



Biology

Stage 6 Syllabus

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1 The Higher School Certificate Program of Study

The purpose of the Higher School Certificate program of study is to:

- provide a curriculum structure that encourages students to complete secondary education;
- foster the intellectual, social and moral development of students, in particular developing their:
 - knowledge, skills, understanding and attitudes in the fields of study they choose
 - capacity to manage their own learning
 - desire to continue learning in formal or informal settings after school
 - capacity to work together with others
 - respect for the cultural diversity of Australian society;
- provide a flexible structure within which students can prepare for:
 - further education and training
 - employment
 - full and active participation as citizens;
- provide formal assessment and certification of students' achievements;
- provide a context within which schools also have the opportunity to foster students' physical and spiritual development.

2 Rationale for Biology in the Stage 6 Curriculum

Biology in Stage 6 Science provides students with a contemporary and coherent understanding of the concepts explaining the functioning, origins and evolution of living things.

Biology Stage 6 explores the levels of organisation of life, from the molecular level through cellular to higher levels of organisational structure and function, which exhibit evolution as a common source of unity and diversity. It includes developing an understanding of the interactions within and between organisms and between organisms and their environment.

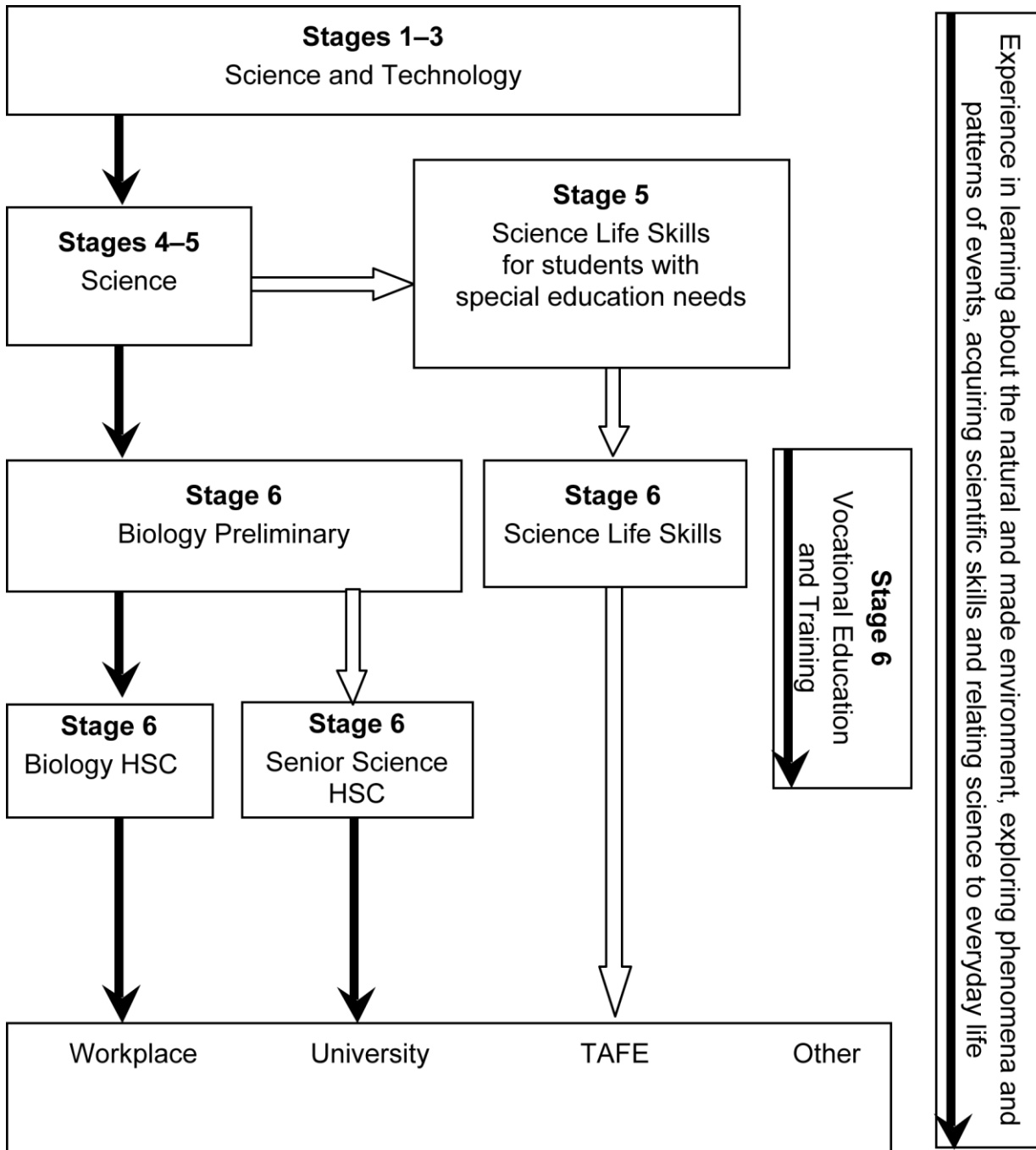
The study of biology recognises that, while humans are part of nature, they continue to have a greater influence on the environment than any other species. The history and philosophy of science, as it relates to the development of the understanding, utilisation and manipulation of living systems by the human species, is an integral part of the study of contemporary biology and assists students to recognise their responsibility to conserve, protect, maintain and improve the quality of all environments for future generations.

Biology in Stage 6 draws upon, and builds onto, the knowledge and understanding, skills and values and attitudes developed in Science Stages 4–5. It further develops students' understanding of science as a continually developing body of knowledge, the role of experimentation in deciding between competing theories, the provisional nature of scientific explanations, the interdisciplinary nature of science, the complex relationship between evidence and ideas and the impact of science on society.

The study of biology involves students working individually and with others in practical, field and interactive activities that are related to the theoretical concepts considered in the course. It is expected that students studying biology will apply investigative and problem-solving skills, effectively communicate biological information and understanding and appreciate the contribution that a study of biology makes to their understanding of the world.

The Biology Stage 6 course is designed for those students who have a substantial achievement level based on the Science Stages 4–5 course performance descriptions. The subject matter of the Biology course recognises the different needs and interests of students by providing a structure that builds upon the foundations laid in Stage 5 yet recognises that students entering Stage 6 have a wide range of abilities, circumstances and expectations.

3 Continuum of Learning for Biology Stage 6 Students



4 Aim

Biology Stage 6 aims to provide learning experiences through which students will:

- acquire knowledge and understanding about fundamental concepts related to living things and their environments, the historical development of these concepts and their application to personal, social, economic, technological and environmental situations
- progress from the consideration of specific data and knowledge to the understanding of models and concepts and the explanation of generalised biology terms, from the collection and organisation of information to problem-solving, and from the use of simple communication skills to those which are more sophisticated
- develop positive attitudes towards the study of living things, the environment and the opinions held by others, recognising the importance of evidence and the use of critical evaluation of different scientific opinions related to various aspects of biology.

5 Objectives

Students will develop knowledge and understanding of:

- 1 the history of biology
- 2 the nature and practice of biology
- 3 applications and uses of biology
- 4 the implications of biology for society and the environment
- 5 current issues, research and developments in biology
- 6 cell ultrastructure and processes
- 7 biological diversity
- 8 environmental interactions
- 9 mechanisms of inheritance
- 10 biological evolution.

Students will develop further skills in:

- 11 planning investigations
- 12 conducting investigations
- 13 communicating information and understanding
- 14 developing scientific thinking and problem-solving techniques
- 15 working individually and in teams.

Students will develop positive values about and attitudes towards:

- 16 themselves, others, learning as a lifelong process, biology and the environment.

6 Course Structure

The *Biology Stage 6 Syllabus* has a Preliminary course and an HSC course. The Preliminary and HSC courses are organised into a number of modules. The Preliminary modules consist of core content that would be covered in 120 indicative hours.

The HSC course consists of core and options organised into a number of modules. The core content covers 90 indicative hours with ONE option covering 30 indicative hours. Students are required to cover ONE of the options.

Practical experiences are an essential component of both the Preliminary and HSC courses. Students will complete 80 indicative hours of practical/field work during both the Preliminary and HSC courses with no less than 35 indicative hours of practical experiences in the HSC course. Practical experiences must include at least one open-ended investigation integrating skill and knowledge outcomes in both the Preliminary and HSC courses.

Practical experiences should emphasise hands-on activities, including:

- undertaking laboratory experiments, including the use of appropriate computer-based technologies
- fieldwork
- research, using a wide range of sources, including print materials, the Internet and digital technologies
- using computer simulations for modelling or manipulating data
- using and reorganising secondary data
- extracting and reorganising information in the form of flow charts, tables, graphs, diagrams, prose and keys
- using animation, video and film resources to capture/obtain information not available in other forms.

