A GTAC guide to teaching Unit 3 for the 2022 – 2026 VCE Biology SD

We have allocated 16 weeks to teaching Unit 3 with 240 min/week - Note that this includes a continued focus on the key science skills (SD pages 7-9) and a focus on bioethical issues to get students practicing examinable skills in approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17). We also introduce key knowledge from Unit 4 AOS3 during Unit 3 to prepare students for their student-designed investigation. 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 3: How do cells maintain life?

- Area of Study 1 – What is the role of nucleic acids and proteins in maintaining life?
  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. Draw on AOS1 key knowledge and related key science skills on SD pages 7 – 9.
- Area of Study 2 - How are biochemical pathways regulated?
  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. Draw on AOS2 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 3 will be determined by School-assessed Coursework. School-assessed Coursework tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe. 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 does not match that of the study design. In particular, the key knowledge areas related to Unit 4, AOS 3 that are introduced here in Unit 3. We decided on this approach so key skills related to Unit 4 AOS3 are a focus throughout the teaching of Unit 3 and 4 as students participate in a variety of practical activities. We also have a focus on practicing the examinable key skills related to approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17).

Note that the Unit 4 AOS3 Outcome 3 can be conducted at any time during unit 3 and 4 or across both units. In our unit timelines this task sits at the end of Unit 4. We encourage you to consider running the task earlier if this works better for your school and your students.

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 (GTAC resources are in orange text with a link)
The relationship between nucleic acids and proteins (Unit 3 AOS1) • nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides • the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes • amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein • proteins as a diverse group of molecules that collectively make an organism's proteome, including enzymes as catalysts in biochemical pathways	Week 1 & 2 Throughout Unit 3 prepare students for Unit 4 AOS3 by teaching relevant *key science skills* (SD page 7 & 8) – these skills are also examinable. Practice approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17) as these skills are examinable and will relate to the outcome task that you develop relating to analysis and evaluation of a contemporary bioethical issue. Introduce the use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Modelling* – Use a method to get student to model the structure and function of DNA • *Modelling* – transcription and translation to learn that the genetic code is degenerate. • *Modelling* – build a gene using string and other materials that reveals exons and introns and demonstrate alternative splicing and RNA processing • *Modelling* – Use an amino acid starter kit to model the 4 hierarchical levels of protein structure or if you don't have the model try this YouTube clip • *Simulation* – GTAC teaching resource: What is Rubisco? – Explore how proteins get their hierarchical structure using the free to download protein visualisation tool, Cn3D • *Case study* – investigate the structure and function of an enzyme and its role in controlling a biochemical pathway (try starting with the online Protein Data Bank, *PDB molecule of the month* who have great explanations of how some common proteins work) Additional GTAC resources: • GTAC student online course: Exploring the structure of DNA
The relationship between nucleic acids and proteins (Unit 3 AOS1) • the role of rough endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of proteins from a cell via the protein secretory pathway • the structure of genes: exons, introns and promoter and operator regions • the basic elements of gene regulation: prokaryotic trp operon as a simplified example of a regulatory process	Week 3 & 4 Continue use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Modelling* – construct a flow chart model of the protein secretory pathway – watch the GTAC animation The dynamic cell to observe the protein secretory pathway in action • *Modelling* – build a model of the trp operon to demonstrate gene regulation in bacteria

