment decisions to suit their students, school context, resources and expertise.

General senior syllabuses contain assessment specifications and conditions for the assessment instruments that must be implemented with Units 3 and 4. These specifications and conditions ensure comparability, equity and validity in assessment.

Within the requirements set out in this syllabus and the *QCE and QCIA policy and procedures handbook*, schools have autonomy to decide:

- specific assessment task details
- assessment contexts to suit available resources
- how the assessment task will be integrated with teaching and learning activities
- how authentic the task will be.

In Unit 1 and Unit 2, schools:

- develop at least two but no more than four assessments
- complete at least one assessment for each unit
- ensure that each unit objective is assessed at least once.

In Units 3 and 4, schools develop three assessments using the assessment specifications and conditions provided in the syllabus.

More information about assessment in senior syllabuses is available in 'The assessment system' section of the *QCE and QCIA policy and procedures handbook*.

Subject matter

Each unit contains a unit description, unit objectives and subject matter. Subject matter is the body of information, mental procedures and psychomotor procedures (see Marzano & Kendall 2007, 2008) that are necessary for students' learning and engagement with the subject. Subject matter itself is not the specification of learning experiences but provides the basis for the design of student learning experiences.

Subject matter has a direct relationship with the unit objectives and provides statements of learning that have been constructed in a similar way to objectives.

Aboriginal perspectives and Torres Strait Islander perspectives

The QCAA is committed to reconciliation. As part of its commitment, the QCAA affirms that:

- Aboriginal peoples and Torres Strait Islander peoples are the first Australians, and have the oldest living cultures in human history
- Aboriginal peoples and Torres Strait Islander peoples have strong cultural traditions and speak diverse languages and dialects, other than Standard Australian English
- teaching and learning in Queensland schools should provide opportunities for students to deepen their knowledge of Australia by engaging with the perspectives of Aboriginal peoples and Torres Strait Islander peoples
- positive outcomes for Aboriginal students and Torres Strait Islander students are supported by successfully embedding Aboriginal perspectives and Torres Strait Islander perspectives across planning, teaching and assessing student achievement.

Guidelines about Aboriginal perspectives and Torres Strait Islander perspectives and resources for teaching are available at www.qcaa.qld.edu.au/k-12-policies/aboriginal-torres-strait-islander-perspectives.

Where appropriate, Aboriginal perspectives and Torres Strait Islander perspectives have been embedded in the subject matter.

Complementary skills

Opportunities for the development of complementary skills have been embedded throughout subject matter. These skills, which overlap and interact with syllabus subject matter, are derived from current education, industry and community expectations and encompass the knowledge, skills, capabilities, behaviours and dispositions that will help students live and work successfully in the 21st century.

These complementary skills are:

- literacy — the knowledge, skills, behaviours and dispositions about language and texts essential for understanding and conveying English language content
- numeracy — the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations, to recognise and understand the role of mathematics in the world, and to develop the dispositions and capacities to use mathematical knowledge and skills purposefully
- 21st century skills — the attributes and skills students need to prepare them for higher education, work, and engagement in a complex and rapidly changing world. These skills include critical thinking, creative thinking, communication, collaboration and teamwork, personal and social skills, and digital literacy. The explanations of associated skills are available at www.qcaa.qld.edu.au/senior/senior-subjects/general-subjects/21st-century-skills.

It is expected that aspects of literacy, numeracy and 21st century skills will be developed by engaging in the learning outlined in this syllabus. Teachers may choose to create additional explicit and intentional opportunities for the development of these skills as they design the course of study.

Additional subject-specific information

Additional subject-specific information has been included to support and inform the development of a course of study.

Science understanding

The science understanding subject matter in each unit develops students' understanding of the key concepts, models and theories that underpin the subject, and of the strengths and limitations of different models and theories for explaining and predicting complex phenomena. It uses cognitions from Objectives 1–4.

The science understanding subject matter from Units 3 and 4 will be assessed by the external assessment.

Science as a human endeavour (SHE)

Each Queensland senior science subject requires students to learn and apply aspects of the knowledge and skill of the discipline. However, it is recognised that students should also develop an appreciation for the *nature* and *development* of science, and its *use* and *influence* on society.

While this appreciation is not directly assessed, the syllabus provides guidance as to where it may be developed. Importantly, this guidance draws students' attention to the way in which science operates, both in relation to the development of understanding and explanations about the world and to its influence on society.

Students should become familiar with the following SHE concepts:

- Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility.
- Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines.
- Advances in science understanding in one field can influence other areas of science, technology and engineering.
- The use and acceptance of scientific knowledge is influenced by social, economic, cultural and ethical contexts.
- The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences.
- Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions.
- Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability.
- ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of datasets with which scientists work.
- Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power.
- Scientific knowledge can be used to inform the monitoring, assessment and evaluation of risk.
- Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question.
- International collaboration is often required when investing in large-scale science projects or addressing issues for the Asia–Pacific region.

To support the development of these concepts, this syllabus identifies SHE subject matter in each unit. This highlights opportunities for teachers to contextualise the associated science understanding and science inquiry subject matter and provides stimulus for the development of claims and research questions for investigation.

Additional opportunities include:

- practicals provide opportunities for students to witness the *nature* of science
- the student experiment provides opportunity for students to experience how the *development* of new science knowledge is built upon existing knowledge
- the research investigation provides opportunity for students to appreciate the *use* and *influence* of scientific evidence to make decisions or to contribute to public debate about a claim.

Science inquiry

Defining *inquiry* in science education

In order to support the school's task of aligning their chosen pedagogical framework with the curriculum and assessment expectations outlined in this syllabus, some guidance has been provided in the form of clarification of the use of the term *inquiry* and the articulation of a framework to describe the process of inquiry. The purpose of this guidance is to prevent misunderstandings and problematic conflations and their subsequent negative impact on student learning. As Abrams, Southerland and Silva (2008, p. xv) stated in their book, *Inquiry in the Classroom: Realities and opportunities*:

> Inquiry in the classroom can be conceived as a complex set of ideas, beliefs, skills, and/or pedagogies. It is evident that attempting to select a singular definition of inquiry may be an insurmountable and fruitless task. Any single definition of inquiry in the classroom would necessarily reflect the thinking of a particular school of thought, at a particular moment in time, or a particular goal, and such a singular definition may serve to limit legitimate and necessary components of science learning. **However, operating without a firm understanding of the various forms of inquiry leaves science educators often 'talking past' one another, and often results in very muddled attempts in the classroom** [emphasis added].

Uses of the term *inquiry*

Common phrases involving the term *inquiry* have been listed below:

- science inquiry
- science inquiry skills
- the inquiry process
- inquiry-based learning.

This syllabus refers to the first three uses listed above. The first, *science inquiry*, defines the practical work of a scientist (Harlen 2013). The second, *science inquiry skills*, refers to the skills required to do the work of a scientist (Harlen 2013). The third, *the inquiry process*, is a framework that can be used to describe the process of asking a question and then answering it.

The final phrase, *inquiry-based learning*, refers to a variety of teaching and learning strategies an educator may choose to use within their school's pedagogical framework. Although a school may choose to adopt an inquiry-based pedagogy, this syllabus is *not* intended to endorse or recommend an inquiry-based learning approach.

Framework to describe the inquiry process

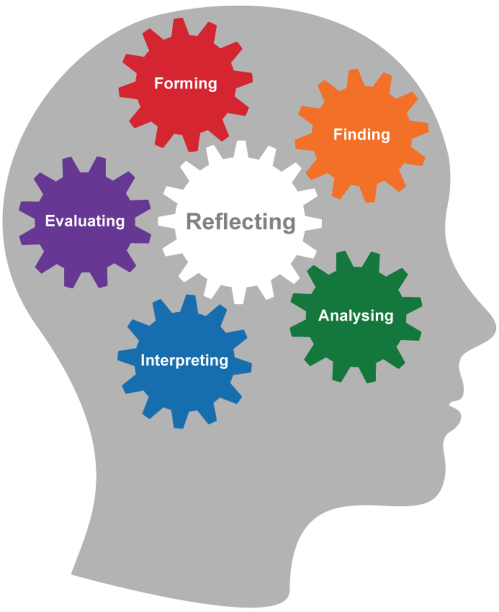
In order to support student engagement in activities involving inquiry, it is useful to establish a common language or framework to distinguish between stages of the process.

The stages involved in any inquiry are:

- forming and describing the inquiry activity
- finding valid and reliable evidence for the inquiry activity
- analysing the evidence collected
- interpreting the evidence selected
- evaluating the conclusions, processes or claims.