6.1 Preliminary Course

120 indicative hours

The Preliminary course incorporates the study of:

- A Local Ecosystem (20 indicative hours)
- Patterns in Nature (40 indicative hours)
- Life on Earth (30 indicative hours)
- Evolution of Australian Biota (30 indicative hours)

6.2 HSC Course

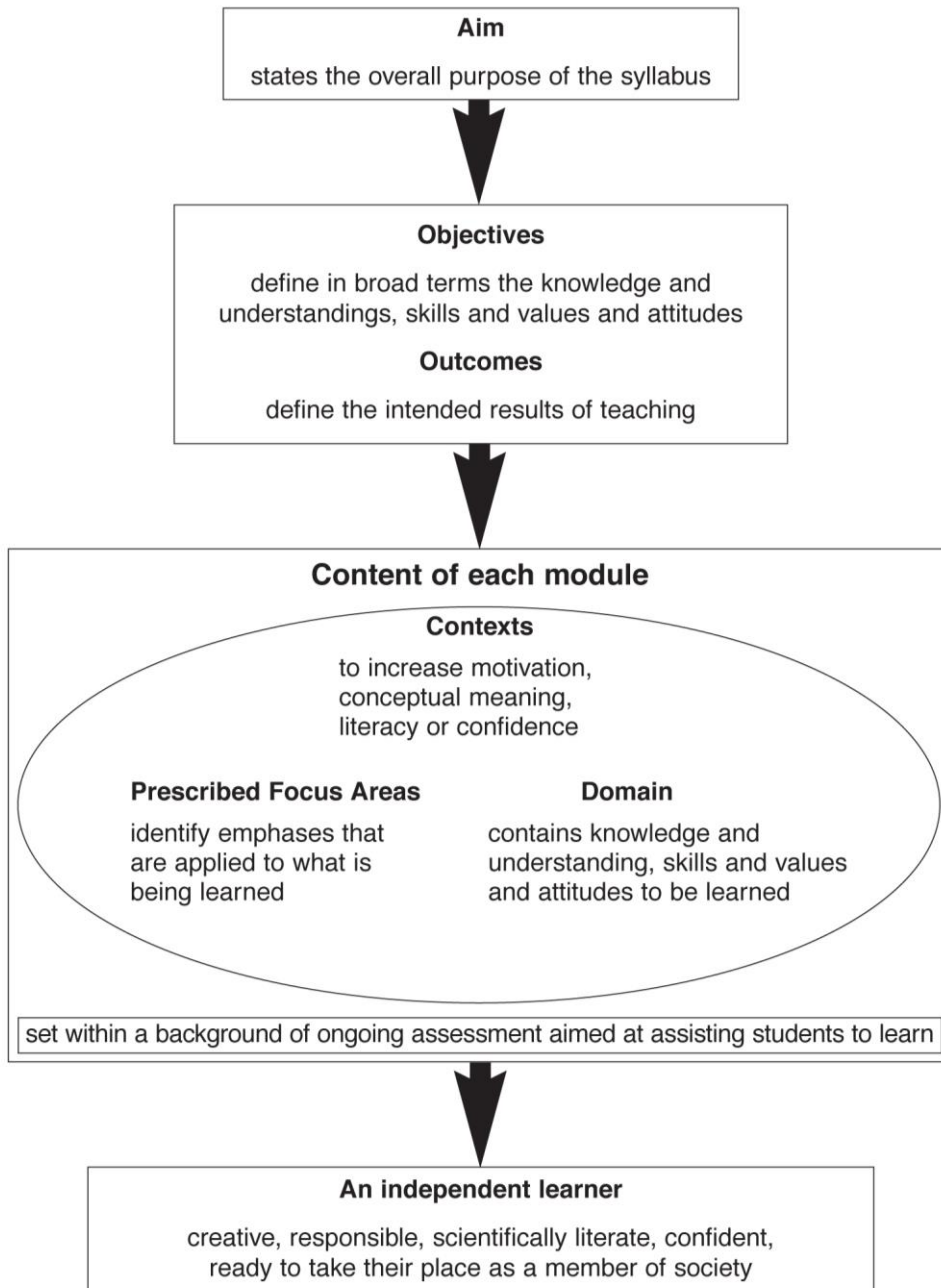
120 indicative hours

The HSC course builds upon the Preliminary course. **The Preliminary course contains content that is considered assumed knowledge for the HSC course.** The HSC course incorporates the study of:

- a) the core, which constitutes 90 indicative hours and includes:
 - Maintaining a Balance (30 indicative hours)
 - Blueprint of Life (30 indicative hours)
 - The Search for Better Health (30 indicative hours)
- b) ONE option, which constitutes 30 indicative hours and may comprise any one of the following:
 - Communication
 - Biotechnology
 - Genetics: The Code Broken?
 - The Human Story
 - Biochemistry

6.3 Overview

The following diagram summarises the relationship between the various elements of the course.



Context

Contexts are frameworks devised to assist students to make meaning of the Prescribed Focus Areas and Domain. Contexts are culturally bound and therefore communicate meanings that are culturally shaped or defined. Contexts draw on the framework of society in all aspects of everyday life. The contexts for each module encourage students to recognise and use their current understanding to further develop and apply more specialised scientific understanding and knowledge.

Prescribed Focus Areas

The Prescribed Focus Areas are different curriculum emphases or purposes designed to increase students' understanding of biology as an ever-developing body of knowledge, the provisional nature of scientific explanations in biology, the complex relationship between evidence and ideas in biology and the impact of biology on society.

The following Prescribed Focus Areas are developed across the modules of the syllabus.

History of biology

Knowledge of the historical background of biology is important for an adequate understanding of the origins, functioning and evolution of living organisms. Students should develop knowledge of:

- the progressive accumulation of knowledge about living things and their environment
- the part that an understanding of living things and their environment plays in shaping society
- how our understanding of living things and their environment is influenced by society.

Nature and practice of biology

A study of biology should enable students to participate in scientific activities and develop knowledge of the practice of biology. Students should develop knowledge of the provisional nature of biological explanations and the complex relationship between:

- existing biological views and the evidence supporting these
- the process and methods of exploring, generating, testing and relating ideas
- the stimulation provided by technological advances in understanding biology
- the constraints imposed on understanding biology by the limitations of current technology and the stimulation this provides for the development of the required technology and technological advances.

Applications and uses of biology

Setting the study of biology into broader contexts allows students to deal with real problems and applications. The study of biology should increase students' knowledge of:

- the relevance, usefulness and applicability of biological concepts and principles
- how increases in our understanding in biology have led to the development of useful technologies and systems
- the contributions biology has made to society, with particular emphasis on Australian achievements.

Implications of biology for society and the environment

Biology has an impact on our society and the environment and students need to develop knowledge of the importance of positive values and practices in relation to society and the environment. The study of biology should enable students to develop:

- understanding about the interrelatedness among people and their biophysical surroundings
- skills in decision-making about issues concerning society and the environment
- an awareness of the social and environmental responsibility of a scientist
- an awareness of areas of biology that relate to distinctively Australian environments.

Current issues, research and developments in biology

Biological issues and developments are more readily known and more information is available to students than ever before about current issues, research and developments in biology. The syllabus should develop students' knowledge of:

- areas currently being researched in biology
- career opportunities in biology and related fields
- events reported in the media that require an understanding of some aspect of biology.

Domain

Knowledge and understanding

As a course that focuses on one of the major disciplines of science, Biology presents a particular way of thinking about the world. It encourages students to use inference, deductive and inductive reasoning and creativity. It presumes that the interactions within organisms, between organisms, and between organisms and their environments occur in consistent patterns that can be understood through careful, systematic study.

The Biology course extends the study developed in the Science Stages 4–5 course, particularly in relation to students' knowledge and understanding of cell theory, evolution, classification of organisms and the Watson-Crick model of DNA. The course builds on the fundamental knowledge and understanding of the functioning of systems and structures in living organisms as well as the interrelationships between living things. The Biology Stage 6 course assumes that students have an elementary knowledge and understanding of ecosystems, biosphere, biodiversity and human impact on the environment which are developed in the Science Stages 4–5 course.

Skills

The Biology course involves the further development of the skills students have developed in the Science Stages 4–5 course through a range of practical experiences in both the Preliminary and HSC courses. The skills developed in Science Stages 4–5 are fundamental to Biology Stage 6, where a more sophisticated level will be developed.

Practical experiences are an essential component of both the Preliminary and HSC courses. Students will complete **80 indicative hours of practical/field work across both the Preliminary and HSC courses** with no less than 35 indicative hours of practical experiences in the HSC course. Practical experiences have been designed to utilise and further develop students' expertise in each of the following skill areas:

- **planning investigations**

This involves increasing students' skills in planning and organising activities, effectively using time and resources, selecting appropriate techniques, materials, specimens and equipment to complete activities, establishing priorities between tasks and identifying ways of reducing risks when using laboratory and field equipment.

- **conducting investigations**

This involves increasing students' skills in locating and gathering information for a planned investigation. It includes increasing students' skills in performing first-hand investigations, gathering first-hand data and accessing and collecting information relevant to biology from secondary sources using a variety of technologies.

- **communicating information and understanding**

This involves increasing students' skills in processing and presenting information. It includes increasing students' skills in speaking, writing and using non-verbal communication, such as diagrams, graphs and symbols, to convey biological information and understanding. Throughout the course, students become increasingly efficient and competent in the use of both technical terminology and the form and style required for written and oral communication in biology.

- **developing scientific thinking and problem-solving techniques**

This involves further increasing students' skills in clarifying issues and problems relevant to biology, framing a possible problem-solving process, developing creative solutions, anticipating issues that may arise, devising appropriate strategies to deal with those issues and working through the issues in a logical and coherent way.

- **working individually and in teams**

This involves further increasing students' skills in identifying a collective goal, defining and allocating roles and assuming an increasing variety of roles in working as an effective member of a team within the agreed time frame to achieve the goal. Throughout the course, students are provided with further opportunities to improve their ability to communicate and relate effectively to each other in a team.

Values and attitudes

By reflecting on past, present and future involvement of biology within society, students are encouraged to develop positive values and informed critical attitudes. These include a responsible regard for both the living and non-living components of the environment, ethical behaviour, a desire for critical evaluation of the consequences of the applications of science and recognising their responsibility to conserve, protect and maintain the quality of all environments for future generations.

