Resources to assist in teaching the changes to the Unit 3 and 4 Biology Curriculum

A 2016 GTAC professional Learning event
Information provided for each module

1. Title
2. Descriptor
3. Curriculum links – key knowledge and key skills
4. Flowchart
5. Resources that will be provided through the GTAC website in 2017
Critically evaluating scientific research

Education design: Jacinta Duncan, Chris Szwed, Carla Daunton and Duncan Goddard

From December 2002 to May 2004

Test group - 101 patients receive Umckaloabo tablets, plus paracetomol if needed

Double blind

204 patients randomly assigned

Double blind

Day 0
1st BSS score

Days 3 – 5
2nd BSS score

Day 7
Last BSS score

Control group - 103 patients receive Placebo, plus paracetomol if needed

BSS = Bronchitis Symptom Score
Critically evaluating scientific research

**Module descriptor**

This module introduces students to a study tool that deconstructs the elements of scientific research that underpin the validity and reliability of a study. Each element of the study tool is unpacked for students through an introductory series of tasks that discuss the steps involved in developing a methodology to test if lactase tablets are viable when they reach the small intestines. This worked example can be used as a guide on how to design a methodology.

Students then apply a tool to critically evaluate three studies and make defensible decisions about whether each study substantiates claims being made by a fictional vitamin company. The first evaluation is guided in steps using media clips (can be teacher led or flip the classroom). Then students work collaboratively to critically evaluate 2 further related studies and practice:

- Identifying the question under investigation
- Evaluating validity (variables, randomisation, accuracy)
- Evaluating reliability (replication, precision, reproducibility, plausibility)
- Evaluating whether data supports conclusions drawn by researchers (correlation and causation)
- Evaluating conflict of interest

Students decide on the strength of each study and whether it substantiates or refutes claims made by a vitamin company.

This task is designed to guide students to recognise the elements that strengthen the validity and reliability of a research study using simplified journal articles. It will help them to develop a methodology when it comes to completing the Unit 4 AOS 3 practical investigation.
Units 1 - 4 Key Skills:

Analyse and evaluate data, methods and scientific models
• Take a qualitative approach when identifying and analysing experimental data with reference to accuracy, precision, reliability, validity, uncertainty and errors (random and systematic)
• Evaluate investigative procedures and possible sources of bias, and suggest improvements

Draw evidence-based conclusions
• Determine to what extent evidence from an investigation supports the purpose of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation
• Draw conclusions consistent with evidence and relevant to the question under investigation
• Critically evaluate various types of information related to biology from journal articles and opinions presented in the public domain

Communicate and explain 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 connection between them
• Identify and explain formal biological terminology about investigations and concepts
Critically evaluating scientific research: Module overview

1. Students watch media clips that introduce the elements of a scientific study that can strengthen the validity and reliability of the study. This is done using an exemplar for investigating if lactase tablets work.

2. Students use guiding questions to discuss a claim made by a vitamin company on their product. They view media clips that provide a breakdown on how to critically evaluate a scientific study related to the claim.

3. In groups students are given two research articles and apply a scientific research evaluation tool to scrutinise each study.

4. Students share their evaluation with the group and collectively discuss the strength of each study and the claims made by the investigators.

5. Based on the critical evaluation of the 3 studies, the students decide if the claim by the company is substantiated or if more information is required.
Available resources: Critically evaluating scientific research

**Step 1: Designing a scientific study**
- *Online student course “Developing a methodology for testing lactase tables: The elements of scientific research that strengthen the validity and reliability of a study”*
- *Student resource: Designing a scientific study checklist*

**Step 2: Discussion of claims made by a vitamin company & Guided critical evaluation of a scientific study**
- *Umckaloabo product label*
- *Student resource: Group discussion questions*
- *Online student course –critical evaluation of a scientific article.*

**Step 3: Critical evaluation of further scientific studies**
- *Student resource: Two scientific studies (modified so that they are accessible for VCE students)*
- *Student resource: Critical evaluation of scientific research tool*
The sunburn response and Melanoma: A case study in a malfunction of apoptosis and promising treatments using monoclonal antibodies
Education design: Jacinta Duncan, Chris Szwed, Dr Nicole Webster and Carla Daunton
The sunburn response and Melanoma: Module descriptor (Part A)

This module comes in two parts

Part A: The role of apoptosis in maintaining cell numbers:

- Students analyse results of a study that contributed to our understanding of apoptosis
- They explore the intrinsic and extrinsic apoptosis pathways
- They investigate the need for apoptosis in regulating cell numbers and how malfunctions in apoptosis can lead to a variety of diseases

Students watch media clips, use models, analyse data and discuss ideas to refine their understanding of why we need apoptosis and how this process occurs. They prepare flow charts to demonstrate the intrinsic and extrinsic pathways of apoptosis. They design stimulus response models to describe how malfunctions in apoptosis can lead to disease.

Prior knowledge
First 3 dot points under “cellular signals” relating to stimulus response pathways
The sunburn response and Melanoma: Module descriptor (Part B)

This module comes in two parts

Part B: Melanoma case study (prior knowledge: apoptosis and the immune system)

• Students explore the intrinsic and extrinsic apoptosis pathways that result when cells are exposed to UV radiation and come to understand the importance of the sun burn response to acute UV
• Students are introduced to a malfunction in apoptosis that leads to skin cancers such as melanoma
• They explore the human and social cost of Melanoma in Australia
• The consider why melanoma is so hard to treat and approaches to treating this disease
• They investigate how monoclonal antibodies are being applied to treat cancers such as melanoma.

Students view media clips that reveal research that has contributed to our understanding of the role of intrinsic and extrinsic apoptosis in response to UV radiation and consider the need for the sun burn response. They learn how malfunctions in apoptosis can lead to skin cancer. They examine data to determine the health and economic burden of this disease in Australia and consider interventions that can reduce this burden.

Students are introduced to a selection of monoclonal antibody treatments for melanoma and prepare an animated diagram to reveal how monoclonal antibodies are being used in treating cancer. They play an educational game to explore the effectiveness of melanoma treatments.

