A GTAC guide to teaching Unit 4 for the 2022 – 2026 VCE Biology Study Design

We have allocated 16 weeks to teaching Unit 4 with 240 min/week - Note that this includes a continued focus on the key science skills (SD pages 7-9). We have allocated a total of 32 teaching weeks across Units 3 and 4.

The Victorian Curriculum and Assessment Authority (VCAA) provide this template to support you to plan for curriculum delivery with a focus on how you will deliver key knowledge and key skills, and the activities you will use to provide appropriate opportunity for students to demonstrate satisfactory achievement of the outcome (S/N) and the assessment tasks that will be used to assess students level of achievement. Note that VCAA provide definitions for terms to support teaching the study design and associated assessment. This includes data and measurement on pages 14 and 15; ethical approaches and concepts on pages 15 and 16; errors, uncertainty and outliers on pages 16 and 17; and Aboriginal and Torres Strait Islander knowledge, cultures and history on page 14.

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

- ### Area of Study 1 – How do organisms respond to pathogens?
  Outcome 1: Analyse the immune response to specific antigens, compare the different ways that immunity may be acquired and evaluate challenges and strategies in the treatment of disease. Draw on AOS1 key knowledge and related key science skills on SD pages 7 – 9.

- ### Area of Study 2 - How are species related over time?
  Outcome 2: Analyse the evidence for genetic changes in populations and changes in species over time, analyse the evidence for relatedness between species, and evaluate the evidence for human change over time. Draw on AOS2 key knowledge and related key science skills on SD pages 7 – 9.

- ### Area of Study 3 - How is scientific inquiry used to investigate cellular processes and/or biological change?
  Outcome 3: design and conduct a scientific investigation related to cellular processes and/or how life changes and responds to challenges,
  and present an aim, methodology and methods, results, discussion and a conclusion in a scientific poster. Draw on AOS3 key knowledge and related key science skills on SD pages 7 – 9.

Assessment of levels of achievement

The student's level of achievement in Unit 4 will be determined by School-assessed Coursework. School-assessed Coursework tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe. The VCAA publishes Support materials for this study, which includes advice on the design of assessment tasks and the assessment of student work for a level of achievement. Teachers will provide to the VCAA a numerical score representing an assessment of the student's level of achievement. The score must be based on the teacher's assessment of the performance of each student on the tasks set out in the following table. The table can be used to support the allocation of an assessment task for each outcome.

Each task type from the following list can only be selected once across Units 3 and 4:

- analysis and evaluation of a selected biological case study
- analysis and evaluation of generated primary and/or collated secondary data
- comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities
- analysis and evaluation of a contemporary bioethical issue.

Outcomes	Marks allocated	**Assessment task**
UNIT 3: Outcome 1 Analyse the relationship between nucleic acids and proteins, and evaluate how tools and techniques can be used and applied in the manipulation of DNA.	40	
UNIT 3: Outcome 2 Analyse the structure and regulation of biochemical pathways in photosynthesis and cellular respiration, and evaluate how biotechnology can be used to solve problems related to the regulation of biochemical pathways.	40	
Total marks unit 3	*80*	***SACs for Unit 3 contribute 20% to the study score***
UNIT 4: Outcome 1 Analyse the immune response to specific antigens, compare the different ways that immunity may be acquired and evaluate challenges and strategies in the treatment of disease.	40	
UNIT 4: Outcome 2 Analyse the evidence for genetic changes in populations and changes in species over time, analyse the evidence for relatedness between species, and evaluate the evidence for human change over time.	40	
UNIT 4: Outcome 3 Design and conduct a scientific investigation related to cellular processes and/or how life changes and responds to challenges, and present an aim, methodology and method, results, discussion and a conclusion in a scientific poster.	40	Communication of the design, analysis and findings of a student-designed and student-conducted scientific investigation through a structured scientific poster and logbook entries. The poster should not exceed 600 words.
Total marks Unit 4	*120*	***SACs for Unit 4 contribute 30% to the study score***
TOTAL MARKS UNIT 3 AND UNIT 4	200	**SACs for Unit 3 and 4 contribute 50% to the study score**

Satisfactory completion

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks to provide a range of opportunities for students to demonstrate the key science skills and key knowledge in the outcomes. The areas of study and key knowledge and relevant key science skills listed for the outcomes should be used for course design and the development of learning activities and assessment tasks.