Students are encouraged to develop attitudes on which scientific investigations depend, such as curiosity, honesty, flexibility, persistence, critical thinking, willingness to suspend judgement, tolerance of uncertainty and an acceptance of the provisional status of scientific knowledge. Students need to balance these with commitment, tenacity, a willingness to take risks and make informed judgements and, at times, inflexibility. As well as knowing something of and/or about biology, students need to value and appreciate biology if they are to become scientifically literate persons.

6.4 Other Considerations

Safety Issues

Schools have a legal obligation in relation to safety. Teachers will need to ensure that they comply with the *Work Health and Safety Act 2011* (NSW) and the *Work Health and Safety Regulation 2011* (NSW), as well as system and school requirements in relation to safety when implementing their programs.

Schools should refer to the resource package *Chemical Safety in Schools* (DET, 1999) to assist them in meeting their legislative obligations.

Animal Research Act

Schools have a legal responsibility in relation to the welfare of animals. All practical activities involving animals must comply with the *Animal Research Act 1985* (NSW) as described in the *Animals in Schools: Animal Welfare Guidelines for Teachers* (2002), produced on behalf of the Schools Animal Care and Ethics Committee (SACEC) by the NSW Department of Education and Training.

7 Objectives and Outcomes

7.1 Table of Objectives and Outcomes

	Objectives	Preliminary Course Outcomes	HSC Course Outcomes
Prescribed Focus Area	<i>Students will develop knowledge and understanding of:</i>	<i>A student:</i>	<i>A student:</i>
	1 the history of biology	P1 outlines the historical development of major biological principles, concepts and ideas	H1 evaluates how major advances in scientific understanding and technology have changed the direction or nature of scientific thinking
	2 the nature and practice of biology	P2 applies the processes that are used to test and validate models, theories and laws of science, with particular emphasis on first-hand investigations in biology	H2 analyses the ways in which models, theories and laws in biology have been tested and validated
	3 applications and uses of biology	P3 assesses the impact of particular technological advances on understanding in biology	H3 assesses the impact of particular advances in biology on the development of technologies
	4 implications of biology for society and the environment	P4 describes applications of biology which affect society or the environment	H4 assesses the impacts of applications of biology on society and the environment
	5 current issues, research and developments in biology	P5 describes the scientific principles employed in particular areas of biological research	H5 identifies possible future directions of biological research
Domain: Knowledge	6 cell ultrastructure and processes	P6 explains how cell ultrastructure and the coordinated activities of cells, tissues and organs contribute to macroscopic processes in organisms	H6 explains why the biochemical processes that occur in cells are related to macroscopic changes in the organism
	7 biological diversity	P7 describes the range of organisms in terms of specialisation for a habitat	H7 analyses the impact of natural and human processes on biodiversity
	8 environmental interactions	P8 analyses the interrelationships of organisms within the ecosystem	H8 evaluates the impact of human activity on the interactions of organisms and their environment
	9 mechanisms of inheritance	P9 explains how processes of reproduction ensure continuity of species	H9 describes the mechanisms of inheritance in molecular terms
	10 biological evolution	P10 identifies and describes the evidence for evolution	H10 describes the mechanisms of evolution and assesses the impact of human activity on evolution

	Objectives	Preliminary Course Outcomes	HSC Course Outcomes
	<i>Students will develop knowledge and understanding of:</i>	<i>A student:</i>	<i>A student:</i>
Domain: Skills	11 planning investigations	P11 identifies and implements improvements to investigation plans	H11 justifies the appropriateness of a particular investigation plan
	12 conducting investigations	P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources	H12 evaluates ways in which accuracy and reliability could be improved in investigations
	13 communicating information and understanding	P13 identifies appropriate terminology and reporting styles to communicate information and understanding in biology	H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
	14 developing scientific thinking and problem-solving techniques	P14 draws valid conclusions from gathered data and information	H14 assesses the validity of conclusions from gathered data and information
	15 working individually and in teams	P15 implements strategies to work effectively as an individual or as a team member	H15 explains why an investigation is best undertaken individually or by a team
Domain: Values & Attitudes	16 themselves, others, learning as a lifelong process, biology and the environment	P16 demonstrates positive values about and attitudes towards both the living and non-living components of the environment, ethical behaviour and a desire for a critical evaluation of the consequences of the applications of science	H16 justifies positive values about and attitudes towards both the living and non-living components of the environment, ethical behaviour and a desire for a critical evaluation of the consequences of the applications of science

7.2 Key Competencies

Biology Stage 6 provides a context within which to develop general competencies considered essential for the acquisition of effective, higher-order thinking skills necessary for further education, work and everyday life.

Key competencies are embedded in the *Biology Stage 6 Syllabus* to enhance student learning and are explicit in the objectives and outcomes of the syllabus. The key competencies of **collecting, analysing and organising information** and **communicating ideas and information** reflect core processes of scientific inquiry and the skills identified in the syllabus assist students to continue to develop their expertise in these areas.

Students work as individuals and as members of groups to conduct investigations and, through this, the key competencies, **planning and organising activities** and **working with others and in teams**, are developed. During investigations, students use appropriate information technologies and so develop the key competency of **using technology**. The exploration of issues and investigations of problems contribute towards students' development of the key competency **solving problems**. Finally, when students analyse statistical evidence, apply mathematical concepts to assist analysis of data and information and construct tables and graphs, they are developing the key competency **using mathematical ideas and techniques**.

8 Content: Biology Stage 6 Preliminary Course

8.1 Biology Skills

During the Preliminary course, it is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving and working individually and in teams. Each module specifies content through which skill outcomes can be achieved. Teachers should develop activities based on that content to provide students with opportunities to develop the full range of skills.

Preliminary Course Outcomes	Content
<i>A student:</i>	<i>Students:</i>
P11 identifies and implements improvements to investigation plans	<p>11.1 identify data sources to:</p> <ul style="list-style-type: none"> a) analyse complex problems to determine appropriate ways in which each aspect may be researched b) determine the type of data which needs to be collected and explain the qualitative or quantitative analysis that will be required for this data to be useful c) identify the orders of magnitude that will be appropriate and uncertainty that may be present in the measurement of data d) identify and use correct units for data that will be collected e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis
	<p>11.2 plan first-hand investigations to:</p> <ul style="list-style-type: none"> a) demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation b) identify variables that need to be kept constant, develop strategies to ensure that these variables are kept constant and demonstrate the use of a control c) design investigations that allow valid and reliable data and information to be collected d) design and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures or repetition of procedures is appropriate e) predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary
	<p>11.3 choose equipment or resources by:</p> <ul style="list-style-type: none"> a) identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation b) carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards c) identifying technology that could be used during investigating and determining its suitability and effectiveness for its potential role in the procedure or investigations d) recognising the difference between destructive and non-destructive testing of material and analysing the potentially different results of these two procedures

Preliminary Course Outcomes	Content
<i>A student:</i>	<i>Students:</i>
<p>P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</p>	<p>12.1 perform first-hand investigations by:</p> <ul style="list-style-type: none"> a) carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments b) efficiently undertaking the planned procedure to minimise hazards and wastage of resources c) disposing carefully and safely of any waste materials produced during the investigation d) identifying and using safe work practices during investigations <p>12.2 gather first-hand information by:</p> <ul style="list-style-type: none"> a) using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors b) measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate <p>12.3 gather information from secondary sources by:</p> <ul style="list-style-type: none"> a) accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet b) practising efficient data collection techniques to identify useful information in secondary sources c) extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms d) summarising and collating information from a range of resources e) identifying practising male and female Australian scientists, the areas in which they are currently working and information about their research <p>12.4 process information to:</p> <ul style="list-style-type: none"> a) assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered b) apply mathematical formulae and concepts c) best illustrate trends and patterns by selecting and using appropriate methods, including computer-assisted analysis d) evaluate the relevance of first-hand and secondary information and data in relation to the area of investigation e) assess the reliability of first-hand and secondary information and data by considering information from various sources f) assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals
<p>P13 identifies appropriate terminology and reporting styles to communicate information and understanding in biology</p>	<p>13.1 present information by:</p> <ul style="list-style-type: none"> a) selecting and using appropriate text types, or combinations thereof, for oral and written presentations b) selecting and using appropriate media to present data and information c) selecting and using appropriate formats to acknowledge sources of information d) using symbols and formulae to express relationships and using appropriate units for physical quantities e) using a variety of pictorial representations to show relationships and present information clearly and succinctly f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately g) identifying situations where use of a curve of best fit is appropriate to present graphical information

Preliminary Course Outcomes	Content
<i>A student:</i>	<i>Students:</i>
P14 draws valid conclusions from gathered data and information	<p>14.1 analyse information to:</p> <ul style="list-style-type: none"> a) identify trends, patterns and relationships as well as contradictions in data and information b) justify inferences and conclusions c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem d) predict outcomes and generate plausible explanations related to the observations e) make and justify generalisations f) use models, including mathematical ones, to explain phenomena and/or make predictions g) use cause and effect relationships to explain phenomena h) identify examples of the interconnectedness of ideas or scientific principles
	<p>14.2 solve problems by:</p> <ul style="list-style-type: none"> a) identifying and explaining the nature of a problem b) describing and selecting from different strategies those which could be used to solve a problem c) using identified strategies to develop a range of possible solutions to a particular problem d) evaluating the appropriateness of different strategies for solving an identified problem
	<p>14.3 use available evidence to:</p> <ul style="list-style-type: none"> a) design and produce creative solutions to problems b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations d) formulate cause and effect relationships
P15 implements strategies to work effectively as an individual or as a member of a team	The Preliminary course further increases students' skills in working individually and in teams. Refer to the content overview on page 14.