Prior knowledge
First 3 dot points under “cellular signals” relating to stimulus response pathways and knowledge of the specific immune response – cell mediated and humoral
VCAA Biology curriculum link

Unit 3 AOS2 Key Knowledge:

Cellular signals

• Apoptosis as a natural, regulatory process of programmed cell death, initiated after a cell receives a signal from inside (mitochondrial pathway) or from outside (death receptor pathway) the cell resulting in the removal of cells that are no longer needed or that may be a threat to an organism, medicated by enzymes (caspases) that cleave specific proteins in the cytoplasm or nucleus (details of specific cytoplasmic or nuclear proteins are not required)

• Malfunctions in apoptosis that result in deviant cell behaviour leading to diseases including cancer

Immunity

• The use of monoclonal antibodies in treating cancer

Key Skills

Analyse and evaluate data, methods and scientific models

• Process quantitative data using appropriate mathematical relationships and units
• Organise, present and interpret data using schematic diagrams and flow charts, tables, bar charts, line graphs, ratios, percentages and calculations of mean
• Take a qualitative approach when identifying and analysing experimental data with reference to accuracy, precision, reliability, validity, uncertainty and errors (random and systematic)
• Explain the merit of replicating procedures and the effects of sample sizes in obtaining reliable data
• Evaluate investigative procedures and possible sources of bias, and suggest improvements
• Explain how models are used to organise and understand observed phenomena and concepts related to biology, identifying limitations of the models
1. Students model the experimental method used to investigate the role of an unknown protein and analyse results to discover its function as a pro-survival, anti-apoptosis protein.

2. Students view media clips, use models, and prepare flow charts to compare and contrast intrinsic and extrinsic apoptosis pathways.

3. Students explore the role of apoptosis in regulating cell numbers and produce stimulus response models to demonstrate how disease can result from malfunctions in apoptosis.

4. Students analyse research data as they investigate sunburn, a case study in apoptosis, and how malfunctions in apoptosis can lead to skin cancer.

5. Students view media clips and prepare an animated diagram to reveal how monoclonal antibodies are being used in treating cancer.

6. Students play an educational game and analyse the effectiveness of different monoclonal antibodies used to treat melanoma.
Available resources: The sunburn response and melanoma

**Step 1 & 2:**
- Student online course “Cell death and apoptosis: The role of Australians in discovery”
- Teacher resource: modelling instructions and templates, cue cards and activity descriptor for analysing Bcl-2 experiments
- Teacher resource: modelling instructions and templates, and activity descriptor for intrinsic apoptosis

**Step 3 & 4:**
- Student online course “Stories of cell death: Why, when and where and how malfunctions can cause disease”
- Teacher resource: modelling instructions and templates, and activity descriptor for modelling intrinsic apoptosis

**Step 5 & 6:**
- Teacher/student resource: Melanoma search and destroy (educational game)
- Student online course – Monoclonal antibodies and melanoma (temporary name)
Evolutionary Developmental Biology Education design: Kian Jin Tan and Dr Tony Chiovitti
Evolutionary Development

Module descriptor

The paradigm example of Darwin’s finches connects the classical mechanism of natural selection with principles drawn from current molecular biology, which explain how profound changes in phenotype can be influenced by the action of just one or a few key regulatory genes. Students carry out a kinaesthetic simulation to test the effect of beak size on survival in situations where different food types are on offer. Students interpret the data in light of the mechanism of natural selection to gain an appreciation of the impact of environment. To explore the impact of genes and phenotype, students progressively order images of Galapagos finches according to beak size alongside images of expression patterns for a gene, BMP4, a gene implicated in bone and beak development in vertebrate animals. Students also interpret time-resolved graphs of expression of BMP4 and a suite of other genes involved in beak development. Students use the data to infer the relationship between BMP4 expression and beak size. Students test their inference by making a prediction about outcomes of experiments manipulating BMP4 expression and evaluating their prediction in the light of second hand data.

Prior knowledge
The relative influences of genetic material, environmental factors and interactions of DNA with other molecules (epigenetic factors) on phenotypes; nucleic acids as information molecules that encode instructions for the synthesis of proteins in cells; steps in gene expression, including transcription, RNA processing, and translation; the functional distinction between structural genes and regulatory genes.
VCAA Biology Key Knowledge

Unit 3 AOS 1 Outcome 1:

Nucleic acids and proteins

- The genetic code as a degenerate triplet code and the steps in gene expression including transcription, RNA processing in eukaryotic cells and translation

Unit 4 AOS 1 Outcome 1:

Changes in the genetic makeup of a population

- The qualitative treatment of the causes of changing allele frequencies in a population’s gene pool including types of mutations (point, frameshift, block) as a source of new alleles, chromosomal abnormalities (aneuploidy and polyploidy), environmental selection pressures on phenotypes as the mechanism for natural selection, gene flow, and genetic drift (bottleneck and founder effects) and the biological consequences of such changes in terms of increased or reduced genetic diversity
- Processes of evolution including through the action of mutations and different selection pressures on a fragmented population and subsequent isolating mechanisms (allopatric speciation) that prevent gene flow

Changes in biodiversity over time

- Patterns of biological change over geological time including divergent evolution, convergent evolution and mass extinctions

Determining relatedness between species
Develop aims and questions, formulate hypotheses and make predictions
• Determine aims, hypotheses, questions and predictions that can be tested

Conduct investigations to collect and record data
• Work independently and collaboratively as appropriate and within identified research constraints
• Systematically generate, collect, record and summarise both qualitative and quantitative data

Analyse and evaluate data, methods and scientific models
• Organise, present and interpret data using schematic diagrams and tables and line graphs

Draw evidence-based conclusions
• Draw conclusions consistent with evidence and relevant to the question under investigation
• Identify, describe and explain the limitations of conclusions, including identification of further evidence required

Communicate and explain scientific ideas
• Discuss relevant biological information, ideas, concepts, theories and models and the connections between them
Module overview