Key knowledge	Suggested teaching timeline and approaches (GTAC resources are in orange text with a link)
	• *Modelling* – build a model of a eukaryotic gene that can be used to demonstrate switching genes on and off and to compare and contrast what occurs in the cell when the gene is switched on compared to switched off (or conduct this as a role play).
DNA manipulation techniques and applications (Unit 3 AOS1) • the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA • amplification of DNA using polymerase chain reaction and the use of gel electrophoresis in sorting DNA fragments, including the interpretation of gel runs for DNA profiling • the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin	Week 5 & 6 Continue use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Simulation* – GTAC teaching resource: Using biotechnology to diagnose Human Papillomavirus infections • *Controlled experiment* - Rural and low socioeconomic schools can request a GTAC transforming bacteria with recombinant plasmid kit be sent to their school so students can transform bacteria with GFP in their classrooms • *Controlled experiment* – visit a program provider such as GTAC, BioLab or EcoLinc to perform experiments that showcase applications of biotechnology • *Simulation* – Use online simulations to demonstrate and practice techniques in molecular biology, try Dolan DNA learning Centre, or Learn Genetics Utah, WEHI TV for animations, and a list of simulations here Additional GTAC resources: • GTAC student online course: Polymerase chain reaction • GTAC student online course: Gel electrophoresis
DNA manipulation techniques and applications (Unit 3 AOS1) • the use of genetically modified and transgenic organisms in agriculture to increase crop productivity and to provide resistance to disease. *NOTE – the key knowedge dot point on the function of CRISPR-Cas-9 in bacteria dot point is introduced later in this timeline* Practice relevant key science skills for an analysis and evaluation of a contemporary bioethical issue.	Week 7 & 8 This is a good time to get students to start considering issues associated with DNA manipulation techniques and applications so they can practice approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17). Possible bioethical issues could relate to: Use of GMO in agriculture to increase crop productivity and to provide resistance to disease. This is also an ideal time to run your SAC for unit 3 AOS1.

Key knowledge	Suggested teaching timeline and approaches (GTAC resources are in orange text with a link)
Key Science Skills from Analyse, evaluate and communicate scientific ideas • Critically evaluate and interpret a range of scientific and media texts (including journal articles, mass media communications and opinions in the public domain), processes, claims and conclusions related to biology by considering the quality of available evidence. • Analyse and evaluate bioethical issues using relevant approaches to bioethics and ethical concepts, including the influence of social, economic, legal and political factors relevant to the selected issue. **Key Science Skills from Construct evidence-based arguments and draw conclusions** • Distinguish between opinion, anecdote and evidence, and scientific and non-scientific ideas. • Use reasoning to construct scientific arguments, and to draw and justify conclusions consistent with the evidence and relevant to the question under investigation.	Continue use of logbook, preparing students for AOS3 and covering *key science skills* (SD page 7 & 8). • *Case study* – a bioethical issue related to DNA manipulation techniques **Additional GTAC resources:** • GTAC student online course: Introduction to ethics • GTAC student study aid: GTAC 6S fact collecting framework • GTAC student study aid: GTAC Ethical analysis tool
Regulation of biochemical pathways in photosynthesis and cellular respiration (Unit 3 AOS2) • the general structure of the biochemical pathways in photosynthesis and cellular respiration from initial reactant to final product • the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration • the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors *SUGGEST that the above dot points are taught alongside the following two dot points that you can return to in weeks 12 – 15* **Photosynthesis as an example of biochemical pathways (Unit 3 AOS2)**	**Week 9 & 10** Continue use of logbooks as you run practical tasks, so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Controlled experiment* – GTAC teaching resource Transformation of energy in cells: where activity 1 and 2 can be used by students to construct word equations for photosynthesis and respiration • *modelling* – GTAC online course The many colours of photosynthesis: Modelling the inputs, outputs and locations of light dependent and light independent stages of photosynthesis • *modelling* – GTAC online course Modelling respiration pathways: Modelling the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield

Key knowledge	Suggested teaching timeline and approaches (GTAC resources are in orange text with a link)
• inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C3 plants (details of biochemical pathway mechanisms are not required) Cellular respiration as an example of biochemical pathways (Unit 3 AOS2) • the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required)	
Photosynthesis as an example of biochemical pathways (Unit 3 AOS2) • inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C3 plants (details of biochemical pathway mechanisms are not required) – *note this was introduced earlier** • the role of Rubisco in photosynthesis, including adaptations of C3, C4 and CAM plants to maximise the efficiency of photosynthesis • the factors that affect the rate of photosynthesis: light availability, water availability, temperature and carbon dioxide concentration **SUGGEST that the first dot point is taught with regulation of biochemical pathways and return to it again here* **Practice relevant key science skills for a comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities – from SD page 7 & 8)** • Develop aims and questions, formulate hypotheses and make predictions • Plan and conduct investigations • Generate, collate and record data • Analyse and evaluate data and investigation methods • Construct evidence-based arguments and draw conclusions • Analyse and evaluate and communicate scientific ideas	Week 11 & 12 This is an ideal time to prepare students for Unit 4 AOS3 by teaching relevant *key science skills* (SD page 7 & 8) – these skills are also examinable. Unit 3 AOS2 is also an ideal time to consider running the SAC task, comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities. Introduce the use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Controlled experiment* – GTAC teaching resource: Using leaf discs to explore factors that affect the rate of photosynthesis - Explore how light wavelength, light intensity, and carbon dioxide concentration can affect the rate of photosynthesis GTAC resources coming in 2022: • *Product, process or system development* – GTAC online course: Design a smart greenhouse - Explore the factors affecting photosynthesis and learn skills to conduct a qualitative analysis of quantitative data – *This resource will be available early in 2022* • GTAC student study aid: Design and evaluate a controlled experiment • *Controlled experiment*– GTAC teaching resource: using alginate balls to explore factors that affect rate of photosynthesis