External assessment

The level of achievement for **Units 3 and 4** is also assessed by an **end-of-year examination, which will contribute 50 per cent** to the study score.

Contributions of SAC tasks and external assessment by examination to the final study score:

Assessment type	Contribution to final study score
Unit 3 SAC tasks (two tasks)	20%
Unit 4 SAC tasks (three tasks)	30%
Unit 3 and 4 end-of-year examination	50%

Practical work

Practical work is a central component of learning and assessment and may include activities such as laboratory experiments, fieldwork, simulations and other direct experiences as described in the scientific investigation methodologies on SD pages 9 and 10. A minimum of ten hours of class time should be devoted to student practical activities and scientific investigations across Areas of Study 1 and 2.

We suggest you cover the different methodologies across Units 1 – 4.

Scientific investigation methodologies (practical tasks) – page 9 & 10 of SD	Unit 3	Unit 4
Case study		
Classification and identification		
Controlled experiment		

Correlational study		
Fieldwork		
Literature review		
Modelling		
Product, process or system development		
Simulation		

GTAC suggested timeline rationale

This is a suggested timeline that we have constructed with reference to the 2022 - 2026 VCAA VCE Biology Study Design. The suggested sequence of some key knowledge points follows the sequence found in the study design. However, note that the Unit 4 AOS3 Outcome 3 can be conducted at any time during unit 3 and 4 or across both units.

The time dedicated to each section is a suggested time. We have attempted to include time buffers for various school activities/events that reduce available teaching time.

Key knowledge	Suggested teaching timeline and approaches
Responding to antigens (Unit 4 AOS1) • physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in animals and plants • the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins and interferons • initiation of an immune response, including antigen presentation, the distinction between self-antigens and non-self antigens, cellular and non-cellular pathogens and allergens **Acquiring immunity (Unit 4 AOS1)** • the role of the lymphatic system in the immune response as a transport network and the role of lymph nodes as sites for antigen recognition by T and B lymphocytes • the characteristics and roles of the components of the adaptive immune response against both extracellular and intracellular threats, including the actions of B lymphocytes and their antibodies, helper T and cytotoxic T cells	**Week 1 & 2 (weeks 17 & 18 for the year)** Throughout Unit 4 prepare students for Unit 4 AOS3 by teaching relevant *key science skills* (SD page 7 & 8) – these skills are also examinable. Continue use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Classification and identification* – cells and proteins in the innate immune response • *Modelling* – GTAC teaching resource for a role play in the classroom: Modelling the adaptive (specific) immune response • *Simulation* – GTAC student learning resource and online course: Pathogen attack: GTAC's immunology game **Additional GTAC resources:** • GTAC student online course: Active immunity – the adaptive (specific) humoral immune response • GTAC student online course: Active immunity – the adaptive (specific) cell-mediated immune response
Acquiring immunity (Unit 4 AOS1) • the difference between natural and artificial immunity and active and passive strategies for acquiring immunity **Disease challenges and strategies (Unit 4 AOS1)** • the emergence of new pathogens and re-emergence of known pathogens in a globally connected world, including the impact of European arrival on Aboriginal and Torres Strait Islander peoples • scientific and social strategies employed to identify and control the spread of pathogens, including identification of the pathogen and host, modes of transmission and measures to control transmission	**Week 3 & 4 (weeks 19 & 20 for the year)** **Suggest you run a SAC task for outcome 1 in weeks 3 – 6:** *Analyse the immune response to specific antigens, compare the different ways that immunity may be acquired and evaluate challenges and strategies in the treatment of disease.* Practice approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17). Related bioethical issues could include issues associated with vaccination programs and herd immunity; and impact of European arrival on Aboriginal and Torres Strait Islander peoples. Continue use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Case study* – GTAC student online course: Active immunity – triggering the humoral immune response to generate immunity

