



Biology

Victorian Certificate of Education Study Design

Victorian Curriculum and Assessment Authority
2005

November 2010

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Latoya BARTON
The sunset (detail)
from a series of twenty-four
9.0 x 9.0 cm each, oil on board



Tarkan ERTURK
Visage (detail)
201.0 x 170.0 cm
synthetic polymer paint, on cotton duck



Liana RASCHILLA
Teapot from the *Crazy Alice* set
19.0 x 22.0 x 22.0 cm
earthenware, clear glaze, lustres



Nigel BROWN
Untitled physics (detail)
90.0 x 440.0 x 70.0 cm
composition board, steel, loudspeakers,
CD player, amplifier, glass



Kate WOOLLEY
Sarah (detail)
76.0 x 101.5 cm, oil on canvas



Chris ELLIS
Tranquility (detail)
35.0 x 22.5 cm
gelatin silver photograph



Christian HART
Within without (detail)
digital film, 6 minutes



Kristian LUCAS
Me, myself, I and you (detail)
56.0 x 102.0 cm
oil on canvas



Merryn ALLEN
Japanese illusions (detail)
centre back: 74.0 cm, waist (flat): 42.0 cm
polyester cotton



Ping (Irene) VINCENT
Boxes (detail)
colour photograph



James ATKINS
Light cascades (detail)
three works, 32.0 x 32.0 x 5.0 cm each
glass, fluorescent light, metal



Tim JOINER
14 seconds (detail)
digital film, 1.30 minutes



Lucy McNAMARA
Precariously (detail)
156.0 x 61.0 x 61.0 cm
painted wood, oil paint, egg shells, glue, stainless steel wire

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IMPORTANT INFORMATION

Accreditation period

Units 1–4: 2006–2014

The accreditation period commences on 1 January 2006.

Other sources of information

The *VCAA Bulletin* is the only official source of changes to regulations and accredited studies. The *VCAA Bulletin*, including supplements, also regularly includes advice on VCE studies. It is the responsibility of each VCE teacher to refer to each issue of the *VCAA Bulletin*. The *VCAA Bulletin* is sent in hard copy to all VCE providers. It is available on the Victorian Curriculum and Assessment Authority's website at www.vcaa.vic.edu.au

To assist teachers in assessing school-assessed coursework in Units 3 and 4, the Victorian Curriculum and Assessment Authority publishes an assessment handbook that includes advice on the assessment tasks and performance descriptors for assessment.

The current year's *VCE and VCAL Administrative Handbook* contains essential information on assessment and other procedures.

VCE providers

Throughout this study design the term 'school' is intended to include both schools and other VCE providers.

Photocopying

VCE schools only may photocopy parts of this study design for use by teachers.

Introduction

RATIONALE

Biology is the study of living things from familiar, complex multicellular organisms that live in the many different habitats of our biosphere to single celled micro-organisms that live in seemingly inhospitable conditions. It is a study of the dynamic relationships between living things, their interdependence, their interactions with the non-living environment, and the processes that maintain life and ensure its continuity. Biology enables students to understand that despite the diverse ways of meeting the challenges of survival, all living things have many structural and functional characteristics in common.

Modern biology draws on increasingly specialised fields of bioscience such as biochemistry, neuroscience, genetics, evolutionary biology, behavioural science, and cell and molecular biology including studies of genomics and proteomics. It makes connections between these fields and the disciplines of physics, chemistry, Earth and space sciences in exploring the nature of past and present life, and the possibility of life forms beyond our planet.

Students acquire knowledge and skills of inquiry that help them to examine critically issues that arise in their own lives and in the public domain, to contribute to debate and to take part in making decisions about their own health and wellbeing and that of society. They build an understanding of the interconnectedness of all living things and their environment. The values and attributes that students develop will help them to recognise the strengths and limitations of science, respect evidence and be sensitive to differences in views and beliefs held by others. They will be able to work collaboratively and yet state their own views from an informed position.

The study of biology prepares students for continuing studies in bioscience and entry into the workforce in a wide range of careers, including those not normally thought of as depending on bioscience. Much of our economic activity is generated through advances in bioscience research, in environmental, medical and associated biotechnologies, and in parallel sciences such as bioinformatics.

Students develop knowledge of bioscience and skills of science inquiry and the values and attributes that will help them to consider issues and implications associated with the application of biological techniques and technologies.

AIMS

This study is designed to enable students to:

- develop an understanding of essential biological principles based upon knowledge of living organisms;
- understand the relationships between living organisms and between living organisms and their environments;
- develop an awareness of the effects of human activities on living organisms and relationships existing in the environment;
- develop an understanding of the importance of experimental and other investigative work;
- acquire practical skills in the study of living organisms in the field and the laboratory;
- apply bioscience understandings in personal, social, environmental and technological contexts;
- develop values and attributes that will help them to consider issues and implications associated with the application of biological techniques and technologies, including
 - flexibility, curiosity, critical reflection and respect for evidence
 - recognition and understanding of the strengths and limitations of science
 - respect for the environment, both living and non-living.

STRUCTURE

The study is made up of four units:

Unit 1: Unity and diversity

Unit 2: Organisms and their environment

Unit 3: Signatures of life

Unit 4: Continuity and change

Each unit deals with specific content and is designed to enable students to achieve a set of outcomes. Each outcome is described in terms of key knowledge and draws on the set of key skills outlined on page 12.

ENTRY

There are no prerequisites for entry to Units 1, 2 and 3. Students must undertake Unit 3 prior to undertaking Unit 4. Units 1 to 4 are designed to a standard equivalent to the final two years of secondary education. All VCE studies are benchmarked against comparable national and international curriculum.

DURATION

Each unit involves at least 50 hours of scheduled classroom instruction.

CHANGES TO THE STUDY DESIGN

During its period of accreditation minor changes to the study will be notified in the *VCAA Bulletin*. The *VCAA Bulletin* is the only source of changes to regulations and accredited studies and it is the responsibility of each VCE teacher to monitor changes or advice about VCE studies published in the *VCAA Bulletin*.

MONITORING FOR QUALITY

As part of ongoing monitoring and quality assurance, the Victorian Curriculum and Assessment Authority will periodically undertake an audit of Biology to ensure the study is being taught and assessed as accredited. The details of the audit procedures and requirements are published annually in the *VCE and VCAL Administrative Handbook*. Schools will be notified during the teaching year of schools and studies to be audited and the required material for submission.

SAFETY

This study may involve the handling of potentially hazardous substances and/or the use of potentially hazardous equipment. It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students undertaking the study.

USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY

In designing courses for this study, teachers should incorporate information and communications technology where appropriate and applicable to the teaching and learning activities. The Advice for Teachers section provides specific examples of how information and communications technology can be used in this study.

KEY COMPETENCIES AND EMPLOYABILITY SKILLS

This study offers a number of opportunities for students to develop key competencies and employability skills. The Advice for Teachers section provides specific examples of how students can demonstrate key competencies during learning activities and assessment tasks.

LEGISLATIVE COMPLIANCE

When collecting and using information, the provisions of privacy and copyright legislation, such as the Victorian *Information Privacy Act 2000* and *Health Records Act 2001*, and the federal *Privacy Act 1988* and *Copyright Act 1968* must be met.

Assessment and reporting

SATISFACTORY COMPLETION

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher's assessment of the student's performance on assessment tasks designated for the unit. Designated assessment tasks are provided in the details for each unit. The Victorian Curriculum and Assessment Authority publishes an assessment handbook that includes advice on the assessment tasks and performance descriptors for assessment for Units 3 and 4.

Teachers must develop courses that provide opportunities for students to demonstrate achievement of outcomes. Examples of learning activities are provided in the Advice for Teachers section.

Schools will report a result for each unit to the Victorian Curriculum and Assessment Authority as S (Satisfactory) or N (Not Satisfactory).

Completion of a unit will be reported on the Statement of Results issued by the Victorian Curriculum and Assessment Authority as S (Satisfactory) or N (Not Satisfactory). Schools may report additional information on levels of achievement.

AUTHENTICATION

Work related to the outcomes will be accepted only if the teacher can attest that, to the best of their knowledge, all unacknowledged work is the student's own. Teachers need to refer to the current year's *VCE and VCAL Administrative Handbook* for authentication procedures.

LEVELS OF ACHIEVEMENT

Units 1 and 2

Procedures for the assessment of levels of achievement in Units 1 and 2 are a matter for school decision. Assessment of levels of achievement for these units will not be reported to the Victorian Curriculum and Assessment Authority. Schools may choose to report levels of achievement using grades, descriptive statements or other indicators.

Units 3 and 4

The Victorian Curriculum and Assessment Authority will supervise the assessment of all students undertaking Units 3 and 4.

In Biology the student's level of achievement will be determined by school-assessed coursework, a mid-year examination and an end-of-year examination. The Victorian Curriculum and Assessment Authority will report the student's level of performance on each assessment component as a grade from A+ to E or UG (ungraded). To receive a study score, students must achieve two or more graded assessments and receive S for both Units 3 and 4. The study score is reported on a scale of 0–50. It is a measure of how well the student performed in relation to all others who took the study. Teachers should refer to the current year's *VCE and VCAL Administrative Handbook* for details on graded assessment and calculation of the study score. Percentage contributions to the study score in Biology are as follows:

- Unit 3 school-assessed coursework: 17 per cent
- Mid-year examination: 33 per cent
- Unit 4 school-assessed coursework: 17 per cent
- End-of-year examination: 33 per cent

Details of the assessment program are described in the sections on Units 3 and 4 in this study design.