1. Introduce students to the natural selection activity
2. Role play natural selection of beak size according to food source and collect data
3. Analyse data collected from the natural selection activity
4. Analyse data of beak shape measurements from different generations of Galapagos finches to determine heritability
5. Use knowledge of transcription and translation to identify data that can be collected by researchers
6. Arrange beak size, and Bmp4 expression levels in three species of finches at day 5 and 7
7. Identify patterns between beak size and Bmp4 expression
8. Predict results if there is overexpression and no expression of Bmp4 on beak size
9. Analyse Bmp4 misexpression experiments on chicken embryos
Resources

Modelling natural selection (steps 1-3)

Teacher resources:
• Instructions for preparing the resources and running the activity
• PowerPoint “Evo Devo”

Student resources:
• “Evo Devo” student worksheet

User-supplied resources for students to use:
• Tongs
• Tweezers
• Cardboard rolls
• Tooth picks
• Ping pong balls
• Gummi worms
• Plastic cups
• Masking tape
Resources

Interpreting research data on \textit{Bmp4} expression in embryonic finch beaks to identify the impact of \textit{Bmp4} on beak shape (steps 4-7)

Teacher resources:
• Instructions for preparing the resources and running the activity
• PowerPoint “Evo Devo”

Student resources:
• “Evo Devo” student worksheet
• Cards with beak shape images
• Cards with images of Bmp4 expression levels in finch embryos on days 5 and 7
• Graphs for expression levels of Bmp4 and other beak formation genes

User-supplied resources for students to use:
• Rulers
Predicting the outcome of misexpression experiments of Bmp4 in chicken embryos (steps 8-9)

Teacher resources:
• Instructions for preparing the resources and running the activity
• PowerPoint “Evo Devo”

Student resources:
• “Evo Devo” student worksheet
• Results of misexpression experiments in chick embryos
Models for Human Evolution
Education design: Dr Tony Chiovitti and Dr Frazer Thorpe
Models for Human Evolution

Module descriptor

Models for human evolution are fluid, often controversial hypotheses that can be tested and refined by complementary strands of evidence drawn from palaeontology, biogeography, and molecular biology. Students explore models for human evolution using a combination of paleontological and molecular evidence. Students first manipulate images of fossils to construct a model for evolution of hominins across the continents over time. From the model, students make inferences about trends in anatomical evolution in hominins and how these trends inform cultural evolution. In a sequence of slides, students interpret DNA evidence to progressively build and refine a phylogenetic tree describing the speciation and subsequent interbreeding between modern humans, Neandertals, and Denosovans.

Prior knowledge

Concept of speciation as a consequence of mutations; evidence for evolution, including fossil and molecular evidence; DNA structure, location, function; constructing and interpreting phylogenetic trees
Unit 4 AOS 1 Outcome 1:

Changes in biodiversity over time

- evidence of biological change over time including from palaeontology (the fossil record, the relative and absolute dating of fossils, types of fossils and the steps in fossilisation), and biogeography

Determining relatedness between species

- molecular homology as evidence of relatedness between species including DNA and amino acid sequences, mtDNA (the molecular clock) and the DNA hybridisation technique
- the use of phylogenetic trees to show relatedness between species

Human change over time

- major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo* including structural, functional and cognitive changes and the consequences for cultural evolution
- the human fossil record as an example of a classification scheme that is open to interpretations that are contested, refined or replaced when new evidence challenges them or when a new model has greater explanatory power, including whether *Homo sapiens* and *Homo neanderthalensis* interbred and the placement of *Homo denisovans* into the *Homo* evolutionary tree.
Analyse and evaluate data, methods and scientific models
- Organise, present and interpret data using schematic diagrams and flow charts, tables, bar charts, line graphs, ratios, percentages and calculations of mean
- Explain the effects of sample sizes in obtaining reliable data
- Explain how models are used to organise and understand observed phenomena and concepts related to biology, identifying limitations of the models

Draw evidence-based conclusions
- Draw conclusions consistent with evidence and relevant to the question under investigation
- Identify, describe and explain the limitations of conclusions, including identification of further evidence required

Communicate and explain scientific ideas
- Discuss relevant biological information, ideas, concepts, theories and models and the connections between them
Module overview

Part A: Developing a model for human evolution

1. Arrange hominin skeletons (B-G) in order of their similarity to the modern human (A) and evaluate the arrangement

2. Arrange hominin skulls (B-H) in order of their similarity to the modern human (A) and re-evaluate the arrangement

3. Use time/location information in the data resource sheet to arrange skeletons and skulls into a hypothetical phylogenetic tree

4. Use the “Analysis of Hominin Skeletons” sheet to analyse trends in the evolution of hominin features

5. Consider hominin features that contribute to cultural evolution

6. The *Homo floresiensis* and *Denisovan* molar challenge: Augment the evolutionary hypothesis
Module overview

Part B: Using molecular homology to infer human evolution

7. Introduction to molecular homology and how it is applied to constructing phylogenetic trees

8. Generate and interpret a phylogenetic tree of the hominoids using the mitochondrial ND5 gene

9. Generate and interpret a phylogenetic tree of hominins using nuclear genome data

10. Consider particular genome variations that augment the model for patterns in hominin evolution
Resources

Part A: Developing a model for human evolution

**Teacher resources:**
- Instructions for preparing the resources and running the activity
- PowerPoint “Human Evolution – Morphology Tasks”

**Student resources:**
- “Developing a model for human evolution” student worksheet
- Cards with images of hominin skeletons labelled A–G
- Cards with images of hominin skulls labelled A–H
- Data resource sheet
- “Analysis of skeletons” information sheet
- Card with image of Homo floresiensis skeleton
- Card with image of Denisovan finger bone
Resources

Part B: Using molecular homology to infer human evolution

Teacher resources:
• Instructions for preparing the resources and running the activity
• PowerPoint “Molecular evidence for human evolution”

Student resources:
• “Molecular evidence for human evolution” student worksheet and instructions for using Biology Workbench
• Primate ND5 gene data file
• Hominin nuclear genome data file
• Computer with access to the Internet (user-supplied)
Manipulating DNA to defend crops against disease: Analysing the biological, social and ethical implications
Education design: Dr Fran Maher and Dr Frazer Thorpe

Original images: top left and bottom left CSIRO, Bottom right Jon Houseman
Manipulating DNA to defend crops from disease: Module descriptor
The ability to manipulate DNA to improve crops is for some an inevitable, sensible, and positive step to help humanity and increase sustainability of world resources. However, others are outraged at what they believe is an unnatural intervention in biology and agriculture, perhaps done with purely financial motives. Students will explore two case studies in which crops are under threat from pathogens and discover the range of methods agronomists are using to defend their crops from disease.