8.2 A Local Ecosystem

Contextual Outline

The environment has an impact on all organisms in ways that a Biology student will learn to recognise and explain. Students are able to draw on existing knowledge of their own local area and expand on their understanding of biological concepts that can be identified through careful analysis of the biotic and abiotic factors operating.

While the study of the relationships of organisms with each other and with their physical environment can be theoretically presented in a classroom setting or by using simulations of natural populations, communities and even ecosystems, the study of ecology in the field is essential. Study of this module must include field experience of a local terrestrial or aquatic ecosystem to observe and measure some of the abiotic parameters to which the main plant and animal species are adapted and to study some of the trophic, competitive and symbiotic interactions between organisms in that ecosystem.

Students should be encouraged to analyse and report on those aspects of the local environment that have been affected by people and propose realistic solutions to the problems that exist. The report should include: a statement of purpose; a clear and detailed description of the area studied; any background material collected on the area; appropriate presentation of data collected; analysis of data; suggestions of the relationships that exist in the area; and an assessment of human impact on the area.

This module increases students' understanding of the nature, practice and applications of biology.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the *Science Years 7–10 Syllabus* for the following:

- 5.10a) distinguish between biotic and abiotic features of the local environment
- 5.10b) describe the importance of cycles of materials in ecosystems
- 5.10c) describe some impacts of human activities on ecosystems
- 5.11.2a) relate pollution to contamination by unwanted substances
- 5.11.2c) discuss strategies used to balance human activities and needs in ecosystems with conserving, protecting and maintaining the quality and sustainability of the environment.

- | | | |
|--|---|--|
| | <i>Students learn to:</i> | <i>Students:</i> |
| 1. The distribution, diversity and numbers of plants and animals found in ecosystems are determined by biotic and abiotic factors | <ul style="list-style-type: none">▪ compare the abiotic characteristics of aquatic and terrestrial environments▪ identify the factors determining the distribution and abundance of a species in each environment▪ describe the roles of photosynthesis and respiration in ecosystems▪ identify uses of energy by organisms▪ identify the general equation for aerobic cellular respiration and outline this as a summary of a chain of biochemical reactions | <ul style="list-style-type: none">▪ process and analyse information obtained from a variety of sampling studies to justify the use of different sampling techniques to make population estimates when total counts cannot be performed |

2. Each local aquatic or terrestrial ecosystem is unique

Students learn to:

- examine trends in population estimates for some plant and animal species within an ecosystem
- outline factors that affect numbers in predator and prey populations in the area studied
- identify examples of allelopathy, parasitism, mutualism and commensalism in an ecosystem and the role of organisms in each type of relationship
- describe the role of decomposers in ecosystems
- explain trophic interactions between organisms in an ecosystem using food chains, food webs and pyramids of biomass and energy
- define the term adaptation and discuss the problems associated with inferring characteristics of organisms as adaptations for living in a particular habitat
- identify some adaptations of living things to factors in their environment
- identify and describe in detail adaptations of a plant and an animal from the local ecosystem
- describe and explain the short-term and long-term consequences on the ecosystem of species competing for resources
- identify the impact of humans in the ecosystem studied

Students:

- choose equipment or resources and undertake a field study of a local terrestrial or aquatic ecosystem to identify data sources and:
 - measure abiotic variables in the ecosystem being studied using appropriate instruments and relate this data to the distribution of organisms
 - estimate the size of a plant population and an animal population in the ecosystem using transects and/or random quadrats
 - collect, analyse and present data to describe the distribution of the plant and animal species whose abundance has been estimated
 - describe two trophic interactions found between organisms in the area studied
 - identify data sources and gather, present and analyse data by:
 - tabulation of data collected in the study
 - calculation of mean values with ranges
 - graphing changes with time in the measured abiotic data
 - evaluating variability in measurements made during scientific investigations
- gather information from first-hand and secondary sources to construct food chains and food webs to illustrate the relationships between member species in an ecosystem
- process and analyse information and present a report of the investigation of an ecosystem in which the purpose is introduced, the methods described and the results shown graphically and use available evidence to discuss their relevance

8.3 Patterns in Nature

Contextual Outline

Detailed examination of one or two species of living things does not provide an overview of the general features of living things. By looking across the range of commonly occurring living organisms, patterns in structure and function can be identified. These patterns reflect the fundamental inputs and outputs of living things – the absorption of necessary chemicals and the release of wastes.

At a microscopic level, there are patterns in the structure and function of cells. The fundamental structural similarities exist because the biochemical processes are similar. Some important differences between plant and animal cells reflect the fundamental differences between plants and animals – the process of photosynthesis in plants.

Many living things have evolved complex and efficient systems with large surface areas to facilitate the intake and removal of substances. Transport systems allow distribution and collection of nutrients and wastes.

This module increases students' understanding of the history, applications and uses of biology.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the *Science Years 7–10 Syllabus* for the following:

- 5.7.3c) construct word equations from observations and written descriptions of a range of chemical reactions
- 5.8.1a) explain that systems in multicellular organisms serve the needs of cells
- 5.8.1b) identify the role of cell division in growth, repair and reproduction in multicellular organisms
- 5.8.2c) identify that information is transferred as DNA on chromosomes when cells reproduce themselves
- 5.8.2d) identify that genes are part of DNA.

Students learn to:

- 1. Organisms are made of cells that have similar structural characteristics**
- outline the historical development of the cell theory, in particular, the contributions of Robert Hooke and Robert Brown
 - describe evidence to support the cell theory
 - discuss the significance of technological advances to developments in the cell theory
 - identify cell organelles seen with current light and electron microscopes
 - describe the relationship between the structure of cell organelles and their function
- 2. Membranes around cells provide separation from and links with the external environment**
- identify the major groups of substances found in living cells and their uses in cell activities
 - identify that there is movement of molecules into and out of cells
 - describe the current model of membrane structure and explain how it accounts for the movement of some substances into and out of cells
 - compare the processes of diffusion and osmosis
 - explain how the surface area to volume ratio affects the rate of movement of substances into and out of cells

Students:

- use available evidence to assess the impact of technology, including the development of the microscope on the development of the cell theory
 - perform a first-hand investigation to gather first-hand information using a light microscope to observe cells in plants and animals and identify nucleus, cytoplasm, cell wall, chloroplast and vacuoles
 - process information from secondary sources to analyse electron micrographs of cells and identify mitochondria, chloroplasts, Golgi bodies, lysosomes, endoplasmic reticulum, ribosomes, nucleus, nucleolus and cell membranes
- plan, choose equipment or resources and perform a first-hand investigation to gather information and use available evidence to identify the following substances in tissues:
- glucose
 - starch
 - lipids
 - proteins
 - chloride ions
 - lignin
- perform a first-hand investigation to model the selectively permeable nature of a cell membrane
 - perform a first-hand investigation to demonstrate the difference between osmosis and diffusion
 - perform a first-hand investigation to demonstrate the effect of surface area to volume ratio on rate of diffusion

3. Plants and animals have specialised structures to obtain nutrients from their environment

Students learn to:

- identify some examples that demonstrate the structural and functional relationships between cells, tissues, organs and organ systems in multicellular organisms
- distinguish between autotrophs and heterotrophs in terms of nutrient requirements
- identify the materials required for photosynthesis and its role in ecosystems
- identify the general word equation for photosynthesis and outline this as a summary of a chain of biochemical reactions
- explain the relationship between the organisation of the structures used to obtain water and minerals in a range of plants and the need to increase the surface area available for absorption
- explain the relationship between the shape of leaves, the distribution of tissues in them and their role
- describe the role of teeth in increasing the surface area of complex foods for exposure to digestive chemicals
- explain the relationship between the length and overall complexity of digestive systems of a vertebrate herbivore and a vertebrate carnivore with respect to:
 - the chemical composition of their diet
 - the functions of the structures involved

Students:

- plan, choose equipment or resources and perform first-hand investigations to gather information and use available evidence to demonstrate the need for chlorophyll and light in photosynthesis
- perform a first-hand investigation to demonstrate the relationship between surface area and rate of reaction
- identify data sources, gather, process, analyse and present information from secondary sources and use available evidence to compare the digestive systems of mammals, including a grazing herbivore, carnivore and a predominantly nectar feeding animal

Students learn to:

- 4. Gaseous exchange and transport systems transfer chemicals through the internal and between the external environments of plants and animals**
- compare the roles of respiratory, circulatory and excretory systems
 - identify and compare the gaseous exchange surfaces in an insect, a fish, a frog and a mammal
 - explain the relationship between the requirements of cells and the need for transport systems in multicellular organisms
 - outline the transport system in plants, including:
 - root hair cells
 - xylem
 - phloem
 - stomates and lenticels
 - compare open and closed circulatory systems using one vertebrate and one invertebrate as examples
- 5. Maintenance of organisms requires growth and repair**
- identify mitosis as a process of nuclear division and explain its role
 - identify the sites of mitosis in plants, insects and mammals
 - explain the need for cytokinesis in cell division
 - identify that nuclei, mitochondria and chloroplasts contain DNA

Students:

- use available evidence to perform a first-hand investigation and gather first-hand data to identify and describe factors that affect the rate of transpiration
 - perform a first-hand investigation of the movement of materials in xylem or phloem
 - use available evidence to discuss, using examples, the role of technologies, such as the use of radioisotopes in tracing the path of elements through living plants and animals
- perform a first-hand investigation using a microscope to gather information from prepared slides to describe the sequence of changes in the nucleus of plant or animal cells undergoing mitosis

8.4 Life on Earth

Contextual Outline

Life has evolved over millions of years from the common elements found in the cosmos. Simple terrestrial life has been found to exist in the most hostile of conditions on Earth and evidence from Australian scientists has shown that bacteria exist kilometres deep in the Earth's crust and have done so for millions of years.