Units 1–4: Key skills

In this study a set of key skills is considered essential to Biology. These skills apply across Units 1 to 4. In designing teaching and learning programs for each unit, teachers must ensure that students are given the opportunity to develop, use and apply these skills and to demonstrate them in a variety of contexts. As the complexity of key knowledge increases from Units 1 to 4, students should demonstrate the skills at a progressively higher level. Advice on the assessment of the key skills is provided in the assessment details for each unit.

These skills include the ability to:

Investigate and inquire scientifically

- formulate questions and construct hypotheses appropriate for conducting first-hand and second-hand investigations;
- plan, design and conduct first-hand investigations: select and use equipment and materials appropriate to the investigation; evaluate experimental procedures and reliability of data;
- collect, process and record information systematically; analyse and synthesise data; draw conclusions consistent with the question under investigation and the evidence obtained;
- act responsibly when conducting investigations: maintain safe practices; work independently and collaboratively as appropriate.

Apply biological understandings

- apply understandings to familiar and new contexts; make connections between concepts; solve problems;
- analyse issues and implications relating to scientific and technological developments;
- analyse and evaluate the reliability of information and opinions presented in the public domain.

Communicate biological information and understandings

- interpret, transpose and communicate information and ideas effectively;
- use techniques of communication appropriate to different audiences and purposes;
- use scientific terminology and conventions appropriately.

Unit 1: Unity and diversity

In this unit students examine the cell as the structural and functional unit of the whole organism. Students investigate the needs of individual cells, how specialised structures carry out cellular activities and how the survival of cells depends on their ability to maintain a dynamic balance between their internal and external environments.

Whether life forms are unicellular or multicellular, whether they live in the depths of the ocean or in the tissues of another living thing, all are faced with the challenge of obtaining nutrients and water, a source of energy, a means of disposing of their waste products, and a means of reproducing themselves.

Though there are many observable differences between living things, they have many fundamental features and biological processes in common. Students explore the diversity of organisms and look for patterns of similarities and differences. They investigate how the structure and functioning of interdependent systems in living things assist in maintaining their internal environment. They relate differences in individual structures and systems to differences in overall function.

As students consider the development of ideas and technological advances that have contributed to our knowledge and understanding of life forms and cell biology, they come to understand the dynamic nature of science. Students investigate technological applications and implications of bioscientific knowledge.

AREA OF STUDY 1

Cells in action

This area of study focuses on the activities of cells. Students investigate the relationship between specialised structures of cells and the processes that maintain life. All organisms, whether unicellular or multicellular, require a relatively stable internal environment for optimal functioning. Students examine how membranes contribute to survival of cells by controlling the movement of substances within cells, and between cells and their external environment.

Students undertake practical investigations into cell structure and functioning in autotrophs and heterotrophs. They consider the development of ideas and technological advances that have contributed to our knowledge and understanding of cell biology. Students investigate the implications of current and emerging techniques and technologies that make use of, and further our knowledge of, cells as functional units.

Outcome 1

On completion of this unit the student should be able to design, conduct and report on a practical investigation related to cellular structure, organisation and processes.

To achieve this outcome the student will draw on the key knowledge outlined in area of study 1, and key skills listed on page 12.

Key knowledge

This knowledge includes

- cell structure: prokaryotic and eukaryotic cells at light and electron microscope levels; cellular organisation;
- cell functioning: specialised parts of cells and their functions; biochemical processes including photosynthesis and cellular respiration in terms of inputs and outputs; general role of enzymes in biochemical activities of cells;
- composition of cells: major groups of organic and inorganic substances including carbohydrates, proteins, lipids, nucleic acids, water, minerals, vitamins; their general role in cell structure and function;
- internal and external environments of cells; plasma membranes; membrane transport including diffusion, osmosis, active transport; surface area to volume ratio;
- cell replication: purposes of cell replication (mitosis and cytokinesis); cell growth, cell size and cell division.

AREA OF STUDY 2

Functioning organisms

This area of study focuses on the relationship between features of organisms and how organisms meet their requirements for life. Students examine a range of organisms and investigate the ways that structures and systems function in terms of obtaining and releasing energy; obtaining nutrients, water and gases; processing and distributing materials to cells and transporting wastes from cells to points of disposal. They consider the needs for systems to be integrated for the organism to function as a whole.

Students examine how patterns of observable similarities and differences in the structure and function of organisms are used in constructing taxonomic systems that are subject to change as new information is obtained.

Students undertake practical investigations into the relationship between structures of autotrophs and heterotrophs and their requirements. They consider the development of ideas and technological advances that have contributed to our knowledge and understanding of living things and relationships between them. Students investigate the implications of techniques and technologies that make use of and further our knowledge of organisms and the way they function.

Outcome 2

On completion of this unit the student should be able to describe and explain the relationship between features and requirements of functioning organisms and how these are used to construct taxonomic systems.

To achieve this outcome the student will draw on the key knowledge outlined in area of study 2, and key skills listed on page 12.

Key knowledge

This knowledge includes

- common requirements of living things
 - obtaining nutrients: organic and inorganic requirements; autotrophs; heterotrophs
 - obtaining energy: inputs and outputs of photosynthesis; structural features of photosynthetic organisms
 - processing nutrients: features of effective systems in heterotrophs; examples of systems in different animals
 - distributing materials: features of effective transport systems; examples of transport systems in multicellular organisms
 - removing wastes: nature of waste products and toxic substances; excretory mechanisms and systems
 - exchanging gases: features of effective surfaces of gaseous exchange; mechanisms and systems of gaseous exchange in multicellular organisms; process of diffusion;
- reproduction: asexual and sexual reproduction; mechanisms and systems of reproduction in unicellular and multicellular organisms;
- classifying organisms: purposes, principles, hierarchy of biological classification; features typically used in constructing major taxonomic groups.

ASSESSMENT

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher's assessment of the student's overall performance on assessment tasks designated for the unit.

The key knowledge for each outcome and key skills listed on page 12 should be used as a guide to course design and the development of learning activities. The key knowledge and skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes. The elements of key knowledge and skills should not be assessed separately.

Assessment 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. Teachers should select a variety of assessment tasks for their assessment program to reflect the key knowledge and skills being assessed and to provide for different learning styles.

For this unit students are required to demonstrate achievement of the two outcomes. As a set these outcomes encompass both areas of study.

Demonstration of achievement of Outcomes 1 and 2 must be based on the student's performance on a selection of assessment tasks. Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand. Assessment tasks for this unit are:

For Outcome 1:

- a student-designed and/or adapted and/or extended practical investigation;

And

For Outcomes 1 and 2:

at least three from the following:

- practical activities;
- multimedia or web page presentation;

- response to a media article;
- oral presentation;
- annotated poster;
- data analysis;
- problem solving;
- test, multiple choice and/or short answer and/or extended response.

Unit 2: Organisms and their environment

The rich diversity of Australian ecosystems provides a variety of contexts for students to study the relationships between living things and their environment. Students investigate particular sets of biotic and abiotic factors that operate in different places in the biosphere, and how these factors influence the kinds of organisms that live there. Students examine how organisms in their particular habitats are part of the integrated and naturally self-sustaining systems in which energy flows and matter is cycled between the living and non-living components of the environment.

Students investigate how features possessed by organisms affect their fitness and reproductive success, in relation to their habitats. They consider how species are affected by changes in environmental conditions, whether natural or human-induced.

In this unit students investigate what changes have taken place in selected ecosystems, how ecological principles can be applied to conserve natural ecosystems, to restore damaged ones and to ensure sustainability of the biosphere. Students investigate how technologies are being applied to monitor natural ecosystems and to manage systems developed to provide resources for humans.

AREA OF STUDY 1

Adaptations of organisms

This area of study focuses on the kinds of environmental factors that are common to all habitats. Students investigate the adaptations of organisms that enable them to exploit the resources of their particular ecological niche. Adaptations are interrelated and can be grouped into structural, physiological, and behavioural categories.

Students make connections between the conditions that operate in habitats, the tolerance range of organisms and the distribution of organisms. They examine individual and collective behaviours that organisms exhibit and relate them to an organism's survival.

Students undertake practical investigations into selected factors operating in habitats and adaptations of organisms to those habitats. They investigate techniques and technologies that monitor and record environmental factors and track the distribution of species.

Outcome 1

On completion of this unit the student should be able to explain and analyse the relationship between environmental factors, and adaptations and distribution of living things.

To achieve this outcome the student will draw on the key knowledge outlined in area of study 1, and key skills listed on page 12.

Key knowledge

This knowledge includes

- environmental factors: biotic and abiotic factors; availability of resources;
- structural adaptations: relating major features of organisms to survival value;
- physiological adaptations
 - tolerance range of organisms; maintaining equilibrium by detecting and responding to changes in environmental conditions
 - nerve control in complex multicellular organisms: major sense organs and pathways of transmission of nerve impulses
 - hormonal control in complex multicellular organisms
 - regulating water balance and controlling temperature;
- plant tropisms: growth responses, rhythmic activities;
- behavioural adaptations: individual and group behaviours of animals including rhythmic activities, feeding behaviours; communication; social and territorial behaviours;
- reproductive adaptations: systems and strategies; development and life cycles;
- techniques used to monitor environmental change and species distribution.