Students critically evaluate a range of stakeholders positions. They analyse potential biological, social and ethical impacts of using traditional methods and DNA technologies to protect crops from fungal pathogens.

Prior knowledge
DNA structure, location, function, pathogens (including fungi).
Manipulating DNA to defend crops against disease: VCAA Biology Key Knowledge

Unit 4 AOS 2 Outcome 2

Key knowledge

DNA manipulation
• the use of enzymes including endonucleases (restriction enzymes), ligases and polymerases
• amplification of DNA using the polymerase chain reaction
• the use of gel electrophoresis in sorting DNA fragments, including interpretation of gel runs
• the use of recombinant plasmids as vectors to transform bacterial cells.

Biological knowledge and society
• techniques that apply DNA knowledge (specifically gene cloning, genetic screening and DNA profiling) including social and ethical implications and issues
• the distinction between genetically modified and transgenic organisms, their use in agriculture to increase crop productivity and to provide resistance to insect predation and/or disease, and the biological, social and ethical implications that are raised by their use
Manipulating DNA to defend crops against disease: VCAA Biology key skills

Draw evidence-based conclusions

• draw conclusions consistent with the evidence and relevant to the question under investigation

• identify, describe and explain the limitations of conclusions, including identification of further evidence required

• critically evaluate various types of information related to biology from journal articles, mass media and opinions presented in the public domain

• discuss the implications of research findings and proposals
1. Case study 1: Introduction to wheat stem rust fungi: The history, biology, spread of disease and control using fungicide

2. Student groups discuss and define the biological, social and ethical implications of continued fungicide use for controlling stem rust disease

3. Students view media clips to explore how GMO and transgenic technologies are applied to agriculture. They consider techniques to clone resistance genes and generate transgenic crops (restriction enzymes, tissue culture, biolistics and transformation)

4. Jigsaw activity part A: Students form ‘Expert’ stakeholder groups. They critically evaluate data and opinions so they can articulate the views of that stakeholder group using supportive evidence.

5. Jigsaw activity part B: Students form groups having a representative from each of the stakeholder positions (from part A). They record the range of biological, social and ethical implications raised by each stakeholder group.

6. Class discussion: Students try to arrive at consensus as a group on the issue of whether to implement GM technology.

7. Case study 2: Bananas under threat from *Fusaria* fungal infection. CSIRO scientists are using precision breeding involving mutagenesis and selection. Students as homework read and explore the biological, social, and ethical implications, and critically evaluate the sources provided
Resources for Manipulating DNA to defend crops against disease:

**Step 1: Introduction to stem rust fungus**
- *Teacher Instructional presentation 1*

**Step 2: Defining biological, social and ethical implications**
- *Student resource: Definitions and examples of biological, social and ethical implications of using DNA technologies [Worksheet 1]*

**Step 3: Introducing GM and transgenic technologies in agriculture**
- *Instructional presentation 2 - Teacher and student resource*
- *Student resource: Genetically modified and transgenic organisms: definitions, methods and applications; DNA technologies for producing transgenic crops [Worksheet 2]*

**Step 4: Jigsaw activity part A**
- *Student resource: Critically evaluating the opinions of stakeholders [Worksheets 3 and 4]*

**Step 5: Jigsaw activity part B**
- *Student resource – Implications of using DNA technologies [Worksheet 4]*

**Step 6: Class discussion**
- *Summary [Worksheet 1 completion]*

**Step 7: Case Study 2 - Bananas under threat from *Fusaria* fungal infection**
- *Student online resources provided: Saving bananas from the threat of *Fusaria* fungal infection – a critical evaluation of the social, biological and ethical issues*
Constructing and critiquing models and critically evaluating research presented in posters to explain how malfunctions of the immune system cause disease

Education design: Dr Nicole Webster and Jacinta Duncan
Module descriptor

In this module students draw on their prior knowledge of the immune system as they investigate the mechanisms of immune deficiency and malfunctions of the immune system through an exploration of three diseases:

• Multiple Sclerosis – an immune-mediated disease where the T cells destroy the myelin sheath of neurons
• Human Immunodeficiency Virus (HIV) – an infection that leads to a loss of T helper cells
• Allergic rhinitis – in some individuals pollen antigens trigger an inappropriate immune response

Students explore research data, presented in poster format with supportive materials, to investigate the mechanism of action for each disease. They analyse research results and consider how this research is contributing to the search for treatments of each disease.

Students will practice skills in

• Understanding and communicating the biology as they read the introduction and use models to explore theories on the mechanism of disease
• Examining experimental methods as they watch media clips providing an overview of the technologies used to collect data
• Analyse results to address a series of discussion questions
• Form a conclusion as they consider the aim and hypothesis of the experiment.
VCAA Biology Key Knowledge

Unit 3, AOS 2 Outcome 2 Key Knowledge: Immunity

- the deficiencies and malfunctions of the immune system as a cause of human diseases including autoimmune diseases (illustrated by multiple sclerosis), immune deficiency diseases (illustrated by HIV) and allergic reactions (illustrated by reactions to pollen)

Posters in this module serve as exemplars for key knowledge dot points in Unit 4, AOS 3

Prior knowledge
Unit 3, AOS 2 – Responding to antigens: all five key knowledge dot points
Unit 3, AOS 2 – apoptosis as a natural, regulatory process of programmed cell death
VCAA Biology Key Science Skills

Analyse and evaluate data, methods and scientific models
- Organise, present and interpret data using schematic diagrams and flow charts, tables, bar charts, line graphs, ratios, percentages and calculations of mean
- Explain the merit of replicating procedures and the effects of sample sizes in obtaining reliable data
- Explain how models are used to organise and understand observed phenomena and concepts relating to biology, identify limitations of the models.