Key knowledge	Suggested teaching timeline and approaches
• vaccination programs and their role in maintaining herd immunity for a specific disease in a human population **Practice relevant key science skills for an analysis and evaluation of a selected biological case study** • Analyse and evaluate data and investigation methodologies • Construct evidence-based arguments and draw conclusions • Analyse, evaluate and communicate scientific ideas **Practice relevant key science skills for an analysis and evaluation of a contemporary bioethical issue.** • Analyse, evaluate and communicate scientific ideas • Construct evidence-based arguments and draw conclusions	• *Case study* – GTAC online student course: Outbreak! Strategies to deal with the emergence of a new infectious disease • *Case study* – GTAC teaching resource: Strategies to deal with the emergence of an outbreak of foodborne disease Additional GTAC resources: • GTAC student online course: Introduction to ethics
Disease challenges and strategies (Unit 4 AOS1) • the development of immunotherapy strategies, including the use of monoclonal antibodies for the treatment of autoimmune diseases and cancer. **Practice relevant key science skills for an analysis and evaluation of generated primary and/or collated secondary data** • Generate, collate and record data • Analyse and evaluate data and investigation methods • Construct evidence-based arguments and draw conclusions	Week 5 – includes additional time for catch up and consolidation Continue use of logbooks as you carry out the Unit 4 Outcome 1 SAC task. Additional GTAC resources: • GTAC teaching resource: Melanoma search and destroy – Monoclonal antibody treatments for melanoma

Key knowledge	Suggested teaching timeline and approaches
Genetic changes in a population over time (Unit 4 AOS 2) • causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift and gene flow; and mutations as the source of new alleles • biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity • manipulation of gene pools through selective breeding programs • consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens **Practice relevant key science skills for an analysis and evaluation of a selected biological case study** • Analyse and evaluate data and investigation methodologies • Construct evidence-based arguments and draw conclusions • Analyse, evaluate and communicate scientific ideas	**Week 6 & 7 (weeks 22 & 23 for the year)** Continue use of logbook, preparing students for AOS3 and covering *key science skills* (SD page 7 & 8). • *Modelling* – GTAC student online course: Changing allele frequencies in a population **Additional GTAC resources:** • GTAC teaching resource: Swift drift and occasional shift • GTAC teaching resource: Investigation related to a genetic cross - use the introductory components of this course to explore selective breeding for modern day corn
Changes in species over time (Unit 4 AOS 2) • changes in species over geological time as evidenced from the fossil record: faunal (fossil) succession, index and transitional fossils, relative and absolute dating of fossils • evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and *Howea* palms on Lord Howe Island as an example of sympatric speciation **Determining the relatedness of species (Unit 4 AOS 2)** • evidence of relatedness between species: structural morphology – homologous and vestigial structures; and molecular homology – DNA and amino acid sequences • the use and interpretation of phylogenetic trees as evidence for the relatedness between species **Practice relevant key science skills for an analysis and evaluation of a contemporary bioethical issue.** • Analyse, evaluate and communicate scientific ideas	**Week 8 & 9 (weeks 24 & 25 for the year)** **Suggest you run a SAC task for outcome 2 in weeks 8 – 10:** *Analyse the evidence for genetic changes in populations and changes in species over time, analyse the evidence for relatedness between species, and evaluate the evidence for human change over time.* Continue to focus on bioethical issues to get students practicing approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17). Related bioethical issues to consider could include issues associated with extinction events and de-extinction genetics (e.g. Jurassic Park or the Tasmanian tiger). Practice skills in conducting case studies. Continue use of logbooks as you run practical tasks, so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Classification and identification* – Identifying the age of fossils to infer changes in species over geological time

Key knowledge	Suggested teaching timeline and approaches
• Construct evidence-based arguments and draw conclusions	• *Case study* – Examples of allopatric speciation in Galapagos finches and sympatric speciation in *Howea* palms on Lord Howe island Additional GTAC resources: • GTAC teaching resource – The AGTC of molecular classification
Human change over time (Unit 4 AOS 2) • the shared characteristics that define mammals, primates, hominoids and hominins • evidence for major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo*: changes in brain size and limb structure • the human fossil record as an example of a classification scheme that is open to differing interpretations that are contested, refined or replaced when challenged by new evidence, including evidence for interbreeding between *Homo sapiens* and *Homo neanderthalensis* and evidence of new putative *Homo* species • ways of using fossil and DNA evidence (mtDNA and whole genomes) to explain the migration of modern human populations around the world, including the migration of Aboriginal and Torres Strait Islander populations and their connection to Country and Place. Practice relevant key science skills for an analysis and evaluation of generated primary and/or collated secondary data • Generate, collate and record data • Analyse and evaluate data and investigation methods • Construct evidence-based arguments and draw conclusions	Week 10 & 11 (weeks 26 & 27 for the year) Continue use of logbook, preparing students for AOS3 and covering *key science skills* (SD page 7 & 8). Continue use of logbooks as you run practical tasks, so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Classification and identification* – shared characteristics that define mammals, primates, hominoids and hominins • *Simulation* – Using model skulls to identify evidence for major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo* • *Case studies* – GTAC student online course: Models of human evolution • *Case studies* – GTAC student online course: Molecular evidence for human evolution

Unit 4 AOS3 - How is scientific inquiry used to investigate cellular processes and/or biological change?