AREA OF STUDY 2

Dynamic ecosystems

With an emphasis on Australian ecosystems, this area of study focuses on the complex and finely balanced relationships that exist between living things and the resources in their particular habitat. This network of relationships can be understood as a system with inputs, processing and outputs: there is a flow of energy and cycling of matter between the living and non-living components of the ecosystem. Ecosystems do not exist in isolation from each other; they form a network of ecosystems that constitute the global system of the biosphere.

Students examine how ecosystems are subject to changes that differ in scope, intensity and regularity. They investigate how human activities such as habitat destruction, resource use and disposal of wastes, affect not only the ecological niche that individual species occupy, but the functioning of ecosystems at local and global levels.

Students undertake practical investigations into interactions between members of the same and different species and between organisms and their non-living environment. They examine the effect on ecosystems of historical practices, and investigate emerging techniques and technologies that help to monitor and maintain them. Students consider the issues and implications associated with human activities that affect the sustainability of ecosystems.

Outcome 2

On completion of this unit the student should be able to design, conduct and report on a field investigation related to the interactions between living things and their environment, and explain how ecosystems change over time.

To achieve this outcome the student will draw on the key knowledge outlined in area of study 2, and key skills listed on page 12.

Key knowledge

This knowledge includes

- components of ecosystems: communities of living organisms, ecological groupings; ecological niche;
- relationships between organisms: feeding including parasite/host, predator/prey, of mutual benefit including mutualism and symbiosis;
- flow of energy: inputs and outputs of the system; productivity; trophic levels and trophic efficiency;
- cycling of matter: principle of exchange between living and non-living components of the ecosystem, including inputs and outputs; biogeochemical systems including those of water, carbon, oxygen, nitrogen; bioaccumulation;
- population dynamics: carrying capacity of ecosystems; factors affecting distribution and abundance of organisms including birth and death rates, migration;
- change to ecosystems over time
 - scope and intensity of regular and irregular natural changes; succession
 - human activity and the sustainability of ecosystems
 - historical practices of indigenous peoples and settlers;
- techniques for monitoring and maintaining ecosystems.

ASSESSMENT

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher's assessment of the student's overall performance on assessment tasks designated for the unit.

The key knowledge for each outcome and key skills listed on page 12 should be used as a guide to course design and the development of learning activities. The key knowledge and skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes. The elements of key knowledge and skills should not be assessed separately.

Assessment 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. Teachers should select a variety of assessment tasks for their assessment program to reflect the key knowledge and skills being assessed and to provide for different learning styles.

For this unit students are required to demonstrate achievement of the two outcomes. As a set these outcomes encompass both areas of study.

Demonstration of achievement of Outcomes 1 and 2 must be based on the student's performance on a selection of assessment tasks. Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand. Assessment tasks for this unit are:

For Outcome 1:

at least three of the following:

- practical activities;
- multimedia or web page presentation;
- response to a media article;
- oral presentation;
- annotated poster;
- data analysis;
- test, multiple choice and/or short answer and/or extended response.

And

For Outcome 2:

- a written report on fieldwork (fieldwork may include a study of habitat within or outside the classroom).

Unit 3: Signatures of life

In this unit students consider the molecules and biochemical processes that are indicators of life. They investigate the synthesis of biomolecules and biochemical processes that are common to autotrophic and heterotrophic life forms. Students consider the universality of DNA and investigate its structure; the genes of an organism, as functional units of DNA and code for the production of a diverse range of proteins in an organism.

Students investigate the significant role of proteins in cell functioning; how technological advances have enabled scientists to determine differences in the molecular structure of proteins, how the structure of a protein relates to its function in an organism's tissues, and how technological advances have given rise to applications such as the design of proteins for specific purposes. Students consider advances in proteomics applied, for example, to medical diagnosis and the development of specific proteomic medications, new pharmaceuticals, nutraceuticals and vaccines.

Students investigate how cells communicate with each other at molecular level in regulating cellular activities; how they recognise 'self' and 'non-self' in detecting possible agents of attack; and how physical barriers and immune responses can protect the organism against pathogens.

Students consider the technological advances that have contributed to our knowledge and understanding of molecular biology, they come to understand the dynamic nature of science. They investigate how the development of bioinformatics makes it possible to store and analyse large volumes of biological information.

Students apply concepts relating to cell structure and function, the needs of cells and their activities.

AREA OF STUDY 1

Molecules of life

In this area of study, students investigate the activities of cells at molecular level; the synthesis of biomolecules that form components of cells and the role of enzymes in catalysing biochemical processes. Students investigate energy transformations in cells and how autotrophs and heterotrophs obtain their energy requirements, particularly through the processes of photosynthesis and cellular respiration.

Students gain an understanding that DNA and proteins are key molecules of life forms, and that units of DNA code for the production of proteins underpins the relationship between changing the code and changing the molecular products of cells. Students explore applications of molecular biology in medical diagnosis and the design of new pharmaceuticals.

Students undertake practical investigations into the molecular composition of cells and biochemical processes including transformation of energy and enzyme activity.

Outcome 1

On completion of this unit the student should be able to analyse and evaluate evidence from practical investigations related to biochemical processes.

To achieve this outcome the student will draw on key knowledge outlined in area of study 1, and key skills listed on page 12.

Key knowledge

This knowledge includes

- the chemical nature of the cell
 - synthesis of biomacromolecules: polysaccharides, nucleic acids and proteins
 - the structure and function of lipids
 - the structure and function of DNA and RNA
 - the structure and functional diversity of proteins: the proteome;
- the role of organelles and plasma membranes in the packaging and transport of biomolecules;
- the nature of biochemical processes
 - enzymes as organic catalysts
 - energy requirements of cells; catabolic and anabolic reactions
 - energy transformations, including main stages in and sites of photosynthesis and cellular respiration; ATP-ADP cycle; factors affecting rate of energy transformations;
- applications of molecular biology in medicine including the design of drugs and in medical diagnosis.

AREA OF STUDY 2

Detecting and responding

This area of study focuses on how cells detect biomolecules that elicit particular responses depending on whether the molecules are ‘self’ or ‘non-self’. Students investigate how signalling molecules, such as hormones and neurotransmitters, assist in coordinating and regulating cell activities by binding to specific receptors on membranes of target cells, initiating a series of molecular changes in response.

Students examine the barriers and mechanisms of organisms that protect them from invasion and infection by pathogenic organisms. They investigate mechanisms that control the effectiveness of pathogens, and specific and non-specific immune responses of organisms to antigens.

Students investigate signalling molecules and their role in regulating activities of organisms such as growth hormones in plants and/or action of antibiotics. They investigate how advances in molecular biology have helped to find causes of disorders in cell communication, and how technologies assist in managing disorders that interfere with coordination and regulation.

Outcome 2

On completion of this unit the student should be able to describe and explain coordination and regulation of an organism’s immune responses to antigens at the molecular level.

To achieve this outcome the student will draw on key knowledge outlined in area of study 2, and key skills listed on page 12.

Key knowledge

This knowledge includes

- coordination and regulation
 - stability and change in the internal environment
 - principles of homeostasis: stimulus-response model and negative feedback model; roles of nervous and endocrine systems
 - signalling molecules: neurotransmitters, hormones, pheromones; plant growth regulators
 - signal transduction: signals, membrane receptors; responses;
- detecting ‘self’ and ‘non-self’ molecules: antigens and membrane receptors
 - pathogens: non-cellular agents, cellular agents; controls;
- physical and chemical barriers to infection in plants and animals;
- immune response
 - structure and overall function of the lymphatic system
 - non-specific: inflammatory response; phagocytosis; blood clotting
 - specific immune response: T-cell lymphocytes and cell-mediated response; B-cell lymphocytes and humoral response, antigens and antibodies; memory cells;
- disorders of the immune response: autoimmunity; hypersensitivity, allergens and allergic responses;
- acquired immunity: natural, artificial including vaccines and antibody serums.

ASSESSMENT

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher’s assessment of the student’s overall performance on assessment tasks designated for the unit. The Victorian Curriculum and Assessment Authority publishes an assessment handbook that includes advice on the assessment tasks and performance descriptors for assessment.

The key knowledge listed for each outcome and the set of key skills listed on page 12 should be used as a guide to course design and the development of learning activities. The key knowledge and skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes. The elements of key knowledge and skills should not be assessed separately.

Assessment of levels of achievement

The student’s level of achievement in Unit 3 will be determined by school-assessed coursework and a mid-year examination.

Contribution to final assessment

School-assessed coursework for Unit 3 will contribute 17 per cent to the study score.

The level of achievement for Unit 3 is also assessed by a mid-year examination, which will contribute 33 per cent to the study score.

School-assessed coursework

Teachers will provide to the Victorian Curriculum and Assessment Authority a score representing an assessment of the student's level of achievement.

The score must be based on the teacher's rating of performance of each student on the tasks set out in the following table and in accordance with an assessment handbook published by the Victorian Curriculum and Assessment Authority. The assessment handbook also includes advice on the assessment tasks and performance descriptors for assessment.

Assessment 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. Where optional assessment tasks are used, teachers must ensure that they are comparable in scope and demand. Teachers should select a variety of assessment tasks for their program to reflect the key knowledge and skills being assessed and to provide for different learning styles.

School-assessed coursework in Biology includes assessment of practical work. Students should maintain their own record of practical work, including a clear, concise report of each experiment. As a guide at least 10 hours of class time should be devoted to student practical work.