Organic molecules formed on Earth in an environment that is very different to that existing today. When these organic molecules were separated from their environment by a membrane, they began to carry out the chemical reactions of life in such a way as to sustain their existence and allow reproduction. The evolution of photosynthesis caused a change from an anoxic to an oxic environment that continues to support most of the living things on Earth today.

Fossil evidence indicates changes in complexity and diversity of life forms. It is the diversity of living organisms that has led scientists to develop classification systems that group these organisms according to their structural or genetic similarity. Recent advances in molecular biology and biochemistry have allowed scientists to better describe the origins, processes and evolution of life.

This module increases students' understanding of the history, nature and practice of biology and current issues, research and developments in biology.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the *Science Years 7–10 Syllabus* for the following:

- 5.8.3a) discuss evidence that present-day organisms have evolved from organisms in the distant past
- 5.9.4b) describe conditions under which fossils form
- 5.9.4c) relate the fossil record to the age of Earth and the time over which life has been evolving.

Students learn to:

1. Analysis of the oldest sedimentary rocks provides evidence for the origin of life

- identify the relationship between the conditions on early Earth and the origin of organic molecules
- discuss the implications of the existence of organic molecules in the cosmos for the origin of life on Earth
- describe two scientific theories relating to the evolution of the chemicals of life and discuss their significance in understanding the origin of life
- discuss the significance of the Urey and Miller experiments in the debate on the composition of the primitive atmosphere
- identify changes in technology that have assisted in the development of an increased understanding of the origin of life and evolution of living things

2. The fossil record provides information about the subsequent evolution of living things

- identify the major stages in the evolution of living things, including the formation of:
 - organic molecules
 - membranes
 - procaryotic heterotrophic cells
 - procaryotic autotrophic cells
 - eucaryotic cells
 - colonial organisms
 - multicellular organisms
- describe some of the palaeontological and geological evidence that suggests when life originated on Earth
- explain why the change from an anoxic to an oxic atmosphere was significant in the evolution of living things
- discuss the ways in which developments in scientific knowledge may conflict with the ideas about the origins of life developed by different cultures

Students:

- gather information from secondary sources to describe the experiments of Urey and Miller and use the available evidence to analyse the:
 - reason for their experiments
 - result of their experiments
 - importance of their experiments in illustrating the nature and practice of science
 - contribution to hypotheses about the origin of life
- process and analyse information to construct a timeline of the main events that occurred during the evolution of life on Earth
- gather first-hand or secondary information to make observations of a range of plant and animal fossils
- identify data sources, gather, process, analyse and present information from secondary sources to evaluate the impact of increased understanding of the fossil record on the development of ideas about the history of life on Earth

Students learn to:

3. Further developments in our knowledge of present-day organisms and the discovery of new organisms allows for better understanding of the origins of life and the processes involved in the evolution of living things

- describe technological advances that have increased knowledge of procaryotic organisms
- describe the main features of the environment of an organism from one of the following groups and identify its role in that environment:
 - Archaea
 - Bacteria

4. The study of present-day organisms increases our understanding of past organisms and environments

- explain the need for scientists to classify organisms
- describe the selection criteria used in different classification systems and discuss the advantages and disadvantages of each system
- explain how levels of organisation in a hierarchical system assist classification
- discuss, using examples, the impact of changes in technology on the development and revision of biological classification systems
- describe the main features of the binomial system in naming organisms and relate these to the concepts of genus and species
- identify and discuss the difficulties experienced in classifying extinct organisms
- explain how classification of organisms can assist in developing an understanding of present and past life on Earth

Students:

- use the available evidence to outline similarities in the environments past and present for a group of organisms within one of the following:
 - Archaea
 - Bacteria
- analyse information from secondary sources to discuss the diverse environments that living things occupy today and use available evidence to describe possible alternative environments in which life may have originated
- perform a first-hand investigation and gather information to construct and use simple dichotomous keys and show how they can be used to identify a range of plants and animals using live and preserved specimens, photographs or diagrams of plants and animals

8.5 Evolution of Australian Biota

Contextual Outline

The very large southern landmass, Gondwana, persisted for some time, giving rise to an array of species that spread across it. When Gondwana broke up, it did so in stages but eventually the Australian continent was isolated from Antarctica and South America.

The available evidence suggests that, as Gondwana was breaking up, a number of global climatic changes were also occurring. These changes in environmental conditions impacted on Australian ecosystems and are reflected in the fossil record. As the biotic and abiotic features of ecosystems were altered, those organisms best adapted to these changes survived and passed on their genetic information to their offspring.

The contribution of paleontology and the study of past environments is important to our understanding of how our present actions may affect our environment and the distribution of flora and fauna in the future.

This module increases students' understanding of the applications and uses of biology, implications for society and the environment and current issues, research and developments in biology.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the *Science Years 7–10 Syllabus* for the following:

- 5.8.3a) discuss evidence that present-day organisms have evolved from organisms in the distant past
- 5.8.1b) identify the role of cell division in growth, repair and reproduction in multicellular organisms
- 5.8.3b) relate natural selection to the theory of evolution
- 5.9.2a) discuss evidence that suggests crustal plates move over time

1. Evidence for the rearrangement of crustal plates and continental drift indicates that Australia was once part of an ancient super continent

Students learn to:

- identify and describe evidence that supports the assertion that Australia was once part of a landmass called Gondwana, including:
 - matching continental margins
 - position of mid-ocean ridges
 - spreading zones between continental plates
 - fossils in common on Gondwanan continents, including *Glossopteris* and *Gangamopteris* flora, and marsupials
 - similarities between present-day organisms on Gondwanan continents
- discuss current research into the evolutionary relationships between extinct species, including megafauna and extant Australian species

Students:

- solve problems to identify the positions of mid-ocean ridges and spreading zones that infer a moving Australian continent
- identify data sources, gather, process and analyse information from secondary sources and use available evidence to illustrate the changing ideas of scientists in the last 200 years about individual species such as the platypus as new information and technologies became available

2. The changes in Australian flora and fauna over millions of years have happened through evolution

Students learn to:

- discuss examples of variation between members of a species
- identify the relationship between variation within a species and the chances of survival of species when environmental change occurs
- identify and describe evidence of changing environments in Australia over millions of years
- identify areas within Australia that experience significant variations in temperature and water availability
- identify changes in the distribution of Australian species, as rainforests contracted and sclerophyll communities and grasslands spread, as indicated by fossil evidence
- discuss current theories that provide a model to account for these changes
- discuss Darwin's observations of Australian flora and fauna and relate these to his theory of evolution

Students:

- gather, process and analyse information from secondary sources to develop a timeline that identifies key events in the formation of Australia as an island continent from its origins as part of Gondwana
- gather information from secondary sources to describe some Australian fossils, where these fossils were found and use available evidence to explain how they contribute to the development of understanding about the evolution of species in Australia
- perform a first-hand investigation, gather information of named Australian fossil samples and use available evidence to identify similarities and differences between current and extinct Australian life forms
- present information from secondary sources to discuss the Huxley–Wilberforce debate on Darwin's theory of evolution
- perform a first-hand investigation to gather information of examples of variation in at least two species of living organism

	<i>Students learn to:</i>	<i>Students:</i>
3. Continuation of species has resulted, in part, from the reproductive adaptations that have evolved in Australian plants and animals	<ul style="list-style-type: none">▪ distinguish between the processes of meiosis and mitosis in terms of the daughter cells produced▪ compare and contrast external and internal fertilisation▪ discuss the relative success of these forms of fertilisation in relation to the colonisation of terrestrial and aquatic environments▪ describe some mechanisms found in Australian flora for:<ul style="list-style-type: none">– pollination– seed dispersal– asexual reproductionwith reference to local examples▪ describe some mechanisms found in Australian fauna to ensure:<ul style="list-style-type: none">– fertilisation– survival of the embryo and of the young after birth▪ explain how the evolution of these reproductive adaptations has increased the chances of continuity of the species in the Australian environment• describe the conditions under which asexual reproduction is advantageous, with reference to specific Australian examples	<ul style="list-style-type: none">▪ analyse information from secondary sources to tabulate the differences that distinguish the processes of mitosis and meiosis▪ identify data sources, gather, process and analyse information from secondary sources and use available evidence to discuss the relative success of internal and external fertilisation in relation to the colonisation of terrestrial and aquatic environments▪ plan, choose equipment or resources and perform a first-hand investigation to gather and present information about flowers of native species of angiosperms to identify features that may be adaptations for wind and insect/bird/mammal pollination
4. A study of palaeontology and past environments increases our understanding of the possible future range of plants and animals	<ul style="list-style-type: none">▪ explain the importance of the study of past environments in predicting the impact of human activity in present environments▪ identify the ways in which palaeontology assists understanding of the factors that may determine distribution of flora and fauna in present and future environments▪ explain the need to maintain biodiversity	<ul style="list-style-type: none">▪ gather, process and analyse information from secondary sources and use available evidence to propose reasons for the evolution, survival and extinction of species, with reference to specific Australian examples▪ process information to discuss a current effort to monitor biodiversity

9 Content: Biology Stage 6 HSC Course

9.1 Biology Skills

During the HSC course, it is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving and working individually and in teams. Each module specifies content through which skill outcomes can be achieved. Teachers should develop activities based on that content to provide students with opportunities to develop the full range of skills.

