

# Biology 2019 v1.2

## General Senior Syllabus

This syllabus is for implementation with Year 11 students in 2019.

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# 1 Course overview

## 1.1 Introduction

### 1.1.1 Rationale

At the core of all science 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.

### **Assumed knowledge, prior learning or experience**

The P–10 Australian Curriculum: Science is assumed knowledge for this syllabus.

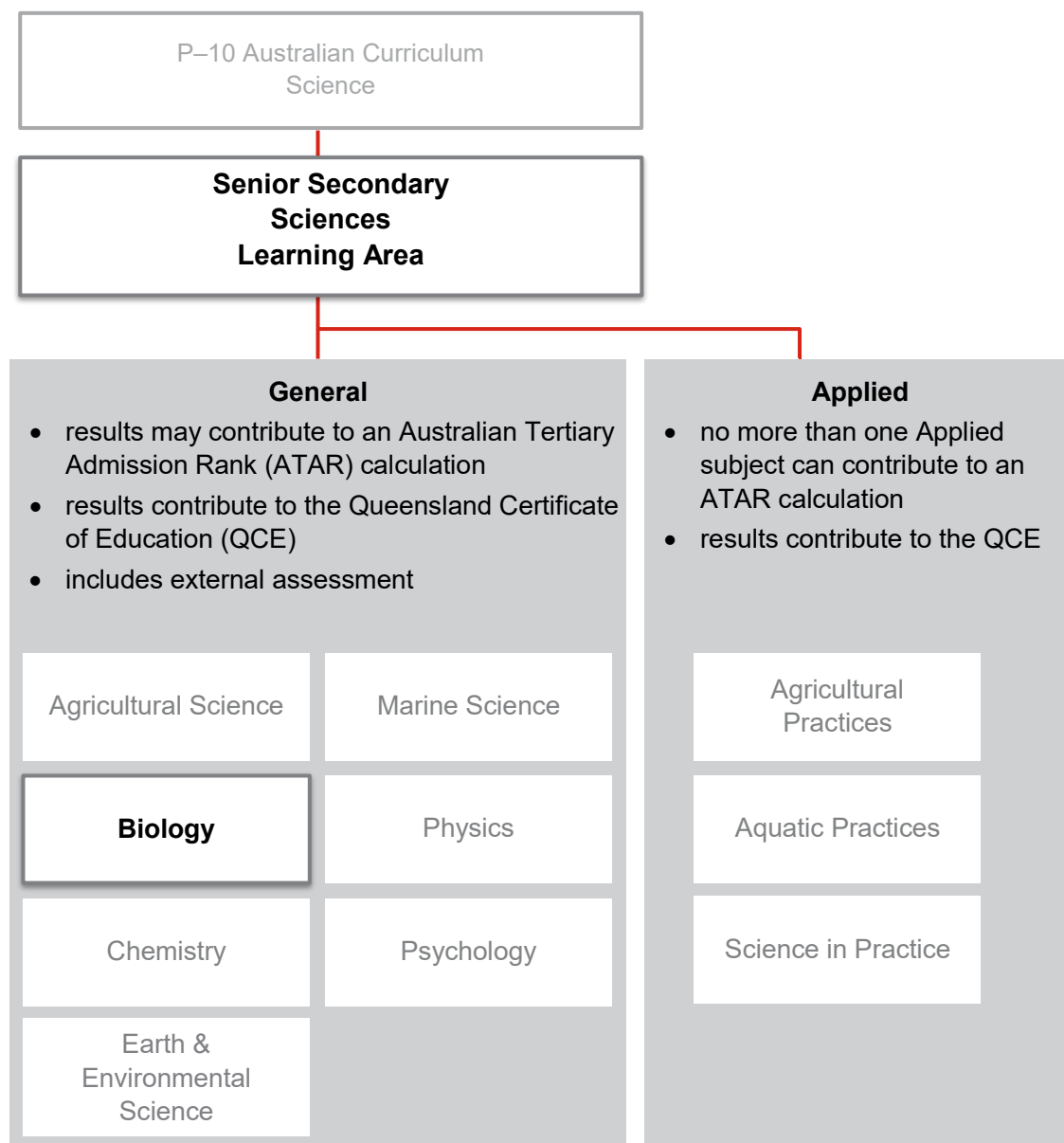
### **Pathways**

Biology is a General subject suited to students who are interested in pathways beyond school that lead to tertiary studies, vocational education or work. A course of study in Biology can establish a basis for further education and employment in the fields of medicine, forensics, veterinary, food and marine sciences, agriculture, biotechnology, environmental rehabilitation, biosecurity, quarantine, conservation and sustainability.

## 1.1.2 Learning area structure

All learning areas build on the P–10 Australian Curriculum.

Figure 1: Learning area structure



### 1.1.3 Course structure

Biology is a course of study consisting of four units. Subject matter, learning experiences and assessment increase in complexity from Units 1 and 2 to Units 3 and 4 as students develop greater independence as learners.

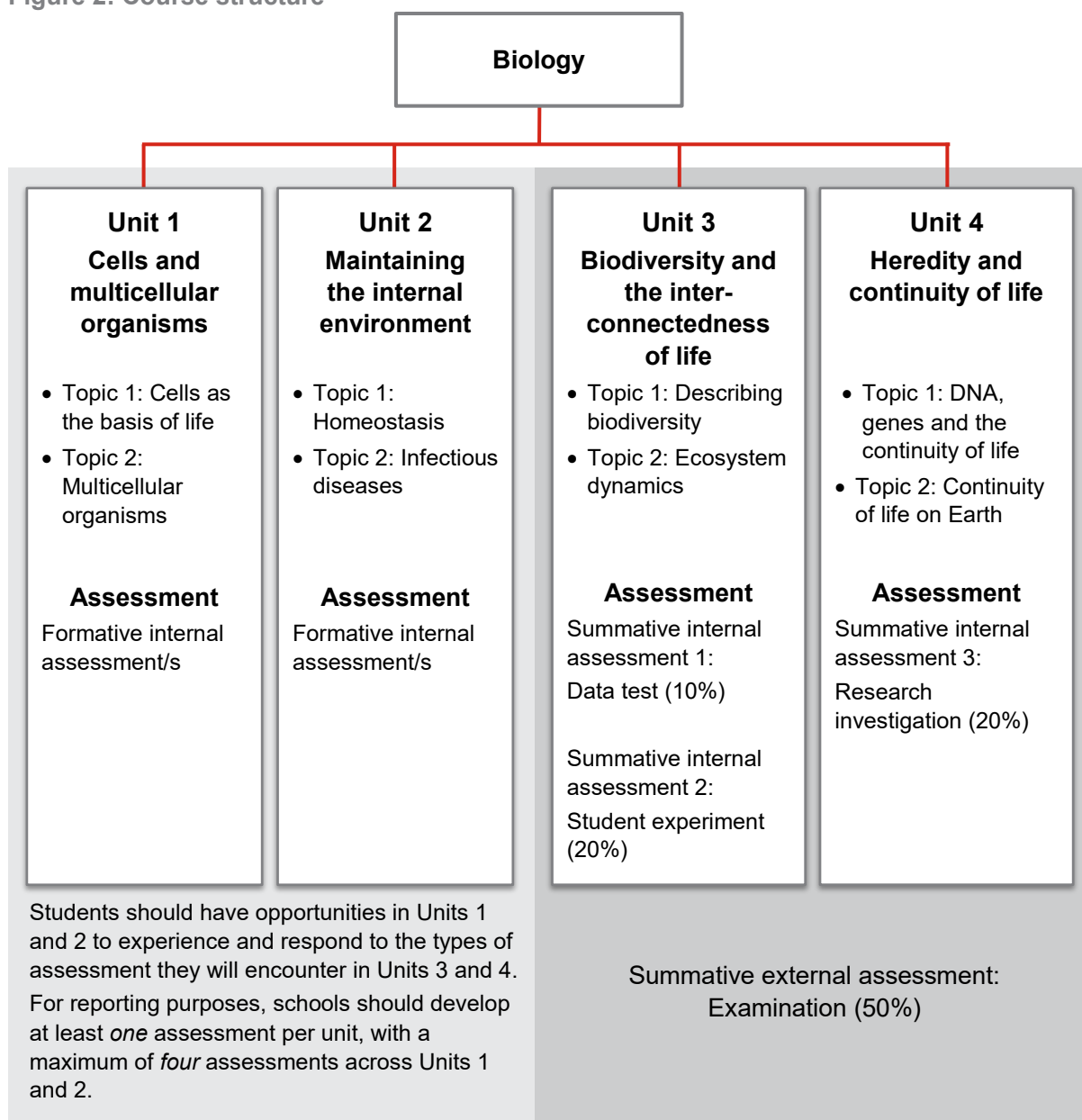
Units 1 and 2 provide foundational learning, which allows students to experience all syllabus objectives and begin engaging with the course subject matter. Students should complete Units 1 and 2 before beginning Units 3 and 4.

Units 3 and 4 consolidate student learning. Only the results from Units 3 and 4 will contribute to ATAR calculations.

Figure 2 outlines the structure of this course of study.

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

**Figure 2: Course structure**



## 1.2 Teaching and learning

### 1.2.1 Syllabus objectives

The syllabus objectives outline what students have the opportunity to learn. Assessment provides evidence of how well students have achieved the objectives.

Syllabus objectives inform unit objectives, which are contextualised for the subject matter and requirements of the unit. Unit objectives, in turn, inform the assessment objectives, which are further contextualised for the requirements of the assessment instruments. The number of each objective remains constant at all levels, i.e. Syllabus objective 1 relates to Unit objective 1 and to Assessment objective 1 in each assessment instrument.

Syllabus objectives are described in terms of actions that operate on the subject matter. Students are required to use a range of cognitive processes in order to demonstrate and meet the syllabus objectives. These cognitive processes are described in the explanatory paragraph following each objective in terms of four levels: retrieval, comprehension, analytical processes (analysis), and knowledge utilisation, with each process building on the previous processes (see Marzano & Kendall 2007, 2008). That is, comprehension requires retrieval, and knowledge utilisation requires retrieval, comprehension and analytical processes (analysis).

By the conclusion of the course of study, students will:

Syllabus objective	Unit 1	Unit 2	Unit 3	Unit 4
1. <u>describe and explain scientific concepts, theories, models and systems and their limitations</u>	•	•	•	•
2. <u>apply understanding of scientific concepts, theories, models and systems within their limitations</u>	•	•	•	•
3. <u>analyse evidence</u>	•	•	•	•
4. <u>interpret evidence</u>	•	•	•	•
5. <u>investigate phenomena</u>	•	•	•	•
6. <u>evaluate processes, claims and conclusions</u>	•	•	•	•
7. <u>communicate understandings, findings, arguments and conclusions.</u>	•	•	•	•

#### 1. **describe and explain scientific concepts, theories, models and systems and their limitations**

When students describe and explain scientific concepts, theories, models and systems and their limitations, they give a detailed account of a concept, theory, model or system making relationships, reasons or causes evident. They reflect on relevant social, economic, ethical and cultural factors.

#### 2. **apply understanding of scientific concepts, theories, models and systems within their limitations**

When students apply their understanding of scientific concepts, theories, models and systems within their limitations, they explain local, regional and global phenomena and determine outcomes, behaviours and implications. They use algebraic, visual and graphical representations of scientific relationships and data to determine unknown scientific quantities or variables. They recognise the limitations of models and theories when discussing results.



### 3. analyse evidence

When students analyse evidence, they recognise the variety of forms of evidence, and distinguish between quantitative, qualitative, primary and secondary evidence. When students analyse evidence in the form of qualitative data, they identify the essential elements, features or components of the data. When students analyse evidence in the form of quantitative data, they use mathematical processes to identify trends, patterns, relationships, limitations and uncertainty in the data.

### 4. interpret evidence

When students interpret evidence, they use their knowledge and understanding of scientific concepts, theories, models and systems and their limitations to draw conclusions based on their analysis of qualitative and quantitative evidence and established criteria.

### 5. investigate phenomena

When students investigate phenomena, they plan and carry out experimental and/or research activities in order to obtain evidence for the purpose of reaching a conclusion. They collect, collate and process evidence. Students ensure that relevant ethical, environmental and safety considerations have been incorporated into their practice.

### 6. evaluate processes, claims and conclusions

When students evaluate processes, claims and conclusions, they critically reflect on the available evidence and make judgments about its application to a research question, and its use to inform further investigation. When students evaluate processes, they use the quality of the evidence to evaluate the validity and reliability of the method used, the appropriateness of assumptions made and possible refinements required. When students evaluate claims, they identify the evidence that would be required to support or refute the claim. They scrutinise evidence for bias, conjecture, alternatives or inaccuracies. When students evaluate conclusions, they consider the credibility of the supporting evidence.

### 7. communicate understandings, findings, arguments and conclusions

When students communicate, they use scientific representations and language within appropriate genres to present information. They use technology to share knowledge by exchanging information and creating information products.

## 1.2.2 Underpinning factors

There are three skill sets that underpin senior syllabuses and are essential for defining the distinctive nature of subjects:

- literacy — the set of knowledge and skills about language and texts essential for understanding and conveying Biology 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 skill sets, which overlap and interact, are derived from current education, industry and community expectations. They encompass the knowledge, skills, capabilities, behaviours and dispositions that will help students live and work successfully in the 21st century.

Together these three skill sets shape the development of senior subject syllabuses. Although coverage of each skill set may vary from syllabus to syllabus, students should be provided with opportunities to learn through and about these skills over the course of study. Each skill set contains identifiable knowledge and skills that can be directly assessed.

## **Literacy in Biology**

The skills of literacy in science (distinct from 'scientific literacy') are essential for successful scientific inquiry (Douglas et al 2006, Saul 2004, Yore et al 2003). In any scientific inquiry activity, literacy skills support students by enabling them to grapple with ideas, conduct research, discuss their thoughts, enhance conceptual understanding and solve problems (Krajcik & Southerland 2010).

The literacy skills important to this subject are those related to the comprehension and composition of texts that provide information, describe and explain events and phenomena, report on experiments, present and analyse data, and offer opinions or claims (ACARA 2015a). Biology students comprehend and compose multimedia texts, such as reports, charts, graphs, diagrams, pictures, maps, animations, models and other visual media. They understand and apply language structures that are used to link information and ideas, give descriptions and explanations, formulate research questions and construct evidence-based arguments capable of expressing an informed position (ACARA 2015a).

Students learn these skills by having opportunity to engage with:

- rich and varied science and media texts
- class activities that use literacy as a tool for learning
- strategies for reading scientific texts (Moore 2009).

The learning opportunities described above can be integrated with stimulus questions, Science as a Human Endeavour subject matter and mandatory practicals. Students could be asked to:

- explain links between new ideas and prior knowledge and experiences
- engage in learning experiences directed by a question that is meaningful to their lives
- connect multiple representations of a concept (e.g. written texts, formulas, graphs or diagrams of the same concept)
- use scientific ideas to compose evidence-based conclusions in the mandatory practicals
- engage with the discourses of science such as those found in scientific literature and media texts (Krajcik & Southerland 2010).

These strategies will promote students' ability to read, write and communicate about science so that they can engage with science-related issues throughout their lives.

These aspects of literacy knowledge and skills are embedded in the syllabus objectives, unit objectives and subject matter, and instrument-specific marking guides (ISMGs) for Biology.

## **Numeracy in Biology**

The skills of numeracy in Biology are essential for successful scientific inquiry. In any scientific inquiry activity, numeracy skills support students by enabling them to make and record observations; order, represent and analyse data; and interpret trends and relationships (ACARA 2015b).

The numeracy skills important to this subject are those related to the interpretation of complex spatial and graphical representations, and the appreciation of the ways in which scientific concepts, theories, systems and models are structured, communicated, interact or change across spatial and temporal scales (ACARA 2015b). Students will use knowledge and skills in areas such as:

- graphing
- ratio and proportion
- converting from one unit to another
- scientific notation
- an understanding of place in number (significant figures)
- estimation and calculation in order to analyse data
- determining the reliability of data
- interpreting and manipulating mathematical relationships in order to calculate and predict values (ACARA 2009, 2015).

Students will learn these skills as they:

- measure and record data during the mandatory practicals
- use or interpret meaning from formulas
- interpret graphical information presented in science and media texts
- undertake class activities that use numeracy as a tool for learning
- use mathematics or equations as justification or evidence for conclusions
- interpret and represent information in a variety of forms.

These aspects of literacy knowledge and skills are embedded in the syllabus objectives, unit objectives and subject matter, and ISMGs for Biology.

## 21st century skills

The 21st century skills identified in the following table reflect a common agreement, both in Australia and internationally, on the skills and attributes students need to prepare them for higher education, work and engagement in a complex and rapidly changing world.

21st century skills	Associated skills	21st century skills	Associated skills
critical thinking	<ul style="list-style-type: none"> <li>• analytical thinking</li> <li>• problem-solving</li> <li>• decision-making</li> <li>• reasoning</li> <li>• reflecting and evaluating</li> <li>• intellectual flexibility</li> </ul>	creative thinking	<ul style="list-style-type: none"> <li>• innovation</li> <li>• initiative and enterprise</li> <li>• curiosity and imagination</li> <li>• creativity</li> <li>• generating and applying new ideas</li> <li>• identifying alternatives</li> <li>• seeing or making new links</li> </ul>
communication	<ul style="list-style-type: none"> <li>• effective oral and written communication</li> <li>• using language, symbols and texts</li> <li>• communicating ideas effectively with diverse audiences</li> </ul>	collaboration and teamwork	<ul style="list-style-type: none"> <li>• relating to others (interacting with others)</li> <li>• recognising and using diverse perspectives</li> <li>• participating and contributing</li> <li>• community connections</li> </ul>
personal and social skills	<ul style="list-style-type: none"> <li>• adaptability/flexibility</li> <li>• management (self, career, time, planning and organising)</li> <li>• character (resilience, mindfulness, open- and fair-mindedness, self-awareness)</li> <li>• leadership</li> <li>• citizenship</li> <li>• cultural awareness</li> <li>• ethical (and moral) understanding</li> </ul>	Information & communication technologies (ICT) skills	<ul style="list-style-type: none"> <li>• operations and concepts</li> <li>• accessing and analysing information</li> <li>• being productive users of technology</li> <li>• digital citizenship (being safe, positive and responsible online)</li> </ul>

Biology helps develop the following 21st century skills:

- critical thinking
- creative thinking
- communication
- collaboration and teamwork
- personal and social skills
- information & communication technologies (ICT) skills.

These elements of 21st century skills are embedded in the syllabus objectives, unit objectives and subject matter, and ISMGs for Biology.

### 1.2.3 Aboriginal perspectives and Torres Strait Islander perspectives

The QCAA is committed to reconciliation in Australia. 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](http://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.

### 1.2.4 Pedagogical and conceptual frameworks

#### 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 connotations 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.**

#### 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.

## 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 science inquiry (Tytler 2007). This expectation can be seen, for example, in the inclusion of the mandatory practicals, student experiment and research investigation.

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 taught science inquiry skills (Krajcik et al 2000). The syllabus outlines a number of these skills in the subject matter. Some science inquiry skills will be used to complete the mandatory and suggested practicals. 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 decide how the science inquiry skills are to be developed. For example, teachers will determine how mandatory practicals 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.

## 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 and 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 3: Stages of inquiry process**



## **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* (<http://ppr.det.qld.gov.au/Pages/default.aspx>) provides guidance about current science safety protocols.