Outcomes	Marks allocated*	Assessment tasks
Outcome 1 Analyse and evaluate evidence from practical investigations related to biochemical processes.	25	A summary report of a practical activity related to a biochemical process.
	25	AND A written report of a practical activity on the movement of substances across membranes.
Outcome 2 Describe and explain coordination and regulation of an organism's immune responses to antigens at the molecular level.	25	A summary report of a plant or animal response to chemical and/or physical stimuli. OR A summary report of a practical activity related to bacteria response to chemical and/or physical stimuli.
	25	A presentation given orally or in annotated poster form on one aspect of the immune response. OR A web page or presentation in multimedia format on one aspect of the immune response.
Total marks	100	

*School-assessed coursework for Unit 3 contributes 17 per cent to the study score.

Mid-year examination**Description**

Students will answer a series of questions set by an examination panel.

All of the key knowledge that underpins the outcomes in Unit 3 and the set of key skills listed on page 12 are examinable.

Format

The examination will be set by a panel appointed by the Victorian Curriculum and Assessment Authority.

Conditions

The examination will be completed under the following conditions:

- Duration: one and a half hours.
- Date: mid-year, on a date to be published annually by the Victorian Curriculum and Assessment Authority.
- Victorian Curriculum and Assessment Authority examination rules will apply. Details of these rules are published annually in the *VCE and VCAL Administrative Handbook*.
- The examination will be marked by a panel appointed by the Victorian Curriculum and Assessment Authority.

Contribution to final assessment

The examination will contribute 33 per cent to the study score.

Unit 4: Continuity and change

In this unit students examine evidence for evolution of life forms over time. Students explore hypotheses that explain how changes to species have come about. In addition to observable similarities and differences between organisms, students explore the universality of DNA, and conservation of genes as evidence for ancestral lines of life that have given rise to the present biodiversity of our planet.

Students investigate how the study of molecular genetics has expanded into genomics – the study of whole sets of genes possessed by an organism. Information obtained by studying genomes and functional genomics has provided insight into gene expression and regulation, and relationships between species.

Students study how genes are transmitted from generation to generation by examining meiosis and patterns of inheritance including pedigree analysis. Students consider the relationship between heritable variations and the environment in accounting for changes to species over time, and for speciation and extinction.

Students examine the interrelationships between biological, cultural and technological evolution. As they consider the historical development of ideas and technological advances that have contributed to our knowledge and understanding of inheritance and evolutionary biology, students come to understand the dynamic nature of science, the human factors that influence developments in science and its increasing reliance on evidence. Students investigate emerging technological applications and the implications of advances in molecular genetics. They consider how developments in bioinformatics assist in collecting and interrogating large volumes of biological data.

The ability to apply technologies that can change the genetic composition of individual organisms and species, including humans, raises controversial issues for individuals and society. Students examine these issues and consider their implications from a variety of perspectives.

AREA OF STUDY 1

Heredity

This area of study focuses on molecular genetics and the investigation not only of individual units of inheritance, but also of the genomes of individuals and species. Students investigate inheritance in asexually reproducing organisms and the mechanism and patterns of transmission of heritable traits in sexually reproducing organisms.

Students examine the process of meiosis in terms of inputs and outputs and, in accounting for variations in offspring, consider the interplay between genotype and environmental factors, the significance of mutations in DNA, and the relationship between alleles.

Students investigate the techniques and technologies that are used to amplify DNA, identify the genetic profile of organisms and manipulate and modify the genomes of organisms. They undertake practical investigations that involve manipulation of DNA and inheritance of traits. They trace patterns of inheritance by analysis of pedigrees.

Outcome 1

On completion of this unit the student should be able to analyse evidence for the molecular basis of heredity, and patterns of inheritance.

To achieve this outcome the student will draw on key knowledge outlined in area of study 1, and key skills listed on page 12.

Key knowledge

This knowledge includes

- molecular genetics
 - genome, gene expression; genes as units of inheritance
 - principal events in transcription and translation;
- tools and techniques: gel electrophoresis; DNA profiling; DNA sequencing; DNA recombination; DNA amplification; gene cloning, gene transformation; gene delivery systems;
- transmission of heritable characteristics
 - genes as units of inheritance; gene regulation
 - eukaryote chromosomes, alleles; prokaryote chromosome and plasmids;
- cell reproduction: cell cycle, DNA replication, apoptosis; binary fission; gamete production; inputs and outputs of meiosis;
- variation: mutations; genotype, phenotype; continuous, discontinuous variation;
- patterns of inheritance in sexually reproducing organisms
 - one gene locus: monohybrid cross including dominance, recessiveness, co-dominance; multiple alleles
 - two gene loci: dihybrid cross
 - pedigree analysis: autosomal, sex-linked inheritance; test cross.

AREA OF STUDY 2

Change over time

This area of study focuses on change to genetic material that occurs over time and the changing nature and reliability of evidence that supports the concept of evolution of life forms. Students investigate changes to species and examine the process of natural selection as a mechanism for evolution.

Students examine how evolutionary biology has been based upon changes in evidence obtained by accumulation of information over time, changes in interpretation and more recently from molecular biology. Students investigate technological advances that have increased understanding of evolutionary processes and phylogenetic relationships.

Students consider how the interaction between human, cultural and technological evolution may have affected evolutionary processes. They also look at how applying reproductive and gene technologies to develop traits in species for particular purposes may affect evolutionary processes in the future.

Students consider the application of gene technologies to genetic screening and profiling of individuals, and gene therapies that affect gene lines, and the bioethical, environmental and legal issues raised.

Outcome 2

On completion of this unit the student should be able to analyse and evaluate evidence for evolutionary change and evolutionary relationships, and describe mechanisms for change including the effect of human intervention on evolutionary processes.

To achieve this outcome the student will draw on key knowledge outlined in area of study 2, and key skills listed on page 12.

Key knowledge

This knowledge includes

- change in populations: gene pool, allele frequencies; selection pressures; genetic drift;
- natural selection as a mechanism of evolution;
- geological time: scale; relative and actual dating techniques;
- evidence of evolution: fossil record, biogeography, comparative anatomy; molecular evidence;
- patterns of evolution: divergent, convergent; allopatric speciation, extinction;
- the development of evolutionary theory;
- evolutionary relationships: conservation of genes; genome phylogeny; mitochondrial evolution;
- hominid evolution: patterns, origin;
- interrelationships between biological, cultural and technological evolution;
- human intervention in evolutionary processes
 - selective breeding
 - application of gene technologies: cloning of organisms; transformation; stem cell differentiation; genetic screening, gene therapy.

ASSESSMENT

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher's assessment of the student's overall performance on assessment tasks designated for the unit. The Victorian Curriculum and Assessment Authority publishes an assessment handbook that includes advice on the assessment tasks and performance descriptors for assessment.

The key knowledge listed for each outcome and the set of key skills listed on page 12 should be used as a guide to course design and the development of learning activities. The key knowledge and skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes. The elements of key knowledge and skills should not be assessed separately.

Assessment of levels of achievement

The student's level of achievement for Unit 4 will be determined by school-assessed coursework and an end-of-year examination.

Contribution to final assessment

School-assessed coursework for Unit 4 will contribute 17 per cent to the study score.

The level of achievement for Unit 4 is also assessed by an end-of-year examination, which will contribute 33 per cent to the study score.

School-assessed coursework

Teachers will provide to the Victorian Curriculum and Assessment Authority a score representing an assessment of the student's level of achievement.

The score must be based on the teacher's rating of performance of each student on the tasks set out in the following table and in accordance with an assessment handbook published by the Victorian Curriculum and Assessment Authority. The assessment handbook also includes advice on the assessment tasks and performance descriptors for assessment.

Assessment 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. Where optional assessment tasks are used, teachers must ensure that they are comparable in scope and demand. Teachers should select a variety of assessment tasks for their program to reflect the key knowledge and skills being assessed and to provide for different learning styles.

School-assessed coursework in Biology includes assessment of practical work. Students should maintain their own record of practical work, including a clear, concise report of each experiment. As a guide at least 10 hours of class time should be devoted to student practical work.

Outcomes	Marks allocated*	Assessment tasks
Outcome 1 Analyse evidence for the molecular basis of heredity, and patterns of inheritance.	25	A summary report of a practical activity related to a genetic cross using first-hand data.
	25	AND A summary report of a practical activity on a DNA manipulation technique.
Outcome 2 Analyse and evaluate evidence for evolutionary change and evolutionary relationships, and describe mechanisms for change including the effect of human intervention on evolutionary processes.	25	An oral or written report that demonstrates evolutionary relationships using first- or second-hand data.
	25	AND A response to an issue related to an application of gene technologies using any one or a combination of the following: <ul style="list-style-type: none"> • an oral report • an annotated poster • a web page • a multimedia format • a written report.
Total marks	100	

*School-assessed coursework for Unit 4 contributes 17 per cent to the study score.

End-of-year examination**Description**

Students will answer a series of questions set by an examination panel.

All of the key knowledge that underpins the outcomes in Unit 4 and the set of key skills listed on page 12 are examinable.

Format

The examination will be set by a panel appointed by the Victorian Curriculum and Assessment Authority.

Conditions

The examination will be completed under the following conditions:

- Duration: one and a half hours.
- Date: end-of-year, on a date to be published annually by the Victorian Curriculum and Assessment Authority.
- Victorian Curriculum and Assessment Authority examination rules will apply. Details of these rules are published annually in the *VCE and VCAL Administrative Handbook*.
- The examination will be marked by a panel appointed by the Victorian Curriculum and Assessment Authority.

Contribution to final assessment

The examination will contribute 33 per cent to the study score.