HSC Course Outcomes	Content
<p><i>A student:</i> H11 justifies the appropriateness of a particular investigation plan</p>	<p><i>Students will learn to:</i></p> <p>11.1 identify data sources to:</p> <ul style="list-style-type: none"> a) analyse complex problems to determine appropriate ways in which each aspect may be researched b) determine the type of data that needs to be collected and explain the qualitative or quantitative analysis that will be required for this data to be useful c) identify the orders of magnitude that will be appropriate and uncertainty that may be present in the measurement of data d) identify and use correct units for data that will be collected e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis
	<p>11.2 plan first-hand investigations to:</p> <ul style="list-style-type: none"> a) demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation b) identify variables that need to be kept constant, develop strategies to ensure that these variables are kept constant and demonstrate the use of a control c) design investigations that allow valid and reliable data and information to be collected d) design and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures or repetition of procedures is appropriate e) predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary
	<p>11.3 choose equipment or resources by:</p> <ul style="list-style-type: none"> a) identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation b) carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards c) identifying technology that could be used during investigations and determining its suitability and effectiveness for its potential role in the procedure or investigations d) recognising the difference between destructive and non-destructive testing of material and analysing potentially different results of these two procedures

HSC Course Outcomes	Content
<p>H12 evaluates ways in which accuracy and reliability could be improved in investigations</p>	<p>12.1 perform first-hand investigations by:</p> <ul style="list-style-type: none"> a) carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments b) efficiently undertaking the planned procedure to minimise hazards and wastage of resources c) disposing carefully and safely of any waste materials produced during the investigation d) identifying and using safe work practices during investigations
	<p>12.2 gather first-hand information by:</p> <ul style="list-style-type: none"> a) using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors b) measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate
	<p>12.3 gather information from secondary sources by:</p> <ul style="list-style-type: none"> a) accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet b) practising efficient data collection techniques to identify useful information in secondary sources c) extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms d) summarising and collating information from a range of resources e) identifying practising male and female Australian scientists, the areas in which they are currently working and information about their research
	<p>12.4 process information to:</p> <ul style="list-style-type: none"> a) assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered b) identify and apply appropriate mathematical formulae and concepts c) best illustrate trends and patterns by selecting and using appropriate methods, including computer-assisted analysis d) evaluate the relevance of first-hand and secondary information and data in relation to the area of investigation e) assess the reliability of first-hand and secondary information and data by considering information from various sources f) assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals
<p>H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding</p>	<p>13.1 present information by:</p> <ul style="list-style-type: none"> a) selecting and using appropriate text types or combinations thereof, for oral and written presentations b) selecting and using appropriate media to present data and information c) selecting and using appropriate methods to acknowledge sources of information d) using symbols and formulae to express relationships and using appropriate units for physical quantities e) using a variety of pictorial representations to show relationships and present information clearly and succinctly f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately g) identifying situations where use of a curve of best fit is appropriate to present graphical information

HSC Course Outcomes	Content
<p>H14 assesses the validity of conclusions from gathered data and information</p>	<p>14.1 analyse information to:</p> <ul style="list-style-type: none"> a) identify trends, patterns and relationships as well as contradictions in data and information b) justify inferences and conclusions c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem d) predict outcomes and generate plausible explanations related to the observations e) make and justify generalisations f) use models, including mathematical ones, to explain phenomena and/or make predictions g) use cause and effect relationships to explain phenomena h) identify examples of the interconnectedness of ideas or scientific principles <p>14.2 solve problems by:</p> <ul style="list-style-type: none"> a) identifying and explaining the nature of a problem b) describing and selecting from different strategies those which could be used to solve a problem c) using identified strategies to develop a range of possible solutions to a particular problem d) evaluating the appropriateness of different strategies for solving an identified problem <p>14.3 use available evidence to:</p> <ul style="list-style-type: none"> a) design and produce creative solutions to problems b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations d) formulate cause and effect relationships
<p>H15 explains why an investigation is best undertaken individually or by a team</p>	<p>The HSC course builds on the Preliminary course and further increases the students' skills in working individually and in teams. Refer to the content overview on page 14.</p>

9.2 Maintaining a Balance

Contextual Outline

Multicellular organisms have specialised organ systems that are adapted for the uptake and transport of essential nutrients from the environment, the utilisation or production of energy and the removal of waste products arising from cellular activities.

The basis of healthy body-functioning in all organisms is the health of their cells. The physical and chemical factors of the environment surrounding these cells must remain within narrow limits for cells to survive. These narrow limits need to be maintained and any deviation from these limits must be quickly corrected. A breakdown in the maintenance of this balance causes problems for the organism.

The nervous and endocrine systems in animals and the hormone system in plants bring about the coordinated functioning of these organ systems. They are able to monitor and provide the feedback necessary to maintain a constant internal environment. Enzyme action is a prime example of the need for this balance. Enzymes control all of the chemical reactions that constitute the body's metabolism. As enzymes normally function only within a narrow temperature range, even a small rise in body temperature can result in the failure of many of the reactions of metabolism that are essential to life.

This module increases students' understanding of the applications and uses of biology, implications for society and the environment and current issues, research and developments in biology.

Students learn to:

1. Most organisms are active in a limited temperature range

- identify the role of enzymes in metabolism, describe their chemical composition and use a simple model to describe their specificity on substrates
- identify the pH as a way of describing the acidity of a substance
- explain why the maintenance of a constant internal environment is important for optimal metabolic efficiency
- describe homeostasis as the process by which organisms maintain a relatively stable internal environment
- explain that homeostasis consists of two stages:
 - detecting changes from the stable state
 - counteracting changes from the stable state
- outline the role of the nervous system in detecting and responding to environmental changes
- identify the broad range of temperatures over which life is found compared with the narrow limits for individual species
- compare responses of named Australian ectothermic and endothermic organisms to changes in the ambient temperature and explain how these responses assist temperature regulation
- identify some responses of plants to temperature change

Students:

- identify data sources, plan, choose equipment or resources and perform a first-hand investigation to test the effect of:
 - increased temperature
 - change in pH
 - change in substrate concentrations on the activity of named enzyme(s)
- gather, process and analyse information from secondary sources and use available evidence to develop a model of a feedback mechanism
- analyse information from secondary sources to describe adaptations and responses that have occurred in Australian organisms to assist temperature regulation

Students learn to:

2. Plants and animals transport dissolved nutrients and gases in a fluid medium

- identify the form(s) in which each of the following is carried in mammalian blood:
 - carbon dioxide
 - oxygen
 - water
 - salts
 - lipids
 - nitrogenous waste
 - other products of digestion
- explain the adaptive advantage of haemoglobin
- compare the structure of arteries, capillaries and veins in relation to their function
- describe the main changes in the chemical composition of the blood as it moves around the body and identify tissues in which these changes occur
- outline the need for oxygen in living cells and explain why removal of carbon dioxide from cells is essential
- describe current theories about processes responsible for the movement of materials through plants in xylem and phloem tissue

Students:

- perform a first-hand investigation to demonstrate the effect of dissolved carbon dioxide on the pH of water
- perform a first-hand investigation using the light microscope and prepared slides to gather information to estimate the size of red and white blood cells and draw scaled diagrams of each
- analyse information from secondary sources to identify current technologies that allow measurement of oxygen saturation and carbon dioxide concentrations in blood and describe and explain the conditions under which these technologies are used
- analyse information from secondary sources to identify the products extracted from donated blood and discuss the uses of these products
- analyse and present information from secondary sources to report on progress in the production of artificial blood and use available evidence to propose reasons why such research is needed
- choose equipment or resources to perform a first-hand investigation to gather first-hand data to draw transverse and longitudinal sections of phloem and xylem tissue

3. Plants and animals regulate the concentration of gases, water and waste products of metabolism in cells and in interstitial fluid

Students learn to:

- explain why the concentration of water in cells should be maintained within a narrow range for optimal function
- explain why the removal of wastes is essential for continued metabolic activity
- identify the role of the kidney in the excretory system of fish and mammals
- explain why the processes of diffusion and osmosis are inadequate in removing dissolved nitrogenous wastes in some organisms
- distinguish between active and passive transport and relate these to processes occurring in the mammalian kidney
- explain how the processes of filtration and reabsorption in the mammalian nephron regulate body fluid composition
- outline the role of the hormones, aldosterone and ADH (anti-diuretic hormone) in the regulation of water and salt levels in blood
- define enantiostasis as the maintenance of metabolic and physiological functions in response to variations in the environment and discuss its importance to estuarine organisms in maintaining appropriate salt concentrations
- describe adaptations of a range of terrestrial Australian plants that assist in minimising water loss

Students:

- perform a first-hand investigation of the structure of a mammalian kidney by dissection, use of a model or visual resource and identify the regions involved in the excretion of waste products
- gather, process and analyse information from secondary sources to compare the process of renal dialysis with the function of the kidney
- present information to outline the general use of hormone replacement therapy in people who cannot secrete aldosterone
- analyse information from secondary sources to compare and explain the differences in urine concentration of terrestrial mammals, marine fish and freshwater fish
- use available evidence to explain the relationship between the conservation of water and the production and excretion of concentrated nitrogenous wastes in a range of Australian insects and terrestrial mammals
- process and analyse information from secondary sources and use available evidence to discuss processes used by different plants for salt regulation in saline environments
- perform a first-hand investigation to gather information about structures in plants that assist in the conservation of water

9.3 Blueprint of Life

Contextual Outline

Because all living things have a finite life span, the survival of each species depends on the ability of individual organisms to reproduce. The continuity of life is assured when the chemical information that defines it is passed on from one generation to the next on the chromosomes.