This framework uses reflection as the connection between, and driver of, all the stages. The progression through the inquiry process requires reflection on the decisions made and any new information that has emerged during the process to inform the next stage. Each stage of the inquiry process is worthy of reflection, the result of which may be the revision of previous stages (Marzano & Kendall 2007).

Figure 1: Stages of inquiry process



Science inquiry and science inquiry skills

Science inquiry involves identifying and posing questions and working to answer them. It is concerned with evaluating claims, investigating ideas, solving problems, reasoning, drawing valid conclusions and developing evidence-based arguments. It can easily be summarised as the ‘work of a scientist’ (Hackling 2005).

Within this syllabus, it is expected that students will engage in *aspects* of the work of a scientist by engaging in scientific inquiry (Tytler 2007). This expectation can be seen, for example, by the inclusion of practicals and investigations in the subject matter, and in the internal assessments for Units 3 and 4.

Science inquiry skills are the skills required to do the work of a scientist. They include writing research questions, planning, conducting, recording information, and reflecting on investigations; processing, analysing and interpreting evidence; evaluating conclusions, processes and claims; and communicating findings (ACARA 2015).

It is expected that students are explicitly taught science inquiry skills (Krajcik et al 2000), a number of which are outlined throughout the syllabus. Some science inquiry skills will be used to complete the listed practicals and investigations. The selection, application and coordination of science inquiry skills will be required in the student experiment and research investigation.

It is the prerogative of the educator to determine how listed practicals and investigations are used as opportunities to:

- develop, rehearse and refine science inquiry skills
- engage students in scaffolded or open-ended science inquiry tasks
- formatively assess science inquiry skills.

Science inquiry skills

Throughout the course of study, students will:

- identify, research and construct questions for investigation
- propose hypotheses and/or predict possible outcomes
- design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data required to obtain valid and reliable evidence, e.g.
  - distinguish between different types of investigations: descriptive, comparative, correlational, experimental, case studies
  - consider replicates, sample size, number of data points and quality of sources
  - identify the types of errors, extraneous variables or confounding factors that are likely to influence results and implement strategies to minimise systematic and random error
- identify and implement strategies to manage risks, ethics and environmental impact, e.g.
  - ethical guidelines
  - cultural guidelines, protocols for working with the knowledges of First Nations peoples
  - material safety data sheets
  - workplace health and safety guidelines
  - appropriate disposal methods
  - standard operating procedures
  - acknowledgment of sources and referencing

- use appropriate equipment, techniques, procedures and sources to systematically and safely collect primary and secondary data, e.g.
  - microscopy techniques: total magnification and field of view, scientific drawing
  - laboratory and field techniques: measurement, equipment calibration, species identification
  - sampling methods: random, systematic, stratified
  - sampling techniques: quadrats, line transect, belt-transect, capture-recapture
  - models and simulations
  - ICTs, scientific texts, databases, online sources
- use scientific language and representations to systematically record information, observations, data and measurement error, e.g.
  - symbols, units and prefixes
  - scale and magnification
  - indicators of measurement uncertainty
  - tables, graphs and diagrams
  - charts and maps
  - logbooks
- translate information between graphical, numerical and/or algebraic forms, e.g.
  - units and measurement conversions
  - ratios and percentages
  - symbols and notation
  - charts and maps
- use mathematical techniques to summarise data in a way that allows for identification of relevant trends, patterns, relationships, limitations and uncertainty, e.g.
  - comparative investigations: mean, standard deviation, standard error, Student's t-test
  - correlational investigations: regression analysis, Pearson's correlation coefficient, Spearman's rank
- select and construct appropriate representations to present data and communicate findings, e.g.
  - summary tables
  - column graphs (with error bars)
  - scatterplots (with trendline and R^2)
  - profile diagrams
  - scientific drawings
  - charts and maps
  - indexes and summary statistics
- analyse data to identify trends, patterns and relationships; recognising error, uncertainty and limitations of evidence
- select, synthesise and use evidence to construct scientific arguments and draw conclusions

- extrapolate findings to determine unknown values, predict outcomes and evaluate claims
- use data and reasoning to discuss and evaluate the validity and reliability of evidence, e.g.
  - discuss ways in which measurement error, instrumental uncertainty, the nature of the procedure, sample size or other factors influence uncertainty and limitations in the data
  - evaluate information sources and compare ideas, information and opinions presented within and between texts, considering aspects such as acceptance, bias, status, appropriateness and reasonableness
  - compare findings to theoretical models or expected values
- suggest improvements and extensions to minimise uncertainty, address limitations and improve the overall quality of evidence
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes
- acknowledge sources of information and use standard scientific referencing conventions
- appreciate the role of peer review in scientific research.

Science inquiry subject matter uses cognitions from across all objectives, and is primarily assessed through the internal assessments for Units 3 and 4. To support the development of these science inquiry skills, this syllabus identifies suggested practicals and investigations for each unit. These highlight opportunities for students to directly experience the associated science understanding subject matter and provide stimulus for student experiments and research investigations.

It is expected that approximately five hours of fieldwork will be required to develop the associated science inquiry skills. Fieldwork can allow students to engage in science inquiry by offering authentic real-world learning. It offers students an opportunity to gather primary data to analyse and respond to questions they pose.

Safety and ethics

Workplace health and safety

Biology is designed to expose students to the practical components of science through practical experiences in the laboratory and the field. These experiences expose students to a variety of hazards, from biological and poisonous substances to injury from equipment. Besides a teacher's duty of care that derives from the *Education (General Provisions) Act 2006*, there are other legislative and regulatory requirements, for example the *Work Health and Safety Act 2011*, that will influence the nature and extent of practical work.

All practical work must be organised with student safety in mind. The *Department of Education and Training (DET) Policy and Procedure Register* (https://ppr.qed.qld.gov.au) provides guidance about current science safety protocols.

It is the responsibility of all schools to ensure that their practices meet current legislation requirements.

Care and use of animals for scientific purposes

Governing principles

The QCAA recognises that school personnel involved in the care and use of animals for scientific purposes have legal obligations under the *Animal Care and Protection Act 2001* (the Act). Queensland schools intending to use animals for scientific purposes must apply for and receive animal ethics approval from the Queensland Schools Animals Ethics Committee (QSAEC) prior to conducting these activities. The purpose of the Act is to promote the responsible care and use of animals, provide standards for the care and use of animals, protect animals from unjustifiable, unnecessary or unreasonable pain, and ensure that the use of animals for scientific purposes is accountable, open and responsible.

The Act also requires mandatory compliance with the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 2013 (8th edition)*, available from the National Health and Medical Research Council's publications website.

It should also be recognised that school personnel and students are not carrying out essential, groundbreaking research. Therefore, standards in schools should be more stringent than those used in universities and research and development organisations.

Separate to the Act and ethical approval, best practice includes referring to the *3Rs* principle of animal welfare:

- **replacement** — any investigations involving animals should initially consider replacing the animals with cells, plants or computer simulations
- **refinement** — refinement of the investigation should aim to alleviate any harm or distress to the animals used
- **reduction** — reduce the number of animals used.

Respect for animals must underpin all decisions and actions involving the care and use of animals. The responsibilities associated with this obligation apply throughout the animal's lifetime, including acquisition, transport, breeding, housing, husbandry and the use of animals in a project. Experiments that require the endpoint as the death of any animal (e.g. lethal dose LD_{50}) are unacceptable.

Animal dissections

There is no requirement for students to witness or carry out a dissection of any animal, invertebrate or vertebrate in this course. If animal dissections are chosen by the teacher as an important educational experience, the *3Rs* principle of animal welfare should be applied (i.e. replacement, refinement and reduction — see above for more information). Teachers should always discuss the purpose of the dissection and allow any student, without requirement for explanation, to opt out if they wish. Teachers should be respectful of the variety of reasons students may have for choosing not to participate.

Experimental studies using humans

If teaching and learning activities include experimental investigations using human subjects, teachers and schools have a legal and moral responsibility to ensure that students follow ethical principles at all times. Best practice includes:

- **protection from harm** — any investigations that create harm, distress or discomfort for participants are not permitted. This includes investigations involving ingestion (e.g. food, drink, smoking or drugs) and deprivation (e.g. sleep, food)
- **gaining informed consent** — any experiments involving humans must be with their written permission. Students under the age of 16 should have written permission from a parent or guardian. All participants should be above the age of 12 and of sound mind. The process of being informed requires that participants understand the purpose of the investigation and that they can withdraw from the process at any stage
- **ensuring confidentiality and anonymity** — all data collected must be kept in a confidential and responsible manner and not divulged to any other person. Anonymity for each participant must be guaranteed.