Advice for teachers

DEVELOPING A COURSE

A course outlines the nature and sequence of teaching and learning necessary for students to demonstrate achievement of the set of outcomes for a unit. The areas of study describe the learning context and the knowledge required for the demonstration of each outcome. Outcomes are introduced by summary statements and are followed by the key knowledge which relate to the outcomes. Each outcome statement also draws on the set of key skills listed on page 12.

For Units 1 and 2, teachers must select assessment tasks from the list provided. Tasks should provide a variety and the mix of tasks should reflect different knowledge and skills, and different learning styles. Tasks do not have to be lengthy to make a decision about student demonstration of achievement of an outcome.

In Units 3 and 4, assessment is more structured. For some outcomes, or aspects of an outcome, the assessment tasks are prescribed. The contribution that each outcome makes to the total score for school-assessed coursework is also stipulated.

Each unit in Biology has two areas of study which are designed to be taught as a teaching sequence. The learning outcome given for each area of study has a distinct focus, which must be central to planning. The list of key knowledge outlined in the areas of study is an indication of the content knowledge and conceptual understandings which should be covered by a designed course. The sequence of teaching an area of study is not necessarily prescribed by the sequence of the listed content.

A set of key skills is integral to all units. The opportunity to develop, use and apply the key skills should be integrated into the teaching sequence through the inclusion of appropriate learning activities, including practical work.

It is an essential part of the teaching and learning of Biology that the designed programs be relevant to students and be contextually based. There are a number of appropriate contexts for presenting the required key knowledge with the key skills in a coherent course.

USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY

In designing courses and developing learning activities for Biology, teachers should make use of applications of information and communications technology and new learning technologies, such as computer-based learning, multimedia and the World Wide Web, where appropriate and applicable to teaching and learning activities. Also, information and communications technology can be valuable in helping students develop some of the key skills.

Data logging can be used in investigations that require taking measurements in the short or long term such as monitoring environmental or physiological parameters over short or long periods. The requirements include sensors, computer interfaces and software. Examples of the sorts of investigation that can be carried out using data logging technology include investigating the relationship between light intensity and dissolved oxygen levels in an aquarium over a few days; monitoring changes in breathing and pulse during exercise; measuring the growth rate of seedlings under different light intensities or temperatures; investigating changes resulting from anaerobic respiration of yeast; measuring changes in skin temperatures under the influence of variations in ambient temperature.

Electronic spreadsheets and graphing can be used to represent first-hand data or second-hand data. This data should be the basis for subsequent analysis and evaluation.

KEY COMPETENCIES AND EMPLOYABILITY SKILLS

Students undertaking the following types of assessment, in addition to demonstrating their understanding and mastery of the content of the study, typically demonstrate the following key competencies and employability skills.

Assessment task	Key competencies and employability skills
Fieldwork	Planning and organisation
Report	Planning and organisation, (written) communication
Multimedia report	Use of information and communications technology, self management, planning and organisation, initiative and enterprise
Investigation	Problem solving
Oral report	Planning and organisation, (oral) communication
Test	Problem solving, planning and organisation, (written) communication, self management
Extended practical investigation	Communication, problem solving, initiative/innovation

In completing work for this study, students may also demonstrate other key competencies and employability skills, such as working with others and in teams, and using mathematical ideas and techniques.

LEARNING ACTIVITIES

Examples of learning activities for each unit are provided in the following sections. Examples highlighted by a shaded box are explained in detail in accompanying boxes. The examples that make use of information and communications technology are identified by this icon .

Unit 1: Unity and diversity

AREA OF STUDY 1: Cells in action

Outcome 1

Design, conduct and report on a practical investigation related to cellular structure, organisation and processes.

Examples of learning activities

examine the structure of a variety of cells under the microscope; include live and prepared specimens

draw and label typical plant and animal cells; prokaryotic and eukaryotic cells; apply understandings to identify unfamiliar specimens



design an interactive multimedia presentation for a cellular structure

prepare a summary of the major groups of organic and inorganic molecules found in cells; relate the molecules and cell function to cell organelles

examine specialised cells under the microscope and relate the observed structure of each specialised cell to its function; apply understandings to unfamiliar specialised cells

collect, process and record information systematically in the form of an annotated flowchart of the inputs and outputs in photosynthesis ($12\text{H}_2\text{O} + 6\text{CO}_2 \rightarrow 6\text{O}_2 + \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O}$) and cellular respiration ($\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$), using scientific terminology and conventions



analyse first-hand data from the use of data logging to investigate a factor affecting the rate of photosynthesis



plan, design and conduct a first-hand experiment involving the use of data logging to investigate the effects of exercise on the rate of cellular respiration



research and collect information to design a multimedia presentation and/or model and/or poster that shows the structure of a cell membrane and the mechanisms by which materials move across them

construct hypotheses for the practical investigation of the movement of materials through membranes

analyse diagrams of different cells in different environments and predict the outcomes of exchange across the cellular membranes for given situations

conduct an experiment to investigate the relationship between surface area and volume and apply the principles to cellular function (for example, in villi, a plant root cell and epidermal cells)

construct a concept map for the purpose and processes of mitosis and cytokinesis, linked to cell replication in prokaryotic and eukaryotic cells

observe prepared slides showing mitosis and cytokinesis using a monocular light microscope

Detailed example

INVESTIGATING CELLS

Aim: To become familiar with the internal and external structure of cells. To become familiar with the relative sizes of cells.

Method:*Part A: Observing Prepared Slides*

Observe a selection of prepared slides under high power using a light microscope and draw a selection of about three cells of each type. Identify the features that are observable. Label each diagram correctly, including the magnification.

Suitable cells for observation include photosynthetic plant tissue, cheek cells, nerve cells.

Part B: Preparing and Observing Wet Mounts

Prepare a wet mount of spring onion epithelium cells and observe them under the light microscope under high power.

Add some iodine to the slide and note the differences.

Draw and label a diagram of the cells observed.

Part C: Observing Live Specimens

Observe live specimens under high power using the light microscope. Draw and label a diagram of the cells observed.

Suitable specimens for observation include amoeba, euglena, elodea, paramecium, volvox, spirogyra.

Questions:

1. What are some observed differences between plant and animal cells?
2. What are the main differences between eukaryotic and prokaryotic cells?
3. Describe the effect that staining had on the plant cells. What is one negative effect of staining?
4. Explain the role of each cellular feature that has been observed.
5. Explain why mitochondria and ribosomes were not observed in cells under the light microscope.

AREA OF STUDY 2: Functioning organisms

Outcome 2

Describe and explain the relationship between features and requirements of functioning organisms and how these are used to construct taxonomic systems.

Examples of learning activities

write a comparative summary which details the differences between autotrophs and heterotrophs; select appropriate examples to demonstrate the differences listed



using diagrams and notes, prepare a PowerPoint presentation that compares the dentition of a variety of animals and the related diet

design a flowchart of the inputs and outputs in photosynthesis, related to supplying energy to autotrophs and heterotrophs

conduct a practical investigation of stomatal activity



conduct a first-hand dissection, for example the digestive system of a rat, a sheep's pluck (heart/lungs), a kidney, fish gills, and/or a virtual dissection

examine prepared slides of xylem and phloem using a microscope



prepare a multimedia presentation and/or poster that shows the variation in the structure and principles of one of the systems operating in animals

prepare a comparative summary of hormones operating in plants and animals

plan and conduct a practical investigation of phototropism and/or geotropism in plants

draw conclusions from second-hand data from an investigation into the effects of various conditions on reaction times in humans

examine budding in Hydra using a light microscope

conduct a dissection of the reproductive system of a rat

conduct a dissection of a flower, draw and label the features observed; relate flower structure to method of pollination

process and record information, and prepare comparative summaries about reproduction; suitable topics could include sexual reproduction compared to asexual reproduction; reproduction in a mammal compared to that in a flowering plant



conduct a short research investigation online into a reproductive technology, for example in vitro fertilisation

explain the need for a taxonomic system; provide a written account of the historical developments related to classification; investigate the name changes and taxonomic status of the echidna

classify a group of objects or made-up organisms into groups and provide explanations for the groupings made



observe, analyse and classify preserved plant and animal specimens using a printed or computer-based key or field guide



collect information and design a PowerPoint presentation and/or model and/or poster that shows examples of the members of defined groups from the five kingdom model, with scientific names

Detailed example**DENTITION AND DIET**

Using a set of diagrams that represent the dentition of a variety of identified animals, prepare a PowerPoint presentation. Present these diagrams with associated notes, labelling and additional diagrams/pictures. These should link the dentition

pattern to diet and identify the animals as heterotrophs and identify linked autotrophs.

Include a bibliography listing the resources used in the research.

Unit 2: Organisms and their environment

AREA OF STUDY 1: Adaptations of organisms

Outcome 1

Explain and analyse the relationship between environmental factors, and adaptations and distribution of living things.