It is the responsibility of all schools to ensure that their practices meet current legislation requirements. References to relevant legislation and regulations are supported by the Reference list located on the Biology subject page of the QCAA website.

### **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 and, thus, standards in schools should be more stringent than those used in universities and research and development organisations.

Separate to the Act and ethical approval, teachers 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. LD<sub>50</sub>, 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).



## 1.2.5 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 Biology. It is particular to each unit in the course of study and provides the basis for student learning experiences.

Subject matter has a direct relationship to the unit objectives, but is of a finer granularity and is more specific. These statements of learning are constructed in a similar way to objectives. Each statement:

- describes an action (or combination of actions) — what the student is expected to do
- describes the element — expressed as information, mental procedures and/or psychomotor procedures
- is contextualised for the topic or circumstance particular to the unit.

### Organisation of subject matter

The subject matter is organised as topics within each unit.

The subject matter indicates the required knowledge and skills that students must acquire. Students should experience the mandatory practicals. It is expected that approximately five hours will be required to complete the mandatory practicals that involve fieldwork.

The subject matter from Units 3 and 4 will be assessed by the external examination.

### Science as a Human Endeavour

Each Queensland senior science subject requires students to learn and apply aspects of the knowledge and skill of the discipline. 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 will not be 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 Science as a Human Endeavour (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 guidance in each topic. This highlights opportunities for teachers to contextualise the associated subject matter and provides stimulus for the development of claims and research questions for investigation.

Additional opportunities include:

- the mandatory and suggested practicals provide opportunity 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.

Finally, the SHE statements at the end of each topic may be used to support the development and interrogation of claims, and be useful as a starting point for the research investigation.

## Guidance

The guidance included with each topic is designed to clarify the scope of the subject matter and identify opportunities to integrate science inquiry skills and SHE strands into the subject matter. A number of tags are used to highlight aspects of the guidance:

- **Notional time:** the depth of subject matter coverage is indicated by the amount of time needed to cover this subject matter in the sequence presented in the syllabus.
- **Formula:** defines a formula described in the subject matter.
- **SHE:** identifies an opportunity to integrate an aspect of the Science as a Human Endeavour strand and may also be used as a starting point for a research investigation.
- **Suggested practical:** identifies an opportunity for inquiry skills to be developed and may be used as a starting point for a student experiment.
- **Manipulative skill:** identifies skills that need to be developed in order for students to complete suggested or mandatory practicals.
- **Syllabus links:** identifies links between syllabus units.

## 1.3 Assessment — general information

Assessments are formative in Units 1 and 2, and summative in Units 3 and 4.

Assessment	Unit 1	Unit 2	Unit 3	Unit 4
Formative assessments	•	•		
Summative internal assessment 1			•	
Summative internal assessment 2			•	
Summative internal assessment 3				•
Summative external assessment			•	•

### 1.3.1 Formative assessments — Units 1 and 2

Formative assessments provide feedback to both students and teachers about each student's progress in the course of study.

Schools develop internal assessments for each senior subject, based on the learning described in Units 1 and 2 of the subject syllabus. Each unit objective must be assessed at least once.

For reporting purposes, schools should devise at least *two* but no more than *four* assessments for Units 1 and 2 of this subject. At least *one* assessment must be completed for *each* unit.

The sequencing, scope and scale of assessments for Units 1 and 2 are matters for each school to decide and should reflect the local context.

Teachers are encouraged to use the A–E descriptors in the reporting standards (Section 1.5) to provide formative feedback to students and to report on progress.

### 1.3.2 Summative assessments — Units 3 and 4

Students will complete a total of *four* summative assessments — three internal and one external — that count towards their final mark in each subject.

Schools develop *three* internal assessments for each senior subject, based on the learning described in Units 3 and 4 of the syllabus.

The three summative internal assessments will be endorsed and the results confirmed by the QCAA. These results will be combined with a single external assessment developed and marked by the QCAA. The external assessment results for Biology will contribute 50% towards a student's result.

#### Summative internal assessment — instrument-specific marking guides

This syllabus provides ISMGs for the three summative internal assessments in Units 3 and 4.

The ISMGs describe the characteristics evident in student responses and align with the identified assessment objectives. Assessment objectives are drawn from the unit objectives and are contextualised for the requirements of the assessment instrument.

#### Criteria

Each ISMG groups assessment objectives into criteria. An assessment objective may appear in multiple criteria, or in a single criterion of an assessment.

## **Making judgments**

Assessment evidence of student performance in each criterion is matched to a performance-level descriptor, which describes the typical characteristics of student work.

Where a student response has characteristics from more than one performance level, a best-fit approach is used. Where a performance level has a two-mark range, it must be decided if the best fit is the higher or lower mark of the range.

## **Authentication**

Schools and teachers must have strategies in place for ensuring that work submitted for internal summative assessment is the student's own. Authentication strategies outlined in QCAA guidelines, which include guidance for drafting, scaffolding and teacher feedback, must be adhered to.

## **Summative external assessment**

The summative external assessment adds valuable evidence of achievement to a student's profile. External assessment is:

- common to all schools
- administered under the same conditions at the same time and on the same day
- developed and marked by the QCAA according to a commonly applied marking scheme.

The external assessment contributes 50% to the student's result in Biology. It is not privileged over the school-based assessment.

## 1.4 Reporting standards

Reporting standards are summary statements that succinctly describe typical performance at each of the five levels (A–E). They reflect the cognitive taxonomy and objectives of the course of study.

The primary purpose of reporting standards is for twice-yearly reporting on student progress. These descriptors can also be used to help teachers provide formative feedback to students and to align ISMGs.

### Reporting standards

#### A

The student accurately describes and explains 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 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 evidence 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 investigates phenomena by carrying out effective experiments and research investigations. They efficiently collect, collate and process relevant evidence. They critically evaluate processes, claims and conclusions by insightfully scrutinising evidence, extrapolating credible findings, and discussing the reliability and validity of experiments.

The student communicates effectively by using scientific representations and language accurately and concisely within appropriate genres.

#### B

The student accurately describes and explains 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 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 evidence by effectively 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 investigates phenomena by carrying out effective experiments and research investigations. They collect, collate and process relevant evidence. They evaluate processes, claims and conclusions by scrutinising evidence, applying relevant findings and discussing the reliability and validity of experiments. The student communicates accurately by using scientific representations and language within appropriate genres to present information.

## C

The student describes and explains 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 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 evidence 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 investigates phenomena by carrying out experiments and research investigations. They collect, collate and process evidence. They evaluate processes, claims and conclusions by describing the quality of evidence, applying findings, and describing the reliability and validity of experiments.

The student communicates using scientific representations and language within appropriate genres to present information.

## D

The student describes and gives accounts of aspects of concepts, theories, models and systems. They use rudimentary representations of scientific relationships or data to determine unknown scientific quantities or variables.

The student analyses evidence 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 carries out aspects of experiments and research investigations. They discuss processes, claims or conclusions. They consider the quality of evidence and conclusions.

The student uses scientific representations or language to present information.

## E

The student describes scenarios and refers 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.

The student communicates information.

## 2 Unit 1: Cells and multicellular organisms

### 2.1 Unit description

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.

### 2.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

1. describe and explain cells as the basis of life, and multicellular organisms
2. apply understanding of cells as the basis of life, and multicellular organisms
3. analyse evidence about cells as the basis of life, and multicellular organisms
4. interpret evidence about cells as the basis of life, and multicellular organisms
5. investigate phenomena associated with cells as the basis of life, and multicellular organisms
6. evaluate processes, claims and conclusions about cells as the basis of life, and multicellular organisms
7. communicate understandings, findings, arguments and conclusions about cells as the basis of life, and multicellular organisms.

## 2.3 Topic 1: Cells as the basis of life

In this topic, students will:

Subject matter	Guidance
<p><b>Cell membrane</b></p> <ul style="list-style-type: none"> <li>• <b>describe</b> the structure of the cell membrane (including protein channels, phospholipids, cholesterol and glycoproteins) based on the fluid mosaic phospholipid bilayer model</li> <li>• describe how the cell membrane maintains relatively stable internal conditions via the passive movement (diffusion, osmosis) of some substances along a concentration gradient</li> <li>• <b>explain</b> how the cell membrane maintains relatively stable internal conditions via the process of active transport of a named substance against a concentration gradient</li> <li>• <b>understand</b> that endocytosis is a form of active transport that usually moves large polar molecules that cannot pass through the hydrophobic cell membrane into the cell</li> <li>• <b>recognise</b> that phagocytosis is a form of endocytosis</li> <li>• <b>predict</b> the direction of movement of materials across cell membranes based on factors such as concentration, physical and chemical nature of the materials</li> <li>• explain how the size of a cell is limited by the relationship between surface area to volume ratio and the rate of diffusion.</li> <li>• <b>Mandatory practical:</b> <b>Investigate</b> the effect of surface area to volume ratio on cell size.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours. Time allocation allows for the review of the P–10 Australian Curriculum: Science related to cells.</li> <li>• Chemical representation of molecules is not required.</li> <li>• <b>Suggested practical:</b> <b>Construct</b> a model to show the selectively permeable nature of a cell membrane (laboratory or virtual).</li> </ul>
<p><b>Prokaryotic and eukaryotic cells</b></p> <ul style="list-style-type: none"> <li>• <b>recognise</b> the requirements of all cells for survival, including <ul style="list-style-type: none"> <li>– energy sources (light or chemical)</li> <li>– matter (gases such as carbon dioxide and oxygen)</li> <li>– simple nutrients in the form of monosaccharides, disaccharides, polysaccharides</li> <li>– amino acids, fatty acids, glycerol, nucleic acids, ions and water</li> <li>– removal of wastes (carbon dioxide, oxygen, urea, ammonia, uric acid, water, ions, metabolic heat)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours</li> <li>• <b>Manipulative skills:</b> <b>Construct</b> a wet mount slide; <b>use</b> a light microscope.</li> <li>• <b>Suggested practical:</b> Use electron micrographs to <b>identify</b> organelles within cells.</li> <li>• <b>SHE:</b> Link the history of cell theory to the development of microscopes.</li> </ul>



Subject matter	Guidance
<ul style="list-style-type: none"> <li>• recognise that prokaryotic and eukaryotic cells have many features in common, which is a reflection of their common evolutionary past</li> <li>• <u>recall</u> that prokaryotic cells lack internal membrane bound organelles, do not have a nucleus, are significantly smaller than eukaryotes, usually have a single circular chromosome and exist as single cells</li> <li>• <u>understand</u> that eukaryotic cells have specialised organelles to facilitate biochemical processes <ul style="list-style-type: none"> <li>– photosynthesis (chloroplasts)</li> <li>– cellular respiration (mitochondria)</li> <li>– synthesis of complex molecules including proteins (rough endoplasmic reticulum), carbohydrates, lipids and steroids (smooth endoplasmic reticulum), pigments, tannins and polyphenols (plastids)</li> <li>– the removal of cellular products and wastes (lysosomes)</li> </ul> </li> <li>• <u>identify</u> the following structures from an electron micrograph: chloroplast, mitochondria, rough endoplasmic reticulum and lysosome</li> <li>• <u>compare</u> the structure of prokaryotes and eukaryotes.</li> <li>• <b>Mandatory practical:</b> Prepare wet mount slides and <u>use</u> a light microscope to observe cells in microorganisms, plants and animals to identify nucleus, cytoplasm, cell wall, chloroplasts and cell membrane. The student is required to <u>calculate</u> total magnification and field of view.</li> </ul>	
<p><b>Internal membranes and enzymes</b></p> <ul style="list-style-type: none"> <li>• <u>explain</u>, using an example, how the arrangement of internal membranes can control biochemical processes (e.g. folding of membrane in mitochondria increases the surface area for enzyme-controlled reactions)</li> <li>• <u>recognise</u> that biochemical processes are controlled and regulated by a series of specific enzymes</li> <li>• <u>describe</u> the structure and role of the active site of an enzyme</li> <li>• explain how reaction rates of enzymes can be affected by factors, including temperature, pH, the presence of inhibitors, and the concentrations of reactants and products.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 4 hours</li> <li>• <b>Suggested practical:</b> <u>Calculate</u> rates of enzyme reaction, investigating inhibitors or surface areas.</li> <li>• <b>SHE:</b> Compare and contrast the induced-fit and lock-and-key models of enzyme.</li> </ul>

Subject matter	Guidance
<p><b>Energy and metabolism</b></p> <ul style="list-style-type: none"> <li>• <b>recall</b> that organisms obtain the energy needed to recycle Adenosine Triphosphate (ATP) from glucose molecules in the process of cellular respiration</li> <li>• recall that the process of photosynthesis is an enzyme-controlled series of chemical reactions that occurs in the chloroplast in plant cells and uses light energy to synthesise organic compounds (glucose), and the overall process can be summarised in a balanced chemical equation</li> </ul> $  \begin{array}{ccc}  \text{carbon dioxide + water} & \xrightarrow{\text{light energy}} & \text{glucose + oxygen + water} \\  6\text{CO}_2 + 12\text{H}_2\text{O} & \xrightarrow{\text{light energy}} & \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}  \end{array}  $ <ul style="list-style-type: none"> <li>• <b>summarise</b> the process of photosynthesis in terms of the light-dependent reactions and light-independent reactions</li> <li>• <b>demonstrate</b> the relationship between the light-dependent reactions and light-independent reactions</li> <li>• <b>recognise</b> that cellular respiration is an enzyme-controlled series of chemical reactions and that the reaction sequence known as <i>aerobic respiration</i> (glycolysis, Krebs cycle and electron transfer chain) requires oxygen</li> <li>• summarise the reactions of aerobic respiration by the chemical equation <math display="block">  \begin{array}{ccc}  \text{glucose + oxygen} &amp; \longrightarrow &amp; \text{carbon dioxide + water + energy} \\  \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 &amp; \longrightarrow &amp; 6\text{CO}_2 + 6\text{H}_2\text{O} + 36\text{--}38 \text{ ATP}  \end{array}  </math> </li> <li>• recall that, with an undersupply of oxygen, ATP is produced from glucose by the reaction sequence known as <i>anaerobic respiration</i> (glycolysis with 'fermentation')</li> <li>• <b>analyse</b> multiple modes (i.e. diagrams, schematics, images) of energy transfer.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours</li> <li>• Each process of photosynthesis (light-dependent reactions and light-independent reactions, cellular respiration, glycolysis, fermentation, Krebs cycle and electron transport chain) should only be summarised in terms of total inputs and outputs and how they are interrelated.</li> <li>• <b>Recognise</b> that glycolysis is the first stage of cellular respiration occurring in the cytoplasm and the second stage occurs in the mitochondria.</li> <li>• <b>Suggested practical:</b> Measure outputs of photosynthesis and/or respiration using plants and/or yeast as examples.</li> </ul>
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Stem cell research:</b> Embryonic stem cells have the potential to be grown into specialised cells and could enable the repair or replacement of ailing organs and tissues.</li> <li>• <b>Photosynthesis and productivity:</b> Engineering or enhancement of photosynthesis has the potential to improve food and fuel production, which</li> </ul>

Subject matter	Guidance
	<p>could lead to a decrease in the reliance on fossil fuels, and improvements in agricultural sustainability.</p> <ul style="list-style-type: none"> <li>• <b>Cell membrane model development:</b> Ongoing research continues to refine the work of Singer and Nicolson's fluid mosaic model, such as research into the structure of channel proteins in the membrane.</li> </ul>

## 2.4 Topic 2: Multicellular organisms

In this topic, students will:

Subject matter	Guidance
<p><b>Cell differentiation and specialisation</b></p> <ul style="list-style-type: none"> <li>• <u>understand</u> that stem cells differ from other cells by being unspecialised, and have properties of self-renewal and potency</li> <li>• <u>recognise</u> that stem cells differentiate into specialised cells to form tissues and organs in multicellular organisms</li> <li>• recognise that multicellular organisms have a hierarchical structural organisation of cells, tissues, organs and systems.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 3 hours</li> <li>• <b>Suggested practical:</b> <u>Use</u> examples from plants and animals to <u>explain</u> the organisation of cells into tissues, organs and systems.</li> <li>• <b>SHE:</b> <u>Discuss</u> the use of adult and embryonic stem cells in medical technology. <u>Analyse data</u> and <u>evaluate</u> a range of alternative perspectives on the use of stem cell research by considering a range of scientific media and texts.</li> <li>• The interdependence of organ systems should focus on how they facilitate the efficient provision or removal of materials to and from all cells of the organism.</li> </ul>
<p><b>Gas exchange and transport</b></p> <ul style="list-style-type: none"> <li>• <u>explain</u> the relationship between the structural features (large surface area, moist, one or two cells thick and surrounded by an extensive capillary system) and function of gaseous exchange surfaces (alveoli and gills) in terms of exchange of gases (oxygen, carbon dioxide)</li> <li>• explain how the structure and function of capillaries facilitates the exchange of materials (water, oxygen, carbon dioxide, ions and nutrients) between the internal environment and cells</li> <li>• <u>use data</u> presented as diagrams, schematics and tables to <u>predict</u> the direction in which materials will be exchanged between <ul style="list-style-type: none"> <li>– alveoli and capillaries</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 7 hours</li> <li>• Oxygen-haemoglobin dissociation curve graphs could be interpreted to support analysis of gas exchange data.</li> </ul>

Subject matter	Guidance
<ul style="list-style-type: none"> <li>– capillaries and muscle tissue.</li> </ul>	
<p><b>Exchange of nutrients and wastes</b></p> <ul style="list-style-type: none"> <li>• <u>identify</u> the characteristics of absorptive surfaces within the digestive system and relate to the structure and function of the villi</li> <li>• <u>describe</u> the role of digestive enzymes (amylase, protease, lipase) in chemical digestion</li> <li>• <u>recognise</u> the different types of nitrogenous wastes produced by the breakdown of proteins</li> <li>• <u>explain</u> the function of each of the sections of the nephron and its function in the production of urine (glomerulus, Bowman's capsule, proximal and distal tubules, Loop of Henle, collecting tubule)</li> <li>• explain how glomerular filtration, selective reabsorption and secretion across nephron membranes contribute to removal of waste.</li> <li>• <b>Mandatory practical:</b> <u>Investigate</u> the effect of temperature on the rate of reaction of an enzyme.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 7 hours</li> <li>• <b>Suggested practical:</b> <u>Investigate</u> the effect of pH on the rate of reaction of an enzyme (e.g. catalase, lipase, amylase). The concentration of substrate could also be considered.</li> <li>• The function of the Loop of Henle should be discussed in terms of the countercurrent system for the production of concentrated urine.</li> </ul>
<p><b>Plant systems — gas exchange and transport systems</b></p> <ul style="list-style-type: none"> <li>• <u>describe</u> the role of stomata and guard cells in controlling the movement of gases (oxygen, carbon dioxide and water vapour) in leaves</li> <li>• <u>explain</u> how the leaf facilitates that gas exchange (oxygen, carbon dioxide and water vapour) in plants</li> <li>• explain the relationship between photosynthesis and the main tissues of leaves (spongy and palisade mesophyll, epidermis, cuticle and vascular bundles)</li> <li>• <u>describe</u> and <u>contrast</u> the structure and function of xylem and phloem tissue (sieve tubes, sieve plates, companion cells)</li> <li>• explain how water and dissolved minerals move through xylem via the roles of root pressure, transpiration stream and cohesion of water molecules</li> <li>• <u>discuss</u> the factors (light, temperature, wind, humidity) that influence the rate of transpiration</li> <li>• explain the transport of products of photosynthesis and some mineral nutrients via translocation in the phloem.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours.</li> <li>• <b>Suggested practical:</b> <u>Investigate</u> the conditions necessary for photosynthesis, e.g. <u>compare</u> starch present in normal, variegated and de-starched leaves.</li> <li>• <b>Manipulative skill:</b> Extract chlorophyll from leaves (qualitative and/or quantitative measurement of rate of photosynthesis under different conditions).</li> <li>• <b>Manipulative skill:</b> Remove the epidermis of the leaf, cut both cross-sections and vertical sections of stem, make wet mounts with the prepared tissue and use the microscope to view mounts.</li> <li>• <b>Suggested practical:</b> Make wet mount slides of the leaf epidermal layer to <u>identify</u>, draw and label stomata, guard cells and epidermal cells and/or view pre-prepared slides; investigate differences in number of stomata in upper and lower epidermis of the leaf and between different species.</li> <li>• <b>Suggested practical:</b> <u>Create</u> models to <u>demonstrate</u> the action of guard cells of stoma (e.g. balloon model).</li> <li>• <b>Suggested practical:</b> View and identify prepared slides (mesophyll, xylem</li> </ul>

Subject matter	Guidance
	<p>and phloem) in cross-sections of leaves, stems and roots.</p> <ul style="list-style-type: none"> <li>• <b>Suggested practical:</b> Investigate the factors affecting the rates of transpiration using a potometer.</li> <li>• <b>Suggested practical:</b> <u>Use</u> different diameter capillary tubes to demonstrate cohesion and adhesion forces in water.</li> </ul>
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Animal ethics:</b> Ethical treatment of animals as sentient, feeling 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.</li> <li>• <b>Organ and tissue transplantation:</b> The increased demand for transplantation has led to illegal organ and tissue trafficking, forced donation and 'transplantation tourism', where individuals travel to other countries where it is easier or cheaper to obtain a transplant. These situations may involve violation of human rights and exploitation of the poor, and pose many ethical concerns.</li> <li>• <b>Bioartificial organs:</b> Cells from a patient or a stem cell bank can be used to produce bioartificial tissues and organs as an alternative to donor tissues and organs.</li> </ul>

## 2.5 Assessment guidance

In constructing assessment instruments for Unit 1, schools should ensure that the objectives cover, or are chosen from, the unit objectives. If one assessment instrument is developed for a unit, it must assess all the unit objectives; if more than one assessment instrument is developed, the unit objectives must be covered across those instruments.