Draw evidence-based conclusions
- Draw conclusions consistent with evidence and relevant to the question under investigation
- Critically evaluate various types of information related to biology from journal articles, mass media and opinions presented in the public domain
- Discuss the implications of research findings and proposals

Communicate and explain scientific ideas
- Discuss relevant biological information, ideas, concepts, theories and models and the connections between them
- Identify and explain formal biological terminology about investigations and concepts
Deficiencies of the immune system: Module overview
(repeat for each of 3 posters)

1. In groups, students read the poster introduction and conduct research to define highlighted terms

2. Students use models to refine science understandings for the healthy versus the disease state to highlight the deficiency/malfunction of the immune system.

3. Students communicate their understanding of the disease by converting the model into a diagrammatic representation of the malfunction process leading to disease.

4. Students read the poster methodology and examine experimental methods as they watch media clips providing an overview of the technologies used to collect data.

5. Students analyse results presented in the poster to address a series of discussion questions and, in doing so, write the discussion section for the poster.

6. Students write a poster conclusion as they consider the aim and hypothesis of the experiment.
Resources for deficiencies of the immune system

• Online student resource - Scientific Posters (introduction, aim, methodology and results) of research into deficiencies of the immune system for:
  • Multiple Sclerosis (MS)
  • allergic rhinitis
  • HIV

• Online student support material to explore the technologies used to collect results for each scientific study

• Teacher resource: templates and instructions for models designed to help students understand the biology relating to the deficiency of the immune system that is causing each disease.

• Teacher resource: sample discussions and conclusions embedded in a completed poster format for each disease
**Outbreak Module descriptor**

This module immerses students in an investigation of how outbreaks of disease are monitored and controlled. Students assume the role of epidemiologists and use predictive modelling, in particular, the $R_0$ equation to predict the spread of disease and the effectiveness of control measures. They model the outbreak of disease to determine the number of individuals infected by an infectious person per day ($\beta$). They use models and animations to understand how the following technologies are applied to identify that the pathogen causing this outbreak of disease is influenza H5N1:

- diagnostic kits
- PCR
- gel electrophoresis
- bioinformatics (BLAST sequence alignment computer tool)

Students use animations and stories about past flu pandemics to explore the pathogenicity of this virus. They perform an ELISA to determine the average duration of infectiousness for a group of patients ($d$). Students then determine the $R_0$ of this disease and use a town outbreak map to consider methods to reduce the spread of infection. They manipulate the $R_0$ equation to test their theories. They consider limitations to the model and how it might be modified to account for changed parameters. Using the protein visualisation tool, Cn3D, students explore the development of the antiviral drug Relenza. Using model flu viruses students learn how vaccines are developed to provide active immunity against strains of influenza. They consider how antivirals and vaccines might be used to control this influenza outbreak.

**Prior knowledge**

How the body responds to antigens (Unit 3, AOS2 - the five key knowledge dot points under the descriptor “responding to antigens”)}
Outbreak! Strategies to deal with the emergence of a new infectious disease
Education design: Chris Szwed and Jacinta Duncan
Outbreak VCAA Biology curriculum link

Unit 3 AOS2 Key Knowledge:
Immunity
• Active strategies for acquiring immunity
• Vaccination programs and their role in maintaining herd immunity for a particular disease in the human population

Unit 4 AOS2 Key Knowledge:
DNA manipulation
• Amplification of DNA using the polymerase chain reaction
• The use of gel electrophoresis in sorting DNA fragments, including interpretation of gel runs

Biological knowledge and society
• Strategies that deal with the emergence of new diseases in a globally connected world, including the distinction between epidemics and pandemics, the use of scientific knowledge to identify the pathogen, and the types of treatments
• The concept of rational drug design in terms of the complementary nature (shape and charge) of small molecules that are designed to bind tightly to target biomolecules (limited to enzymes) resulting in the enzymes inhibition and giving rise to a consequential therapeutic benefit, illustrated by the Australian development of the antiviral drug Relenza as a Neuraminidase inhibitor
• The use of chemical agents against pathogens including the distinction between antibiotics and antiviral drugs with reference to their mode of action and biological effectiveness
Key Skills

Conduct investigations to collect and record data
- Systematically generate, record and summarise both qualitative and quantitative data

Analyse and evaluate data, methods and scientific models
- Process quantitative data using appropriate mathematical relationships and units
- Organise, present and interpret data using schematic diagrams, tables and calculations of mean

Draw evidence-based conclusions
- Draw conclusions consistent with evidence and relevant to the question under investigation
- Identify, describe and explain the limitations of conclusions, including identification of further evidence required
- Discuss the implications of research findings and proposals

Communicate and explain scientific ideas
- Use appropriate biological terminology, representations and conventions
- Discuss relevant biological information, ideas, concepts, theories and models and the connections between them
- Identify and explain formal biological terminology about investigations and concepts
1. Model the spread of the pathogen through a community and obtain a value for the number of people an infected person will infect per day ($\beta$)

2. Identify the pathogen by comparing and contrasting symptoms and morphology of potential pathogens

3. Identify the Influenza type and explore the structure and pathogenicity of the Influenza virus and past flu pandemics

4. Model Polymerase Chain Reaction (PCR) and Gel Electrophoresis, then analyse results to identify the strain of Influenza responsible for the outbreak (H5N1)

5. Use flu genetic sequence to run an alignment (BLAST) to compare the virus with other circulating strains, and utilise WHO records to determine % mortality for this H5N1 strain