Examples of learning activities



analyse first-hand data from the use of data logging to measure abiotic factors (for example, light, dissolved O₂, CO₂, temperature) in a (temporary) pond; represent the data collected in a graphical format; evaluate the experimental procedures and the reliability of the data; relate the abiotic factors to the habitat provided for organisms



investigate the diversity in sets of abiotic and biotic factors that can operate in different habitats using second-hand data, videos, computer simulations (for example, Rock Platform Ecology), a field trip (for example, zoo)

conduct a dissection of an eye; explain how the eye functions to detect and respond to light



research online and collect information about an organism and the adaptations it has for water control or temperature control (for example, an Australian mammal); communicate the information and ideas clearly through a presentation to an audience of peers

analyse given information about the tolerance limits for a range of organisms and describe suitable habitats for these organisms

conduct a first-hand practical investigation into the effects of light or gravity on plant growth; prepare a written report of the findings

design a poster that shows a comparative overview of different reproductive adaptations (or development cycles, or life cycles) for plants and animals from several different habitats, indicating how the adaptations enable them to survive

conduct and report on field investigations related to the detailing components of an ecological niche for one organism; in the report detail the way the organism feeds, describe its activity and describe the habitat, including the resources available to the organism; also, identify the adaptive features that the organism has and the way that the organism uses these to make use of the resources available

record first-hand data from a field trip (for example, zoo), analyse related population distribution data, interpret the interactions occurring between members of the population and then answer a series of related questions

analyse and evaluate distribution patterns from second-hand data and draw conclusions from the information

research the classification and location of an Australian native flowering plant; present a map showing the distribution and discuss some of their adaptive features



collect information online or from the print media; describe the techniques and technologies that are used in the field by scientists to measure and monitor the distribution of living things

Detailed example

MEASURING THE ABIOTIC FACTORS IN HABITATS

Aim:

To quantitatively measure physical factors in a habitat.

Method:

Select an appropriate abiotic factor to monitor in the chosen habitat, for example a pond, and plan and design a suitable method for measuring the physical factor over time.

The parameter to be measured will be dependent on the measuring instruments available. Possible physical factors might include light, dissolved oxygen, pH, salinity or temperature.

Results:

1. Present the data collected in a suitable table.
2. Present the data collected in a suitable graphical format.

Questions:

1. Name one factor that may have affected the reliability of the data collected. Explain how this factor may have influenced the results that were obtained.
2. Explain how the physical factor that was monitored might influence the abundance and distribution of the animals and plants in the habitat?

AREA OF STUDY 2: Dynamic ecosystems

Outcome 2

Design, conduct and report on a field investigation related to the interactions between living things and their environment, and explain how ecosystems change over time.

Examples of learning activities

prepare an annotated poster that presents examples of the different relationships between organisms living together

use understandings of the interactions between species to classify a variety of described interactions between different organisms

explain how the niche size of organisms can be affected by competition

 collect information online or from the print media; describe the techniques and technologies that are used in the field by scientists to investigate ecosystems; describe the data that is collected and the ways it is collated

 plan and undertake a field investigation of an ecosystem; identify the different ecological components and investigate the interactions taking place between organisms; note observations and record relevant abiotic factors; take digital images of the organisms and build into the report

analyse described ecosystems, food webs, food chains and ecological pyramids

construct food webs, food chains and ecological pyramids from provided information/diagrams

write a hypothesis for the effects of change on the populations of organisms in an ecosystem; use second-hand data to form conclusions

analyse second-hand data and/or scenarios related to energy changes, population changes and bioaccumulation

 using online or print media, research a report on a way in which an ecosystem has undergone change over time; describe the composition of the ecosystem, clearly state the nature of the change and describe the subsequent changes that took place; include management techniques that were put in place to restore ecological balance

prepare a written response to an article that describes an example of an ecosystem undergoing a change

Detailed example**FIELD INVESTIGATION OF AN ECOSYSTEM**

Students plan and undertake a field investigation of an ecosystem. They identify the different ecological components and investigate the interactions taking place between organisms; students should observe and record relevant abiotic factors, and take digital images of the organism to use in their report.

The report should include:

- field notes and field data
- a description of the organisms at the different trophic levels
- a representation of the population density and distribution of the main organisms found
- a food web for the ecosystem
- several food chains (digital images could be used)
- a likely ecological pyramid
- a description of the flow of energy through the ecosystem
- a description of one way that bioaccumulation might occur
- a description of the ways in which the population of the main organisms in the ecosystem might change over time
- a flowchart to describe the cycling of carbon and nitrogen through the ecosystem studied
- a description of the inputs and outputs of water and oxygen for the ecosystem.

Unit 3: Signatures of life

AREA OF STUDY 1: Molecules of life

Outcome 1

Analyse and evaluate evidence from practical investigations related to biochemical processes.

Examples of learning activities

examine, identify and draw the organelles involved in biosynthesis, using the light microscope (for both prepared slides and live specimens) and electron micrographs

construct a model of a biomolecule; answer a series of structured questions related to biomolecular composition; consider proteins, as a series of linked amino acids with a 3D structure; monosaccharides, disaccharides and polysaccharides; lipids; nucleic acids

draw and label a diagram of a plasma membrane to show the biomolecular composition

model the structure of DNA and RNA; draw and label a diagram of the models

prepare a table describing some proteins that are formed within cells and the roles that they carry out within living things

consider the relationship between the DNA code and the molecular products of cells, for example, the effect of base changes on the structure of haemoglobin to form sickle cells, achondroplasia



research online the relationship between a gene and its expression into one or more proteins (not including transcription and translation): the concept of an individual's proteome, and how this idea is being applied in some medical treatments; construct a flowchart to show the relationships found

 research online and write an article that describes a technique that is used by scientists in the field of biotechnology and the advances that are being made as a result of its application (for example, the control of anthrax through control of enzyme action, the production of new drugs such as Relenza)

 use a central database to investigate proteomics; write an account of the information that is available to scientists and the nature of the source of the data

 prepare a PowerPoint presentation to describe the sequence of organelles involved in the processing, packaging and transport of a protein

conduct a practical investigation into the movement of biomolecules, for example starch and glucose across a membrane; draw conclusions from the data collected

 examine the structure and specialisation of a variety of cells using a light microscope and electron micrographs; identify the ways different cells are specialised for biosynthesis (for example, distribution of particular organelles, storage of starch)

model how an enzyme operates and explain the action modelled (induced fit and lock and key)

form a hypothesis related to a factor affecting enzyme activity; plan and conduct an experiment to test the hypothesis

investigate the separation of plant pigments using chromatography; answer a series of questions related to the role of pigments in plants, the location of pigments within a cell and their role in the production of biomolecules

annotate a diagram of a chloroplast to show the main stages and sites in photosynthesis (light dependent reaction: $12\text{H}_2\text{O} \rightarrow 6\text{O}_2 + 24\text{H}^+ + 18\text{ATP}$, light-independent reaction: $6\text{CO}_2 + 24\text{H}^+ + 18\text{ATP} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O}$) and a mitochondrion to show the main stages in cellular respiration ($\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 36\text{ADP} + 36\text{Pi} \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + 36\text{ATP}$)

respond to a series of questions related to cellular energy transformations and a comparison of the energy changes in the different stages in photosynthesis and respiration

Detailed example

THE SEPARATION OF PLANT PIGMENTS BY CHROMATOGRAPHY

Aim

To separate plant pigments using chromatography.

Procedure

1. Cut a strip of chromatography paper 15 cm long and 3 cm wide. Rule a faint pencil line about 1 cm from the bottom of the paper.
2. Apply pigment to the line by placing a leaf (geranium, spinach or ivy) directly on the paper near to the line and rolling a coin firmly onto the paper.
3. Dry the pigment and then suspend the paper in 70% ethanol, in a chromatography reaction chamber (or beaker). Use a lid to prevent evaporation of the solvent. Make sure the pigment is above the level of solvent used in the chamber.
4. Wait 20 to 30 minutes.
5. Mark with a pencil where the solvent stopped.
6. Assign a reference number to each pigment band. Measure the distance of each band and the solvent front from the initial line of pigment.
7. Record the data.

Results

Distance the solvent front moved: _____ mm

Band Number	Distance (mm)	Rf Value	Band Colour
1			
2			

Questions

1. From the results obtained, how many different plant pigments were in the plant type used?
2. What is the function of plant pigments in photosynthesis and the formation of biomolecules, such as starch?
3. Describe where pigments are located in the leaf of a plant?
4. Research to find out the wavelength range used by the different pigments found in plants. What adaptive value does having different pigments confer to a plant?

AREA OF STUDY 2: Detecting and responding

Outcome 2

Describe and explain coordination and regulation of an organism's immune responses to antigens at the molecular level.