Teachers should refer to the following for detailed advice:

- the National Statement on Ethical Conduct in Human Research (2007), issued by the National Health and Medical Research Council (NHMRC) in accordance with the *NHMRC Act 1992* (Cwlth)
- the National Privacy Principles in the *Privacy Amendment (Private Sector) Act 2000* (Cwlth)
- the Code of Ethics of the Australian Psychological Society (APS).

Strategies for retaining and recalling information for assessment

The following practices[1] can support preparation for senior assessment in Biology.

The spacing effect

The spacing effect draws on research about forgetting and learning curves. By recalling and revisiting information at intervals, rather than at the end of a study cycle, students remember a greater percentage of the information with a higher level of accuracy. Exposing students to information and materials numerous times over multiple spaced intervals solidifies long-term memory, positively affecting retention and recall.

Teachers should plan teaching and learning sequences that allow time to revisit previously taught information and skills at several intervals. These repeated learning opportunities also provide opportunities for teachers to provide formative feedback to students.

The retrieval effect

The retrieval effect helps students to practise remembering through quick, regular, low-stakes questioning or quizzes that exercise their memories and develop their ability to engage in the deliberate act of recalling information. This has been shown to be more effective at developing long-term memories than activities that require students to search through notes or other resources.

Students may see an inability to remember as an obstacle, but they should be encouraged to understand that this is an opportunity for learning to take place. By trying to recall information, students exercise or strengthen their memory and may also identify gaps in their learning. The more difficult the retrieval practice, the better it can be for long-term learning.

Interleaving

Interleaving involves interspersing the concepts, categories, skills or types of questions that students focus on in class or revision. This is in contrast to blocking, in which these elements are grouped together in a block of time. For example, for concepts A, B and C:

- Blocking A A A A A B B B B B C C C C C
- Interleaving A B C B C A B A C A C B C A B

Studies have found that interleaving in instruction or revision produces better long-term recall of subject matter. Interleaving also ensures that spacing occurs, as instances of practice are spread out over time.

Additionally, because exposure to one concept is interleaved with exposure to another, students have more opportunities to distinguish between related concepts. This highlighting of differences may explain why studies have found that interleaving enhances inductive learning, where participants use exemplars to develop an understanding of broader concepts or categories. Spacing without interleaving does not appear to benefit this type of learning.

Interleaving can seem counterintuitive — even in studies where interleaving enhanced learning, participants often felt that they had learnt more with blocked study. Despite this, their performance in testing indicated greater learning through the interleaving approach.

[1] Based on Agarwal, Roediger, McDaniel & McDermott (2020); Birnbaum, Kornell, Ligon Bjork & Bjork (2013); Carpenter & Agarwal (2020); Chen, Paas & Sweller (2021); Ebbinghaus (1885); Rohrer (2012); Taylor & Rohrer (2010).

Reporting

General information about determining and reporting results for senior syllabuses is provided in the 'Determining and reporting results' section of the *QCE and QCIA policy and procedures handbook*.

Reporting standards

Reporting standards are summary statements that describe typical performance at each of the five levels (A–E).

A
The student accurately describes a variety of concepts, theories, models and systems, and their limitations. They give clear and detailed accounts of a variety of concepts, theories, models and systems by making relationships, reasons or causes evident. The student communicates effectively by using scientific representations and language accurately and concisely within appropriate genres. They efficiently collect, collate and process relevant evidence. The student accurately applies their understanding of scientific concepts, theories, models and systems within their limitations to explain a variety of phenomena, and predict outcomes, behaviours and implications. They accurately use representations of scientific relationships and data to determine a variety of unknown scientific quantities and perceptively recognise the limitations of models and theories when discussing results. The student analyses systematically and effectively by identifying the essential elements, features or components of qualitative data. They use relevant mathematical processes to appropriately identify trends, patterns, relationships, limitations and uncertainty in quantitative data. They interpret evidence insightfully by using their knowledge and understanding to draw justified conclusions based on their thorough analysis of evidence and established criteria. The student critically evaluates conclusions, claims and processes by insightfully scrutinising evidence, extrapolating credible findings, and discussing the reliability and validity of experiments. They investigate phenomena by carrying out effective experiments and research investigations.
B
The student accurately describes concepts, theories, models and systems, and their limitations. They give clear and detailed accounts of concepts, theories, models and systems by making relationships, reasons or causes evident. The student communicates accurately by using scientific representations and language within appropriate genres to present information. They collect, collate and process relevant evidence. The student accurately applies their understanding of scientific concepts, theories, models and systems within their limitations to explain phenomena and predict outcomes, behaviours and implications. They accurately use representations of scientific relationships and data to determine unknown scientific quantities, and accurately recognise the limitations of models and theories when discussing results. The student analyses effectively by identifying the essential elements, features or components of qualitative data. They use mathematical processes to appropriately identify trends, patterns, relationships, limitations and uncertainty in quantitative data. They interpret evidence by using their knowledge and understanding to draw reasonable conclusions based on their accurate analysis of evidence and established criteria. The student evaluate processes, claims and conclusions by scrutinising evidence, applying relevant findings and discussing the reliability and validity of experiments. They investigate phenomena by carrying out effective experiments and research investigations.

C
The student describes concepts, theories, models and systems, and their limitations. They give detailed accounts of concepts, theories, models and systems by making relationships, reasons or causes evident. The student communicates using scientific representations and language within appropriate genres to present information. They collect, collate and process evidence. The student applies their understanding of scientific concepts, theories, models and systems within their limitations to explain phenomena and predict outcomes, behaviours and implications. They use representations of scientific relationships and data to determine unknown scientific quantities and recognise the limitations of models and theories when discussing results. The student analyses by identifying the essential elements, features or components of qualitative data. They use mathematical processes to identify trends, patterns, relationships, limitations and uncertainty in quantitative data. They interpret evidence by using their knowledge and understanding to draw conclusions based on their analysis of evidence and established criteria. The student evaluates processes, claims and conclusions by describing the quality of evidence, applying findings, and describing the reliability and validity of experiments. They investigate phenomena by carrying out experiments and research investigations.
D
The student describes and gives accounts of aspects of concepts, theories, models and systems. The student uses scientific representations or language to present information. They use rudimentary representations of scientific relationships or data to determine unknown scientific quantities or variables. The student analyses by identifying the elements, features or components of qualitative data. They use parts of mathematical processes to identify trends, patterns, relationships, limitations or uncertainty in quantitative data. They interpret evidence by drawing conclusions based on evidence or established criteria. The student considers the quality of evidence and conclusions and discusses processes, claims or conclusions. They carry out aspects of experiments and research investigations.
E
The student describes scenarios and communicates by referring to representations of information. They discuss physical phenomena and evidence. They follow established methodologies in research situations. They discuss evidence. The student carries out elements of experiments and research investigations.

Determining and reporting results

Unit 1 and Unit 2

Schools make judgments on individual assessment instruments using a method determined by the school. They may use the reporting standards or develop an instrument-specific marking guide (ISMG). Marks are not required for determining a unit result for reporting to the QCAA.

The unit assessment program comprises the assessment instrument/s designed by the school to allow the students to demonstrate the unit objectives. The unit judgment of A–E is made using reporting standards.

Schools report student results for Unit 1 and Unit 2 to the QCAA as satisfactory (S) or unsatisfactory (U). Where appropriate, schools may also report a not rated (NR).

Units 3 and 4

Schools mark each of the three internal assessment instruments implemented in Units 3 and 4 using ISMGs.

Schools report a provisional mark by criterion to the QCAA for each internal assessment.

Once confirmed by the QCAA, these results will be combined with the result of the external assessment developed and marked by the QCAA.

The QCAA uses these results to determine each student's subject result as a mark out of 100 and as an A–E.

Units

Unit 1: Cells and multicellular organisms

In Unit 1, students explore the ways biology is used to describe and explain how the structure and function of cells and their components are related to the need to exchange matter and energy with their immediate environment. An understanding of the structure and function of cells is essential to appreciate the processes vital for survival. Students investigate the structure and function of cells and multicellular organisms. They examine the structure and function of plant and animal systems at cell and tissue levels in order to analyse how they facilitate the efficient provision or removal of materials.

Contexts that could be investigated in this unit include stem cell research, animal ethics, organ and tissue transplantation, bio-artificial organs and photosynthesis productivity. Through the investigation of these contexts, students may explore the ethical considerations that apply to the use of living organisms in research.

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of the relationship between structure and function of cells and multicellular organisms. Collaborative experimental work also helps students to develop communication, interaction, character and management skills.

Throughout the unit, students develop skills in conducting real or virtual laboratory work and carrying out microscopic examination of cells and tissues. They use these skills to construct and use models to describe and interpret data about the functions of cells and organisms and to explain cellular processes.