6. Model an ELISA and analyse ELISA results to determine the duration of infectiousness for an infected person ($d$)

7. Use $R_0$ equation to predict how quickly this disease will spread and propose and analyse interventions to contain the outbreak

8. Use Cn3D and models to explore the development and action of the anti-viral Relenza. Use models to explore the development of a flu vaccine and assess their utility in controlling this outbreak.
Outbreak resources

Step 1: Modelling an outbreak of disease and determining how many people are infected by an infectious person per day

- **Teacher/lab tech resource**: Information for setting up modelling outbreak activity: Students assume the role of townspeople to model interactions that take place where body fluids can be exchanged. They analyse their movements and disease status to determine how many people are infected by an infectious person per day ($\beta$)

Step 2: Initial identification of the pathogen

- **Student resource**: Graphic organisers characterising viral families for use in making preliminary identification of pathogen

Step 3: Identification of the Influenza type

- **Student online course**: exploring the flu virus and identifying the flu type in this outbreak

Step 4: Identification of the Influenza subtype

- **Teacher resource**: instructions and templates for using the Polymerase Chain Reaction and Gel Electrophoresis models to identify the Influenza subtype for this outbreak
**Step 5: Searching global databases to identify and research the Influenza strain**

- **Student resource:** instructions for using BLAST to identify the full name of the Influenza strain, and explore statistics using the World Health Organisation reports and publications.

**Step 6: Determining the duration of infectiousness for an infected person**

**Teacher resource:**
- **Teacher resource:** instructions and templates for using the ELISA model to establish the duration (days) of infectiousness for an infected person (d)

**Step 7: Constructing a predictive model and controlling the outbreak**

- **Teacher resource:** leading a discussion on methods for containing this outbreak of disease
- **Student resource:** activity for using mathematical modelling to analyse vaccine efficacy and determine the threshold of vaccinated individuals within the community required to achieve herd immunity.

**Step 8: Investigating Relenza and its mechanisms to treat Influenza infections**

**Teacher resource:** Instructions and templates for modelling activity to simulate development of the antiviral drug Relenza.

**Student resource:** Using the protein visualisation tool Cn3D to explore the action of the neuraminidase inhibitor Relenza.
Strategies to deal with the emergence of an outbreak of foodborne disease

Education design: Chris Szwed and Jacinta Duncan
Strategies to deal with the emergence of an outbreak of foodborne disease

**Module descriptor**

This module introduces students to the approaches taken by epidemiologists and pathologists to contain an epidemic of bacterial foodborne disease. Students will view methods and technologies and will analyse data to identify the causative agent from a suspect list of ten bacteria. They will then identify the source of the outbreak. Students will analyse:

- Patient notes to examine symptoms and determine the onset of disease
- Microbiological techniques, examining positive and negative controls and the results of tests, to diagnose the pathogen
- DNA profiles to identify the source of the outbreak (using models of DNA technologies including Polymerase Chain Reaction (PCR) and gel electrophoresis)

Students perform an experiment to determine the best antibiotic to use to treat new cases of this disease. This task can be conducted as an exemplar practical investigation for Unit 4 AOS 3 key knowledge:

- Research and communicate the biological concepts specific to the investigation
- Collaboratively develop a methodology
- Practice skills in microbiology (prepare a bacterial lawn and apply antibiotic mast rings)
- Practice techniques of primary qualitative and quantitative data collection
- Identify and apply relevant health, safety and bioethical guidelines
- Explore methods for organising, analysing and evaluating primary data
- Report on the key findings of the investigation
Strategies to deal with the emergence of an outbreak of foodborne disease

**Module descriptor (continued)**

Students discuss interventions to control this outbreak of foodborne disease including:

- Treatment for patients
- Treating the source
- Education
- Closing hubs with high transmission rates

**Extension activity:**

students apply the bioinformatics program, BLAST (Basic Local Alignment Search Tool), to identify the causative pathogens in case studies of foodborne disease. BLAST is an algorithm for comparing unknown primary sequence data with a database of sequences, looking for matching or closely related sequences.

**Suggested linking activity:**

Unit 4 AOS 3 Practical investigation (determining the dose of antibiotic to treat a bacterial infection)
Unit 4 AOS 2 Key knowledge

DNA manipulation
- Amplification of DNA using the polymerase chain reaction
- The use of gel electrophoresis in sorting DNA fragments, including interpretation of gel runs

Biological knowledge and society
- Strategies that deal with the emergence of new diseases in a globally connected world, including the distinction between epidemics and pandemics, the use of scientific knowledge to identify the pathogen, and the types of treatments
- The use of chemical agents against pathogens including the distinction between antibiotics and antiviral drugs with reference to their mode of action and biological effectiveness

Unit 4 AOS 3 Key knowledge
- Independent, dependent and controlled variables
- The biological concepts specific to the investigation and their significance, including definitions of key terms, and biological representations
- The characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation (laboratory work)
- Ethics and issues of research including identification and application of relevant health, safety and bioethical guidelines
VCAA Biology curriculum link (continued)

Unit 4 AOS 3 Key knowledge (continued)

- Methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and limitations of data and methodologies
- Models, theories and classification keys, and their use in organising and explaining observed phenomena and biological concepts including their limitations
- The nature of evidence that supports or refutes a hypothesis, model or theory
- The key findings of the selected investigation and their relationship to biochemical concepts
- The conventions of scientific report writing including biological terminology and representations, standard abbreviations, units of measurement and acknowledgement of references

Units 1 – 4: Key science skills:

Develop aims and questions, formulate hypotheses and make predictions

- Determine aims
- Identify independent, dependent and controlled variables

Plan and undertake investigations

- Conduct experiments; solve a scientific problem; use of databases; simulations; access secondary data, including data sourced through the internet
- Use equipment, materials and procedures appropriate to the investigation, taking into account potential sources of error and uncertainty
VCAA Biology curriculum link (continued)

Units 1 – 4: Key science skills: (continued)