It is suggested that student performance on Unit 1 is assessed using a student experiment and data test modelled on the techniques used in Unit 3 and 4, and an examination covering Unit 1 and 2 subject matter to be held at the conclusion of Units 1 and 2.

## 3 Unit 2: Maintaining the internal environment

### 3.1 Unit description

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.

### 3.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

1. describe and explain homeostasis and infectious disease
2. apply understanding of homeostasis and infectious disease
3. analyse evidence about homeostasis and infectious disease
4. interpret evidence about homeostasis and infectious disease
5. investigate phenomena associated with homeostasis and infectious disease
6. evaluate processes, claims and conclusions about homeostasis and infectious disease
7. communicate understandings, findings, arguments and conclusions about homeostasis and infectious disease.

## 3.3 Topic 1: Homeostasis

In this topic, students will:

Subject matter	Guidance
<p><b>Homeostasis</b></p> <ul style="list-style-type: none"> <li>• <u>recall</u> that homeostasis involves a stimulus-response model in which change in the condition of the external or internal environment is detected and appropriate responses occur via negative feedback</li> <li>• <u>recognise</u> that sensory receptors (chemo, thermos, mechano, photo, noci) detect stimuli and can be classified by the type of stimulus</li> <li>• <u>recall</u> that effectors are either muscles (which contract in response to neural stimuli) or glands (which produce secretions)</li> <li>• <u>interpret</u> feedback control diagrams for either nervous or hormonal systems (i.e. recognise stimulus, receptors, control centre, effector and communication pathways)</li> <li>• <u>understand</u> that metabolism describes all of the chemical reactions involved in sustaining life and is either catabolic or anabolic</li> <li>• <u>explain</u> why changes in metabolic activity alter the optimum conditions for catalytic activity of enzymes (with reference to tolerance limits).</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 4 hours</li> <li>• <i>Tolerance limits</i> can also be referred to as <i>tolerance range</i>.</li> <li>• <b>Suggested practical:</b> <u>Investigate</u> tolerance limits for water or salt balance on plant growth.</li> <li>• Examples of feedback control diagrams could include proprioception, thermoregulation, osmoregulation or glucose regulation.</li> </ul>
<p><b>Neural homeostatic control pathways</b></p> <ul style="list-style-type: none"> <li>• <u>identify</u> cells that transport nerve impulses from sensory receptors to neurons to effectors</li> <li>• <u>discriminate</u> between a sensory neurone and a motor neurone (consider dendrites, soma, body, axon, myelin sheath, nodes of Ranvier, axon terminal and synapse)</li> <li>• <u>explain</u> the process of the passage of a nerve impulse in terms of transmission of an action potential (conduction within neuron) and synaptic transmission (communication between neurones). Refer to neurotransmitters, receptors, synaptic cleft, vesicles, postsynaptic and presynaptic neurones and signal transduction.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 5 hours</li> <li>• <b>Suggested practical:</b> <u>Examine</u> a virtual nerve impulse.</li> <li>• <b>Suggested practical:</b> <u>Investigate</u> simple reflex arcs.</li> </ul>



Subject matter	Guidance
<p><b>Hormonal homeostatic control pathways</b></p> <ul style="list-style-type: none"> <li>• <u>recall</u> that hormones are chemical messengers (produced mostly in endocrine glands) that relay messages to cells displaying specific receptors for each hormone via the circulatory or lymphatic system</li> <li>• <u>recognise</u> how a cell's sensitivity to a specific hormone is directly related to the number of receptors it displays for that hormone (an increase in receptors = upregulation, a decrease = downregulation)</li> <li>• <u>describe</u> how receptor binding activates a signal transduction mechanism and alters cellular activity (results in an increase or decrease in normal processes).</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 5 hours</li> </ul>
<p><b>Thermoregulation</b></p> <ul style="list-style-type: none"> <li>• <u>identify</u> and <u>explain</u> the varying thermoregulatory mechanisms of endotherms and how they control heat exchange and metabolic activity in terms of <ul style="list-style-type: none"> <li>– structural features (brown adipose tissue, increased number of mitochondria per cell, insulation)</li> <li>– behavioural responses (kleptothermy, hibernation, aestivation and torpor)</li> <li>– physiological mechanisms (vasomotor control, evaporative heat loss, countercurrent heat exchange, thermogenesis/metabolic activity from organs and tissues)</li> <li>– homeostatic mechanisms (thyroid hormones, insulin).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 5 hours</li> <li>• Behavioural responses also include consumption of water and changing habitat/location. The student should <u>understand</u> these responses but is not required to <u>recall</u> them.</li> </ul>
<p><b>Osmoregulation</b></p> <ul style="list-style-type: none"> <li>• <u>identify</u> and <u>explain</u> the various homeostatic mechanisms that maintain water balance in animals (osmoregulators and osmoconformers) in terms of <ul style="list-style-type: none"> <li>– structural features (excretory system)</li> <li>– behavioural responses</li> <li>– physiological mechanisms</li> <li>– homeostatic mechanisms (antidiuretic hormone (ADH) and the kidney)</li> </ul> </li> <li>• identify and explain the various mechanisms that maintain water balance in plants in terms of structural features (stomata, vacuoles, cuticle) and homeostatic mechanisms (abscisic acid); consider xerophytes, hydrophytes, halophytes and mesophytes in responses.</li> <li>• <b>Mandatory practical:</b> <u>Compare</u> the distribution of stomata and guard cells in plants adapted to different environments (aquatic, terrestrial) as an adaptation for osmoregulation in plant tissue.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 5 hours</li> <li>• <b>Manipulative skill:</b> Prepare wet mounts of leaf cuticle tissue from different species of plants and use a microscope to make observations.</li> </ul>

Subject matter	Guidance
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.</li> </ul>	<ul style="list-style-type: none"> <li><b>Modelling human thermoregulation:</b> Models of human thermoregulatory responses can be used in the design of clothing, environments and safety regulations.</li> <li><b>Use of hormones in the dairy industry (rBST):</b> Growth hormones and other hormones are used in the livestock industry to increase productivity (while reducing production costs and increasing food affordability), but further evidence is required to determine associated risks.</li> <li><b>Snake antivenom production:</b> Production of antivenoms, through the use of synthetic DNA to produce an antibody response, could replace conventional methods of 'milking' venomous animals.</li> </ul>

## 3.4 Topic 2: Infectious disease

In this topic, students will:

Subject matter	Guidance
<p><b>Infectious disease</b></p> <ul style="list-style-type: none"> <li><u>identify</u> the difference between infectious diseases (invasion by a pathogen and can be transmitted from one host to another) and non-infectious diseases (genetic and lifestyle diseases)</li> <li>identify the following pathogens: prions, viruses, bacteria, fungi, protists and parasites</li> <li><u>describe</u> the following virulence factors that aid in pathogenesis: adherence factors, invasion factors, capsules, toxins and lifecycle changes</li> <li>identify from given <u>data</u> and describe the following modes of disease transmission: direct contact, contact with body fluids, contaminated food, water and disease-specific vectors.</li> <li><b>Mandatory practical:</b> <u>Investigate</u> the effect of an antimicrobial on the growth of a microbiological organism (via the measurement of zones of inhibition) — laboratory or virtual.</li> </ul>	<ul style="list-style-type: none"> <li><b>Notional time:</b> 6 hours</li> <li>Virulence factors do not need to be described biochemically.</li> <li><b>SHE:</b> Explore the historical development of our understanding of the nature of disease transmission (e.g. the work of Koch and Semmelweis).</li> </ul>

Subject matter	Guidance
<p><b>Immune response and defence against disease</b></p> <ul style="list-style-type: none"> <li>• <b>understand</b> how pathogens (bacterial and viral) can cause both physical and chemical changes in host cells that stimulate the host immune responses (introduction of foreign chemicals via the surface of the pathogen, production of toxins, recognition of self and non-self)</li> <li>• <b>recognise</b> that all plants and animals have innate immune responses (general/non-specific) and that vertebrates also have adaptive (specific) immune responses</li> <li>• <b>recall</b> examples of physical defence strategies (barriers and leaf structures) and chemical defence strategies (plant defensins and production of toxins) of plants in response to the presence of pathogens</li> <li>• recall that the innate immune response in vertebrates comprises surface barriers (skin, mucus and cilia), inflammation and the complement system</li> <li>• <b>describe</b> the inflammatory response (prostaglandins, vasodilation, phagocytes) and the role of the complement system</li> <li>• <b>explain</b> the adaptive immune responses in vertebrates — humoral (production of antibodies by B lymphocytes) and cell-mediated (T lymphocytes) — and recognise that memory cells are produced in both situations</li> <li>• <b>interpret</b> long-term immune response <b>data</b></li> <li>• <b>analyse</b> the differences and similarities between passive immunity (antibodies gained via the placenta and via antibody serum injection) and active immunity (acquired via natural exposure to a pathogen or through the use of vaccines) for both naturally and artificially acquired immunity.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 9 hours</li> <li>• Examples of plant chemical defences could include pyrethrins.</li> <li>• <b>SHE:</b> Long-term and short-term immunity could be contextualised with current vaccination practices and controversies.</li> <li>• <b>SHE:</b> Extension of long-term immunity could include comparison of individual and population immunities of different geographical and demographical populations.</li> <li>• <b>SHE:</b> Analyse longitudinal health programs for the prevention and eradication of infectious diseases (e.g. smallpox, influenza).</li> <li>• <b>SHE:</b> Discuss the factors influencing organ donor suitability, organ transplant, immunosuppression and rejection with the focus on the physiological immune responses and evaluation of individual, social and cultural considerations.</li> </ul>

Subject matter	Guidance
<p><b>Transmission and spread of disease (epidemiology)</b></p> <ul style="list-style-type: none"> <li>• <b>recognise</b> that the transmission of disease is facilitated by regional and global movement of organisms</li> <li>• <b>identify</b> the interrelated factors affecting immunity (persistence of pathogens within host, transmission mechanism, proportion of the population that is immune or has been immunised, mobility of individuals in the affected population)</li> <li>• <b>analyse</b> these factors to <b>predict</b> potential outbreaks</li> <li>• <b>evaluate</b> strategies to control the spread of disease <ul style="list-style-type: none"> <li>– personal hygiene measures</li> <li>– community level: contact tracing and quarantine, school and workplace closures, reduction of mass gatherings, temperature screening and travel restrictions</li> </ul> </li> <li>• <b>make decisions</b> and <b>justify</b> them in regard to best practice for the prevention of disease outbreaks based on the <b>critical</b> analysis of <b>relevant</b> and current information</li> <li>• <b>interpret data</b> for the modelling of the spread of disease using secondary data or computer simulations.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours</li> <li>• Analysis of the spread and control of disease could include hand hygiene, quarantine, biosecurity measures for the prevention of the spread of polio, smallpox, influenza, Ebola, cholera, bird flu, malaria.</li> <li>• <b>Suggested practical:</b> Using agar plates or another modelling activity, <b>investigate</b> the efficiency of hand washing compared to alcohol-based antiseptic gels for reducing bacterial load on hands.</li> </ul>
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Modelling disease outbreak and spread:</b> Mass vaccination programs are more successful when informed by disease outbreak models.</li> <li>• <b>Managing pandemics in the Asia region:</b> Asia has been described as being more susceptible to epidemics and pandemics of infectious diseases due to increasing migration and global travel, high population density in urban areas and underdeveloped healthcare systems in some countries. The high cost of drugs and vaccines presents a particular challenge for developing countries in Asia, as does community mistrust of vaccination.</li> <li>• <b>Quarantine and biosecurity:</b> 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.</li> </ul>

## 3.5 Assessment guidance

In constructing assessment instruments for Unit 2, schools should ensure that the objectives cover, or are chosen from, the unit objectives. If one assessment instrument is developed for a unit, it must assess all the unit objectives; if more than one assessment instrument is developed, the unit objectives must be covered across those instruments.

It is suggested that student performance on Unit 2 is assessed using a research investigation modelled on the techniques used in Unit 4 and an examination covering Unit 1 and 2 subject matter to be held at the conclusion of Units 1 and 2.

## 4 Unit 3: Biodiversity and the interconnectedness of life

### 4.1 Unit description

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.

## 4.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

Unit objective	IA1	IA2	EA
1. <u>describe</u> and <u>explain</u> biodiversity and ecosystem dynamics			•
2. <u>apply understanding</u> of biodiversity and ecosystem dynamics	•	•	•
3. <u>analyse evidence</u> about biodiversity and ecosystem dynamics	•	•	•
4. <u>interpret evidence</u> about biodiversity and ecosystem dynamics	•	•	•
5. <u>investigate phenomena</u> associated with biodiversity and ecosystem dynamics		•	
6. <u>evaluate processes, claims and conclusions</u> about biodiversity and ecosystem dynamics		•	
7. <u>communicate understandings, findings, arguments</u> and conclusions about biodiversity and ecosystem dynamics.		•	

## 4.3 Topic 1: Describing biodiversity

In this topic, students will:

Subject matter	Guidance
<p><b>Biodiversity</b></p> <ul style="list-style-type: none"> <li>• <u>recognise</u> that biodiversity includes the diversity of species and ecosystems</li> <li>• <u>determine</u> diversity of species using measures such as species richness, evenness (relative species abundance), percentage cover, percentage frequency and Simpson's diversity index</li> <li>• use species diversity indices, species interactions (predation, competition, symbiosis, disease) and abiotic factors (climate, substrate, size/depth of area) to <u>compare</u> ecosystems across spatial and temporal scales</li> <li>• <u>explain</u> how environmental factors limit the distribution and abundance of species in an ecosystem.</li> <li>• <b>Mandatory practical:</b> Determine species diversity of a group of organisms based on a given index.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 9 hours</li> <li>• <u>Use</u> local context throughout the unit to develop the content objectives.</li> <li>• Diversity indices and measurements should be supported through <u>fieldwork</u> and based on classification. Measures of biodiversity, i.e. species richness (S) and Simpson's diversity index (D) should be used where applicable.</li> <li>• <b>Formula:</b> The formula used to quantify biodiversity of a habitat is Simpson's diversity index (SDI), shown as:  <math display="block">SDI = 1 - \left( \frac{\sum n(n-1)}{N(N-1)} \right)</math> <p>where:  <i>N</i> = total number of organisms of all species  <i>n</i> = number of organisms of one species</p> </li> <li>• <b>Manipulative skill:</b> Use <u>appropriate</u> technology, such as data loggers, chemical tests, turbidity tubes and other equipment to measure factors.</li> <li>• <b>Suggested practical:</b> Measure abiotic factors in the classroom using field samples (e.g. pH, nitrogen nutrients, salinity, carbonates, turbidity).</li> <li>• <b>Suggested practical:</b> Measure abiotic factors in the field (e.g. dissolved oxygen, light, temperature, wind speed, infiltration rate).</li> </ul>
<p><b>Classification processes</b></p> <ul style="list-style-type: none"> <li>• <u>recognise</u> that biological classification can be hierarchical and based on different levels of similarity of physical features, methods of reproduction and molecular sequences</li> <li>• <u>describe</u> the classification systems for <ul style="list-style-type: none"> <li>– similarity of physical features (the Linnaean system)</li> <li>– methods of reproduction (asexual, sexual — K and r selection)</li> <li>– molecular sequences (molecular phylogeny — also called cladistics)</li> </ul> </li> <li>• <u>define</u> the term <u>clade</u></li> <li>• <u>recall</u> that common assumptions of cladistics include a common ancestry, bifurcation and physical change</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 12 hours</li> <li>• Students should <u>understand</u> that the concept of classification is directly related to the purpose for which the <u>data</u> will be used.</li> <li>• Students should <u>recognise</u> that the Linnean system does not rely solely on physical features for classification.</li> <li>• Classification should be supported by the analysis of field data.</li> <li>• Students should recognise that conserved sequences (e.g. mitochondrial DNA) are assumed to accumulate mutations at a constant rate over time and, therefore, provide a method for dating divergence.</li> <li>• <u>Identification</u> of applications of molecular phylogeny (DNA barcoding and</li> </ul>