Examples of learning activities

draw an annotated diagram to show the events occurring at the synapse of a nerve junction; identify the substances involved at the synapse; identify the effect of nerve poisons on these

conduct an investigation into the movement of coleoptiles to light; construct a hypothesis for the investigation and draw conclusions from the results obtained

map stimulus-response models for glucose control and temperature control (related to physiological responses) and apply the principles to other contexts (for example, water control)

examine disease-causing organisms microscopically and macroscopically; prepare a comparative table detailing the characteristics observed

 design a multimedia presentation for the adaptations of eukaryotic pathogens to a parasitic way of life (for example, the lifecycle of Plasmodium)

conduct a practical investigation of the effects of antibiotics and disinfectants on bacterial growth; write a report that includes a critique of the experimental processes employed

prepare an annotated flowchart for the sequence of events occurring in the cell-mediated and humeral response

 design a computer-based flowchart for the human immune system

prepare an annotated poster of the immune responses operating in plants

 using print and electronic resources, research and prepare a report on a disorder of the immune system

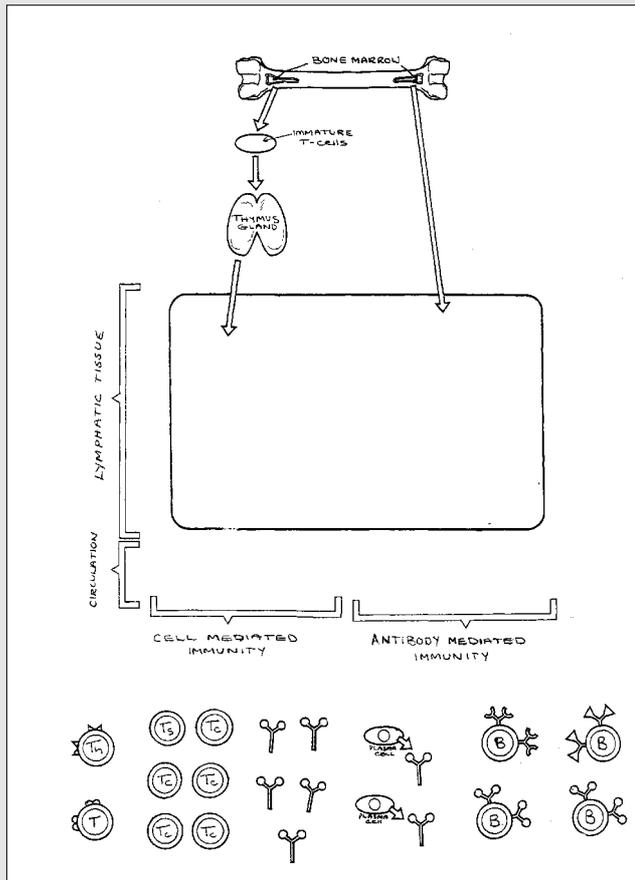
describe an example of a disorder of the immune response, highlighting the related mechanisms of the immune response and the cellular involvement

prepare a listing of the vaccination schedules currently in use for children; compare the scheduling of vaccines and antibody serums and discuss views in the community on vaccination

Detailed example

CELL-MEDIATED AND HUMERAL IMMUNE RESPONSES

Use diagrams and a template to prepare a flowchart that depicts the cell-mediated and humeral immune responses. Use appropriate labels and biological terminology to identify each of the cellular components and to describe the key events occurring.



Unit 4: Continuity and change

AREA OF STUDY 1: Heredity

Outcome 1

Analyse evidence for the molecular basis of heredity, and patterns of inheritance.

Examples of learning activities

 use a web-based multimedia learning program to become familiar with the processes of transcription and translation (for example, DNA interactive); write an account of protein synthesis

complete a series of questions related to the complementary base-pairing occurring during protein synthesis and the resultant amino acid sequencing

model the effects of mutation on protein synthesis

form a hypothesis and conduct an experiment to investigate the effects of environmental conditions on the expression of a trait (for example, light on genetically modified barley); form conclusions from the results obtained

prepare a concept map to show the events in cell reproduction

observe prepared slides showing meiosis using a light microscope

conduct a practical investigation into monohybrid crosses, using beads to model dominance and recessiveness

complete a series of applied exercises relating to monohybrid crosses, dihybrid crosses and pedigree analysis; predict outcomes and/or explain the basis for given outcomes using biological terminology

 use a computer simulation to investigate patterns of inheritance in, for example, *Drosophila*

 using the Internet and/or other media, research the tools and techniques used for gene manipulation; compile a resource file and use this to prepare a summary of their purpose and the way they manipulate or modify DNA

use first-hand data or second-hand data from DNA manipulation experiments to analyse evidence and predict pedigree outcomes

 using the Internet and/or other media, investigate an application of the techniques and technologies used to manipulate DNA; report the findings in a short presentation to peers, detailing the DNA techniques and technologies involved

Detailed example

INVESTIGATING HEREDITY AND ENVIRONMENT USING GENETIC BARLEY

Aim

To investigate and form a hypothesis on the effect of environment on the expression of leaf colour in genetic barley.

Procedure

1. Make a bed of cotton wool in the base of two petri dishes.
2. Dampen with water.
3. Place 10 of the barley seeds into each dish. Use forceps to arrange the seeds so that they are well spaced from each other.
4. Put on the lids. Label one 'L' and one 'D'. Put 'L' into non-direct light. Put 'D' into a completely dark place, near to the location of 'L'.

Results

Observe the shoots that emerge as the seeds germinated. Roots are white or colourless, the shoots will be green or yellowish. Count the numbers of each present on each day. Day one is when at least half the seeds have germinated.

Record results for three days. Leave both petri dishes into the light for 24 hours and then record results for the fourth day.

Present the data collected in an appropriate table.

Questions

1. Explain why 10 seeds were placed into each petri dish.
2. What experimental variables are there in this practical exercise?
3. What conclusion can be drawn from the results obtained?
4. Describe the genetic basis for the expression of the pigment biomolecules.
5. Name another factor that could effect the phenotypic expression of plants. Explain the effect of this factor on plant growth and/or appearance. Using an example, illustrate the effect described.

AREA OF STUDY 2: Change over time

Outcome 2

Analyse and evaluate evidence for evolutionary change and evolutionary relationships, and describe mechanisms for change including the effect of human intervention on evolutionary processes.

Examples of learning activities

construct hypotheses for the effects of different selection pressures on gene frequencies in a model population; conduct modelling exercises to test the hypotheses and draw conclusions from the data gathered

analyse case study descriptions and associated second-hand data related to population change for a particular species; answer a set of structured questions related to the interpretation of data and the explanation of related mechanisms of change over time

write a comparative account of the mechanism of evolution according to the theories of Lamarck and Darwin

 use a computer simulation to investigate natural selection in, for example, peppered moths, frogs, beetles

analyse descriptions of different situations and describe a set of likely events related to natural selection as a mechanism of evolution (for example, beak shape and seed type in the finches of Galapagos Islands, the emergence of resistant stains of bacteria)

examine fossil evidence concerning the evolution of molluscs; answer a set of structured questions related to the fossil record and geological time presented by evidence of various mollusc species

 model radioisotope dating; write a comparison of this technique to other dating methods

apply an understanding of the patterns of evolution to categorise and explain descriptions of different examples (for example, comparison of Australian marsupials and American placentals, the Eastern and Western Grey Kangaroo, the finches of the Galapagos Islands)

 collect and process information to design a multimedia presentation and/or model and/or poster that details the different types of evidence for evolution and includes visual representations for each type

prepare written responses to a set of structured questions related to the trends in human evolution and the interpretation of phylogenetic representations for the evolution of humans

prepare a written response to an article about human evolution; linking to evidence, geological time, patterns of change, origins, as appropriate

 use the Internet or print resources to research one application of gene technology such as cloning of organisms, transformation, stem cell differentiation, genetic screening, gene therapy, and prepare a class presentation; detail the tools and techniques used; write an account of the issues that are associated with the chosen application and the possible effect on evolutionary processes

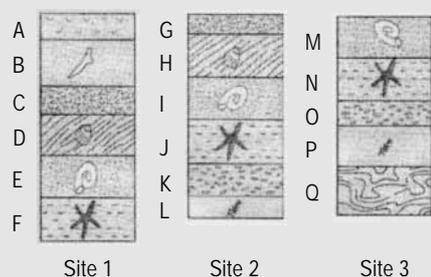
prepare a table that lists different applications of gene technology and identifies the biological concepts that are involved in each that have been covered by the coursework in Unit 4

Detailed example

EVOLUTIONARY PATTERNS IN MOLLUSCS

Cenozoic molluscs

One palaeontologist working on Cenozoic molluscs uses them to determine the ages of sedimentary rocks (biostratigraphy). Cuttings through a rock face in a quarry revealed the rock strata and fossils illustrated by Site 1 in the following diagram. Sites 2 and 3 represent the rock strata and fossils exposed in rock cuttings at different locations. Assume that the rock strata and associated fossils were laid down in the order they appear.



Consider the diagrams and answer the following questions:

1. Name three rock strata shown in the diagram which were laid down about the same time. Give a reason for your choice.
2. Which rock stratum contains the oldest fossils?
3. Which rock stratum contains the youngest fossils?
4. Suggest one reason to account for the absence from Sites 2 and 3 of the fossil species contained in stratum B.

5. Describe a likely sequence of events that would have resulted in the formation of these fossilised remains.

Limpets

Cellana tramoserica, the Variegated limpet, is a current mollusc species found on sedimentary rocks near to shore. The 'limpet' shape has developed many times during snail evolution. The occurrence of this shell shape in the fossil records indicates a similar environment might have existed to that which we see on the shore-line today.

Describe two selective pressures that act to develop the 'limpet' shaped shell.

Nudibranches

In molluscs the shell is an important protection against attack from predators. The loss of the shell in nudibranch sea-slugs means that they have had to evolve other means of defence. Species of one nudibranch family, the Chromodorids, have brilliant colour patterns. Research suggests that their bright colours are a warning to predators as they carry a toxic poison and cannot be eaten without killing the predator. It is found that groups of unrelated species that inhabit the same area have evolved almost identical colour patterns.

Explain how the unrelated species have evolved over time to have an almost identical colour pattern to the Chromodorids.

SCHOOL-ASSESSED COURSEWORK

In Units 3 and 4 teachers must select appropriate tasks from the assessment table provided for each unit. Advice on the assessment tasks and performance descriptors to assist teachers in designing and marking assessment tasks will be published by the Victorian Curriculum and Assessment Authority in an assessment handbook. The following is an example of a teacher's assessment program using a selection of the tasks from the Unit 3 and 4 assessment tables.