Outcome 3: design and conduct a scientific investigation related to cellular processes and/or how life changes and responds to challenges, and present an aim, methodology and methods, results, discussion and a conclusion in a scientific poster.

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

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

A minimum of 10 hours of class time should be devoted to student designing and undertaking the student-designed scientific investigation and communicating findings.

In our timeline 3 weeks (12 hours) is allocated to Unit 4 AOS3 outcome 3. You may choose to run this outcome at any time during Unit 3 or Unit 4, or across both Units 3 and 4 in segments such as those shown in the table below in the *suggested teaching timeline and approaches* column. All student work should be recorded in their logbook and should be authenticated as you provide opportunities for students to show satisfactory completion of the outcome. Draw on relevant key science skills to guide students through the task and to provide opportunities to achieve satisfactory completion of the outcome.

The assessment component of the task, the SAC task, is the *Communication of the design, analysis and findings of a student-designed and student-conducted scientific investigation through a structured scientific poster and logbook entries.* Draw on relevant key science skills to develop your rubric for the SAC task. Students record in their logbooks all elements of their investigation planning, comprising identification and management of relevant risks, recording of raw data, and preliminary analysis and evaluation of results, including identification of outliers and their subsequent treatment. Both the students' poster and logbook entries are assessed as part of Unit 4, outcome 3.

The poster format is provided by VCAA on page 11 & 12 of the study design and this includes the expected content for each component of the poster.

Key knowledge	Key science skills relevant to Unit 4 AOS3 key knowledge areas	Suggested teaching timeline and approaches
Investigation design • biological concepts specific to the selected scientific investigation and their significance, including definitions of key terms • characteristics of the selected scientific methodology and method, and appropriateness of the use of	Develop aims and questions, formulate hypotheses and make predictions • Identify, research and construct aims and questions for investigation • Identify independent, dependent and controlled variables in controlled experiments. • Formulate hypotheses to focus investigation. • Predict possible outcomes. Plan and conduct investigations • Determine appropriate investigation methodology	Week 12 & 13 – Unit 4 AOS3 outcome 3 investigation (weeks 28 & 29 for the year) Note – you can run this outcome at any time during Unit 3 or Unit 4. It can be done all at once or in segments across several weeks. Students need to generate primary data relating to cellular processes and/or how life changes and responds to challenges. The investigation can be undertaken in the laboratory and/or in the field. Provide guidance as to

Key knowledge	Key science skills relevant to Unit 4 AOS3 key knowledge areas	Suggested teaching timeline and approaches
independent, dependent and controlled variables in the selected scientific investigation • techniques of primary quantitative data generation relevant to the selected scientific investigation • the accuracy, precision, reproducibility, repeatability and validity of measurements • the health, safety and ethical guidelines relevant to the selected scientific investigation Scientific evidence • the nature of evidence that supports or refutes a hypothesis, model or theory • ways of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and uncertainty • authentication of generated primary data through the use of a logbook • assumptions and limitations of investigation methodology and/or data generation and/or analysis methods	• Design and conduct investigations; select and use methods appropriate to the investigation, including consideration of sampling technique and size, equipment and procedures, taking into account potential sources of error and uncertainty; determine the type and amount of qualitative and/or quantitative data to be generated or collated. Comply with safety and ethical guidelines • Demonstrate safe laboratory practices when planning and conducting investigations by using risk assessments that are informed by safety data sheets (SDS), and accounting for risks. • Apply relevant occupational health and safety guidelines while undertaking practical investigations. Generate, collate and record data • Systematically generate and record primary data (NOTE – must generate primary data in this investigation) • Record and summarise both qualitative and quantitative data, including use of a logbook as an authentication of generated data. • Organise and present data in useful and meaningful ways, including schematic diagrams, flow charts, tables, bar charts and line graphs. Analyse and evaluate data and investigation methods • Process quantitative data using appropriate mathematical relationships and units, including calculations of ratios, percentages, percentage change and mean. • Identify and analyse experimental data qualitatively, handling where appropriate concepts of: accuracy, precision, repeatability, reproducibility and validity of measurements; errors (random and systematic); and certainty in data, including effects of sample size in obtaining reliable data. • Identify outliers, and contradictory or provisional data • Repeat experiments to ensure findings are robust	possible topics for investigation in relation to, availability of lab equipment and consumables at your school, or the field trip that is planned to support completion of outcome 3. 1. Students identify a topic related to cellular processes and/or how life changes and responds to challenges. 2. Students research their topic to develop a question, state an aim and formulate a hypothesis. They decide upon the scientific methodology to use to answer their question (see SD page 9 & 10). (*2 lessons*) **Teacher checkpoint for (S/N & relevant SAC assessment of logbook) – assess/discuss individual student aim, hypothesis and methodology. Provide feedback then move to next step.** 3. Students design a method to answer their question, they determine techniques of primary qualitative and quantitative data collection, source equipment and consumables, and plan for complying with safety and ethical guidelines. (*2 lessons*) **Teacher checkpoint for (S/N & relevant SAC assessment of logbook) – assess/discuss individual student methodology and method and check safe and ethical practice plan. Provide feedback and move to next step.** 4. Students undertake the investigation to generate primary quantitative data and record data in their logbook. They organise and present the data in meaningful ways, including schematic diagrams, flow charts, tables, bar charts and line graphs. (*3 lessons*) **Teacher checkpoint for (S/N & relevant SAC assessment of logbook) – assess individual students conducting their investigation and assess/discuss their presentation of primary data.**