Subject matter	Guidance
<ul style="list-style-type: none"> <li>• <u>interpret</u> cladograms to <u>infer</u> the evolutionary relatedness between groups of organisms</li> <li>• <u>analyse data</u> from molecular sequences to infer species evolutionary relatedness</li> <li>• recognise the need for multiple definitions of species</li> <li>• <u>identify</u> one example of an interspecific hybrid that does not produce fertile offspring (e.g. mule, <i>Equus mulus</i>)</li> <li>• <u>explain</u> the classification of organisms according to the following species interactions: predation, competition, symbiosis and disease</li> <li>• <u>understand</u> that ecosystems are composed of varied habitats (microhabitat to ecoregion)</li> <li>• interpret data to <u>classify</u> and name an ecosystem</li> <li>• explain how the process of classifying ecosystems is an important step towards effective ecosystem management (consider old-growth forests, productive soils and coral reefs)</li> <li>• describe the process of stratified sampling in terms of <ul style="list-style-type: none"> <li>– purpose (estimating population, density, distribution, environmental gradients and profiles, zonation, stratification)</li> <li>– site selection</li> <li>– choice of ecological surveying technique (quadrats, transects)</li> <li>– minimising bias (size and number of samples, random-number generators, counting criteria, calibrating equipment and noting associated precision)</li> <li>– methods of data presentation and analysis.</li> </ul> </li> <li>• <b>Mandatory practical:</b> <u>Use</u> the process of stratified sampling to <u>collect</u> and analyse primary biotic and abiotic field data to classify an ecosystem.</li> </ul>	<p>genetic testing) should be linked to understanding of subject matter in Unit 4.</p> <ul style="list-style-type: none"> <li>• Refer to the glossary for a definition of <u>clade</u>.</li> <li>• Students should be familiar with the <u>limitations</u> of different definitions of species, e.g. biological species concept and phylogenetic species concept.</li> <li>• Classification of ecosystems could be based on the Holdridge life zone classification scheme, Specht's classification system, ANAE classification system or EUNIS habitat classification system.</li> </ul>
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Technology as a tool to measure, analyse and monitor biodiversity:</b> Advances in remote sensing radar imagery and satellite tracking in real time have enabled scientists to measure and monitor populations, and play a significant role in surveying and monitoring large or inaccessible ecosystems.</li> <li>• <b>International biodiversity protection:</b> International agreements about biodiversity protection, such as the World Heritage Convention, are based on the premise that local, regional and international biodiversity represent a global resource, vital for human survival, that should be maintained for future generations.</li> </ul>

Subject matter	Guidance
	<ul style="list-style-type: none"> <li>• <b>Biodiversity targets:</b> Setting agreed biodiversity targets is required to achieve positive international action towards biodiversity conservation by reducing the rate of biodiversity loss at global, regional and national levels.</li> </ul>

## 4.4 Topic 2: Ecosystem dynamics

In this topic, students will:

Subject matter	Guidance
<p><b>Functioning ecosystems</b></p> <ul style="list-style-type: none"> <li>• <u>sequence</u> and <u>explain</u> the transfer and transformation of solar energy into biomass as it flows through biotic components of an ecosystem, including             <ul style="list-style-type: none"> <li>– converting light to chemical energy</li> <li>– producing biomass and interacting with components of the carbon cycle</li> </ul> </li> <li>• <u>analyse</u> and <u>calculate</u> energy transfer (food chains, webs and pyramids) and transformations within ecosystems, including             <ul style="list-style-type: none"> <li>– loss of energy through radiation, reflection and absorption</li> <li>– efficiencies of energy transfer from one trophic level to another</li> <li>– biomass</li> </ul> </li> <li>• <u>construct</u> and analyse simple energy-flow diagrams illustrating the movement of energy through ecosystems, including the productivity (gross and net) of the various trophic levels</li> <li>• <u>describe</u> the transfer and transformation of matter as it cycles through ecosystems (water, carbon and nitrogen)</li> <li>• <u>define</u> <i>ecological niche</i> in terms of habitat, feeding relationships and interactions with other species</li> <li>• <u>understand</u> the competitive exclusion principle</li> <li>• <u>analyse data</u> to <u>identify</u> species (including microorganisms) or populations occupying an ecological niche</li> <li>• <u>define</u> <i>keystone species</i> and understand the critical role they play in maintaining the structure of a community</li> <li>• <u>analyse data</u> (from an Australian ecosystem) to identify a keystone species and <u>predict</u> the outcomes of removing the species from an ecosystem.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 12 hours</li> <li>• Energy transfers through ecosystems should be <u>demonstrated</u> using food chains, webs and pyramids.</li> <li>• A detailed description and <u>understanding</u> of the multiple biochemical steps in photosynthesis and respiration (from Unit 1) is not required. Gross inputs and outputs are required.</li> <li>• Interactions between the biotic and abiotic components of the ecosystem should be represented through food webs, biomass pyramids, the water cycle and biogeochemical cycles — carbon and nitrogen.</li> <li>• <u>Fieldwork</u> should be used to <u>develop</u> scientific skills and <u>collect data</u>, as well as to develop student <u>understanding</u> of <u>concepts</u>, especially abiotic–biotic <u>relationships</u> and biotic–biotic relationships.</li> <li>• Refer to the glossary for a definition of <i>ecological niche</i> and <i>keystone species</i>.</li> <li>• <b>Suggested practical:</b> Study the abundance of each trophic level in a simple food chain.</li> <li>• <b>Suggested practical:</b> Measure the wet biomass of producer samples.</li> <li>• <b>Suggested practical:</b> <u>Test</u> the competitive exclusion principle hypothesis by studying vertical zonation on a tree.</li> <li>• <b>Suggested practical:</b> Carry out a longitudinal study of a keystone species and <u>relevant</u> ecological interactions.</li> </ul>

Subject matter	Guidance
<p><b>Population ecology</b></p> <ul style="list-style-type: none"> <li>• <b>define</b> the term <i>carrying capacity</i></li> <li>• <b>explain</b> why the carrying capacity of a population is determined by limiting factors (biotic and abiotic)</li> <li>• <b>calculate</b> population growth rate and change (using birth, death, immigration and emigration data)</li> <li>• <b>use</b> the Lincoln Index to estimate population size from secondary or primary data</li> <li>• <b>analyse</b> population growth data to <b>determine</b> the mode (exponential growth J-curve, logistic growth S-curve) of population growth</li> <li>• <b>discuss</b> the effect of changes within population-limiting factors on the carrying capacity of the ecosystem.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 4 hours</li> <li>• Refer to the glossary for a definition of <i>carrying capacity</i>.</li> <li>• Limiting factors of population growth should include <ul style="list-style-type: none"> <li>– biotic factors — competition for resources, predation and disease</li> <li>– abiotic factors — space, availability of nutrients, pollution, natural disasters, extreme climatic events (drought, cyclones, global temperature change).</li> </ul> </li> <li>• <b>Formula:</b> The formula for estimation of population size by the capture–recapture measure is the Lincoln index, shown as: <math display="block">N = \frac{M \times n}{m}</math> <p>where:</p> <p><i>M</i> = number of individuals caught, marked and released initially</p> <p><i>n</i> = number of individuals caught on second sampling</p> <p><i>m</i> = number of individuals recaptured that were marked</p> </li> <li>• <b>Suggested practical:</b> <b>Conduct</b> an abundance and distribution study, including abiotic and biotic factors.</li> <li>• <b>Suggested practical:</b> Measure the population of microorganisms in Petri dishes to observe carrying capacity.</li> </ul>
<p><b>Changing ecosystems</b></p> <ul style="list-style-type: none"> <li>• <b>explain</b> the <b>concept</b> of ecological succession (refer to pioneer and climax communities and seres)</li> <li>• <b>differentiate</b> between the two main modes of succession: primary and secondary</li> <li>• <b>identify</b> the features of pioneer species (ability to fixate nitrogen, tolerance to extreme conditions, rapid germination of seeds, ability to photosynthesise) that make them <b>effective</b> colonisers</li> <li>• <b>analyse data</b> from the fossil record to observe past ecosystems and changes in biotic and abiotic components</li> <li>• analyse ecological data to <b>predict</b> temporal and spatial successional changes</li> <li>• predict the impact of human activity on the reduction of biodiversity and on the magnitude, duration and speed of ecosystem change.</li> <li>• <b>Mandatory practical:</b> <b>Select</b> and <b>appraise</b> an ecological surveying technique</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 8 hours</li> <li>• Predictions of succession could be based on r-selected species versus K-selected species, biodiversity, biomass, or changes in biotic and abiotic interactions.</li> <li>• Human activities could include overexploitation, habitat destruction, monocultures or pollution.</li> </ul>

Subject matter	Guidance
to analyse species diversity between two spatially variant ecosystems of the same classification (e.g. a disturbed and undisturbed dry sclerophyll forest).	
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Aboriginal knowledge and Torres Strait Islander knowledge of ecosystem interactions and change:</b> Aboriginal communities and Torres Strait Islander communities have knowledge of environmental change and interactions between abiotic and biotic elements of ecosystems in their local contexts. This can provide valuable data for understanding ecosystem dynamics, which can complement practices in conservation areas.</li> <li>• <b>Marine reserves:</b> Scientific knowledge based on local data collection and analysis, computer simulation of future scenarios and analysis of analogous scenarios is required to analyse the unique factors that affect marine ecosystems to classify areas and predict the likelihood that the reserve will successfully protect marine biodiversity.</li> <li>• <b>Keystone species and conservation:</b> Keystone species can be more effective as a conservation strategy to maintain complex ecosystem dynamics compared with other strategies such as conservation of flagship species and umbrella species.</li> </ul>

## 4.5 Assessment

### 4.5.1 Summative internal assessment 1 (IA1): Data test (10%)

#### Description

This assessment focuses on the application of a range of cognitions to multiple provided items.

Student responses must be completed individually, under supervised conditions, and in a set timeframe.

#### Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

2. apply understanding of biodiversity or ecosystem dynamics to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features
3. analyse evidence about biodiversity or ecosystem dynamics to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about biodiversity or ecosystem dynamics to draw conclusions based on analysis of datasets.

**Note:** Objectives 1, 5, 6 and 7 are not assessed in this instrument.

#### Specifications

##### Description

Students respond to items using qualitative data and/or quantitative data derived from the mandatory or suggested practicals, activities or case studies from the unit being studied.

The data test contains two to four datasets consists of a number of different types of items, which include:

- short response items requiring single-word, sentence or short paragraph responses
- calculating using algorithms
- interpreting datasets.

## Mark allocations

Percentage of marks	Objective	Cognition and nature of response
~ 30%	2. <u>apply understanding</u> of biodiversity or ecosystem dynamics to given algebraic, visual or graphical <u>representations</u> of <u>scientific relationships</u> and <u>data</u> to <u>determine</u> unknown scientific <u>quantities</u> or <u>features</u>	Students <u>calculate</u> , <u>identify</u> , <u>recognise</u> and <u>use evidence</u> to <u>determine</u> unknown scientific <u>quantities</u> or <u>features</u> .
~ 30%	3. <u>analyse evidence</u> about biodiversity or ecosystem dynamics to <u>identify trends</u> , <u>patterns</u> , <u>relationships</u> , <u>limitations</u> or <u>uncertainty</u> in datasets	Students <u>categorise</u> , <u>classify</u> , <u>contrast</u> , <u>distinguish</u> , <u>organise</u> or <u>sequence evidence</u> to <u>identify trends</u> , <u>patterns</u> , <u>relationships</u> , <u>limitations</u> or <u>uncertainty</u> in datasets.
~ 40%	4. <u>interpret evidence</u> about biodiversity or ecosystem dynamics to <u>draw conclusions</u> based on analysis of datasets	Students <u>compare</u> , <u>deduce</u> , <u>extrapolate</u> , <u>infer</u> , <u>justify</u> or <u>predict</u> using <u>evidence</u> to <u>draw conclusions</u> based on <u>analysis</u> of the <u>datasets</u> .

## Conditions

- Time: 60 minutes plus 10 minutes perusal.
- Length: up to 500 words in total, consisting of
  - short responses, i.e. single words, sentences or short paragraphs (fewer than 50 words)
  - paragraphs, 50–250 words per item
  - other types of item responses (e.g. interpreting and calculating) should allow students to complete the response in the set time.
- Other:
  - QCAA-approved graphics calculator permitted
  - unseen stimulus.

## Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the data test.

Criterion	Objectives	Marks
Data test	2, 3 and 4	10
<b>Total</b>		<b>10</b>

**Note:** Unit objectives 1, 5, 6 and 7 are not assessed in this instrument.

## Instrument-specific marking guide

### Criterion: Data test

#### Assessment objectives

2. apply understanding of biodiversity or ecosystem dynamics to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features
3. analyse evidence about biodiversity or ecosystem dynamics to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about biodiversity or ecosystem dynamics to draw conclusions based on analysis of datasets

The student work has the following characteristics:	Cut-off	Marks
<ul style="list-style-type: none"> <li>• <u>consistent</u> demonstration, across a range of scenarios about biodiversity or ecosystem dynamics, of               <ul style="list-style-type: none"> <li>– <u>selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications</u></li> <li>– <u>correct calculation of quantities</u> through the use of algebraic, visual and graphical <u>representations of scientific relationships and data</u></li> <li>– <u>correct and appropriate use of analytical techniques</u> to correctly <u>identify trends, patterns, relationships, limitations and uncertainty</u></li> <li>– <u>correct interpretation of evidence</u> to draw <u>valid conclusions</u>.</li> </ul> </li> </ul>	> 90%	10
	> 80%	9
<ul style="list-style-type: none"> <li>• <u>consistent</u> demonstration, in scenarios about biodiversity or ecosystem dynamics, of               <ul style="list-style-type: none"> <li>– <u>selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications</u></li> <li>– <u>correct calculation of quantities</u> through the use of algebraic, visual and graphical <u>representations of scientific relationships and data</u></li> <li>– <u>correct use of analytical techniques</u> to correctly <u>identify trends, patterns, relationships, limitations and uncertainty</u></li> <li>– <u>correct interpretation of evidence</u> to draw <u>valid conclusions</u>.</li> </ul> </li> </ul>	> 70%	8
	> 60%	7
<ul style="list-style-type: none"> <li>• <u>adequate</u> demonstration, in scenarios about biodiversity or ecosystem dynamics, of               <ul style="list-style-type: none"> <li>– <u>selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications</u></li> <li>– <u>correct calculation of quantities</u> through the use of algebraic, visual and graphical <u>representations of scientific relationships and data</u></li> <li>– <u>correct use of analytical techniques</u> to correctly <u>identify trends, patterns, relationships, limitations and uncertainty</u></li> <li>– <u>correct interpretation of evidence</u> to draw <u>valid conclusions</u>.</li> </ul> </li> </ul>	> 50%	6
	> 40%	5
<ul style="list-style-type: none"> <li>• Demonstration, in scenarios about biodiversity or ecosystem dynamics, of elements of               <ul style="list-style-type: none"> <li>– <u>selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications</u></li> <li>– <u>correct calculation of quantities</u> through the use of algebraic, visual or graphical <u>representations of scientific relationships or data</u></li> <li>– <u>correct use of analytical techniques</u> to correctly <u>identify trends, patterns, relationships, limitations or uncertainty</u></li> <li>– <u>correct interpretation of evidence</u> to draw <u>valid conclusions</u>.</li> </ul> </li> </ul>	> 30%	4
	> 20%	3

<ul style="list-style-type: none"> <li>• Demonstration, in scenarios about biodiversity or ecosystem dynamics, of elements of               <ul style="list-style-type: none"> <li>– <u>application of scientific concepts, theories, models or systems to predict outcomes, behaviours or implications</u></li> <li>– <u>calculation of quantities through the use of algebraic or graphical representations of scientific relationships and data</u></li> <li>– <u>use of analytical techniques to identify trends, patterns, relationships, limitations or uncertainty</u></li> <li>– <u>interpretation of evidence to draw conclusions.</u></li> </ul> </li> </ul>	> 10%	2
	> 1%	1
<ul style="list-style-type: none"> <li>• does not satisfy any of the descriptors above.</li> </ul>	≤ 1%	0



## 4.5.2 Summative internal assessment 2 (IA2): Student experiment (20%)

### Description

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

### Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

2. apply understanding of biodiversity or ecosystem dynamics to modify experimental methodologies and process primary data
3. analyse experimental evidence about biodiversity or ecosystem dynamics
4. interpret experimental evidence about biodiversity or ecosystem dynamics
5. investigate phenomena associated with biodiversity or ecosystem dynamics through an experiment
6. evaluate experimental processes and conclusions about biodiversity or ecosystem dynamics
7. communicate understandings and experimental findings, arguments and conclusions about biodiversity or ecosystem dynamics.

**Note:** Objective 1 is not assessed in this instrument.

### Specifications

#### Description

In the student experiment, students modify (i.e. refine, extend or redirect) an experiment in order to address their own related hypothesis or question. It is sufficient that students use a practical performed in class or a simulation as the basis for their methodology and research question.

In order to complete the assessment task, students must:

- 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 sufficient and 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 extensions to the experiment
- communicate findings in an appropriate scientific genre (e.g. report, poster presentation, journal article, conference presentation).

\*The steps indicated with an asterisk above may be completed in groups. All other elements must be completed individually.

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.

### Conditions

- Time: 10 hours class time. This time will not necessarily be sequential. Students must perform the majority of the task during class time, including
  - performing background research and developing the methodology
  - conducting the experiment
  - processing and analysing evidence and evaluating the methodology
  - preparing and presenting the response (e.g. writing the scientific report, constructing and presenting the scientific poster).
- Length:
  - written (e.g. scientific report), 1500–2000 words
  - or
  - multimodal presentation (e.g. scientific poster presentation), 9–11 minutes.
- Other:
  - students may work collaboratively with other students to develop the methodology and perform the experiment; all other stages (e.g. processing of data, analysis of evidence and evaluation of the experimental process) must be carried out individually
  - the response must be presented using an appropriate scientific genre (e.g. report, poster presentation, journal article, conference presentation) and contain
    - a research question
    - a rationale for the experiment
    - reference to the initial experiment and identification and justification of modifications to the methodology
    - raw and processed qualitative data and/or quantitative data
    - analysis of the evidence
    - conclusion/s based on the interpretation of the evidence
    - evaluation of the methodology and suggestions of improvements and extensions to the experiment
    - a reference list.

## Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the student experiment.