Comply with safety and ethical guidelines
• Apply relevant occupational health and safety guidelines while undertaking practical investigations, including following relevant bioethical guidelines when handling live materials

Conduct investigations to collect and record data
• Systematically generate, collect and record and summarise both qualitative and quantitative data

Analyse and evaluate data, methods and scientific models
• process quantitative data using appropriate mathematical relationships and units
• Organise, present and interpret data using schematic diagrams and flow charts, tables, bar charts, line graphs, ratios, percentages and calculations of mean
• Take a qualitative approach when identifying and analysing experimental data with reference to accuracy, precision, reliability, validity, uncertainty and errors (random and systematic)

Draw evidence-based conclusions
• Draw conclusions consistent with evidence and relevant to the question under investigation
• Discuss the implications of research findings and proposals

Communicate and explain scientific ideas
• Use appropriate biological terminology, representations and conventions, including standard abbreviations, graphing conventions and units of measurement.
1. Students use an online model of outbreak to record patient symptoms, places they ate and what they ate and complete an epidemiology report as the they track the progress of disease and recognise there is an epidemic.

2. Students consider a list of 10 possible foodborne disease causal bacteria and predict which suspects might be causing this epidemic based on patient symptoms and disease onset.

3. Students view techniques for performing diagnostic tests to identify bacteria. They compare results to positive and negative controls to eliminate suspect bacteria from their list.

4. On identifying the bacteria species students view techniques for performing a diagnostic test to identify the strain of this bacteria and make a diagnosis on viewing results.

5. Students examine models of PCR and Gel electrophoresis and analyse a DNA profile to locate the source of this outbreak of foodborne disease.

6. Students perform an experiment to determine the best antibiotic to use to treat new cases of this disease.

8. Students discuss methods for containing this outbreak of disease.
Containing an outbreak of foodborne disease: Resources

**Resources to support this activity**

- **Student online activity: tracking an outbreak of disease: the role of epidemiologists**
- **Student resource: Identifying the bacterial pathogen causing an outbreak of foodborne disease**
- **Student online course: diagnostic tests to identify the species and strain of bacteria causing an outbreak of foodborne disease**
- **Student online course: using PCR and gel electrophoresis to identify the source of an outbreak of foodborne disease**
- **Student resource: identifying the best antibiotic to use in treating an outbreak of foodborne disease**
- **Teacher resource: Coordinating a class discussion on methods for containing an outbreak of foodborne disease**
Unit 4, AOS 3: Practical investigation

Education design: Dr Fran Maher, Alex Sipidias and Jacinta Duncan
Module descriptor
This module is designed to provide a method for teachers to run the Unit 4, AOS 3, Practical Investigation with. The SAC task is run over a series of lessons allowing for student work to be authenticated as they progress through various levels of the investigation applying key knowledge dot points. Work is recorded in students’ log books. Log books are kept in the classroom (or by teacher). A rubric is supplied to students to provide information on how the key knowledge for Unit 4, AOS 3 is being assessed.

• Students conduct a preliminary experiment to learn practical and analytical skills.
• Students then design an experimental method to answer a related question. A methodology checklist is provided. **Checkpoint 1: assesses question and methodology**
• Students are provided with a method to conduct the investigation. This ensures that students who designed a weak methodology have the opportunity to produce data that can be analysed.
• Students perform the experiment in pairs, record observations and measurements and add their quantitative data to a class set of results. **Checkpoint 2: assesses practical work**
• Students organise, analyse and evaluate the class primary data, preparing the results section and the conclusion section for their poster in their log books. **Checkpoint 3: authenticate results analysis and conclusion**
• Students prepare a poster using a poster template and their log book records. Students apply the conventions of scientific poster presentation to communicate their research. **Checkpoint 4: assesses poster**
Prior knowledge
Throughout the year students are provided with activities designed to practise and apply the key knowledge dot points listed for Unit 4, AOS3 so they are equipped with the skills to complete this SAC activity. A guided investigation is supplied to familiarise students with the practical skills and structure of this SAC task. Students draw upon this study to develop a new research question and methodology for the AOS3 Practical Investigation.

Unit 4 AOS2 Key Knowledge:
Biological knowledge and society
• Strategies that deal with the emergence of new diseases in a globally connected world, including the distinction between epidemics and pandemics, the use of scientific knowledge to identify the pathogen, and the types of treatments
• The use of chemical agents against pathogens including the distinction between antibiotics and antiviral drugs with reference to their mode of action and biological effectiveness
Unit 4 AOS3 Key Knowledge:

- Independent, dependent and controlled variables
- The biological concepts specific to the investigation and their significance, including definitions of key terms, and biological representations
- The characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation, including laboratory work (biochemistry, cytology, immunology) and/or fieldwork (geomorphology); precision, accuracy, reliability and validity of data; and minimisation of experimental bias
- Ethics and issues of research including identification and application of relevant health, safety and bioethical guidelines
- Methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and limitations of data and methodologies
- Models, theories and classification keys, and their use in organising and explaining observed phenomena and biological concepts including their limitations
- The nature of evidence that supports or refutes a hypothesis, model or theory
- The key findings of the selected investigation and their relationship to cytological, biochemical and/or evolutionary concepts
- The conventions of scientific report writing and scientific poster presentation including biological terminology and representations, standard abbreviations, units of measurements and acknowledgement of references
VCAA Biology Key Science Skills

The module draws on all Key science skills from Units 1 – 4

• Develop aims and questions, formulate hypotheses and make predictions
• Plan and undertake investigations
• Comply with safety and ethical guidelines
• Conduct investigations to collect and record data
• Analyse and evaluate data, methods and scientific models
• Draw evidence-based conclusions
• Communicate and explain scientific ideas
PRELIMINARY EXPERIMENT – ANTIBIOTICS IN ACTION
Conduct an experiment to investigate antibiotic sensitivity in one or more bacteria.
Address Key Knowledge in Unit 4 AOS2
Learn skills for Unit 4 AOS3 Practical Investigation