Outcomes	Marks allocated	Assessment tasks
Unit 3		
Outcome 1 Analyse and evaluate evidence from practical investigations related to biochemical processes.	25	A summary report of a practical activity that demonstrates enzyme action.
Outcome 2 Describe and explain coordination and regulation of an organism's immune responses to antigens at the molecular level.	25	A written report of osmosis based on an investigation of the effects of varying sucrose solutions on the weight of sultanas.
	25	A summary report detailing the design and results of a practical activity investigating phototropism in plants.
	25	An annotated poster that depicts non-specific immunity in humans.
Total marks for Unit 3	100	
Unit 4		
Outcome 1 Analyse evidence for the molecular basis of heredity, and patterns of inheritance.	25	A summary report which considers the design and results of a practical activity that models monohybrid genetic crosses.
Outcome 2 Analyse and evaluate evidence for evolutionary change and evolutionary relationships, and describe mechanisms for change including the effect of human intervention on evolutionary processes.	25	A summary report of a gel-electrophoresis practical activity.
	25	A written report that answers questions related to a population scenario.
	25	An annotated poster explaining how selective breeding has impacted on the evolutionary process.
Total marks for Unit 4	100	

SUITABLE RESOURCES

Some of the print resources listed in this section may be out of print. They have been included because they may still be available from libraries, bookshops and private collections.

At the time of publication the URLs (website addresses) cited were checked for accuracy and appropriateness of content. However, due to the transient nature of material placed on the web, their continuing accuracy cannot be verified. Teachers are strongly advised to prepare their own indexes of sites that are suitable and applicable to the courses they teach, and to check these addresses prior to allowing student access.

GENERAL

Books

Allen, R & Greenwood, T 2005, *Year 11 Biology*, Biozone Learning Media Ltd, New Zealand (updated annually).

Allen, R & Greenwood, T 2005, *Year 12 Biology*, Biozone Learning Media Ltd, New Zealand (updated annually).

Australian Academy of Science 1991, *Biology: The Common Threads, Parts 1 and 2*, Australian Academy of Science, Canberra.

Dirks, R 1991, *Disease and Society: A Resource Book*, Australian Academy of Science, Canberra.

Jackel, S & Roberts, R 1998, *Biology Study Dictionary*, Oxford University Press, Australia.

Kent, M 2000, *Advanced Biology*, Oxford University Press, UK.

Kinnear, J & Martin, M 2005 (forthcoming), *Nature of Biology, Book 1, 3E (textbooks and activity manual)*, John Wiley & Sons (Jacaranda), Australia.

Kinnear, J & Martin, M 2005 (forthcoming), *Nature of Biology, Book 2, 3E (textbooks and activity manual)*, John Wiley & Sons (Jacaranda), Australia.

Martin, E, Hine, R 2004, *Oxford Dictionary of Biology*, Oxford University Press, UK.

Pickering, WR 2002, *Advanced Biology Through Diagrams*, 2nd edn, Oxford University Press, UK.

Pickering, WR 2002, *Advanced Human Biology Through Diagrams*, 2nd edn, Oxford University Press, UK.

Thain, M, Hickman, M, Thian, M, Raymond Turvey (Illustrator) 2001, *The Penguin Dictionary of Biology*, Penguin, UK.

Text listings can be accessed from the publisher's websites:

Australian Academy of Science
www.science.org.au/index.htm

Biozone Resource Hub
www.biozone.co.uk/resource-hub.html

Heinemann
www.heinemann.com/

Jacaranda
www.jaconline.com.au/

Macmillan
www.macmillan.com/

Oxford University Press
http://au.oup.com

Thomson Learning
www.thomsonlearning.com.au/secondary/Science/index.asp

Journals

Australian Geographic (Journal of the Australian Geographic Society)

Australian Science Teachers Journal

ECOS (CSIRO)

Habitat (Australian Conservation Foundation)

Labtalk (STAV)

Nature

New Scientist

Scientific American

Audiovisual and software

Biozone Presentation Media Titles
www.biozone.com.au/products_OHT.html

DNAinteractive
www.dnai.org/index.htm

Catalogues of available titles can be accessed from suppliers:

Didasko Learning Resources
833 Dandenong Road
East Malvern Vic 3145
Postal: PO Box 312
Tel: (03) 9573 3900
Fax: (03) 9573 3901
Email: videos@didasko.com.au
Website: www.ema.com.au

Video Education Australasia (VEA)
111A Mitchell Street
Bendigo Vic 3550
Tel: (03) 5442 2433
Fax: (03) 5441 1148
Email: vea@vea.com.au
Website: www.vea.com.au

WEBSITES

Bio Links Online Database
(with many biology links, updated regularly)
www.biozone.com.au/links.html

EdNA Online
www.edna.edu.au

Eisenhower National Clearinghouse
www.enc.org

Interviews with Australian Scientists (Australian Academy of Science)
www.science.org.au/scientists

Nova (Australian Academy of Science)
www.science.org.au/nova

Quantum – ABC Television (biology links)
www.abc.net.au/quantum/links.htm

The ABC Online
www.abc.net.au

VCAA Biology Study
www.vcaa.vic.edu.au/vce/studies/biology/biologyindex.html

Victorian Education Channel (searchable resource database)
www.education.vic.gov.au/ch/

Organisations

CSIRO
Bag 10
Clayton South Vic 3169
Tel: 1300 363 400
Email: enquiries@csiro.au
Website: www.csiro.au
(Research Divisions and Programs can be accessed from this site)

Department of Innovation, Industry and Regional Development
PO Box 4509RR
Melbourne Vic 3001
Tel: (03) 9655 3315
Email: contact.us@synchrotron.vic.gov.au

Department of Sustainability and Environment
Tel: 136 186
Email: customer.service@dse.vic.gov.au

Gene Technology Access Centre (GTAC)
(University High School)
1H Royal Parade
Parkville Vic 3052
Tel: (03) 9340 3600
Fax: (03) 9348 2174
Email: gtac@gtac.edu.au
Program bookings:
Tel: (03) 9340 3600 (Wednesday–Friday)
Email: jbirtles@gtac.edu.au

Healesville Sanctuary
Badger Creek Road
Healesville Vic 3777
Tel: (03) 5957 2800
Fax: (03) 5957 2870
Email: hs@zoo.org.au
Website: www.zoo.org.au

Lisachem Materials
PO Box 721
Bacchus Marsh Vic 3340
Tel: (03) 5367 3641
Fax: (03) 5367 7383
Email: Lisachem@bigpond.net.au

Melbourne Museum
11 Nicholson Street
Carlton Vic 3053
GPO Box 666E
Melbourne Vic 3001
General enquiries: 13 11 02 (within Victoria)
Bookings: 1300 130 152
Australia-wide: (03) 8341 7777
Email (Education Staff): mmeducation@museum.vic.gov.au
Website: www.melbourne.museum.vic.gov.au

University of Melbourne
Department of Genetics
Parkville Vic 3010
Tel: (03) 8344 6240
Fax: (03) 8344 5139
Email: genetics-info@unimelb.edu.au
Website: www.genetics.unimelb.edu.au
Genetic Education and Community Interactions:
Website: www.genetics.unimelb.edu.au/GenEd/

Melbourne Zoo
Elliott Avenue
Parkville Vic 3052
Tel: (03) 9285 9300
Fax: (03) 9285 9350
Email: mz@zoo.org.au
Website: www.zoo.org.au

National Educational Advancement Programs (NEAP)
58 Pelham Street
Carlton Vic 3053
Tel: (03) 9663 2523
Fax: (03) 9663 7182

Parks Victoria Information Centre
Level 10, 535 Bourke Street
Melbourne Vic 3000
Tel: 131 963
Fax: (03) 9629 5563
Email: info@parks.vic.gov.au
Website: www.dse.vic.gov.au

Royal Botanic Gardens
Birdwood Avenue
South Yarra Vic 3141
Tel: (03) 9252 2300
Fax: (03) 9252 2442
General Enquiries: rbg@rbg.vic.gov.au
Visitor Information: visitor.centre@rbg.vic.gov.au
Bookings: edserv@rbg.vic.gov.au
Website: www.rbg.vic.gov.au

Science Teachers' Association of Victoria (STAV)
STAV House
5 Munro Street
Coburg Vic 3058
Postal: PO Box 109, Coburg Vic 3058
Tel: (03) 9385 3999
Fax: (03) 9386 6722
Email: info@stav.vic.edu.au
Website: www.stav.vic.edu.au

Scienceworks
2 Booker Street
Spotswood Vic 3015
Tel: (03) 9392 4800
Website: www.scienceworks.museum.vic.gov.au

Southern Biological Services, Pty Ltd
PO Box 57, Nunawading 3131
Tel: (03) 9877 4597; (03) 9877 9396
Fax: (03) 9894 2309
Email: southernbiological@bigpond.com

Tain Electronics Pty Ltd
10 Rowern Court
Box Hill North Vic 3129
Tel: (03) 9898 7366
Fax: (03) 9899 7992
Email: info@tain.com.au
Website: www.tainlab.com

Victorian Space Science Education Centre
Pascoe Vale Road
Strathmore Vic 3041
Tel: (03) 9379 7999
Fax: (03) 9379 2812
Email: spencer.phillip@edumail.vic.gov.au
pakakis.michael.k@edumail.vic.gov.au

Werribee Open Range Zoo
K Road, Werribee
PO Box 460
Werribee Vic 3030
Tel: (03) 9731 9600
Fax: (03) 9731 9606
Email: worz@zoo.org.au
Website: www.zoo.org.au