Modern molecular biology is providing opportunities to alter the information transferred from one generation to the next in technologies such as cloning and in the production of transgenic species.

The segregation and independent assortment of the genetic information within a species provides the variation necessary to produce some individuals with characteristics that better suit them to surviving and reproducing in their environment. Changes in the environment may act on these variations. The identification of mutations and their causes becomes important in preventing mutations and in identifying and potentially nullifying the effects of mutations in living organisms.

This module increases students' understanding of the history, nature and practice of biology, the applications and uses of biology, the implications of biology for society and the environment and current issues, research and developments in biology.

	<i>Students learn to:</i>	<i>Students:</i>
1. Evidence of evolution suggests that the mechanisms of inheritance, accompanied by selection, allow change over many generations	<ul style="list-style-type: none">▪ outline the impact on the evolution of plants and animals of:<ul style="list-style-type: none">– changes in physical conditions in the environment– changes in chemical conditions in the environment– competition for resources▪ describe, using specific examples, how the theory of evolution is supported by the following areas of study:<ul style="list-style-type: none">– palaeontology, including fossils that have been considered as transitional forms– biogeography– comparative embryology– comparative anatomy– biochemistry▪ explain how Darwin/Wallace's theory of evolution by natural selection and isolation accounts for divergent evolution and convergent evolution	<ul style="list-style-type: none">▪ plan, choose equipment or resources and perform a first-hand investigation to model natural selection▪ analyse information from secondary sources to prepare a case study to show how an environmental change can lead to changes in a species▪ perform a first-hand investigation or gather information from secondary sources (including photographs/diagrams/models) to observe, analyse and compare the structure of a range of vertebrate forelimbs▪ use available evidence to analyse, using a named example, how advances in technology have changed scientific thinking about evolutionary relationships▪ analyse information from secondary sources on the historical development of theories of evolution and use available evidence to assess social and political influences on these developments

	<i>Students learn to:</i>	<i>Students:</i>
2. Gregor Mendel's experiments helped advance our knowledge of the inheritance of characteristics	<ul style="list-style-type: none">▪ outline the experiments carried out by Gregor Mendel▪ describe the aspects of the experimental techniques used by Mendel that led to his success▪ describe outcomes of monohybrid crosses involving simple dominance using Mendel's explanations▪ distinguish between homozygous and heterozygous genotypes in monohybrid crosses▪ distinguish between the terms allele and gene, using examples▪ explain the relationship between dominant and recessive alleles and phenotype using examples▪ outline the reasons why the importance of Mendel's work was not recognised until some time after it was published	<ul style="list-style-type: none">▪ perform an investigation to construct pedigrees or family trees, trace the inheritance of selected characteristics and discuss their current use▪ solve problems involving monohybrid crosses using Punnett squares or other appropriate techniques▪ process information from secondary sources to describe an example of hybridisation within a species and explain the purpose of this hybridisation

3. Chromosomal structure provides the key to inheritance

Students learn to:

- outline the roles of Sutton and Boveri in identifying the importance of chromosomes
- describe the chemical nature of chromosomes and genes
- identify that DNA is a double-stranded molecule twisted into a helix with each strand comprised of a sugar-phosphate backbone and attached bases – adenine (A), thymine (T), cytosine (C) and guanine (G) – connected to a complementary strand by pairing the bases, A-T and G-C
- explain the relationship between the structure and behaviour of chromosomes during meiosis and the inheritance of genes
- explain the role of gamete formation and sexual reproduction in variability of offspring
- describe the inheritance of sex-linked genes, and alleles that exhibit co-dominance and explain why these do not produce simple Mendelian ratios
- describe the work of Morgan that led to the understanding of sex linkage
- explain the relationship between homozygous and heterozygous genotypes and the resulting phenotypes in examples of co-dominance
- outline ways in which the environment may affect the expression of a gene in an individual

Students:

- process information from secondary sources to construct a model that demonstrates meiosis and the processes of crossing over, segregation of chromosomes and the production of haploid gametes
- solve problems involving co-dominance and sex linkage
- identify data sources and perform a first-hand investigation to demonstrate the effect of environment on phenotype

Students learn to:

4. The structure of DNA can be changed and such changes may be reflected in the phenotype of the affected organism

- describe the process of DNA replication and explain its significance
- outline, using a simple model, the process by which DNA controls the production of polypeptides
- explain the relationship between proteins and polypeptides
- explain how mutations in DNA may lead to the generation of new alleles
- discuss evidence for the mutagenic nature of radiation
- explain how an understanding of the source of variation in organisms has provided support for Darwin's theory of evolution by natural selection
- describe the concept of punctuated equilibrium in evolution and how it differs from the gradual process proposed by Darwin

Students:

- perform a first-hand investigation or process information from secondary sources to develop a simple model for polypeptide synthesis
- analyse information from secondary sources to outline the evidence that led to Beadle and Tatum's 'one gene – one protein' hypothesis and to explain why this was altered to the 'one gene – one polypeptide' hypothesis
- process information to construct a flow chart that shows that changes in DNA sequences can result in changes in cell activity
- process and analyse information from secondary sources to explain a modern example of 'natural' selection
- process information from secondary sources to describe and analyse the relative importance of the work of:
 - James Watson
 - Francis Crick
 - Rosalind Franklin
 - Maurice Wilkinsin determining the structure of DNA and the impact of the quality of collaboration and communication on their scientific research

5. Current reproductive technologies and genetic engineering have the potential to alter the path of evolution

- identify how the following current reproductive techniques may alter the genetic composition of a population:
 - artificial insemination
 - artificial pollination
 - cloning
- outline the processes used to produce transgenic species and include examples of this process and reasons for its use
- discuss the potential impact of the use of reproduction technologies on the genetic diversity of species using a named plant and animal example that have been genetically altered

- process information from secondary sources to describe a methodology used in cloning
- analyse information from secondary sources to identify examples of the use of transgenic species and use available evidence to debate the ethical issues arising from the development and use of transgenic species

9.4 The Search for Better Health

Contextual Outline

When physiological processes malfunction, the body tries to repair the damage. The process is similar in all living things and it is only when the process fails to contain the damage that disease can be recognised.

Humans have long recognised the symptoms of disease both in themselves and the animals and plants around them. Since the beginnings of recorded history, they have noted the signs that reveal that the body is malfunctioning. Increasing understanding of the causes of disease together with accompanying advances in technology have changed approaches to treatment and management of disease.

The search for measures to treat and manage diseases of humans and other organisms continues and this search is paralleled by continued refinements in technology.

This module increases students' understanding of the history, nature and practice of biology, the applications and uses of biology, and the implications of biology for society and the environment.

Students learn to:

1. What is a healthy organism?

- discuss the difficulties of defining the terms 'health' and 'disease'
- outline how the function of genes, mitosis, cell differentiation and specialisation assist in the maintenance of health

2. Over 3000 years ago the Chinese and Hebrews were advocating cleanliness in food, water and personal hygiene

- distinguish between infectious and non-infectious disease
- explain why cleanliness in food, water and personal hygiene practices assist in control of disease
- identify the conditions under which an organism is described as a pathogen

Students:

- use available evidence to analyse the links between gene expression and maintenance and repair of body tissues
- identify data sources, plan and choose equipment or resources to perform a first-hand investigation to identify microbes in food or in water
- gather, process and analyse information from secondary sources to describe ways in which drinking water can be treated and use available evidence to explain how these methods reduce the risk of infection from pathogens

Students learn to:

3. During the second half of the nineteenth century, the work of Pasteur and Koch and other scientists stimulated the search for microbes as causes of disease

- describe the contribution of Pasteur and Koch to our understanding of infectious diseases
- distinguish between:
 - prions
 - viruses
 - bacteria
 - protozoans
 - fungi
 - macro-parasitesand name one example of a disease caused by each type of pathogen
- identify the role of antibiotics in the management of infectious disease

4. Often we recognise an infection by the symptoms it causes. The immune response is not so obvious, until we recover

- identify defence barriers to prevent entry of pathogens in humans:
 - skin
 - mucous membranes
 - cilia
 - chemical barriers
 - other body secretions
- identify antigens as molecules that trigger the immune response
- explain why organ transplants should trigger an immune response
- identify defence adaptations, including:
 - inflammation response
 - phagocytosis
 - lymph system
 - cell death to seal off pathogen

Students:

- perform an investigation to model Pasteur's experiment to identify the role of microbes in decay
- gather and process information to trace the historical development of our understanding of the cause and prevention of malaria
- identify data sources, gather process and analyse information from secondary sources to describe one named infectious disease in terms of its:
 - cause
 - transmission
 - host response
 - major symptoms
 - treatment
 - prevention
 - control
- process information from secondary sources to discuss problems relating to antibiotic resistance
- gather, process and present information from secondary sources to show how a named disease results from an imbalance of microflora in humans

Students learn to:

5. MacFarlane Burnet's work in the middle of the twentieth century contributed to a better understanding of the immune response and the effectiveness of immunisation programs

- identify the components of the immune response:
 - antibodies
 - T cells
 - B cells
- describe and explain the immune response in the human body in terms of:
 - interaction between B and T lymphocytes
 - the mechanisms that allow interaction between B and T lymphocytes
 - the range of T lymphocyte types and the difference in their roles
- outline the way in which vaccinations prevent infection
- outline the reasons for the suppression of the immune response in organ transplant patients

6. Epidemiological studies involve the collection and careful statistical analysis of large quantities of data. Such studies assist the causal identification of non-infectious diseases