AOS3 PRACTICAL INVESTIGATION
Step 1: DESIGN AN EXPERIMENT
Students develop a research question and design their methodology (submit for assessment)
CHECKPOINT 1 - ASSESS RESEARCH QUESTION & METHODOLOGY (LOGBOOK)

Step 2: PERFORM A STANDARDISED EXPERIMENT
Students use protocol provided by the teacher, work in pairs, perform experiment, measure and record first hand data, collate class data set
CHECKPOINT 2 – VALIDATE & ASSESS EXPERIMENT (LOGBOOK)

Step 3: ANALYSE RESULTS
Students work individually to analyse, tabulate or graph data.
Students draw conclusions about the inhibitory concentration of ampicillin
CHECKPOINT 3 – AUTHENTICATE DATA ANALYSIS & CONCLUSIONS

Step 4: PREPARE POSTER
Students prepare an individual scientific poster to communicate their research
CHECKPOINT 4 – AUTHENTICATE & ASSESS POSTER
Procedure for Unit 4 AOS3 Practical Investigation

Part 1: Experiment conducted in Unit 4 AOS2
Antibiotics in action - Investigate the effects of a range of antibiotics on bacteria

Resources/Activities:
• Students conduct an experiment using a protocol supplied by the teacher to investigate a range of antibiotics on one or more species of bacteria
• Students learn the practical and analytical skills relevant to designing a related Practical Investigation

Part 2
Step 1: Design an experiment related to antibiotic concentration and bacterial growth

Resources/Activities:
• Students use their practical skills and knowledge from the preliminary investigation, as well as further background information, to develop a research question and design a methodology to determine the minimum inhibitory concentration of ampicillin required to inhibit the growth of Escherichia coli

CHECKPOINT 1 – Assess the research question and methodology
Step 2: Perform a standardised experiment to determine the ampicillin concentration that effectively inhibits growth of *E. coli*

Resources/Activities:
- Students work in pairs to follow the protocol provided by the teacher (all students move forward with the same protocol and have the opportunity to produce data that can be analysed)
- Students measure and record their own results and contribute data to a pooled class data set

CHECKPOINT 2
- Validate and assess safe conduct and completion of experiment according to protocol and as recorded in log book
- Teacher prepares class data set (students move forward with the same data)
Step 3: Students analyse results to determine the inhibitory concentration of ampicillin

Resources/Activities:
- Students work individually, under authentication conditions, to analyse the class data set, present the data in tables/graphs as appropriate, and draw conclusions.
- Using the criteria established for defining positive and negative effects, students determine the “minimum inhibitory concentration” of ampicillin for E. coli.
- Students consider the validity and reliability of the experimental design and results.

CHECKPOINT 3 – Assess data analysis, graphs and conclusions.

Step 4: Students prepare a poster to summarise the Practical Investigation

Resources/Activities:
- Students work individually to analyse the class data set, present the data in tables/graphs as appropriate and write an introduction and discussion including references.

CHECKPOINT 4 – Assess the poster: title, introduction, methodology, results, discussion, conclusion, references and acknowledgements.
Resources to support practical investigation

• Student Worksheets
  • AOS2 Experiment – Antibiotics in Action
  • AOS3 Practical Investigation overview
• AOS3 Step 1 – Develop a research question
• AOS3 Step 2 – Standard class practical
• AOS3 Step 3 – Analyse class results
• AOS3 Step 4 – Prepare the poster

• Poster Template
• Assessment Rubric

• Teacher Guide
  • Implementation notes
  • Suggested answers
  • Sourcing practical materials
Unit 4, AOS 3: Critically evaluating scientific posters
Education design: Alex Sipidias, Carla Daunton and Jacinta Duncan
Critically evaluating the content of scientific posters

**Module descriptor**

In this module students compare and contrast two scientific research posters on the same topic. One is designed to showcase a substandard study and poster, and another to showcase a high quality study and poster. Students critically evaluate each poster using a practical investigation and poster evaluation tool. In doing this they determine how well each poster addresses elements of Key Knowledge in Unit 4 AOS 3 Outcome 3.

In pairs, students discuss each poster and comment on any issues they have identified. They make recommendations for improving the study and the poster.

Students then evaluate a number of scientific posters to discuss strengths and limitations of the study and poster communication for each.

This task is designed to stimulate students to recognise elements of strong and weak studies and poster communications so that they can be empowered to complete their own practical investigation and poster. It also helps them to understand how aspects of their work will be assessed.
VCAA Biology Key Skills

Units 1 - 4 Key Skills:

Analyse and evaluate data, methods and scientific models
- Organise, present and interpret data using schematic diagrams and flow charts, tables, bar charts, line graphs, ratios, percentages and calculations of mean
- Evaluate investigative procedures and possible sources of bias, and suggest improvements

Draw evidence-based conclusions
- Determine to what extent evidence from an investigation supports the purpose of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation
- Identify, describe and explain the limitations of conclusions, including identification of further evidence required
- Discuss the implications of research findings and proposals

Communicate and explain scientific ideas
- Discuss relevant biological information, ideas, concepts, theories and models and the connection between them
- Identify and explain formal biological terminology about investigations and concepts
Module overview

1. Students individually evaluate a substandard exemplar of a scientific research poster using an evaluation tool

2. In pairs, students compare their findings and summarise which areas of the poster have issues

3. In pairs, students provide recommendations on how the poster could be improved

4. Students then evaluate a high quality exemplar on the same topic to determine if they identified all issues with the original poster

5. Students then re-evaluate their recommendations to reflect any changes
Scientific Poster Resources

**Resources to support this activity**

**Resource 1:**
- *Poster 1* – ‘Curing the burns of children in developing countries’ - substandard exemplar poster

**Resource 2:**
- *Poster 2* – ‘Does treatment with antibody improve scar strength?’
  - high quality exemplar poster

**Resource 3:**
- *Scientific Poster Evaluation Tool* – to assist students in evaluating posters