Criterion	Objectives	Marks
Research and planning	2, 5	6
Analysis of evidence	2, 3, 5	6
Interpretation and evaluation	4, 6	6
Communication	7	2
<b>Total</b>		<b>20</b>

**Note:** Unit objective 1 is not assessed in this instrument.

## Instrument-specific marking guide

### Criterion: Research and planning

#### Assessment objectives

2. apply understanding of biodiversity or ecosystem dynamics to modify experimental methodologies and process primary data
5. investigate phenomena associated with biodiversity or ecosystem dynamics through an experiment

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"> <li><u>informed application of understanding</u> of biodiversity or ecosystem dynamics to <u>modify experimental methodologies</u> demonstrated by               <ul style="list-style-type: none"> <li>a <u>considered rationale</u> for the <u>experiment</u></li> <li><u>justified modifications</u> to the methodology</li> </ul> </li> <li><u>effective and efficient investigation of phenomena</u> associated with biodiversity or ecosystem dynamics demonstrated by               <ul style="list-style-type: none"> <li>a <u>specific and relevant research question</u></li> <li>a methodology that enables the <u>collection</u> of <u>sufficient</u>, relevant <u>data</u></li> <li>considered <u>management</u> of risks and ethical or environmental issues.</li> </ul> </li> </ul>	5–6
<ul style="list-style-type: none"> <li><u>adequate application of understanding</u> of biodiversity or ecosystem dynamics to <u>modify experimental methodologies</u> demonstrated by               <ul style="list-style-type: none"> <li>a <u>reasonable rationale</u> for the <u>experiment</u></li> <li><u>feasible modifications</u> to the methodology</li> </ul> </li> <li><u>effective investigation of phenomena</u> associated with biodiversity or ecosystem dynamics demonstrated by               <ul style="list-style-type: none"> <li>a <u>relevant research question</u></li> <li>a methodology that enables the <u>collection</u> of relevant <u>data</u></li> <li><u>management</u> of risks and ethical or environmental issues.</li> </ul> </li> </ul>	3–4
<ul style="list-style-type: none"> <li><u>rudimentary application of understanding</u> of biodiversity or ecosystem dynamics to <u>modify experimental methodologies</u> demonstrated by               <ul style="list-style-type: none"> <li>a <u>vague or irrelevant rationale</u> for the <u>experiment</u></li> <li><u>inappropriate modifications</u> to the methodology</li> </ul> </li> <li><u>ineffective investigation of phenomena</u> associated with biodiversity or ecosystem dynamics demonstrated by               <ul style="list-style-type: none"> <li>an <u>inappropriate research question</u></li> <li>a methodology that causes the <u>collection</u> of <u>insufficient</u> and <u>irrelevant data</u></li> <li><u>inadequate management</u> of risks and ethical or environmental issues.</li> </ul> </li> </ul>	1–2
<ul style="list-style-type: none"> <li>does not satisfy any of the descriptors above.</li> </ul>	0

## Criterion: Analysis of evidence

### Assessment objectives

2. apply understanding of biodiversity or ecosystem dynamics to modify experimental methodologies and process primary data
3. analyse experimental evidence about biodiversity or ecosystem dynamics
5. investigate phenomena associated with biodiversity or ecosystem dynamics through an experiment

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"> <li>• <u>appropriate application</u> of algorithms, visual and graphical <u>representations of data</u> about biodiversity or ecosystem dynamics demonstrated by <u>correct</u> and <u>relevant processing</u> of data</li> <li>• <u>systematic and effective analysis</u> of <u>experimental evidence</u> about biodiversity or ecosystem dynamics demonstrated by               <ul style="list-style-type: none"> <li>– <u>thorough identification</u> of relevant <u>trends, patterns or relationships</u></li> <li>– thorough and appropriate identification of the <u>uncertainty</u> and <u>limitations</u> of evidence</li> </ul> </li> <li>• effective and <u>efficient investigation</u> of <u>phenomena</u> associated with biodiversity or ecosystem dynamics demonstrated by the <u>collection of sufficient</u> and relevant raw data.</li> </ul>	5–6
<ul style="list-style-type: none"> <li>• <u>adequate application</u> of algorithms, visual and graphical <u>representations of data</u> about biodiversity or ecosystem dynamics demonstrated by <u>basic processing</u> of data</li> <li>• <u>effective analysis</u> of <u>experimental evidence</u> about biodiversity or ecosystem dynamics demonstrated by               <ul style="list-style-type: none"> <li>– <u>identification of obvious trends, patterns or relationships</u></li> <li>– <u>basic</u> identification of <u>uncertainty</u> and <u>limitations</u> of evidence</li> </ul> </li> <li>• effective <u>investigation</u> of <u>phenomena</u> associated with biodiversity or ecosystem dynamics demonstrated by the <u>collection of relevant</u> raw data.</li> </ul>	3–4
<ul style="list-style-type: none"> <li>• <u>rudimentary application</u> of algorithms, visual and graphical <u>representations of data</u> about biodiversity or ecosystem dynamics demonstrated by <u>incorrect</u> or <u>irrelevant processing</u> of data</li> <li>• <u>ineffective analysis</u> of <u>experimental evidence</u> about biodiversity or ecosystem dynamics demonstrated by               <ul style="list-style-type: none"> <li>– <u>identification of incorrect or irrelevant trends, patterns or relationships</u></li> <li>– incorrect or <u>insufficient</u> identification of <u>uncertainty</u> and <u>limitations</u> of evidence</li> </ul> </li> <li>• ineffective <u>investigation</u> of <u>phenomena</u> associated with biodiversity or ecosystem dynamics demonstrated by the <u>collection</u> of insufficient and irrelevant raw data.</li> </ul>	1–2
<ul style="list-style-type: none"> <li>• does not satisfy any of the descriptors above.</li> </ul>	0

## Criterion: Interpretation and evaluation

### Assessment objectives

4. interpret experimental evidence about biodiversity or ecosystem dynamics
6. evaluate experimental processes and conclusions about biodiversity or ecosystem dynamics

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"><li>• <u>insightful interpretation of experimental evidence</u> about biodiversity or ecosystem dynamics demonstrated by <u>justified conclusion/s linked to the research question</u></li><li>• <u>critical evaluation of experimental processes</u> about biodiversity or ecosystem dynamics demonstrated by<ul style="list-style-type: none"><li>– <u>justified discussion of the reliability and validity of the experimental process</u></li><li>– <u>suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence.</u></li></ul></li></ul>	5–6
<ul style="list-style-type: none"><li>• <u>adequate interpretation of experimental evidence</u> about biodiversity or ecosystem dynamics demonstrated by <u>reasonable conclusion/s relevant to the research question</u></li><li>• <u>basic evaluation of experimental processes</u> about biodiversity or ecosystem dynamics demonstrated by<ul style="list-style-type: none"><li>– <u>reasonable description of the reliability and validity of the experimental process</u></li><li>– <u>suggested improvements and extensions to the experiment that are related to the analysis of evidence.</u></li></ul></li></ul>	3–4
<ul style="list-style-type: none"><li>• <u>invalid interpretation of experimental evidence</u> about biodiversity or ecosystem dynamics demonstrated by <u>inappropriate or irrelevant conclusion/s</u></li><li>• <u>superficial evaluation of experimental processes</u> about biodiversity or ecosystem dynamics demonstrated by<ul style="list-style-type: none"><li>– <u>cursor or simplistic statements</u> about the reliability and validity of the experimental process</li><li>– <u>ineffective or irrelevant suggestions.</u></li></ul></li></ul>	1–2
<ul style="list-style-type: none"><li>• does not satisfy any of the descriptors above.</li></ul>	0

## Criterion: Communication

### Assessment objective

7. communicate understandings and experimental findings, arguments and conclusions about biodiversity or ecosystem dynamics

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"><li>• <u>effective communication of understandings and experimental findings, arguments and conclusions</u> about biodiversity or ecosystem dynamics demonstrated by<ul style="list-style-type: none"><li>– <u>fluent and concise use of scientific language and representations</u></li><li>– <u>appropriate use of genre conventions</u></li><li>– <u>acknowledgment of sources of information through appropriate use of referencing conventions.</u></li></ul></li></ul>	2
<ul style="list-style-type: none"><li>• <u>adequate communication of understandings and experimental findings, arguments and conclusions</u> about biodiversity or ecosystem dynamics demonstrated by<ul style="list-style-type: none"><li>– <u>competent use of scientific language and representations</u></li><li>– <u>use of basic genre conventions</u></li><li>– <u>use of basic referencing conventions.</u></li></ul></li></ul>	1
<ul style="list-style-type: none"><li>• does not satisfy any of the descriptors above.</li></ul>	0

### **4.5.3 Summative external assessment (EA): Examination (50%)**

#### **General information**

Summative external assessment is developed and marked by the QCAA. In Biology it contributes 50% to a student's overall subject result.

Summative external assessment assesses learning from both Units 3 and 4.

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

See Section 5.5.2.

# 5 Unit 4: Heredity and continuity of life

## 5.1 Unit description

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.

## 5.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

Unit objective	IA3	EA
1. <u>describe</u> and <u>explain</u> DNA, genes and the continuity of life, and the continuity of life on Earth		•
2. <u>apply understanding</u> of DNA, genes and the continuity of life, and the continuity of life on Earth	•	•
3. <u>analyse evidence</u> about DNA, genes and the continuity of life, and the continuity of life on Earth	•	•
4. <u>interpret evidence</u> about DNA, genes and the continuity of life, and the continuity of life on Earth	•	•
5. <u>investigate phenomena</u> associated with DNA, genes and the continuity of life, and the continuity of life on Earth	•	
6. <u>evaluate processes, claims and conclusions</u> about DNA, genes and the continuity of life, and the continuity of life on Earth	•	
7. <u>communicate understandings, findings, arguments</u> and conclusions about DNA, genes and the continuity of life, and the continuity of life on Earth	•	



## 5.3 Topic 1: DNA, genes and the continuity of life

In this topic, students will:

Subject matter	Guidance
<p><b>DNA structure and replication</b></p> <ul style="list-style-type: none"> <li>• <u>understand</u> that deoxyribonucleic acid (DNA) is a double-stranded molecule that occurs bound to proteins (histones) in chromosomes in the nucleus, and as unbound circular DNA in the cytosol of prokaryotes, and in the mitochondria and chloroplasts of eukaryotic cells</li> <li>• <u>recall</u> the structure of DNA, including             <ul style="list-style-type: none"> <li>– nucleotide composition</li> <li>– complementary base pairing</li> <li>– weak, base-specific hydrogen bonds between DNA strands</li> </ul> </li> <li>• <u>explain</u> the role of helicase (in terms of unwinding the double helix and separation of the strands) and DNA polymerase (in terms of formation of the new complementary strands) in the process of DNA replication. Reference should be made to the direction of replication.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 5 hours</li> <li>• <u>Identification</u> and <u>use</u> of chemical formulas are not required for <u>recalling</u> the components in DNA structure. Students should be able to use a schematic model identifying nucleotides (nitrogenous base + phosphate + sugar) and the associated hydrogen bonds.</li> <li>• Specific numbers of hydrogen bonds and reference to purines and pyrimidines are not required for the description of hydrogen bonding in DNA.</li> <li>• Reference to DNA polymerase I and II is not required in the explanation of DNA replication.</li> <li>• <b>Suggested practical:</b> Extract DNA from strawberries, kiwifruit or wheat germ.</li> <li>• <b>SHE:</b> <u>Understand</u> the development of the double-helix model through the contributions of James Watson, Francis Crick and Rosalind Franklin.</li> </ul>
<p><b>Cellular replication and variation</b></p> <ul style="list-style-type: none"> <li>• within the process of meiosis I and II             <ul style="list-style-type: none"> <li>– <u>recognise</u> the role of homologous chromosomes</li> <li>– <u>describe</u> the processes of crossing over and recombination and <u>demonstrate</u> how they contribute to genetic variation</li> <li>– <u>compare</u> and <u>contrast</u> the process of spermatogenesis and oogenesis (with reference to haploid and diploid cells).</li> </ul> </li> <li>• demonstrate how the process of independent assortment and random fertilisation alter the variations in the genotype of offspring.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 5 hours (time allocation should consider a SHE)</li> <li>• <b>SHE:</b> <u>Discuss</u> implications of genetic screening technologies, such as preimplantation genetic diagnosis and CRISPR, on reproductive technologies.</li> </ul>

Subject matter	Guidance
<p><b>Gene expression</b></p> <ul style="list-style-type: none"> <li>• <u>define</u> the terms <u>genome</u> and <u>gene</u></li> <li>• <u>understand</u> that genes include 'coding' (exons) and 'noncoding' DNA (which includes a variety of transcribed proteins: functional RNA (i.e. tRNA), centromeres, telomeres and introns. <u>Recognise</u> that many functions of 'noncoding' DNA are yet to be determined)</li> <li>• <u>explain</u> the process of protein synthesis in terms of <ul style="list-style-type: none"> <li>– transcription of a gene into messenger RNA in the nucleus</li> <li>– translation of mRNA into an amino acid sequence at the ribosome (refer to transfer RNA, codons and anticodons)</li> </ul> </li> <li>• recognise that the purpose of gene expression is to <u>synthesise</u> a functional gene product (protein or functional RNA); that the process can be regulated and is used by all known life</li> <li>• <u>identify</u> that there are factors that regulate the phenotypic expression of genes <ul style="list-style-type: none"> <li>– during transcription and translation (proteins that bind to specific DNA sequences)</li> <li>– through the products of other genes</li> <li>– via environmental exposure (consider the twin methodology in epigenetic studies)</li> </ul> </li> <li>• recognise that differential gene expression, controlled by transcription factors, regulates cell differentiation for tissue formation and morphology</li> <li>• <u>recall</u> an example of a transcription factor gene that regulates morphology (HOX transcription factor family) and cell differentiation (sex-determining region Y).</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours</li> <li>• Refer to glossary for definitions of <u>genome</u> and <u>gene</u>.</li> <li>• The term <i>junk DNA</i> is misleading and should not be used in reference to 'noncoding' DNA.</li> <li>• When <u>identifying</u> transcription factors in the regulation of gene expression, reference to operators, promoters, regulators, enhancers, silencers, insulators, TATA boxes, polyadenylation and DNA methylation is not required.</li> <li>• Students should <u>recognise</u> gene expression in the context of an example. They are not required to <u>explain</u> or <u>describe</u> the mechanisms of this process.</li> </ul>

Subject matter	Guidance
<p><b>Mutations</b></p> <ul style="list-style-type: none"> <li>• <u>identify</u> how mutations in genes and chromosomes can result from errors in             <ul style="list-style-type: none"> <li>– DNA replication (point and frameshift mutation)</li> <li>– cell division (non-disjunction)</li> <li>– damage by mutagens (physical, including UV radiation, ionising radiation and heat and chemical)</li> </ul> </li> <li>• <u>explain</u> how non-disjunction leads to aneuploidy</li> <li>• <u>use</u> a human karyotype to identify ploidy changes and <u>predict</u> a genetic disorder from given data</li> <li>• <u>describe</u> how inherited mutations can alter the variations in the genotype of offspring.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 3 hours</li> <li>• Students are not required to <u>identify</u> the effects of mutations (i.e. silent, missense, nonsense).</li> <li>• <u>Recall</u> of specific chemical mutagens is not required. Rather, an <u>understanding</u> should be developed that a large number of chemical mutagens are carcinogenic and interact directly with DNA.</li> <li>• Examples of aneuploidy could include trisomy 21.</li> </ul>
<p><b>Inheritance</b></p> <ul style="list-style-type: none"> <li>• <u>predict</u> frequencies of genotypes and phenotypes using <u>data</u> from probability models (including frequency histograms and Punnett squares) and by taking into consideration <u>patterns</u> of inheritance for the following types of alleles: autosomal dominant, sex linked and multiple</li> <li>• <u>define</u> <u>polygenic inheritance</u> and predict frequencies of genotypes and phenotypes for using three of the possible alleles.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 3 hours</li> <li>• Refer to the glossary for a definition of <u>polygenic inheritance</u>.</li> <li>• <u>Multiple allele inheritance</u> refers to situations where there are more than two alleles considered, i.e. incomplete and co-dominance situations.</li> <li>• Examples for patterns of inheritance could include haemophilia (sex linked) and ABO blood types (multiple), grain colour in wheat (polygenic).</li> </ul>
<p><b>Biotechnology</b></p> <ul style="list-style-type: none"> <li>• <u>describe</u> the process of making recombinant DNA             <ul style="list-style-type: none"> <li>– isolation of DNA, cutting of DNA (restriction enzymes)</li> <li>– insertion of DNA fragment (plasmid vector)</li> <li>– joining of DNA (DNA ligase)</li> <li>– amplification of recombinant DNA (bacterial transformation)</li> </ul> </li> <li>• <u>recognise</u> the applications of DNA sequencing to map species' genomes and DNA profiling to <u>identify</u> unique genetic information</li> <li>• <u>explain</u> the purpose of polymerase chain reaction (PCR) and gel electrophoresis</li> <li>• <u>appraise</u> <u>data</u> from an outcome of a current genetic biotechnology technique to <u>determine</u> its success rate.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 8 hours</li> <li>• Examples for species genome mapping could include the Human Genome Project. The BLAST database could be used to <u>develop understanding</u> of bioinformatics.</li> <li>• <b>Suggested practical:</b> Perform a bacterial transformation.</li> <li>• <b>Suggested practical:</b> <u>Interpret</u> DNA profiles from gel electrophoresis (either laboratory or computer simulation based).</li> <li>• Examples of current biotechnology techniques could include gel electrophoresis, PCR or CRISPR-based technologies.</li> <li>• <u>Data</u> for appraisal could be from DNA banding, frequency of DNA fragments, effectiveness of restriction enzymes, location of a gene or gene expression. This could be supported with a practical.</li> <li>• <b>SHE:</b> <u>Analyse</u> the implications of DNA profiling for individuals.</li> </ul>

Subject matter	Guidance
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for the research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Bioinformatics:</b> Bioinformatics can be used to analyse the relationships in biological data, such as amino acid sequences or nucleotide sequences (e.g. the Human Genome Project).</li> <li>• <b>A \$1000 genome:</b> Low-cost genome sequencing can be used to enable people to identify whether they have gene variants associated with genetic diseases.</li> <li>• <b>Genetically modified organisms:</b> Transgenic organisms have potential for advancement in agriculture and pharmaceuticals.</li> </ul>

## 5.4 Topic 2: Continuity of life on Earth

In this topic, students will:

Subject matter	Guidance
<p><b>Evolution</b></p> <ul style="list-style-type: none"> <li>• <u>define</u> the terms <i>evolution</i>, <i>microevolution</i> and <i>macroevolution</i></li> <li>• <u>determine</u> episodes of evolutionary radiation and mass extinctions from an evolutionary timescale of life on Earth (approximately 3.5 billion years)</li> <li>• <u>interpret data</u> (i.e. degree of DNA similarity) to reveal phylogenetic relationships with an <u>understanding</u> that comparative genomics involves the comparison of genomic features to provide <u>evidence</u> for the theory of evolution.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 3 hours</li> <li>• Refer to the glossary for definitions of <i>evolution</i>, <i>microevolution</i> and <i>macroevolution</i>.</li> <li>• Evolutionary radiation refers to an increase in taxonomic diversity or morphological disparity.</li> </ul>
<p><b>Natural selection and microevolution</b></p> <ul style="list-style-type: none"> <li>• <u>recognise</u> natural selection occurs when the pressures of environmental selection confer a selective advantage on a specific phenotype to enhance its survival (viability) and reproduction (fecundity)</li> <li>• <u>identify</u> that the selection of allele frequency in a gene pool can be positive or negative</li> <li>• <u>interpret data</u> and <u>describe</u> the three main types of phenotypic selection: stabilising, directional and disruptive</li> <li>• <u>explain</u> microevolutionary change through the main processes of mutation, gene flow and genetic drift.</li> <li>• <b>Mandatory practical:</b> <u>Analyse</u> genotypic changes for a selective pressure in a gene pool (modelling can be based on laboratory work or computer simulation).</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours</li> <li>• Examples of natural selection could include beak size in the Galapagos finches, antibiotic resistance or insecticide resistance.</li> <li>• <u>Recognise</u> that mutation is the ultimate source of genetic variation, as it introduces new alleles to a population (syllabus link to Unit 4, Topic 1).</li> </ul>

Subject matter	Guidance
<p><b>Speciation and macroevolution</b></p> <ul style="list-style-type: none"> <li>• <b>recall</b> that speciation and macroevolutionary changes result from an accumulation of microevolutionary changes over time</li> <li>• <b>identify</b> that diversification between species can follow one of four patterns: divergent, convergent, parallel and coevolution</li> <li>• <b>describe</b> the modes of speciation: allopatric, sympatric, parapatric</li> <li>• <b>understand</b> that the different mechanisms of isolation — geographic (including environmental disasters, habitat fragmentation), reproductive, spatial, and temporal — influence gene flow</li> <li>• <b>explain</b> how populations with reduced genetic diversity (i.e. those affected by population bottlenecks) face an increased risk of extinction</li> <li>• <b>interpret</b> gene flow and allele frequency <b>data</b> from different populations in order to <b>determine</b> speciation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Notional time:</b> 6 hours.</li> <li>• Habitat fragmentation should be referred to in terms of natural and human causes.</li> <li>• Populations with reduced genetic diversity should be linked to subject matter in Unit 3.</li> <li>• Students should be able to <b>determine</b> the modes of speciation from <b>interpretation of data</b>.</li> </ul>
<p><b>Science as a Human Endeavour (SHE)</b></p> <ul style="list-style-type: none"> <li>• SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for the research investigation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Evidence for evolution:</b> Technological developments in the fields of comparative genomics, comparative biochemistry and bioinformatics enable identification of further evidence for evolutionary relationships.</li> <li>• <b>Human evolution — are we still evolving?</b> Human evolution is still occurring (particularly in Western societies) after the significant cultural events of the Industrial Revolution and the introduction of agriculture, modern medicine and mass transportation.</li> <li>• <b>Unsustainable population size and reserve area:</b> Calculating minimum reserve sizes for a target conservation species should consider the viability of a single large reserve vs. a number of smaller reserves that are connected by 'green corridors'.</li> </ul>

## 5.5 Assessment

### 5.5.1 Summative internal assessment 3 (IA3): Research investigation (20%)

#### Description

This assessment requires students to evaluate a claim. They will do this by researching, analysing and interpreting secondary evidence from scientific texts to form the basis for a justified conclusion about the claim. A research investigation uses research practices to assess a range of cognitions in a particular context. Research practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

#### Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

2. apply understanding of DNA, genes and the continuity of life or the continuity of life on Earth to develop research questions
3. analyse research evidence about DNA, genes and the continuity of life or the continuity of life on Earth
4. interpret research evidence about DNA, genes and the continuity of life or the continuity of life on Earth
5. investigate phenomena associated with DNA, genes and the continuity of life or the continuity of life on Earth through research
6. evaluate research processes, claims and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth
7. communicate understandings and research findings, arguments and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth.