Key knowledge	Suggested teaching timeline and approaches (GTAC resources are in orange text with a link)
Cellular respiration as an example of biochemical pathways (Unit 3 AOS2) • the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required) • the location, inputs and the difference in outputs of anaerobic fermentation in animals and yeasts • the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration *SUGGEST that the first dot point is taught with regulation of biochemical pathways and return to it again here* **Practice key science skills relevant to a comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities – from SD page 7 & 8)** • Develop aims and questions, formulate hypotheses and make predictions • Plan and conduct investigations • Generate, collate and record data • Analyse and evaluate data and investigation methods • Construct evidence-based arguments and draw conclusions • Analyse and evaluate and communicate scientific ideas	**Week 13 & 14** Introduce the use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Controlled experiment* – GTAC teaching resource: Exploring factors that affect rate of cellular respiration in yeast **Additional GTAC resources:** • GTAC Student study aid: A qualitative analysis of quantitative data GTAC resource coming in 2022: • *Product, process or system development* – GTAC online course: Designing an insect farm - Explore the factors that affect cellular respiration and learn skills in developing aims and questions, formulating hypotheses and make predictions – *This resource will be available early in 2022*
DNA manipulation techniques and applications (Unit 3 AOS1) • the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome **Biotechnological applications of biochemical pathways (Unit 3 AOS2)** • potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields • uses and applications of anaerobic fermentation of biomass for biofuel production.	**Week 15 & 16** Practice approaches to bioethics and principles for investigating ethical concepts (SD page 16 & 17) as you consider a bioethical issue related to the use of CRISPR. Introduce the use of logbooks as you run practical tasks so students get exposure to different *scientific investigation methodologies* (SD page 9 & 10). For example, • *Modelling* – GTAC teaching resource: Modelling CRISPR-Cas-9 in bacteria • *Case study* – GTAC teacher resource: Using CRISPR-Cas-9 to treat sickle cell anaemia

Key knowledge	Suggested teaching timeline and approaches (GTAC resources are in orange text with a link)
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 **Practice relevant key science skills for an analysis and evaluation of a contemporary bioethical issue.** Key science skills from Analyse, evaluate and communicate scientific ideas • Critically evaluate and interpret a range of scientific and media texts (including journal articles, mass media communications and opinions in the public domain), processes, claims and conclusions related to biology by considering the quality of available evidence. • Analyse and evaluate bioethical issues using relevant approaches to bioethics and ethical concepts, including the influence of social, economic, legal and political factors relevant to the selected issue. Key science skills from Construct evidence-based arguments and draw conclusions • Distinguish between opinion, anecdote and evidence, and scientific and non-scientific ideas. • Use reasoning to construct scientific arguments, and to draw and justify conclusions consistent with the evidence and relevant to the question under investigation.	• *Case study* – GTAC student online course and second-hand data analysis task: It's a knockout! The impacts of CRISPR-Cas-9 modification of rubisco • *Case study* – A bioethical issue related to biomass energy – clean or dirty? Should we use food sources to produce biofuel? • *Controlled experiment* – optimising respiration in yeast for biofuel production. Additional GTAC resources: • GTAC student online course: What is Rubisco? • GTAC resource developed in collaboration with the Convergence Science Network – Stories from the research lab: Victorian researchers using CRISPR-Cas-9 technologies