Unit objectives

1. Describe ideas and findings about cells as the basis of life, exchange of nutrients and wastes, and cellular energy, gas exchange and plant physiology.
2. Apply understanding of cells as the basis of life, exchange of nutrients and wastes, and cellular energy, gas exchange and plant physiology.
3. Analyse data about cells as the basis of life, exchange of nutrients and wastes, and cellular energy, gas exchange and plant physiology.
4. Interpret evidence about cells as the basis of life, exchange of nutrients and wastes, and cellular energy, gas exchange and plant physiology.
5. Evaluate processes, claims and conclusions about cells as the basis of life, exchange of nutrients and wastes, and cellular energy, gas exchange and plant physiology.
6. Investigate phenomena associated with cells as the basis of life, exchange of nutrients and wastes, and cellular energy, gas exchange and plant physiology.

Subject matter

Topic 1: Cells as the basis of life (15 hours)

Science understanding

- Compare prokaryotic and eukaryotic cells.
- Identify key organelles and their functions, including the nucleus, mitochondria, rough ER, ribosomes, smooth ER, Golgi apparatus, lysosomes, vacuoles and chloroplasts.
- Describe how stem cells originate through the process of mitosis and differentiate into specialised cells to form tissues.
- Distinguish between unipotent, multipotent, pluripotent and totipotent stem cells.
- Describe how the hierarchical organisation of cells, tissues, organs and systems allow multicellular organisms to
  - obtain nutrients, e.g. digestive and circulatory systems
  - exchange gases, e.g. respiratory and circulatory systems
  - remove wastes, e.g. respiratory, circulatory and excretory systems.
- Explain that each body system contains specialised cells and tissues that are structurally suited to function, including
  - size and shape (SA:V ratio)
  - organelle composition.
- Describe the structure and function of the cell membrane based on the fluid mosaic model, including the role of protein channels, phospholipids, cholesterol and glycoproteins.
- Explain how the cell membrane regulates movement of substances into and out of the cell via
  - osmosis
  - simple diffusion
  - facilitated diffusion
  - protein-mediated active transport
  - endocytosis and exocytosis.
- Compare active and passive transport.
- Explain how the size of a cell is limited by surface area-to-volume ratio and rate of diffusion.
- Interpret data from an experiment investigating the effect of surface area-to-volume ratio on the rate of diffusion.

Science as a human endeavour

- Appreciate that
  - to make sense of the complexity of biological systems, scientists often divide them into simpler components that are easier to study, but at each level of the biological hierarchy, new properties emerge
  - pluripotent stem cells have the potential to be grown into specialised cells that can be used to repair or replace ailing organs and tissues. Advances in technology have allowed scientists to reprogram cells to become pluripotent
  - the use of animals in research has played an important role in furthering scientific understanding of the structure and function of multicellular organisms. Ethical treatment of animals as sentient beings has been accepted as a global principle in research and the three strategies of replacement, reduction and refinement form the basis of many international guidelines.

Science inquiry

- Use a light microscope or photographs to
  - view tissues from the respiratory, circulatory, excretory, digestive and/or plant systems
  - compare epithelial, connective, muscle and nervous tissues
  - calculate total magnification and field of view.
- Compare organelle composition of different cell types using electron micrographs.
- Investigate the effect of surface area-to-volume ratio on rate of diffusion.
- Explore the safety, ethics and efficacy of stem cell technologies.

Topic 2: Exchange of nutrients and wastes (15 hours)

Science understanding

- Describe the structure and function of carbohydrates, proteins and lipids.
- Describe the roles of amylase, protease and lipase in chemical digestion.
- Explain how structural features of exchange surfaces in the digestive and circulatory systems of mammals (e.g. villi and capillaries) allow for efficient nutrient exchange.
- Describe how closed circulatory systems facilitate the efficient transport of materials to and from all cells in the body.
- Identify the parts of a nephron and their functions in the production of urine, i.e. glomerulus, Bowman's capsule, proximal tubule, Loop of Henle, distal tubule and collecting duct.
- Explain how glomerular filtration, selective reabsorption and secretion across nephron membranes contribute to the removal of waste.
- Explain how metabolic processes, such as digestion, are controlled and regulated by enzymes.
- Describe the structure and function of enzymes, including the role of the active site.
- Compare the induced-fit and lock-and-key models of enzyme function.
- Explain how enzyme activity is affected by factors such as temperature, pH, presence of inhibitors and substrate concentration.
- Interpret data from an experiment investigating factors affecting enzyme activity.

Science as a human endeavour

- Appreciate how understanding the anatomy and physiology of different body systems allows medical professionals to predict, diagnose, monitor and treat disease.

Science inquiry

- Investigate the effect of temperature/pH/substrate concentration on the reaction rate of different enzymes.
- Explore how understanding enzymes, and their roles in metabolism, can be used to diagnose and treat metabolic disease.

Topic 3: Cellular energy, gas exchange and plant physiology (15 hours)

Science understanding

- Distinguish between catabolism and anabolism.
- Explain how ATP allows energy from catabolic reactions to be used in anabolic reactions.
- Describe the process of aerobic respiration, identifying the location in the cell and net inputs and outputs of
  - glycolysis
  - Krebs cycle and electron transport chain
  - the overall reaction ($C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + 36–38 ATP).
- Compare aerobic and anaerobic respiration.
- Explain how structural features of exchange surfaces in the respiratory and circulatory systems of mammals (alveoli and capillaries) allow for efficient gas exchange.
- Analyse data to predict the direction that materials will be exchanged between
  - alveoli and capillaries
  - capillaries and muscle tissue.
- Describe the process of photosynthesis, identifying the location in the cell and net inputs and outputs of
  - light-dependent reactions
  - light-independent reactions
  - the overall reaction ($6CO_2 + 6H_2O$ + light energy $\rightarrow C_6H_{12}O_6 + 6O_2$).
- Compare the structure and function of xylem and phloem tissues.
- Explain how stomata and guard cells facilitate gas exchange in plants.
- Interpret data from an experiment investigating the effect of light intensity, temperature, wind or humidity on the rate of transpiration.

Science as a human endeavour

- Appreciate how scientists use their understanding of natural systems to develop new technologies.

Science inquiry

- Investigate
  - factors affecting the rate of transpiration in different plants.
  - adaptations that allow for efficient nutrient and/or gas exchange in plants or animals.
- Explore how understanding natural systems can be used to design new technologies, e.g. artificial leaves that convert solar energy into liquid fuel.

Unit 2: Maintaining the internal environment

In Unit 2, students explore the ways biology is used to describe and explain the responses of homeostatic mechanisms to stimuli and the human immune system. An understanding of personal and communal responses is essential to appreciate personal lifestyle choices and community health. Students develop scientific skills and conceptual understanding in homeostasis, the immune system and the relationships between global, community and individual immunity. They examine geographical and population data to analyse strategies that may have personal and communal consequences.

Contexts that could be investigated in this unit include historical and current epidemics and pandemics. Through the investigation of these contexts, students may explore immunisation, quarantine, management strategies and travel preparation (both local and international).

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of controlling the internal environment. Collaborative experimental work also helps students to develop communication, interaction, character and management skills.

Throughout the unit, students develop skills in the application of technology, scientific practicals and investigations, analysis and evaluation. These skills allow them to describe and explain relationships between external and internal stimuli on controlling the internal environment.

Unit objectives

1. Describe ideas and findings about homeostasis, and infectious disease and epidemiology.
2. Apply understanding of homeostasis, and infectious disease and epidemiology.
3. Analyse data about homeostasis, and infectious disease and epidemiology.
4. Interpret evidence about homeostasis, and infectious disease and epidemiology.
5. Evaluate processes, claims and conclusions about homeostasis, and infectious disease and epidemiology.
6. Investigate phenomena associated with homeostasis, and infectious disease and epidemiology.