**Note:** Objective 1 is not assessed in this instrument.

#### Specifications

##### Description

In the research investigation, students gather secondary evidence related to a research question in order to evaluate the claim. The students develop their research question based on a number of possible claims provided by their teacher. Students work individually throughout this task.

Evidence must be obtained by researching scientifically credible sources, such as scientific journals, books by well-credentialed scientists and websites of governments, universities, independent research bodies or science and technology manufacturers.

In order to complete the assessment task, students must:

- select a claim to be evaluated
- identify the relevant scientific concepts associated with the claim
- pose a research question addressing an aspect of the claim

- conduct research to gather scientific evidence that may be used to address the research question and subsequently evaluate the claim
- analyse the data to identify sufficient and relevant evidence
- identify the trends, patterns or relationships in the evidence
- analyse the evidence to identify limitations
- interpret the evidence to construct justified scientific arguments
- interpret the evidence to form a justified conclusion to the research question
- discuss the quality of the evidence
- evaluate the claim by extrapolating the findings of the research question to the claim
- suggest improvements and 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.

### Conditions

- Time: 10 hours class time. This time will not necessarily be sequential. Students must perform the majority of the task during class time, including
  - performing background research
  - developing the research question
  - collecting scientific evidence
  - analysing and interpreting evidence and evaluating the claim
  - preparing and presenting the response (e.g. writing the scientific essay).
- Length:
  - written (e.g.scientific essay), 1500–2000 words
  - or
  - multimodal presentation (e.g. scientific conference presentation), 9–11 minutes.
- Other:
  - students are to work individually throughout this task
  - the response must be presented using an appropriate scientific genre (e.g. report, journal article, essay, conference presentation) and contain
    - a claim
    - a research question
    - a rationale for the investigation
    - justified scientific arguments using evidence
    - a conclusion to the research question based on the interpretation of the evidence
    - evaluation of the claim and suggestions of improvements and extensions to the investigation
    - a reference list.



## Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the research investigation.

Criterion	Objectives	Marks
Research and planning	2, 5	6
Analysis and interpretation	3, 4	6
Conclusion and evaluation	4, 6	6
Communication	7	2
<b>Total</b>		<b>20</b>

**Note:** Unit objective 1 is not assessed in this instrument.

## Instrument-specific marking guide

### Criterion: Research and planning

#### Assessment objectives

2. apply understanding of DNA, genes and the continuity of life or the continuity of life on Earth to develop research questions
5. investigate phenomena associated with DNA, genes and the continuity of life or the continuity of life on Earth through research

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"> <li>• <u>informed application</u> of <u>understanding</u> of DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by a <u>considered rationale</u> identifying <u>clear</u> development of the <u>research question</u> from the <u>claim</u></li> <li>• <u>effective</u> and <u>efficient investigation</u> of <u>phenomena</u> associated with DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by               <ul style="list-style-type: none"> <li>– a <u>specific</u> and <u>relevant</u> research question</li> <li>– <u>selection</u> of <u>sufficient</u> and <u>relevant</u> sources.</li> </ul> </li> </ul>	5–6
<ul style="list-style-type: none"> <li>• <u>adequate application</u> of <u>understanding</u> of DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by a <u>reasonable rationale</u> that <u>links</u> the <u>research question</u> and the <u>claim</u></li> <li>• <u>effective investigation</u> of <u>phenomena</u> associated with DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by               <ul style="list-style-type: none"> <li>– a <u>relevant</u> research question</li> <li>– <u>selection</u> of <u>relevant</u> sources.</li> </ul> </li> </ul>	3–4
<ul style="list-style-type: none"> <li>• <u>rudimentary application</u> of <u>understanding</u> of DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by a <u>vague</u> or <u>irrelevant rationale</u> for the <u>investigation</u></li> <li>• <u>ineffective</u> investigation of <u>phenomena</u> associated with DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by               <ul style="list-style-type: none"> <li>– an <u>inappropriate research question</u></li> <li>– <u>selection</u> of <u>insufficient</u> and <u>irrelevant</u> sources.</li> </ul> </li> </ul>	1–2
<ul style="list-style-type: none"> <li>• does not satisfy any of the descriptors above.</li> </ul>	0

## Criterion: Analysis and interpretation

### Assessment objectives

3. analyse research evidence about DNA, genes and the continuity of life or the continuity of life on Earth
4. interpret research evidence about DNA, genes and the continuity of life or the continuity of life on Earth

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"><li>• <u>systematic and effective analysis</u> of <u>qualitative data</u> and/or <u>quantitative data</u> within the sources about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by<ul style="list-style-type: none"><li>– the <u>identification</u> of <u>sufficient</u> and <u>relevant evidence</u></li><li>– <u>thorough</u> identification of relevant <u>trends</u>, <u>patterns</u> or <u>relationships</u></li><li>– thorough and <u>appropriate</u> identification of <u>limitations</u> of evidence</li></ul></li><li>• <u>insightful interpretation</u> of <u>research evidence</u> about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by <u>justified</u> scientific <u>argument/s</u>.</li></ul>	5–6
<ul style="list-style-type: none"><li>• <u>effective analysis</u> of <u>qualitative data</u> and/or <u>quantitative data</u> within the sources about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by<ul style="list-style-type: none"><li>– the <u>identification</u> of <u>relevant evidence</u></li><li>– identification of <u>obvious trends</u>, <u>patterns</u> or <u>relationships</u></li><li>– <u>basic</u> identification of <u>limitations</u> of evidence</li></ul></li><li>• <u>adequate interpretation</u> of <u>research evidence</u> about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by <u>reasonable</u> scientific <u>argument/s</u>.</li></ul>	3–4
<ul style="list-style-type: none"><li>• <u>rudimentary analysis</u> of <u>qualitative data</u> and/or <u>quantitative data</u> within the sources about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by<ul style="list-style-type: none"><li>– the <u>identification</u> of <u>insufficient</u> and <u>irrelevant evidence</u></li><li>– identification of <u>incorrect</u> or <u>irrelevant trends</u>, <u>patterns</u> or <u>relationships</u></li><li>– incorrect or insufficient identification of <u>limitations</u> of evidence</li></ul></li><li>• <u>invalid interpretation</u> of <u>research evidence</u> about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by <u>inappropriate</u> or <u>irrelevant argument/s</u>.</li></ul>	1–2
<ul style="list-style-type: none"><li>• does not satisfy any of the descriptors above.</li></ul>	0

## Criterion: Conclusion and evaluation

### Assessment objectives

4. interpret research evidence about DNA, genes and the continuity of life or the continuity of life on Earth
6. evaluate research processes, claims and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"><li>• <u>insightful interpretation of research evidence</u> about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by <u>justified</u> conclusion/s linked to the <u>research question</u></li><li>• <u>critical evaluation</u> of the research <u>processes</u>, claims and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by<ul style="list-style-type: none"><li>– <u>insightful discussion</u> of the <u>quality of evidence</u></li><li>– <u>extrapolation</u> of <u>credible findings</u> of the research to the claim</li><li>– suggested <u>improvements</u> and <u>extensions</u> to the <u>investigation</u> that are <u>considered</u> and <u>relevant</u> to the claim.</li></ul></li></ul>	5–6
<ul style="list-style-type: none"><li>• <u>adequate interpretation of research evidence</u> about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by <u>reasonable</u> conclusion/s <u>relevant</u> to the <u>research question</u></li><li>• <u>basic evaluation</u> of the research <u>processes</u>, claims and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by<ul style="list-style-type: none"><li>– <u>reasonable description</u> of the <u>quality of evidence</u></li><li>– <u>application</u> of relevant <u>findings</u> of the research to the claim</li><li>– suggested <u>improvements</u> and <u>extensions</u> to the <u>investigation</u> that are relevant to the claim.</li></ul></li></ul>	3–4
<ul style="list-style-type: none"><li>• <u>invalid interpretation of research evidence</u> about DNA, genes and the continuity of life and or continuity of life on Earth demonstrated by <u>inappropriate</u> or <u>irrelevant</u> conclusion/s</li><li>• <u>superficial evaluation</u> of the research <u>processes</u>, claims and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by<ul style="list-style-type: none"><li>– <u> cursory or simplistic statements</u> about the <u>quality of evidence</u></li><li>– <u>application</u> of insufficient or <u>inappropriate findings</u> of the research to the claim</li><li>– <u>ineffective</u> or irrelevant suggestions.</li></ul></li></ul>	1–2
<ul style="list-style-type: none"><li>• does not satisfy any of the descriptors above.</li></ul>	0

## Criterion: Communication

### Assessment objective

7. communicate understandings and research findings, arguments and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth

The student work has the following characteristics:	Marks
<ul style="list-style-type: none"><li>• <u>effective communication of understandings and research findings, arguments and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by</u><ul style="list-style-type: none"><li>– <u>fluent and concise use of scientific language and representations</u></li><li>– <u>appropriate use of genre conventions</u></li><li>– <u>acknowledgment of sources of information through appropriate use of referencing conventions.</u></li></ul></li></ul>	2
<ul style="list-style-type: none"><li>• <u>adequate communication of understandings and research findings, arguments and conclusions about DNA, genes and the continuity of life or the continuity of life on Earth demonstrated by</u><ul style="list-style-type: none"><li>– <u>competent use of scientific language and representations</u></li><li>– <u>use of basic genre conventions</u></li><li>– <u>use of basic referencing conventions.</u></li></ul></li></ul>	1
<ul style="list-style-type: none"><li>• <u>does not satisfy any of the descriptors above.</u></li></ul>	0

## 5.5.2 Summative external assessment (EA): Examination (50%)

### General information

Summative external assessment is developed and marked by the QCAA. In Biology, it contributes 50% to a student's overall subject result.

Summative external assessment assesses learning from both Units 3 and 4.

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

### Description

The examination assesses the application of a range of cognitions to multiple provided items — questions, scenarios and problems.

Student responses must be completed individually, under supervised conditions and in a set timeframe.

### Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

1. describe and explain biodiversity, ecosystem dynamics, DNA, genes and the continuity of life, and the continuity of life on Earth
2. apply understanding of biodiversity, ecosystem dynamics, DNA, genes and the continuity of life, and the continuity of life on Earth
3. analyse evidence about biodiversity, ecosystem dynamics, DNA, genes and the continuity of life, and the continuity of life on Earth to identify trends, patterns, relationships, limitations or uncertainty
4. interpret evidence about biodiversity, ecosystem dynamics, DNA, genes and the continuity of life, and the continuity of life on Earth to draw conclusions based on analysis.

**Note:** Objectives 5, 6 and 7 are not assessed in this instrument.

### Specifications

#### Description

This examination will include two papers. Each paper consists of a number of different types of possible items:

- multiple choice
- short response items requiring single-word, sentence or paragraph responses
- calculating using algorithms
- interpreting graphs, tables or diagrams
- responding to unseen data and/or stimulus
- extended response (300–350 words or equivalent).

#### Conditions

##### Paper 1

- Time: 90 minutes plus 10 minutes perusal.
- Other: QCAA-approved graphics calculator permitted.

#### Paper 2

- Time: 90 minutes plus 10 minutes perusal.
- Other: QCAA -approved graphics calculator permitted.

### **Instrument-specific marking guide**

No ISMG is provided for the external assessment.

## 6 Glossary

Term	Explanation
<b>A</b>	
<b>accomplished</b>	highly trained or skilled in a particular activity; perfected in knowledge or training; expert
<b>accuracy</b>	the condition or quality of being true, correct or exact; freedom from error or defect; precision or exactness; correctness; in science, the extent to which a measurement result represents the quantity it purports to measure; an accurate measurement result includes an estimate of the true value and an estimate of the uncertainty
<b>accurate</b>	precise and exact; to the point; consistent with or exactly conforming to a truth, standard, rule, model, convention or known facts; free from error or defect; meticulous; correct in all details
<b>acknowledgment</b>	recognition of the authority or validity of something
<b>adept</b>	very/highly skilled or proficient at something; expert
<b>adequate</b>	satisfactory or acceptable in quality or quantity equal to the requirement or occasion
<b>algebraic representations</b>	a set of symbols linked by mathematical operations; the set of symbols summarises relationships between variables (ACARA 2015c)
<b>algorithm</b>	an effective procedure for solving a particular mathematical problem in a finite number of steps
<b>analyse</b>	dissect to ascertain and examine constituent parts and/or their relationships; break down or examine in order to identify the essential elements, features, components or structure; determine the logic and reasonableness of information; examine or consider something in order to explain and interpret it, for the purpose of finding meaning or relationships and identifying patterns, similarities and differences
<b>analysis</b>	examination of evidence to identify the essential features, components, elements or structure; identification of patterns, similarities and differences
<b>analytical technique</b>	a procedure or method for analysing data
<b>anomaly</b>	something that deviates from what is standard, normal, or expected (Taylor 1982)
<b>applied learning</b>	the acquisition and application of knowledge, understanding and skills in real-world or lifelike contexts that may encompass workplace, industry and community situations; it emphasises learning through doing and includes both theory and the application of theory, connecting subject knowledge and understanding with the development of practical skills
<b>Applied subject</b>	a subject whose primary pathway is work and vocational education; it emphasises applied learning and community connections; a subject for which a syllabus has been developed by the QCAA

Term	Explanation
	with the following characteristics: results from courses developed from Applied syllabuses contribute to the QCE; results may contribute to ATAR calculations
<b>apply</b>	use knowledge and understanding in response to a given situation or circumstance; carry out or use a procedure in a given or particular situation
<b>appraise</b>	evaluate the worth, significance or status of something; judge or consider a text or piece of work
<b>appreciate</b>	recognise or make a judgment about the value or worth of something; understand fully; grasp the full implications of
<b>appropriate</b>	acceptable; suitable or fitting for a particular purpose, circumstance, context, etc.
<b>apt</b>	suitable to the purpose or occasion; fitting, appropriate
<b>area of study</b>	a division of, or a section within a unit
<b>argue</b>	give reasons for or against something; challenge or debate an issue or idea; persuade, prove or try to prove by giving reasons
<b>argument</b>	process of reasoning; series of reasons; a statement or fact tending to support a point
<b>aspect</b>	a particular part of a feature of something; a facet, phase or part of a whole
<b>assess</b>	measure, determine, evaluate, estimate or make a judgment about the value, quality, outcomes, results, size, significance, nature or extent of something
<b>assessment</b>	purposeful and systematic collection of information about students' achievements
<b>assessment instrument</b>	a tool or device used to gather information about student achievement
<b>assessment objectives</b>	drawn from the unit objectives and contextualised for the requirements of the assessment instrument (see also 'syllabus objectives', 'unit objectives')
<b>assessment technique</b>	the method used to gather evidence about student achievement (e.g. examination, project, investigation)
<b>astute</b>	showing an ability to accurately assess situations or people; of keen discernment
<b>ATAR</b>	Australian Tertiary Admission Rank
<b>authoritative</b>	able to be trusted as being accurate or true; reliable; commanding and self-confident; likely to be respected and obeyed
<b>B</b>	
<b>balanced</b>	keeping or showing a balance; not biased; fairly judged or presented; taking everything into account in a fair, well-judged way
<b>basic</b>	fundamental



Term	Explanation
<b>behaviour</b>	in science, the action of any material; the action or activity of an individual
<b>C</b>	
<b>calculate</b>	determine or find (e.g. a number, answer) by using mathematical processes; obtain a numerical answer showing the relevant stages in the working; ascertain/determine from given facts, figures or information
<b>carrying capacity</b>	in Biology, the size of the population that can be supported indefinitely on the available resources and services of that ecosystem
<b>categorise</b>	place in or assign to a particular class or group; arrange or order by classes or categories; classify, sort out, sort, separate
<b>challenging</b>	difficult but interesting; testing one's abilities; demanding and thought-provoking; usually involving unfamiliar or less familiar elements
<b>characteristic</b>	a typical feature or quality
<b>clade</b>	a group of organisms that consists of a common ancestor and all its lineal descendants
<b>claim</b>	an assertion made without any accompanying evidence to support it
<b>clarify</b>	make clear or intelligible; explain; make a statement or situation less confused and more comprehensible
<b>clarity</b>	clearness of thought or expression; the quality of being coherent and intelligible; free from obscurity of sense; without ambiguity; explicit; easy to perceive, understand or interpret
<b>classify</b>	arrange, distribute or order in classes or categories according to shared qualities or characteristics
<b>clear</b>	free from confusion, uncertainty, or doubt; easily seen, heard or understood
<b>clearly</b>	in a clear manner; plainly and openly, without ambiguity
<b>coherent</b>	having a natural or due agreement of parts; connected; consistent; logical, orderly; well-structured and makes sense; rational, with parts that are harmonious; having an internally consistent relation of parts
<b>cohesive</b>	characterised by being united, bound together or having integrated meaning; forming a united whole
<b>collate</b>	put together; compare
<b>collection</b>	in science, a systematic approach to gathering and measuring evidence from a variety of sources in order to evaluate outcomes and make predictions
<b>comment</b>	express an opinion, observation or reaction in speech or writing; give a judgment based on a given statement or result of a calculation