Key knowledge	Key science skills relevant to Unit 4 AOS3 key knowledge areas	Suggested teaching timeline and approaches
	• Evaluate investigation methods and possible sources of personal errors/mistakes or bias, and suggest improvements to increase accuracy and precision, and to reduce the likelihood of errors. Construct evidence-based arguments and draw conclusions • Evaluate data to determine the degree to which the evidence supports the aim of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation. • Evaluate data to determine the degree to which the evidence supports or refutes the initial prediction or hypothesis • Identify, describe and explain the limitations of conclusions, including identification of further evidence required. • Discuss the implications of research findings and proposals	5. Students analyse and evaluate the data, identify limitations of data and methods, link experimental results to scientific ideas, discuss implications of the results, and draw a conclusion in response to the question. (*3 lessons*) **Teacher checkpoint for (S/N & relevant SAC assessment of logbook) – assess student analysis and evaluation of data and their construction of evidence-based arguments and the conclusions they draw from their data in relation to their question.** **Note:** Checkpoints are established in this approach to support formative assessment and to provide students the opportunity to achieve satisfactory achievement of the outcome
Science communication • conventions of science communication: scientific terminology and representations, symbols, formulas, standard abbreviations and units of measurement • conventions of scientific poster presentation, including succinct communication of the selected scientific investigation and acknowledgements and references • the key findings and implications of the selected scientific investigation.	Analyse, evaluate and communicate scientific ideas • Use appropriate biological terminology, representations and conventions, including standard abbreviations, graphing conventions and units of measurement. • Discuss relevant biological information, ideas, concepts, theories and models and the connections between them. • Use clear, coherent and concise expression to communicate to specific audiences and for specific purposes in appropriate scientific genres, including *~~scientific reports and~~ posters • Acknowledge sources of information and assistance, and use standard scientific referencing conventions. *strikethrough added to indicate that the communication method is via poster, not a scientific report	Week 14 - Continue Unit 4 AOS3 Outcome 3 (week 30 for the year) 6. Students use the VCAA poster format and descriptors to communicate their research investigation using a poster (SD page 11 & 12). They present their introduction, aim, methodology and methods, results, discussion, conclusion and references and acknowledgements (*2 lessons*). **Note:** Each lesson indicated here would be approximately 60 minutes duration. You may choose to have students present their findings for assessment using a different format

Key knowledge	Key science skills relevant to Unit 4 AOS3 key knowledge areas	Suggested teaching timeline and approaches
Unit 3 and 4 key knowledge	Units 1 – 4 key science skills	Week 15 and 16 (weeks 31 & 32 for the year) Revision for exam

The VCAA provide information for implementation of the VCE biology study design 2022 – 2026

The following image is taken from the pdf they provide for the presentation and provides information related to the formatting of the Scientific poster for Unit 4 AOS3. The QR code is a link to a you tube video titled *how to create a better research poster in less time*