Subject matter

Topic 1: Homeostasis (24 hours)

Science understanding

- Explain how the nervous and endocrine systems use negative feedback to coordinate responses to internal/external stimuli and maintain homeostasis (stimulus-response model).
- Identify the different types of sensory receptors and their stimuli, including chemoreceptors, thermoreceptors, mechanoreceptors, photoreceptors and nociceptors.
- Describe the structure and function of nerve cells, including dendrites, soma, body, axon, myelin sheath, nodes of Ranvier, axon terminal and synapse.
- Distinguish between sensory neurons, interneurons and motor neurons.
- Explain the passage of a nerve impulse in terms of transmission of an action potential and synaptic transmission, referring to neurotransmitters, receptors, synaptic cleft, vesicles, postsynaptic and presynaptic neurons and signal transduction.
- Describe how hormones relay messages to cells displaying specific receptors via the circulatory or lymphatic system.
- Explain how receptor binding alters cellular activity, recognising that a cell's sensitivity to a specific hormone is directly related to the number of receptors it displays for that hormone.
- Analyse feedback-control diagrams to identify the stimulus, receptor/s, control centre, effector/s and communication pathway/s in different scenarios.
- Explain thermoregulatory mechanisms of endotherms, including
  - structural features: brown adipose tissue, insulation
  - behavioural responses: kleptothermy, hibernation, aestivation and topor
  - physiological mechanisms: evaporative heat loss, thermogenesis and vasomotor control.
- Explain thermoregulation in humans, including the role of sweating, shivering, vasodilation and vasoconstriction using feedback control diagrams.
- Explain osmoregulation in humans, including the role antidiuretic hormone (ADH) and the kidney using feedback control diagrams.
- Explain how structural and homeostatic mechanisms maintain water balance in plants, including the roles of stomata, vacuoles, cuticle and abscisic acid.
- Interpret data from an experiment comparing the number and distribution of stomata in plants adapted to different environments.

Science as a human endeavour

- Appreciate that
  - living things need to regulate their internal environment so that factors such as pH and temperature are within the tolerance ranges of enzymes that regulate metabolism
  - understanding natural systems can lead to advances in technology and engineering. For example, computer models of human thermoregulation responses, including heat transfer, perspiration, respiration and blood flows, have been developed for use in the design of clothing and environments that aim to protect humans from hyper- and hypothermia.

Science inquiry

- Investigate
  - tolerance limits for water or salt balance on plant growth
  - structural, behavioural, physiological and/or homeostatic mechanisms used by different species to control heat exchange/metabolic activity/water balance
  - the use of hormones in agriculture.
- Compare the number and distribution of stomata in plants adapted to different environments.

Topic 2: Infectious disease and epidemiology (21 hours)

Science understanding

- Distinguish between infectious and non-infectious disease.
- Identify key features of prions, viruses, bacteria, fungi, protists and parasites.
- Explain how adherence factors, invasion factors, capsules and toxins affect pathogenesis.
- Explain how host cells recognise self from non-self.
- Identify the three lines of defence in vertebrates
  - the innate immune response: skin and mucous membranes (non-specific)
  - inflammatory response and complement system (non-specific)
  - adaptive immune response (specific).
- Describe the inflammatory response, including the roles of
  - prostaglandins and vasodilation
  - neutrophils and macrophages
  - natural killer cells.
- Explain the adaptive immune response, including the
  - humoral response (B lymphocytes, antibodies)
  - cell-mediated response (T lymphocytes)
  - role of memory cells.
- Compare active and passive immunity, both naturally acquired and artificially acquired.
- Interpret long-term immune response data.
- Describe the innate immune responses in plants, including
  - physical defence strategies: barriers and leaf structures
  - chemical defence strategies: plant defensins and production of toxins.
- Interpret data from an experiment investigating the effect of an antimicrobial agent on the growth of a microorganism.
- Describe modes of disease transmission, including direct contact, contact with body fluids, contaminated food, contaminated water and disease-specific vectors.

- Explain how the following factors affect the spread of disease
  - persistence of pathogens within host
  - transmission mechanism
  - proportion of the population that are immune or have been immunised
  - mobility of individuals in the affected population.
- Explain how personal hygiene measures, contact tracing and quarantine are used to control the spread of disease.
- Analyse data to
  - predict outbreaks
  - determine the source of an outbreak
  - infer the mode of disease transmission
  - determine the effectiveness of different strategies in controlling the spread of disease.

Science as a human endeavour

- Appreciate that
  - for thousands of years, First Nations peoples' knowledges of natural antiseptics and bush medicines have been used to prevent and treat infections
  - scientific advancement and the development of complex models often requires contribution from multiple individuals across a range of disciplines
  - Australia has an advantage over many other countries because its borders are easier to protect against the influx of disease-carrying materials and organisms. However, as global trade and air travel become more prevalent, it is increasingly important for Australia to protect its agriculture industry and environment through quarantine measures. These include surveillance, monitoring, examination and clearance activities and conform to policies and protocols that are based on scientific data and risk analysis
  - mass vaccination programs are more successful when informed by disease outbreak models.

Science inquiry

- Investigate
  - the effect of an antimicrobial agent on the growth of a microorganism (via the measurement of zones of inhibition) in either a laboratory or virtual context
  - how the transmission of disease is facilitated by regional and global movement
  - the effectiveness of heath programs for the prevention and eradication of infectious diseases, e.g. smallpox, influenza, polio, Ebola, cholera, malaria.
- Explore
  - how First Nations peoples' knowledges of natural antiseptics and bush medicines are used to prevent and treat infections
  - how the work of scientists such as Rosalyn Sussman Yalow and Peter C Doherty has improved our understanding of infectious disease and the immune response
  - vaccine development.

Unit 3: Biodiversity and the interconnectedness of life

In Unit 3, students explore the ways biology is used to describe and explain: the biodiversity within ecosystems; a range of biotic and abiotic components; species interactions; adaptations of organisms to their environment; principles of population dynamics; and how classification systems are used to identify organisms and aid scientific communication. An understanding of the structure of ecosystems, the processes involved in the movement of energy and matter in ecosystems and how environmental factors limit populations is essential to appreciate the dynamics, diversity and underlying unity of these systems. Students investigate the interactions within and between species, and the interactions between abiotic and biotic components of ecosystems. They also investigate how measurements of abiotic factors, population numbers, species diversity and descriptions of interactions between species can form the basis for spatial and temporal comparisons between ecosystems. They examine and analyse data collected from fieldwork to understand the interconnectedness of organisms, the physical environment and the impact of human activity.

Contexts that could be investigated in this unit include the local ecosystem; fishing and mining industries; habitat destruction; and ecosystem management systems. Through investigating these contexts, students may explore the impact of human activity on biodiversity, and sustainability of practices.

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which scientific knowledge interacts with social, economic, cultural and ethical factors. Collaborative experimental work also helps students to develop communication, interaction, character and management skills.

Throughout the unit, students develop skills in sampling ecological systems, organising and analysing data and developing ecological models to describe and explain the diversity and interconnectedness of life on Earth.

Unit objectives

1. Describe ideas and findings about biodiversity and populations, and functioning ecosystems and succession.
2. Apply understanding of biodiversity and populations, and functioning ecosystems and succession.
3. Analyse data about biodiversity and populations, and functioning ecosystems and succession.
4. Interpret evidence about biodiversity and populations, and functioning ecosystems and succession.
5. Evaluate processes, claims and conclusions about biodiversity and populations, and functioning ecosystems and succession.
6. Investigate phenomena associated with biodiversity and populations, and functioning ecosystems and succession.

Subject matter

Topic 1: Biodiversity and populations (20 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

- Describe genetic, species and ecosystem diversity.
- Describe the biological species concept and identify its limitations.
- Identify the major taxa in the Linnaean system of biological classification and explain how it is used to classify and name species.
- Use dichotomous keys to identify and classify organisms.
- Use the Lincoln index ($N = \frac{M \times n}{m}$) to estimate the size of a population.
- Determine the diversity of species using measures such as species richness, evenness (relative species abundance), percentage cover, percentage frequency and Simpson's diversity index, $SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$.
- Describe how sampling can be used to investigate the species diversity of a given area, considering the most appropriate
  - sampling method: random, systematic, stratified
  - sampling technique: quadrats, line transect, belt-transect, capture-recapture
  - strategies to minimise bias: size and number of samples, random-number generators, counting criteria, calibrating equipment and noting associated precision
  - measure/s of diversity.
- Describe how the distribution and abundance of species in an ecosystem are influenced by
  - biotic factors — food availability, competition for resources, predation, disease
  - abiotic factors — space, shelter, availability of water, nutrients, environmental conditions.
- Explain that ecosystems are composed of varied habitats, including microhabitats, which may impact the distribution of species (e.g. uniform, random or clumped), and therefore the validity and reliability of different sampling methods/techniques.
- Interpret data from an experiment investigating how abiotic factors affect the distribution, abundance and/or biodiversity of species in an ecosystem.
- Interpret data to classify and name ecosystems using Specht's classification system and the Holdridge life zone classification scheme.
- Identify and explain different modes of population growth, including
  - exponential growth (J-curve)
  - logistic growth (S-curve).
- Compare the reproductive strategies and growth curves of K- and r- strategists.
- Calculate population growth rate and change using birth, death, immigration and emigration data.