Term	Explanation
<b>communicate</b>	convey knowledge and/or understandings to others; make known; transmit
<b>compare</b>	display recognition of similarities and differences and recognise the significance of these similarities and differences
<b>competent</b>	having suitable or sufficient skills, knowledge, experience, etc. for some purpose; adequate but not exceptional; capable; suitable or sufficient for the purpose; having the necessary ability, knowledge or skill to do something successfully; efficient and capable (of a person); acceptable and satisfactory, though not outstanding
<b>competently</b>	in an efficient and capable way; in an acceptable and satisfactory, though not outstanding, way
<b>complex</b>	composed or consisting of many different and interconnected parts or factors; compound; composite; characterised by an involved combination of parts; complicated; intricate; a complex whole or system; a complicated assembly of particulars
<b>comprehend</b>	understand the meaning or nature of; grasp mentally
<b>comprehensive</b>	inclusive; of large content or scope; including or dealing with all or nearly all elements or aspects of something; wide-ranging; detailed and thorough, including all that is relevant
<b>concept</b>	in science, an idea or model explaining some natural phenomenon; a theoretical construct; a thought, idea or notion
<b>concise</b>	expressing much in few words; giving a lot of information clearly and in a few words; brief, comprehensive and to the point; succinct, clear, without repetition of information
<b>concisely</b>	in a way that is brief but comprehensive; expressing much in few words; clearly and succinctly
<b>conclusion</b>	a judgment based on evidence (ACARA 2015c)
<b>conduct</b>	direct in action or course; manage; organise; carry out
<b>consider</b>	think deliberately or carefully about something, typically before making a decision; take something into account when making a judgment; view attentively or scrutinise; reflect on
<b>considerable</b>	fairly large or great; thought about deliberately and with a purpose
<b>considered</b>	formed after careful and deliberate thought
<b>consistent</b>	agreeing or accordant; compatible; not self-opposed or self-contradictory, constantly adhering to the same principles; acting in the same way over time, especially so as to be fair or accurate; unchanging in nature, standard, or effect over time; not containing any logical contradictions (of an argument); constant in achievement or effect over a period of time
<b>construct</b>	create or put together (e.g. an argument) by arranging ideas or items; display information in a diagrammatic or logical form; make; build

Term	Explanation
<b>contrast</b>	display recognition of differences by deliberate juxtaposition of contrary elements; show how things are different or opposite; give an account of the differences between two or more items or situations, referring to both or all of them throughout
<b>controlled</b>	shows the exercise of restraint or direction over; held in check; restrained, managed or kept within certain bounds
<b>convincing</b>	persuaded by argument or proof; leaving no margin of doubt; clear; capable of causing someone to believe that something is true or real; persuading or assuring by argument or evidence; appearing worthy of belief; credible or plausible
<b>correct</b>	conforming to fact or truth; accurate
<b>course</b>	a defined amount of learning developed from a subject syllabus
<b>create</b>	bring something into being or existence; produce or evolve from one's own thought or imagination; reorganise or put elements together into a new pattern or structure or to form a coherent or functional whole
<b>creative</b>	resulting from originality of thought or expression; relating to or involving the use of the imagination or original ideas to create something; having good imagination or original ideas
<b>credible</b>	capable or worthy of being believed; believable; convincing
<b>criterion</b>	the property or characteristic by which something is judged or appraised
<b>critical</b>	involving skilful judgment as to truth, merit, etc.; involving the objective analysis and evaluation of an issue in order to form a judgment; expressing or involving an analysis of the merits and faults of a work of literature, music, or art; incorporating a detailed and scholarly analysis and commentary (of a text); rationally appraising for logical consistency and merit
<b>critique</b>	review (e.g. a theory, practice, performance) in a detailed, analytical and critical way
<b>cursory</b>	hasty, and therefore not thorough or detailed; performed with little attention to detail; going rapidly over something, without noticing details; hasty; superficial
<b>D</b>	
<b>data</b>	in science, measurements of an attribute or attributes; data may be quantitative or qualitative and be from primary or secondary sources (ACARA 2015c)
<b>dataset</b>	qualitative data and/or quantitative data (e.g. diagram, graph, image, map, photograph, table) derived from a practical, activity or case study
<b>decide</b>	reach a resolution as a result of consideration; make a choice from a number of alternatives
<b>deduce</b>	reach a conclusion that is necessarily true, provided a given set of assumptions is true; arrive at, reach or draw a logical conclusion from reasoning and the information given

Term	Explanation
<b>defensible</b>	justifiable by argument; capable of being defended in argument
<b>define</b>	give the meaning of a word, phrase, concept or physical quantity; state meaning and identify or describe qualities
<b>demonstrate</b>	prove or make clear by argument, reasoning or evidence, illustrating with practical example; show by example; give a practical exhibition
<b>derive</b>	arrive at by reasoning; manipulate a mathematical relationship to give a new equation or relationship; in mathematics, obtain the derivative of a function
<b>describe</b>	give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something
<b>design</b>	produce a plan, simulation, model or similar; plan, form or conceive in the mind; in English, select, organise and use particular elements in the process of text construction for particular purposes; these elements may be linguistic (words), visual (images), audio (sounds), gestural (body language), spatial (arrangement on the page or screen) and multimodal (a combination of more than one)
<b>detailed</b>	executed with great attention to the fine points; meticulous; including many of the parts or facts
<b>determine</b>	establish, conclude or ascertain after consideration, observation, investigation or calculation; decide or come to a resolution
<b>develop</b>	elaborate, expand or enlarge in detail; add detail and fullness to; cause to become more complex or intricate
<b>devise</b>	think out; plan; contrive; invent
<b>differentiate</b>	identify the difference/s in or between two or more things; distinguish, discriminate; recognise or ascertain what makes something distinct from similar things; in mathematics, obtain the derivative of a function
<b>discerning</b>	discriminating; showing intellectual perception; showing good judgment; making thoughtful and astute choices; selected for value or relevance
<b>discriminate</b>	note, observe or recognise a difference; make or constitute a distinction in or between; differentiate; note or distinguish as different
<b>discriminating</b>	differentiating; distinctive; perceiving differences or distinctions with nicety; possessing discrimination; perceptive and judicious; making judgments about quality; having or showing refined taste or good judgment
<b>discuss</b>	examine by argument; sift the considerations for and against; debate; talk or write about a topic, including a range of arguments, factors or hypotheses; consider, taking into account different issues and ideas, points for and/or against, and supporting opinions or conclusions with evidence
<b>disjointed</b>	disconnected; incoherent; lacking a coherent order/sequence or connection

Term	Explanation
<b>distinguish</b>	recognise as distinct or different; note points of difference between; discriminate; discern; make clear a difference/s between two or more concepts or items
<b>diverse</b>	of various kinds or forms; different from each other
<b>document</b>	support (e.g. an assertion, claim, statement) with evidence (e.g. decisive information, written references, citations)
<b>draw conclusions</b>	make a judgment based on reasoning and evidence
<b>E</b>	
<b>ecological niche</b>	the role and space that an organism fills in an ecosystem, including all its interactions with the biotic and abiotic factors of its environment
<b>effective</b>	successful in producing the intended, desired or expected result; meeting the assigned purpose
<b>efficient</b>	working in a well-organised and competent way; maximum productivity with minimal expenditure of effort; acting or producing effectively with a minimum of waste, expense or unnecessary effort
<b>element</b>	a component or constituent part of a complex whole; a fundamental, essential or irreducible part of a composite entity
<b>elementary</b>	simple or uncompounded; relating to or dealing with elements, rudiments or first principles (of a subject); of the most basic kind; straightforward and uncomplicated
<b>erroneous</b>	based on or containing error; mistaken; incorrect
<b>essential</b>	absolutely necessary; indispensable; of critical importance for achieving something
<b>evaluate</b>	make an appraisal by weighing up or assessing strengths, implications and limitations; make judgments about ideas, works, solutions or methods in relation to selected criteria; examine and determine the merit, value or significance of something, based on criteria
<b>evidence</b>	in science, evidence is data that has been selected as it is considered reliable and valid and can be used to support a particular idea, conclusion or decision; evidence gives weight or value to data by considering its credibility, acceptance, bias, status, appropriateness and reasonableness (ACARA 2015c)
<b>evolution</b>	change in the genetic composition of a population during successive generations, which may result in the development of new species
<b>examination</b>	a supervised test that assesses the application of a range of cognitions to one or more provided items such as questions, scenarios and/or problems; student responses are completed individually, under supervised conditions, and in a set timeframe
<b>examine</b>	investigate, inspect or scrutinise; inquire or search into; consider or discuss an argument or concept in a way that uncovers the assumptions and interrelationships of the issue

Term	Explanation
<b>experiment</b>	try out or test new ideas or methods, especially in order to discover or prove something; undertake or perform a scientific procedure to test a hypothesis, make a discovery or demonstrate a known fact in science, an investigation that involves carrying out a practical activity
<b>experimental</b>	relating to, derived from, or founded on experiment
<b>explain</b>	make an idea or situation plain or clear by describing it in more detail or revealing relevant facts; give an account; provide additional information
<b>explicit</b>	clearly and distinctly expressing all that is meant; unequivocal; clearly developed or formulated; leaving nothing merely implied or suggested
<b>explore</b>	look into both closely and broadly; scrutinise; inquire into or discuss something in detail
<b>express</b>	convey, show or communicate (e.g. a thought, opinion, feeling, emotion, idea or viewpoint); in words, art, music or movement, convey or suggest a representation of; depict
<b>extend</b>	in science, to extend an experiment is to modify the methodology to overcome limitations of the scope or applicability of the data
<b>extended response</b>	an open-ended assessment technique that focuses on the interpretation, analysis, examination and/or evaluation of ideas and information in response to a particular situation or stimulus; while students may undertake some research when writing the extended response, it is not the focus of this technique; an extended response occurs over an extended and defined period of time; an item on an examination may also require an extended response, either written or oral
<b>Extension subject</b>	a two-unit subject for which a syllabus has been developed by QCAA; it is an extension of one or more general or alternative sequence subject/s; studied concurrently with the final two units of that subject/s or after completion of, the final two units of that subject/s
<b>extensions</b>	in science, modifications to an investigation that could be used to further examine a claim
<b>extensive</b>	of great extent; wide; broad; far-reaching; comprehensive; lengthy; detailed; large in amount or scale
<b>external assessment</b>	summative assessment that occurs towards the end of a course of study and is common to all schools; developed and marked by the QCAA according to a commonly applied marking scheme
<b>external examination</b>	a supervised test, developed and marked by the QCAA, that assesses the application of a range of cognitions to multiple provided items such as questions, scenarios and/or problems; student responses are completed individually, under supervised conditions, and in a set timeframe

Term	Explanation
<b>extrapolate</b>	infer or estimate by extending or projecting known information; conjecture; infer from what is known; extend the application of something (e.g. a method or conclusion) to an unknown situation by assuming that existing trends will continue or similar methods will be applicable
<b>extrapolation</b>	extension of a conclusion to a new situation with the assumption that existing trends will continue
<b>F</b>	
<b>factual</b>	relating to or based on facts; concerned with what is actually the case; actually occurring; having verified existence
<b>familiar</b>	well-acquainted; thoroughly conversant with; well known from long or close association; often encountered or experienced; common; (of materials, texts, skills or circumstances) having been the focus of learning experiences or previously encountered in prior learning activities
<b>feasible</b>	capable of being achieved, accomplished or put into effect; reasonable enough to be believed or accepted; probable; likely
<b>feature</b>	distinctive attribute, characteristic, property or quality of evidence
<b>fieldwork</b>	research carried out in the field (i.e. beyond the classroom) which includes data collection
<b>findings</b>	in science, the outcomes of research, investigation or experimentation, including facts or principles established in these ways
<b>fluent</b>	spoken or written with ease; able to speak or write smoothly, easily or readily; articulate; eloquent; in artistic performance, characteristic of a highly developed and excellently controlled technique; flowing; polished; flowing smoothly, easily and effortlessly
<b>fluently</b>	in a graceful and seemingly effortless manner; in a way that progresses smoothly and readily
<b>formative assessment</b>	assessment whose major purpose is to improve teaching and student achievement
<b>fragmented</b>	disorganised; broken down; disjointed or isolated
<b>frequent</b>	happening or occurring often at short intervals; constant, habitual, or regular
<b>fundamental</b>	forming a necessary base or core; of central importance; affecting or relating to the essential nature of something; part of a foundation or basis
<b>G</b>	
<b>gene</b>	region/s of DNA that are made up of nucleotides; the molecular unit of heredity
<b>General subject</b>	a subject for which a syllabus has been developed by the QCAA with the following characteristics: results from courses developed from General syllabuses contribute to the QCE; General subjects

Term	Explanation
	have an external assessment component; results may contribute to ATAR calculations
<b>generate</b>	produce; create; bring into existence
<b>genome</b>	all the genetic material in the chromosomes of an organism, including its genes and DNA sequences
<b>genre conventions</b>	agreed and acceptable conditions; a style or category
<b>graphical representation</b>	in science, a visual representation of the relationship between quantities plotted with reference to a set of axes; also known as a graph (ACARA 2015c)
<b>H</b>	
<b>hypothesis</b>	in science, a tentative explanation for an observed phenomenon, expressed as a precise and unambiguous statement that can be supported or refuted by experiment (ACARA 2015c)
<b>hypothesise</b>	formulate a supposition to account for known facts or observed occurrences; conjecture, theorise, speculate; especially on uncertain or tentative grounds
<b>I</b>	
<b>identify</b>	distinguish; locate, recognise and name; establish or indicate who or what someone or something is; provide an answer from a number of possibilities; recognise and state a distinguishing factor or feature
<b>illogical</b>	lacking sense or sound reasoning; contrary to or disregarding of the rules of logic; unreasonable
<b>implement</b>	put something into effect, e.g. a plan or proposal
<b>implication</b>	a likely consequence of something; a conclusion that may be drawn though it is implied rather than explicit
<b>implicit</b>	implied, rather than expressly stated; not plainly expressed; capable of being inferred from something else
<b>improbable</b>	not probable; unlikely to be true or to happen; not easy to believe
<b>improvements</b>	in science, modifications to an investigation that mitigate the limitations of the evidence, method or design
<b>inaccurate</b>	not accurate
<b>inadequate</b>	not satisfactory or acceptable in quality and/or quantity to the requirements of the situation
<b>inappropriate</b>	not suitable or proper in the circumstances
<b>inconsistent</b>	lacking agreement, as one thing with another, or two or more things in relation to each other; at variance; not consistent; not in keeping; not in accordance; incompatible, incongruous
<b>incorrect</b>	not conforming to fact or truth
<b>independent</b>	thinking or acting for oneself, not influenced by others



Term	Explanation
<b>in-depth</b>	comprehensive and with thorough coverage; extensive or profound; well-balanced or fully developed
<b>ineffective</b>	not producing a result, or not producing any significant result; not producing the intended, desired or expected result
<b>infer</b>	derive or conclude something from evidence and reasoning, rather than from explicit statements; listen or read beyond what has been literally expressed; imply or hint at
<b>informed</b>	knowledgeable; learned; having relevant knowledge; being conversant with the topic; based on an understanding of the facts of the situation (of a decision or judgment)
<b>innovative</b>	new and original; introducing new ideas; original and creative in thinking
<b>insightful</b>	showing understanding of a situation or process; understanding relationships in complex situations; informed by observation and deduction
<b>instrument-specific marking guide</b>	ISMG; a tool for marking that describes the characteristics evident in student responses and aligns with the identified objectives for the assessment (see 'assessment objectives')
<b>insufficient</b>	not enough; inadequate for the purpose
<b>integral</b>	<i>adjective</i> necessary for the completeness of the whole; essential or fundamental; <i>noun</i> in mathematics, the result of integration; an expression from which a given function, equation, or system of equations is derived by differentiation
<b>intended</b>	designed; meant; done on purpose; intentional
<b>internal assessment</b>	assessments that are developed by schools; summative internal assessments are endorsed by the QCAA before use in schools and results externally confirmed; contributes towards a student's final result
<b>interpret</b>	use knowledge and understanding to recognise trends and draw conclusions from given information; make clear or explicit; elucidate or understand in a particular way; bring out the meaning of, e.g. a dramatic or musical work, by performance or execution; bring out the meaning of an artwork by artistic representation or performance; give one's own interpretation of; identify or draw meaning from, or give meaning to, information presented in various forms, such as words, symbols, pictures or graphs
<b>invalid</b>	not sound, just or well-founded; not having a sound basis in logic or fact (of an argument or point); not reasonable or cogent; not able to be supported; not legitimate or defensible; not applicable

Term	Explanation
<b>investigate</b>	carry out an examination or formal inquiry in order to establish or obtain facts and reach new conclusions; search, inquire into, interpret and draw conclusions about data and information
<b>investigation</b>	<p>an assessment technique that requires students to research a specific problem, question, issue, design challenge or hypothesis through the collection, analysis and synthesis of primary and/or secondary data;</p> <p>it uses research or investigative practices to assess a range of cognitions in a particular context; an investigation occurs over an extended and defined period of time</p> <p>in science, a scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities (ACARA 2015c)</p>
<b>irrelevant</b>	not relevant; not applicable or pertinent; not connected with or relevant to something
<b>ISMG</b>	instrument-specific marking guide; a tool for marking that describes the characteristics evident in student responses and aligns with the identified objectives for the assessment (see 'assessment objectives')
<b>isolated</b>	detached, separate, or unconnected with other things; one-off; something set apart or characterised as different in some way
<b>J</b>	
<b>judge</b>	form an opinion or conclusion about; apply both procedural and deliberative operations to make a determination
<b>justified</b>	sound reasons or evidence are provided to support an argument, statement or conclusion
<b>justify</b>	give reasons or evidence to support an answer, response or conclusion; show or prove how an argument, statement or conclusion is right or reasonable
<b>K</b>	
<b>keystone species</b>	a plant or animal that plays a unique and crucial role in the way an ecosystem functions
<b>L</b>	
<b>learning area</b>	a grouping of subjects, with related characteristics, within a broad field of learning, e.g. the Arts, sciences, languages
<b>limitation</b>	a weak point or disadvantage that makes evidence less effective
<b>link</b>	anything serving to connect one part or thing with another
<b>logical</b>	rational and valid; internally consistent; reasonable; reasoning in accordance with the principles/rules of logic or formal argument; characterised by or capable of clear, sound reasoning; (of an action, decision, etc.) expected or sensible under the circumstances

Term	Explanation
<b>logically</b>	according to the rules of logic or formal argument; in a way that shows clear, sound reasoning; in a way that is expected or sensible
<b>M</b>	
<b>macroevolution</b>	the variation of allele frequencies at or above the level of species over geological time, resulting in the divergence of taxonomic groups, in which the descendant is in a different taxonomic group to the ancestor
<b>make decisions</b>	select from available options; weigh up positives and negatives of each option and consider all the alternatives to arrive at a position
<b>management</b>	handling, direction or control
<b>manipulate</b>	adapt or change to suit one's purpose
<b>mental procedures</b>	a domain of knowledge in Marzano's taxonomy, and acted upon by the cognitive, metacognitive and self-systems; sometimes referred to as 'procedural knowledge' there are three distinct phases to the acquisition of mental procedures — the cognitive stage, the associative stage, and the autonomous stage; the two categories of mental procedures are skills (single rules, algorithms and tactics) and processes (macroprocedures)
<b>methodical</b>	performed, disposed or acting in a systematic way; orderly; characterised by method or order; performed or carried out systematically
<b>methodology</b>	a systematic, ordered approach to gathering data in a scientific experiment or investigation
<b>microevolution</b>	small-scale variation of allele frequencies within a species or population, in which the descendant is of the same taxonomic group as the ancestor
<b>minimal</b>	least possible; small, the least amount; negligible
<b>model</b>	in science, a representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea (ACARA 2015c)
<b>modifications</b>	in science, changes to methodology to extend, refine or redirect the research focus
<b>modify</b>	change the form or qualities of; make partial or minor changes to something
<b>multimodal</b>	uses a combination of at least two modes (e.g. spoken, written), delivered at the same time, to communicate ideas and information to a live or virtual audience, for a particular purpose; the selected modes are integrated so that each mode contributes significantly to the response
<b>N</b>	
<b>narrow</b>	limited in range or scope; lacking breadth of view; limited in amount; barely sufficient or adequate; restricted