Science as a human endeavour

The following subject matter may be assessed in the internal assessments.

- Appreciate that
  - methods of classification are directly related to the purpose for which the data will be used. Hierarchical systems, such as the Linnaean system, can be used to organise, analyse and communicate data about biodiversity. For example, the hierarchical nature of the Linnaean system allows scientists to infer similarities between species; however, as the system was originally based primarily on physical features, the categorisation of species does not always reflect evolutionary relatedness. Species may be re-classified as new information becomes available
  - there are multiple definitions for *species*, and each has limitations. Examples include the biological species concept, phylogenetic species concept, ecological species concept and morphological species concept
  - developments in software, computing and supercomputing have been important in ecological classification as they have enabled scientists to classify regions according to large sets of biotic and abiotic data and to compare data over time. Supercomputers have also enabled the development of large, complex models to analyse species data collected from multiple individuals in a range of locations, and to infer relationships between species, including their shared evolutionary past.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Use the process of stratified sampling to
  - identify different habitats within an ecosystem
  - investigate changes to abiotic factors in different strata
  - investigate changes to community composition in different strata, e.g. layers of a forest
  - infer species interactions within and between strata
  - classify an ecosystem.
- Investigate
  - how abiotic factors affect the distribution and/or abundance of species in an ecosystem
  - changes in species composition along an environmental gradient
  - how environmental factors affect the global distribution of ecosystems
  - how the process of classifying ecosystems allows for effective ecosystem management.
- Compare species diversity in two spatially variant ecosystems of the same classification.

Topic 2: Functioning ecosystems and succession (25 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

- Explain the transfer and transformation of energy as it flows through the biotic components of an ecosystem, including the
  - conversion of light into chemical energy
  - production of biomass and its interactions with components of the carbon cycle
  - loss of energy as heat.
- Analyse food chains, energy flow diagrams and ecological pyramids to determine
  - efficiencies of energy and biomass transfer
  - gross and net productivity
  - loss of energy through radiation, reflection and absorption.
- Describe the transfer and transformation of matter (water, carbon, nitrogen) as it cycles through ecosystems.
- Explain the following species interactions: predation, competition, mutualism, commensalism and parasitism.
- Describe the concept of an ecological niche.
- Explain the competitive exclusion principle.
- Explain the critical role that keystone species play in maintaining the structure of a community.
- Analyse ecological data (e.g. food webs, population data) to
  - identify keystone species
  - infer species interactions
  - predict the outcomes of removing species from an ecosystem.
- Explain how overexploitation, habitat destruction, monocultures and pollution affect community structure and ecosystem functioning.
- Explain how the carrying capacity of an ecosystem can be impacted by changes to biotic and abiotic factors, including climatic events.
- Describe the process of ecological succession.
- Distinguish between primary and secondary succession.
- Identify the features of pioneer species that make them effective colonisers.
- Explain successional changes, with reference to species interactions, abiotic factors, K- and r-selected species, biodiversity and biomass.
- Interpret ecological data to compare ecosystems across spatial and temporal scales.

Science as a human endeavour

The following subject matter may be assessed in the internal assessments.

- Appreciate that
  - First Nations peoples' knowledges of environmental change and interactions between abiotic and biotic elements of ecosystems has developed over thousands of years and provides valuable data for understanding ecosystem dynamics. This includes knowledge of land management practices that can maintain ecosystems at specific successional points
  - some biologists have advocated for keystone species to be special targets for conservation efforts and keystone species theory has informed many conservation strategies; however, there are differing views about the effectiveness of single-species conservation (such as keystone species, flagship species or umbrella species) in maintaining complex ecosystem dynamics
  - the fossil record and sedimentary rock characteristics provide evidence of past ecosystems.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Investigate
  - species interactions, e.g. by looking for correlation in abundance data
  - the competitive exclusion principle, e.g. by studying vertical zonation on a tree
  - factors affecting carrying capacity
  - the effectiveness of single-species conservation in maintaining complex ecosystem dynamics
  - how the fossil record and sedimentary rock characteristics provide evidence of past ecosystems.
- Explore how First Nations peoples' knowledges of environmental change and interactions between abiotic and biotic elements of ecosystems inform land management practices.

Unit 4: Heredity and continuity of life

In Unit 4, students explore the ways biology is used to describe and explain the cellular processes and mechanisms that ensure the continuity of life. An understanding of the processes and mechanisms of how life on Earth has persisted, changed and diversified over the last 3.5 billion years is essential to appreciate the unity and diversity of life.

Students investigate different factors that affect cellular processes and gene pools. They examine different patterns of inheritance and the genetic basis of the theory of evolution through natural selection to analyse the use of predictive models in decision-making.

Contexts that could be investigated in this unit include DNA profiling, gene therapy and genetically modified organisms. Through the investigation of these contexts, students may explore the impact of the development of these technologies on future society.

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of patterns of inheritance and the effect of a variety of factors on gene pools. Collaborative experimental work also helps students to develop communication, interaction, character and management skills.

Throughout the unit, students develop skills in modelling processes to describe and explain inheritance and population genetics.

Unit objectives

1. Describe ideas and findings about genetics and heredity, and the continuity of life on Earth.
2. Apply understanding of genetics and heredity, and the continuity of life on Earth.
3. Analyse data about genetics and heredity, and the continuity of life on Earth.
4. Interpret evidence about genetics and heredity, and the continuity of life on Earth.
5. Evaluate processes, claims and conclusions about genetics and heredity, and the continuity of life on Earth.
6. Investigate phenomena associated with genetics and heredity, and the continuity of life on Earth.

Subject matter

Topic 1: Genetics and heredity (30 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

- Describe the structure and function of DNA, genes and chromosomes in prokaryotes and eukaryotes, including
  - helical structure, nucleotide composition (nitrogenous base + sugar + phosphate), complementary base pairing, hydrogen bonds
  - introns and exons, promoter region
  - homologous chromosomes (i.e. sister chromatids, centromeres, telomeres, gene loci, alleles), role of histones
  - circular chromosomes (i.e. prokaryotes, mitochondria, chloroplasts) and plasmids.
- Describe the process of DNA replication with reference to helicase, DNA polymerase and the joining of Okazaki fragments.
- Explain how errors in DNA replication and damage by physical/chemical factors in the environment can lead to point and frameshift mutations.
- Describe the process of meiosis and explain how crossing over, independent assortment and random fertilisation produce variation in the genotypes of offspring.
- Compare spermatogenesis and oogenesis.
- Explain how errors in meiosis can lead to chromosomal abnormalities such as insertions, deletions, duplications, inversions, translocations and aneuploidy.
- Identify ploidy changes within a human karyotype to predict a genetic disorder.
- Explain the process of protein synthesis in terms of
  - transcription of a gene into messenger RNA in the nucleus
  - RNA processing (5’ cap, RNA splicing, poly-A tail)
  - translation of mRNA into an amino acid sequence at the ribosome, referring to transfer RNA, codons and anticodons.
- Determine the effect of point and frameshift mutations on polypeptides using the genetic code.
- Explain how gene expression is regulated in response to environmental signals and to allow for cell differentiation, including
  - chemical tags that affect chromatin structure (heterochromatin vs. euchromatin)
  - proteins that bind to the promoter region of a gene (transcription factors).
- Explain how genes from the HOX transcription factor family regulate morphology.
- Describe dominant, recessive, autosomal, sex-linked, polygenic and multiple-allele inheritance.

- Infer patterns of inheritance and predict frequencies of genotypes and phenotypes from genetic data, including
  - histograms (polygenic inheritance)
  - pedigrees (dominant/recessive, autosomal/sex-linked)
  - Punnett squares (dominant/recessive, autosomal/sex-linked and multiple-allele inheritance).
- Describe the process of making recombinant DNA, including the role of restriction enzymes, plasmids and DNA ligase.
- Describe how PCR and gel electrophoresis are used in DNA profiling and explain how differences in DNA allow for characteristic banding patterns.
- Interpret DNA profiles from gel electrophoresis.

Science as a human endeavour

The following subject matter may be assessed in the internal assessments.