Term	Explanation
<b>nuanced</b>	showing a subtle difference or distinction in expression, meaning, response, etc.; finely differentiated; characterised by subtle shades of meaning or expression; a subtle distinction, variation or quality; sensibility to, awareness of, or ability to express delicate shadings, as of meaning, feeling, or value
<b>O</b>	
<b>objectives</b>	see 'syllabus objectives', 'unit objectives', 'assessment objectives'
<b>obvious</b>	clearly perceptible or evident; easily seen, recognised or understood
<b>optimal</b>	best, most favourable, under a particular set of circumstances
<b>organise</b>	arrange, order; form as or into a whole consisting of interdependent or coordinated parts, especially for harmonious or united action
<b>organised</b>	systematically ordered and arranged; having a formal organisational structure to arrange, coordinate and carry out activities
<b>outcome</b>	result of something; a consequence
<b>outlier</b>	a value that 'lies outside' (is much smaller or larger than) most of the other values in a set of data
<b>outstanding</b>	exceptionally good; clearly noticeable; prominent; conspicuous; striking
<b>P</b>	
<b>partial</b>	not total or general; existing only in part; attempted, but incomplete
<b>particular</b>	distinguished or different from others or from the ordinary; noteworthy
<b>pattern</b>	a repeated occurrence or sequence (ACARA 2015c)
<b>perceptive</b>	having or showing insight and the ability to perceive or understand; discerning (see also 'discriminating')
<b>performance</b>	an assessment technique that requires students to demonstrate a range of cognitive, technical, creative and/or expressive skills and to apply theoretical and conceptual understandings, through the psychomotor domain; it involves student application of identified skills when responding to a task that involves solving a problem, providing a solution or conveying meaning or intent; a performance is developed over an extended and defined period of time
<b>persuasive</b>	capable of changing someone's ideas, opinions or beliefs; appearing worthy of approval or acceptance; (of an argument or statement) communicating reasonably or credibly (see also 'convincing')
<b>perusal time</b>	time allocated in an assessment to reading items and tasks and associated assessment materials; no writing is allowed; students may not make notes and may not commence responding to the assessment in the response space/book

Term	Explanation
<b>phenomena</b>	events that are not artificial and can be observed through the senses or can be scientifically described or explained
<b>planning time</b>	time allocated in an assessment to planning how to respond to items and tasks and associated assessment materials; students may make notes but may not commence responding to the assessment in the response space/book; notes made during planning are not collected, nor are they graded or used as evidence of achievement
<b>polished</b>	flawless or excellent; performed with skilful ease
<b>polygenic inheritance</b>	when one characteristic is controlled by two or more genes
<b>practical</b>	in science, an activity that produces primary data
<b>precise</b>	definite or exact; definitely or strictly stated, defined or fixed; characterised by definite or exact expression or execution
<b>precision</b>	accuracy; exactness; exact observance of forms in conduct or actions in science, exactness; how close two or more measurements of the same object or phenomena are to each other
<b>predict</b>	give an expected result of an upcoming action or event; suggest what may happen based on available information
<b>primary data</b>	data collected directly by a person or group (ACARA 2015c)
<b>process</b>	in science, to collect and manipulate data to produce meaningful information; operate on a set of data to extract the required information in an appropriate form such as tables or graphs
<b>product</b>	an assessment technique that focuses on the output or result of a process requiring the application of a range of cognitive, physical, technical, creative and/or expressive skills, and theoretical and conceptual understandings; a product is developed over an extended and defined period of time
<b>proficient</b>	well advanced or expert in any art, science or subject; competent, skilled or adept in doing or using something
<b>project</b>	an assessment technique that focuses on a problem-solving process requiring the application of a range of cognitive, technical and creative skills and theoretical understandings; the response is a coherent work that documents the iterative process undertaken to develop a solution and includes written paragraphs and annotations, diagrams, sketches, drawings, photographs, video, spoken presentations, physical prototypes and/or models; a project is developed over an extended and defined period of time
<b>propose</b>	put forward (e.g. a point of view, idea, argument, suggestion) for consideration or action
<b>prove</b>	use a sequence of steps to obtain the required result in a formal way

Term	Explanation
<b>psychomotor procedures</b>	a domain of knowledge in Marzano's taxonomy, and acted upon by the cognitive, metacognitive and self-systems; these are physical procedures used to negotiate daily life and to engage in complex physical activities; the two categories of psychomotor procedures are skills (foundational procedures and simple combination procedures) and processes (complex combination procedures)
<b>purposeful</b>	having an intended or desired result; having a useful purpose; determined; resolute; full of meaning; significant; intentional
<b>Q</b>	
<b>QCE</b>	Queensland Certificate of Education
<b>qualitative data</b>	information that is not numerical in nature
<b>quality of evidence</b>	the standard of evidence, as measured against relevant criteria
<b>quantitative data</b>	numerical information (Taylor 1982)
<b>quantity</b>	in science, having magnitude, size, extent, amount or the like
<b>R</b>	
<b>rationale</b>	a set of reasons, or logical basis for a course of action or decision
<b>raw data</b>	unprocessed and/or unanalysed data; data that has been collected without any additional processing (Taylor 1982)
<b>realise</b>	create or make (e.g. a musical, artistic or dramatic work); actualise; make real or concrete; give reality or substance to
<b>reasonable</b>	endowed with reason; having sound judgment; fair and sensible; based on good sense; average; appropriate, moderate
<b>reasoned</b>	logical and sound; based on logic or good sense; logically thought out and presented with justification; guided by reason; well-grounded; considered
<b>recall</b>	remember; present remembered ideas, facts or experiences; bring something back into thought, attention or into one's mind
<b>recognise</b>	identify or recall particular features of information from knowledge; identify that an item, characteristic or quality exists; perceive as existing or true; be aware of or acknowledge
<b>redirect</b>	in science, to redirect an experiment is to modify the methodology to gain further insight into the phenomena observed in the original experiment
<b>referencing conventions</b>	agreed, consistent ways of referencing a source of information
<b>refine</b>	in science, to refine an experiment is to modify the methodology to obtain more accurate or precise data
<b>refined</b>	developed or improved so as to be precise, exact or subtle
<b>reflect on</b>	think about deeply and carefully
<b>rehearsed</b>	practised; previously experienced; practised extensively

Term	Explanation
<b>related</b>	associated with or linked to
<b>relationship</b>	in science, connections or associations between ideas or between components of systems and structures (ACARA 2015c)
<b>relevance</b>	being related to the matter at hand
<b>relevant</b>	bearing upon or connected with the matter in hand; to the purpose; applicable and pertinent; having a direct bearing on
<b>reliable</b>	constant and dependable or consistent and repeatable
<b>reliability</b>	in science, the likelihood that another experimenter will obtain the same results (or very similar results) if they perform exactly the same experiment under the same conditions (ACARA 2015c, Taylor 1982)
<b>repetitive</b>	containing or characterised by repetition, especially when unnecessary or tiresome
<b>reporting</b>	providing information that succinctly describes student performance at different junctures throughout a course of study
<b>representation</b>	in science, verbal, physical or mathematical demonstration of understanding of a science concept or concepts; a concept can be represented in a range of ways and using multiple models (ACARA 2015c)
<b>research</b>	to locate, gather, record and analyse information in order to develop understanding (ACARA 2015c)
<b>research ethics</b>	norms of conduct that determine ethical research behaviour; research ethics are governed by principles such as honesty, objectivity, integrity, openness and respect for intellectual property and include consideration of animal ethics (ACARA 2015c)
<b>research question</b>	a question that directs the scientific inquiry activity; it focuses the research investigation or student experiment, informing the direction of the research, and guiding all stages of inquiry, analysis, interpretation and evaluation
<b>resolve</b>	in the Arts, consolidate and communicate intent through a synthesis of ideas and application of media to express meaning
<b>risk assessment</b>	evaluations performed to identify, assess and control hazards in a systematic way that is consistent, relevant and applicable to all school activities; requirements for risk assessments related to particular activities will be determined by jurisdictions, schools or teachers as appropriate (ACARA 2015c)
<b>routine</b>	often encountered, previously experienced; commonplace; customary and regular; well-practised; performed as part of a regular procedure, rather than for a special reason
<b>rudimentary</b>	relating to rudiments or first principles; elementary; undeveloped; involving or limited to basic principles; relating to an immature, undeveloped or basic form

Term	Explanation
<b>S</b>	
<b>safe</b>	secure; not risky
<b>scientific language</b>	terminology that has specific meaning in a scientific context
<b>scrutinise</b>	examine closely or critically
<b>secondary data</b>	data collected by a person or group other than the person or group using the data (ACARA 2015c)
<b>secure</b>	sure; certain; able to be counted on; self-confident; poised; dependable; confident; assured; not liable to fail
<b>select</b>	choose in preference to another or others; pick out
<b>sensitive</b>	capable of perceiving with a sense or senses; aware of the attitudes, feelings or circumstances of others; having acute mental or emotional sensibility; relating to or connected with the senses or sensation
<b>sequence</b>	place in a continuous or connected series; arrange in a particular order
<b>show</b>	provide the relevant reasoning to support a response
<b>significant</b>	important; of consequence; expressing a meaning; indicative; includes all that is important; sufficiently great or important to be worthy of attention; noteworthy; having a particular meaning; indicative of something
<b>simple</b>	easy to understand, deal with and use; not complex or complicated; plain; not elaborate or artificial; may concern a single or basic aspect; involving few elements, components or steps
<b>simplistic</b>	characterised by extreme simplification, especially if misleading; oversimplified
<b>simulation</b>	a representation of a process, event or system which imitates a real or idealised situation (ACARA 2015c)
<b>sketch</b>	execute a drawing or painting in simple form, giving essential features but not necessarily with detail or accuracy; in mathematics, represent by means of a diagram or graph; the sketch should give a general idea of the required shape or relationship and should include features
<b>skilful</b>	having technical facility or practical ability; possessing, showing, involving or requiring skill; expert, dexterous; demonstrating the knowledge, ability or training to perform a certain activity or task well; trained, practised or experienced
<b>skilled</b>	having or showing the knowledge, ability or training to perform a certain activity or task well; having skill; trained or experienced; showing, involving or requiring skill



Term	Explanation
<b>solve</b>	find an answer to, explanation for, or means of dealing with (e.g. a problem); work out the answer or solution to (e.g. a mathematical problem); obtain the answer/s using algebraic, numerical and/or graphical methods
<b>sophisticated</b>	of intellectual complexity; reflecting a high degree of skill, intelligence, etc.; employing advanced or refined methods or concepts; highly developed or complicated
<b>source</b>	any piece of scientific literature or text from which scientific evidence is drawn
<b>specific</b>	clearly defined or identified; precise and clear in making statements or issuing instructions; having a special application or reference; explicit, or definite; peculiar or proper to something, as qualities, characteristics, effects, etc.
<b>sporadic</b>	happening now and again or at intervals; irregular or occasional; appearing in scattered or isolated instances
<b>statement</b>	a communication or declaration setting forth facts, particulars; an expression
<b>straightforward</b>	without difficulty; uncomplicated; direct; easy to do or understand
<b>stratified sampling</b>	a type of sampling in which a sample is taken of each strata of the population
<b>structure</b>	<i>verb</i> give a pattern, organisation or arrangement to; construct or arrange according to a plan; <i>noun</i> in languages, arrangement of words into larger units, e.g. phrases, clauses, sentences, paragraphs and whole texts, in line with cultural, intercultural and textual conventions
<b>structured</b>	organised or arranged so as to produce a desired result
<b>subject</b>	a branch or area of knowledge or learning defined by a syllabus; school subjects are usually based in a discipline or field of study (see also 'course')
<b>subject matter</b>	the subject-specific body of information, mental procedures and psychomotor procedures that are necessary for students' learning and engagement within that subject
<b>substantial</b>	of ample or considerable amount, quantity, size, etc.; of real worth or value; firmly or solidly established; of real significance; reliable; important, worthwhile
<b>substantiated</b>	established by proof or competent evidence
<b>subtle</b>	fine or delicate in meaning or intent; making use of indirect methods; not straightforward or obvious
<b>successful</b>	achieving or having achieved success; accomplishing a desired aim or result
<b>succinct</b>	expressed in few words; concise; terse; characterised by conciseness or brevity; brief and clear

Term	Explanation
<b>sufficient</b>	enough or adequate for the purpose
<b>suitable</b>	appropriate; fitting; conforming or agreeing in nature, condition, or action
<b>summarise</b>	give a brief statement of a general theme or major point/s; present ideas and information in fewer words and in sequence
<b>summative assessment</b>	assessment whose major purpose is to indicate student achievement; summative assessments contribute towards a student's subject result
<b>superficial</b>	concerned with or comprehending only what is on the surface or obvious; shallow; not profound, thorough, deep or complete; existing or occurring at or on the surface; cursory; lacking depth of character or understanding; apparent and sometimes trivial
<b>supported</b>	corroborated; given greater credibility by providing evidence
<b>sustained</b>	carried on continuously, without interruption, or without any diminishing of intensity or extent
<b>syllabus</b>	a document that prescribes the curriculum for a course of study
<b>syllabus objectives</b>	outline what the school is required to teach and what students have the opportunity to learn; described in terms of actions that operate on the subject matter; the overarching objectives for a course of study (see also 'unit objectives', 'assessment objectives')
<b>symbolise</b>	represent or identify by a symbol or symbols
<b>synthesise</b>	combine different parts or elements (e.g. information, ideas, components) into a whole, in order to create new understanding
<b>system</b>	a group of interacting objects, materials or processes that form an integrated whole; can be open or closed (ACARA 2015c)
<b>systematic</b>	done or acting according to a fixed plan or system; methodical; organised and logical; having, showing, or involving a system, method, or plan; characterised by system or method; methodical; arranged in, or comprising an ordered system
<b>T</b>	
<b>test</b>	take measures to check the quality, performance or reliability of something
<b>theory</b>	in science, a set of concepts, claims and/or laws that can be used to explain and predict a wide range of related observed or observable phenomena; theories are typically founded on clearly identified assumptions, are testable, produce reproducible results and have explanatory power (ACARA 2015c)
<b>thorough</b>	carried out through, or applied to the whole of something; carried out completely and carefully; including all that is required; complete with attention to every detail; not superficial or partial; performed or written with care and completeness; taking pains to do something carefully and completely

Term	Explanation
<b>thoughtful</b>	occupied with, or given to thought; contemplative; meditative; reflective; characterised by or manifesting thought
<b>topic</b>	a division of, or sub-section within a unit; all topics/sub-topics within a unit are interrelated
<b>trend</b>	general direction in which something is changing (ACARA 2015c)
<b>U</b>	
<b>uncertainty</b>	range of values for a measurement result, taking account of the likely values that could be attributed to the measurement result given the measurement equipment, procedure and environment (ACARA 2015c); indicators of uncertainty may include percentage and/or absolute measurement uncertainty, confidence intervals, inferential statistics, statistical measures of spread, e.g. range, standard deviation
<b>unclear</b>	not clear or distinct; not easy to understand; obscure
<b>understand</b>	perceive what is meant by something; grasp; be familiar with (e.g. an idea); construct meaning from messages, including oral, written and graphic communication
<b>understanding</b>	perception of what is meant by something
<b>uneven</b>	unequal; not properly corresponding or agreeing; irregular; varying; not uniform; not equally balanced
<b>unfamiliar</b>	not previously encountered; situations or materials that have not been the focus of prior learning experiences or activities
<b>unit</b>	a defined amount of subject matter delivered in a specific context or with a particular focus; it includes unit objectives particular to the unit, subject matter and assessment direction
<b>unit objectives</b>	drawn from the syllabus objectives and contextualised for the subject matter and requirements of a particular unit; they are assessed at least once in the unit (see also 'syllabus objectives', 'assessment objectives')
<b>unrelated</b>	having no relationship; unconnected
<b>use</b>	operate or put into effect; apply knowledge or rules to put theory into practice
<b>V</b>	
<b>vague</b>	not definite in statement or meaning; not explicit or precise; not definitely fixed, determined or known; of uncertain, indefinite or unclear character or meaning; not clear in thought or understanding; couched in general or indefinite terms; not definitely or precisely expressed; deficient in details or particulars; thinking or communicating in an unfocused or imprecise way
<b>valid</b>	sound, just or well-founded; authoritative; having a sound basis in logic or fact (of an argument or point); reasonable or cogent; able to be supported; legitimate and defensible; applicable

Term	Explanation
<b>validity</b>	in science, the extent to which tests measure what was intended; the extent to which data, inferences and actions produced from tests and other processes are accurate (ACARA 2015c)
<b>variable</b>	<i>adjective</i> apt or liable to vary or change; changeable; inconsistent; (readily) susceptible or capable of variation; fluctuating, uncertain; <i>noun</i> in mathematics, a symbol, or the quantity it signifies, that may represent any one of a given set of number and other objects in science, a factor that can be changed, kept the same or measured in an investigation, e.g. time, distance, light, temperature
<b>variety</b>	a number or range of things of different kinds, or the same general class, that are distinct in character or quality; (of sources) a number of different modes or references
<b>visual representations</b>	in science, an image that shows relationships within scientific evidence
<b>W</b>	
<b>wide</b>	of great range or scope; embracing a great number or variety of subjects, cases, etc.; of full extent
<b>with expression</b>	in words, art, music or movement, conveying or indicating feeling, spirit, character, etc.; a way of expressing or representing something; vivid, effective or persuasive communication

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## 8 Version history

Version	Date of change	Update
1.1	December 2017	Editorial changes
		Syllabus objective 2: Amendment to explanatory paragraph
		IA1: Data test <ul style="list-style-type: none"> <li>• Minor amendments to Assessment objectives 2,3 &amp; 4</li> <li>• Percentage of marks modified <ul style="list-style-type: none"> <li>– objective 3 — 40% changed to 30%</li> <li>– objective 4 — 30% changed to 40%</li> </ul> </li> <li>• Condition amendment (Length) — 400 words changed to ‘up to 500 words’</li> </ul>
		IA2: Student experiment <ul style="list-style-type: none"> <li>• Minor amendment to Assessment objective 5</li> </ul>
		IA3: Research investigation <ul style="list-style-type: none"> <li>• Minor amendment to Assessment objective 5</li> </ul>
		Amendments to ISMGs to reflect modifications to objectives
		Glossary update
1.2	June 2018	Editorial changes
		IA1: Data test <ul style="list-style-type: none"> <li>• Minor amendments to Assessment objective 2</li> <li>• Minor amendments to description and conditions</li> <li>• Addition of information about cognition and nature of response for each objective</li> </ul>
		IA2: Student experiment <ul style="list-style-type: none"> <li>• Minor editorial changes to ISMG</li> </ul>
		IA3: Research investigation <ul style="list-style-type: none"> <li>• Minor editorial changes to ISMG</li> </ul>
		EA: Examination <ul style="list-style-type: none"> <li>• Minor amendments to Assessment objectives 3 and 4</li> <li>• Minor amendments to description and conditions</li> </ul>
		Glossary update

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