- Appreciate that
  - the Human Genome Project was an international, collaborative research project which resulted in the publication of the full sequence of the human genome in 2003. The databases associated with the project are freely available via the internet and used extensively by the international scientific community
  - full genome sequencing enables people to identify whether they have certain gene variants, which may enable doctors to structure individualised healthcare programs that will lead to better health; however, there is concern about the risks of making this data available, and the privacy issues regarding ownership and availability of the information
  - a wide range of transgenic crops are currently on the market, some having been engineered to resist pesticides, insects and disease; however, there is concern about the long term ecological impact of releasing engineered organisms into the environment, including the effects on non-target organisms, a speeding of the evolution of pesticide-resistant pest species, and the possibility of gene flow from crop species to weed species resulting in the emergence of ‘super weeds’
  - our understanding of genetics and heredity has resulted from collaboration of people from a range of disciplines and continues to develop as new evidence comes to light. Examples of scientists who have advanced our knowledge in this field include
    - Emmanuelle Charpentier and Jennifer A Doudna — genome editing (CRISPR)
    - Elizabeth H Blackburn, Carol W Greider and Jack W Szostak — telomeres
    - Roger D Kornberg — transcription
    - Edward B Lewis, Christiane Nüsslein-Volhard and Eric F Wieschaus — HOX genes
    - Richard J Roberts and Phillip A Sharp — introns and exons.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Extract DNA from strawberries, kiwifruit or wheat germ.
- Interpret DNA profiles from gel electrophoresis (laboratory work or computer simulation).
- Investigate
  - the safety and efficacy of gene technologies such as CRISPR and GM crops
  - how advances in our understanding of genetics/epigenetics are changing the way we prevent, diagnose and/or treat disease
  - applications of bioinformatics and/or data from the Human Genome Project.
- Explore how the work of different scientists has contributed to our understanding of genetics and heredity.

Topic 2: Continuity of life on Earth (15 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

- Distinguish between microevolution and macroevolution.
- Explain microevolutionary change through the main processes of mutation, gene flow and genetic drift.
- Explain natural selection and identify the three main types of phenotypic selection: stabilising, directional and disruptive.
- Calculate allele frequencies from genotype data.
- Analyse data to determine the effect of a selection pressure on a population, recognising that selection for an allele can be positive or negative.
- Describe how macroevolutionary changes result from the accumulation of microevolutionary changes using examples of divergent, convergent, parallel and coevolution.
- Explain how geographic, temporal and spatial isolation influence gene flow and may lead to allopatric, sympatric and parapatric speciation.
- Explain why populations with reduced genetic diversity face increased risk of extinction.
- Explain how comparative genomics provides evidence for the theory of evolution and how conserved sequences can be used to date divergence.
- Infer species relatedness from cladograms, phylograms and molecular sequence data.
- Determine episodes of evolutionary radiation and mass extinctions from an evolutionary timescale of life on Earth (approximately 3.5 billion years).

Science as a human endeavour

The following subject matter may be assessed in the internal assessments.

- Appreciate that
  - ICTs such as genetic databases and The Basic Local Alignment Search Tool (BLAST) have allowed large-scale mapping and analysis of DNA and protein sequences. Technological developments in the fields of comparative genomics, comparative biochemistry and bioinformatics have enabled identification of further evidence for evolutionary relationships
  - scientific theories are explanations of the natural world that have been repeatedly tested and corroborated in accordance with the scientific method. Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power. Contemporary evidence for evolution comes from palaeontology, biogeography, developmental biology, morphology and genetics.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Analyse genotypic changes for a selective pressure in a gene pool (laboratory work or computer simulation).
- Investigate
  - how different selection pressures (e.g. human activities, changes in climate) are affecting evolution
  - how phylogenetic data is used to track and monitor viruses
  - the effectiveness of 'green corridors' in maintaining gene flow between populations
  - how data from palaeontology, biogeography, developmental biology, morphology and/or genetics is used to provide evidence for the theory of evolution
  - how genomic data is used to track human migration.

Assessment

Internal assessment 1: Data test (10%)

Students respond to items using qualitative data and/or quantitative data derived from practicals, activities or case studies relevant to Unit 3 subject matter.

Assessment objectives

2. Apply understanding of biodiversity and populations or functioning ecosystems and succession to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features.
3. Analyse data about biodiversity and populations or functioning ecosystems and succession to identify trends, patterns, relationships, limitations or uncertainty in datasets.
4. Interpret evidence about biodiversity and populations or functioning ecosystems and succession to draw conclusions based on analysis of datasets.

Specifications

The teacher provides an examination that may ask students to respond using:

- single words
- sentences (up to 150 words per question)
- calculations.

Question specifications

The examination must be aligned to the specifications provided in the table below.

Focus of question	Mark allocation (± 2%)	Objective	In these questions, students:
Unknown scientific quantities or features of datasets	~ 30%	2	calculate using algorithms, determine, identify, use
Trends, patterns, relationships, limitations or uncertainty in datasets	~ 30%	3	categorise, classify, compare, contrast, identify, organise, sequence
Conclusions based on analysis of datasets	~ 40%	4	deduce, determine, draw (a conclusion), extrapolate, infer, interpolate, justify, predict

Stimulus specifications

The teacher provides unseen stimulus that:

- uses qualitative data and/or quantitative data from the listed practicals, activities or case studies from Unit 3
- contains between two and four datasets.

Conditions

- Time allowed
  - Perusal time: 5 minutes
  - Working time: 60 minutes
- This is an individual supervised task.
- Students are permitted a QCAA-approved graphics or scientific calculator.

Mark allocation

Criterion	Assessment objectives	Marks
Data test	2, 3, 4	10
	Total marks:	10

Instrument-specific marking guide (IA1)

Data test	Cut-off	Marks
The student response has the following characteristics:		
• consistent demonstration, across a range of scenarios, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct and appropriate use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions	> 90%	10
	> 80%	9
• consistent demonstration of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions	> 70%	8
	> 60%	7
• adequate demonstration of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions	> 50%	6
	> 40%	5
• demonstration of elements of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual or graphical representations of scientific relationships or data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations or uncertainty – correct interpretation of evidence to draw valid conclusions	> 30%	4
	> 20%	3
• demonstration of elements of – application of scientific concepts, theories, models or systems to predict outcomes, behaviours or implications – calculation of quantities through the use of algebraic or graphical representations of scientific relationships and data – use of analytical techniques to identify trends, patterns, relationships, limitations or uncertainty – interpretation of evidence to draw conclusions.	> 10%	2
	> 1%	1
The student response does not match any of the descriptors above.	≤ 1%	0

Internal assessment 2: Student experiment (20%)

Students modify (i.e. refine, extend or redirect) an experiment relevant to Unit 3 subject matter to address their own related hypothesis or question. This assessment provides opportunities to assess science inquiry skills.

Assessment objectives

1. Describe ideas and experimental findings about biodiversity and populations or functioning ecosystems and succession.
2. Apply understanding of biodiversity and populations or functioning ecosystems and succession to modify experimental methodologies and process data.
3. Analyse experimental data about biodiversity and populations or functioning ecosystems and succession.
4. Interpret experimental evidence about biodiversity and populations or functioning ecosystems and succession.
5. Evaluate experimental processes and conclusions about biodiversity and populations or functioning ecosystems and succession.
6. Investigate phenomena associated with biodiversity and populations or functioning ecosystems and succession through an experiment.

Specifications

This task requires students to:

- identify an experiment to modify
- develop a research question to be investigated
- research relevant background scientific information to inform the modification of the research question and methodology
- conduct a risk assessment and account for risks in the methodology
- conduct the experiment
- collect relevant qualitative data and/or quantitative data to address the research question
- process and present the data appropriately
- analyse the evidence to identify trends, patterns or relationships
- analyse the evidence to identify uncertainty and limitations
- interpret the evidence to draw conclusion/s to the research question
- evaluate the reliability and validity of the experimental process
- suggest possible improvements and/or extensions to the experiment
- communicate findings in an appropriate scientific genre, e.g. report, poster presentation, journal article, conference presentation.

Scientific inquiry is a non-linear, iterative process. Students will not necessarily complete these steps in the stated order; some steps may be repeated or revisited.

It is recommended that this task is designed so that students can develop a response in approximately 10 hours of class time.

Conditions

- Students can develop their responses in class time and their own time.
- This is an individual task.
- The following aspects of the task may be completed as a group
  - identifying an experiment
  - developing a research question
  - conducting a risk assessment
  - conducting the experiment
  - collecting data.
- Students use a practical or simulation performed in class as the basis for their methodology and research question.

Response requirements

One of the following:

- Multimodal (at least two modes delivered at the same time): up to 11 minutes
- Written: up to 2000 words

Mark allocation

Criterion	Assessment objectives	Marks
Forming	1, 2, 6	5
Finding	1, 6	5
Analysing	2, 3	5
Interpreting and Evaluating	4, 5	5
	Total marks:	20

Instrument-specific marking guide (IA2)

Forming	Marks
The student response has the following characteristics:	
• a considered rationale for the experiment • justified modifications to the methodology • a specific and relevant research question • a methodology that enables the collection of sufficient and relevant data • appropriate use of genre and referencing conventions	4–5
• a reasonable rationale for the experiment • feasible modifications to the methodology • a relevant research question • a methodology that enables the collection of relevant data • use of basic genre and referencing conventions	2–3
• a vague or irrelevant rationale for the experiment • inappropriate modifications to the methodology • an inappropriate research question • a methodology that causes the collection of insufficient and irrelevant data • inadequate use of genre and referencing conventions.	1
The student response does not match any of the descriptors above.	0

Finding	Marks
The student response has the following characteristics:	
• considered management of risks/ethical issues/environmental issues • collection of sufficient and relevant raw data • fluent and concise use of scientific language and representations	4–5
• management of risks/ethical issues/environmental issues • collection of relevant raw data • competent use of scientific language and representations	2–3
• inadequate management of risks/ethical issues/environmental issues • collection of insufficient and irrelevant raw data • simplistic use of language and representations.	1
The student response does not match any of the descriptors above.	0

Analysing	Marks
The student response has the following characteristics:	
• correct and relevant processing of data • thorough identification of relevant trends/patterns/relationships • thorough and appropriate identification of the uncertainty and limitations of evidence	4–5
• basic processing of data • identification of obvious trends/patterns/relationships • basic identification of uncertainty and/or limitations of evidence	2–3
• incorrect or irrelevant processing of data • identification of incorrect or irrelevant trends/patterns/relationships • incorrect or insufficient identification of uncertainty and limitations of evidence.	1
The student response does not match any of the descriptors above.	0

Interpreting and Evaluating	Marks
The student response has the following characteristics:	
• justified conclusion/s linked to the research question • justified discussion of the reliability and validity of the experimental process • suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence	4–5
• reasonable conclusion/s relevant to the research question • reasonable description of the reliability and/or validity of the experimental process • suggested improvements and/or extensions to the experiment that are related to the analysis of evidence	2–3
• inappropriate or irrelevant conclusion/s • cursory or simplistic statements about the reliability and validity of the experimental process • ineffective or irrelevant suggestions.	1
The student response does not match any of the descriptors above.	0

Internal assessment 3: Research investigation (20%)

Students gather evidence related to a research question to evaluate a claim relevant to Unit 4 subject matter. This assessment provides opportunities to assess science inquiry skills and science as a human endeavour (SHE) subject matter.

Assessment objectives

1. Describe ideas and findings about genetics and heredity or the continuity of life on Earth.
2. Apply understanding of genetics and heredity or the continuity of life on Earth to develop research questions.
3. Analyse research data about genetics and heredity or the continuity of life on Earth.
4. Interpret research evidence about genetics and heredity or the continuity of life on Earth.
5. Evaluate research processes, claims and conclusions about genetics and heredity or the continuity of life on Earth.
6. Investigate phenomena associated with genetics and heredity or the continuity of life on Earth through research.

Specifications

This task requires students to:

- select a claim to be evaluated, from a list provided by the teacher
- identify the relevant scientific concepts associated with the claim
- conduct research to gather evidence from scientifically credible sources to evaluate the claim
- pose a research question that addresses an aspect of the claim
- identify relevant evidence to answer the research question
- identify the trends, patterns or relationships in the evidence
- analyse the evidence to identify limitations
- interpret the evidence to construct scientific arguments
- interpret the evidence to form a conclusion to the research question
- discuss the quality of the evidence
- evaluate the claim by applying the findings of the research to the claim
- suggest improvements and/or extensions to the investigation
- communicate findings in an appropriate scientific genre, e.g. report, journal article, essay, conference presentation.

Scientific inquiry is a non-linear, iterative process. Students will not necessarily complete these steps in the stated order; some steps may be repeated or revisited.

Evidence must be obtained by researching scientifically credible sources, such as:

- books and podcasts by well-credentialed scientists
- ‘popular’ science websites or magazines
- websites of governments, universities, independent research bodies or science and technology manufacturers
- scientific journals.

It is recommended that this task is designed so that students can develop a response in approximately 10 hours of class time.

Conditions

- Students can develop their responses in class time and their own time.
- This is an individual task.
- The following aspects of the task may be completed as a group
  - selecting a claim
  - identifying the relevant scientific concepts associated with the claim
  - conducting research.

Response requirements

One of the following:

- Multimodal (at least two modes delivered at the same time): up to 11 minutes
- Written: up to 2000 words

Mark allocation

Criterion	Assessment objectives	Marks
Forming and Finding	1, 2, 6	5
Analysing	3	5
Interpreting	1, 4	5
Evaluating	5	5
	Total marks:	20

Instrument-specific marking guide (IA3)

Forming and Finding	Marks
The student response has the following characteristics:	
• a considered rationale identifying clear development of the research question from the claim • a specific and relevant research question • selection of sufficient and relevant sources • appropriate use of genre conventions • acknowledgment of sources of information through appropriate use of referencing conventions	4–5
• a reasonable rationale that links the research question and the claim • a relevant research question • selection of relevant sources • use of basic genre conventions • use of basic referencing conventions	2–3
• a vague or irrelevant rationale for the investigation • an inappropriate research question • selection of insufficient or irrelevant sources • inadequate use of genre conventions • inadequate acknowledgment of sources.	1
The student response does not match any of the descriptors above.	0

Analysing	Marks
The student response has the following characteristics:	
• the identification of sufficient and relevant evidence • thorough identification of relevant trends/patterns/relationships in evidence • thorough and appropriate identification of limitations of evidence	4–5
• the identification of relevant evidence • identification of obvious trends/patterns/relationships in evidence • basic identification of limitations of evidence	2–3
• the identification of insufficient and irrelevant evidence • identification of incorrect or irrelevant trends/patterns/relationships in evidence • incorrect or insufficient identification of limitations of evidence.	1
The student response does not match any of the descriptors above.	0

Interpreting	Marks
The student response has the following characteristics:	
• justified scientific argument/s • justified conclusion linked to the research question • fluent and concise use of scientific language/representations	4–5
• reasonable scientific argument/s • reasonable conclusion relevant to the research question • competent use of scientific language/representations	2–3
• inappropriate or irrelevant argument/s • inappropriate or irrelevant conclusion • incorrect use of language/representations.	1
The student response does not match any of the descriptors above.	0

Evaluating	Marks
The student response has the following characteristics:	
• justified discussion of the quality of evidence • extrapolation of credible findings of the research to the claim • suggested improvements and extensions to the investigation that are considered and relevant to the claim	4–5
• reasonable description of the quality of evidence • application of relevant findings of the research to the claim • suggested improvements and/or extensions to the investigation that are relevant to the claim	2–3
• cursory or simplistic statements about the quality of evidence • application of insufficient or inappropriate findings of the research to the claim • ineffective or irrelevant suggestions.	1
The student response does not match any of the descriptors above.	0

External assessment: Examination — combination response (50%)

External assessment is developed and marked by the QCAA. The external assessment in Biology is common to all schools and administered under the same conditions, at the same time, on the same day.

Assessment objectives

1. Describe ideas and findings about biodiversity and populations, functioning ecosystems and succession, genetics and heredity, and the continuity of life on Earth.
2. Apply understanding of biodiversity and populations, functioning ecosystems and succession, genetics and heredity, and the continuity of life on Earth.
3. Analyse data about biodiversity and populations, functioning ecosystems and succession, genetics and heredity, and the continuity of life on Earth to identify trends, patterns, relationships, limitations or uncertainty.
4. Interpret evidence about biodiversity and populations, functioning ecosystems and succession, genetics and heredity, and the continuity of life on Earth to draw conclusions based on analysis.

Specifications

This examination:

- includes two papers. Each paper consists of a number of different types of questions relating to Units 3 and 4
- may ask students to respond using
  - multiple choice
  - single words
  - sentences or paragraphs
- may ask students to
  - calculate using algorithms
  - interpret unseen stimulus, including graphs, tables or diagrams.

Conditions

Paper 1

- Mode: written
- Time allowed
  - Perusal time: 5 minutes
  - Working time: 90 minutes
- Students may use a QCAA-approved graphics or scientific calculator.

Paper 2

- Mode: written
- Time allowed
  - Perusal time: 5 minutes
  - Working time: 90 minutes
- Students may use a QCAA-approved graphics or scientific calculator.

Glossary

The syllabus glossary is available at www.qcaa.qld.edu.au/downloads/senior-qce/common/snr_glossary_cognitive_verbs.pdf.

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Version history

Version	Date of change	Information
1.0	January 2024	Released for familiarisation and planning (with implementation starting in 2025)
1.1	July 2024	Released for implementation with minor updates
1.2	October 2024	ISBN removed and minor updates