- identify and describe the main features of epidemiology using lung cancer as an example
- identify causes of non-infectious disease using an example from each of the following categories:
 - inherited diseases
 - nutritional deficiencies
 - environmental diseases

Students:

- process, analyse and present information from secondary sources to evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common diseases, including smallpox, diphtheria and polio
- gather, process and analyse information to identify the cause and effect relationship of smoking and lung cancer
- identify data sources, plan and perform a first-hand investigation or gather information from secondary sources to analyse and present information about the occurrence, symptoms, cause, treatment/management of a named non-infectious disease

7. Increased understanding has led to the development of a wide range of strategies to prevent and control disease

Students learn to:

- discuss the role of quarantine in preventing the spread of disease and plants and animals into Australia or across regions of Australia
- explain how one of the following strategies has controlled and/or prevented disease:
 - public health programs
 - pesticides
 - genetic engineering to produce disease-resistant plants and animals

Students:

- perform an investigation to examine plant shoots and leaves and gather first-hand information of evidence of pathogens and insect pests
- process and analyse information from secondary sources to evaluate the effectiveness of quarantine in preventing the spread of plant and animal disease into Australia or across regions of Australia
- gather and process information and use available evidence to discuss the changing methods of dealing with plant and animal diseases, including the shift in emphasis from treatment and control to management or prevention of disease

9.5 Option — Communication

Contextual Outline

Humans are social animals and, as such, are in constant communication with others. Many animals have an extensive range of communication strategies that include both visual and vocal signals. Learning these signals relies heavily on the involvement of all the sensory organs as well as the brain.

While the full range of senses can be involved in communication, the relative importance of each of the senses differs from animal to animal. This module focuses on the two senses that are important for many vertebrate and invertebrate animals – sight and hearing.

Human cultural development exploded with the development of speech and the concurrent increasing complexity of communication. For some people, however, communication signals are not identified effectively because of faults in the sending, receiving or deciphering of some of the signals. With increasing advances in technology, assistance for people with difficulties in communicating continues to improve.

This module increases students’ understanding of the history, applications and uses of biology, the implications of biology for society and the environment, and current issues, research and developments in biology.

	<i>Students learn to:</i>	<i>Students:</i>
1. Humans, and other animals, are able to detect a range of stimuli from the external environment, some of which are useful for communication	<ul style="list-style-type: none"> ▪ identify the role of receptors in detecting stimuli ▪ explain that the response to a stimulus involves: <ul style="list-style-type: none"> – stimulus – receptor – messenger – effector – response 	<ul style="list-style-type: none"> ▪ identify data sources, gather and process information from secondary sources to identify the range of senses involved in communication
2. Visual communication involves the eye registering changes in the immediate environment	<ul style="list-style-type: none"> ▪ describe the anatomy and function of the human eye, including the: <ul style="list-style-type: none"> – conjunctiva – cornea – sclera – choroid – retina – iris – lens – aqueous and vitreous humor – ciliary body – optic nerve ▪ identify the limited range of wavelengths of the electromagnetic spectrum detected by humans and compare this range with those of other vertebrates and invertebrates 	<ul style="list-style-type: none"> ▪ plan, choose equipment or resources and perform a first-hand investigation of a mammalian eye to gather first-hand data to relate structures to functions ▪ use available evidence to suggest reasons for the differences in range of electromagnetic radiation detected by humans and other animals

Students learn to:

3. The clarity of the signal transferred can affect interpretation of the intended visual communication

- identify the conditions under which refraction of light occurs
- identify the cornea, aqueous humor, lens and vitreous humor as refractive media
- identify accommodation as the focusing on objects at different distances, describe its achievement through the change in curvature of the lens and explain its importance
- compare the change in the refractive power of the lens from rest to maximum accommodation
- distinguish between myopia and hyperopia and outline how technologies can be used to correct these conditions.
- explain how the production of two different images of a view can result in depth perception

4. The light signal reaching the retina is transformed into an electrical impulse

- identify photoreceptor cells as those containing light sensitive pigments and explain that these cells convert light images into electrochemical signals that the brain can interpret
- describe the differences in distribution, structure and function of the photoreceptor cells in the human eye
- outline the role of rhodopsin in rods
- identify that there are three types of cones, each containing a separate pigment sensitive to either blue, red or green light
- explain that colour blindness in humans results from the lack of one or more of the colour-sensitive pigments in the cones

Students:

- plan, choose equipment or resources and perform a first-hand investigation to model the process of accommodation by passing rays of light through convex lenses of different focal lengths
- analyse information from secondary sources to describe changes in the shape of the eye's lens when focusing on near and far objects
- process and analyse information from secondary sources to describe cataracts and the technology that can be used to prevent blindness from cataracts and discuss the implications of this technology for society
- process and analyse information from secondary sources to compare and describe the nature and functioning of photoreceptor cells in mammals, insects and in one other animal
- process and analyse information from secondary sources to describe and analyse the use of colour for communication in animals and relate this to the occurrence of colour vision in animals

Students learn to:

5. Sound is also a very important communication medium for humans and other animals

- explain why sound is a useful and versatile form of communication
- explain that sound is produced by vibrating objects and that the frequency of the sound is the same as the frequency of the vibration of the source of the sound
- outline the structure of the human larynx and the associated structures that assist the production of sound

6. Animals that produce vibrations also have organs to detect vibrations

- outline and compare the detection of vibrations by insects, fish and mammals
- describe the anatomy and function of the human ear, including:
 - pinna
 - tympanic membrane
 - ear ossicles
 - oval window
 - round window
 - cochlea
 - organ of Corti
 - auditory nerve
- outline the role of the Eustachian tube
- outline the path of a sound wave through the external, middle and inner ear and identify the energy transformations that occur
- describe the relationship between the distribution of hair cells in the organ of Corti and the detection of sounds of different frequencies
- outline the role of the sound shadow cast by the head in the location of sound

Students:

- plan and perform a first-hand investigation to gather data to identify the relationship between wavelength, frequency and pitch of a sound
- gather and process information from secondary sources to outline and compare some of the structures used by animals other than humans to produce sound
- gather, process and analyse information from secondary sources on the structure of a mammalian ear to relate structures to functions
- process information from secondary sources to outline the range of frequencies detected by humans as sound and compare this range with two other mammals, discussing possible reasons for the differences identified
- process information from secondary sources to evaluate a hearing aid and a cochlear implant in terms of:
 - the position and type of energy transfer occurring
 - conditions under which the technology will assist hearing
 - limitations of each technology

7. Signals from the eye and ear are transmitted as electro-chemical changes in the membranes of the optic and auditory nerves

Students learn to:

- identify that a nerve is a bundle of neuronal fibres
- identify neurones as nerve cells that are the transmitters of signals by electro-chemical changes in their membranes
- define the term ‘threshold’ and explain why not all stimuli generate an action potential
- identify those areas of the cerebrum involved in the perception and interpretation of light and sound
- explain, using specific examples, the importance of correct interpretation of sensory signals by the brain for the coordination of animal behaviour

Students:

- perform a first-hand investigation using stained prepared slides and/ or electron micrographs to gather information about the structure of neurones and nerves
- perform a first-hand investigation to examine an appropriate mammalian brain or model of a human brain to gather information to distinguish the cerebrum, cerebellum and medulla oblongata and locate the regions involved in speech, sight and sound perception
- present information from secondary sources to graphically represent a typical action potential

9.6 Option — Biotechnology

Contextual Outline

Biotechnology has been an identifiable part of human culture for thousands of years; people learned to use yeasts and other micro-organisms to produce bread, wine, yoghurt, cheeses and antibiotics.

Biotechnology now refers to the practical application of modern laboratory techniques, such as recombinant DNA technology, to support a wide range of human needs, including food and medicines. Applications of biotechnology are currently being investigated in areas as diverse as medicine, marine aquaculture and forensic science. Increased knowledge and understanding of biotechnological processes has promoted further applications of these processes in bioremediation, biosubstitution and the production of genetically modified organisms (GMOs). All of these can assist in the maintenance and protection of natural environments as well as assisting humans.

This module increases students' understanding of the nature and practice of biology and the applications and uses of biology, implications of biology for society and the environment, and current issues, research and developments in biology.

	<i>Students learn to:</i>	<i>Students:</i>
<p>1. The origins of biotechnology date back at least 10 000 years</p>	<ul style="list-style-type: none"> ▪ describe the origins of biotechnology in early societies who collected seeds of wild plants and domesticated some species of wild animals ▪ explain why the collection of seeds and breeding of animals with desired characteristics, could be described as early biotechnology ▪ describe the changes in one group of animals and one group of plants as a result of artificial selection of characteristics suitable for agricultural stock 	<ul style="list-style-type: none"> ▪ use available evidence to describe the changes in a species of grain or animal as a result of domestication and agricultural processes ▪ process information to outline an ancient Australian Aboriginal use of biotechnology
<p>2. Biotechnology has come to be recognised as the use of living organisms to make or modify a product, to improve plants or animals or to utilise micro-organisms for specific uses</p>	<ul style="list-style-type: none"> ▪ outline the key events that led to the use of biotechnological practices, including: <ul style="list-style-type: none"> – yeast in the manufacture of bread – yeast and fermentation for alcohol production – the use of other micro-organisms for the manufacture of yoghurt and cheeses 	<ul style="list-style-type: none"> ▪ plan, choose equipment or resources, perform a first-hand investigation to demonstrate the use of fermentation processes in bread or alcohol production

Students learn to:

3. Classical biotechnology exploited knowledge of cell biochemistry to produce industrial fermentation procedures

- describe the expansion of fermentation since the early 18th century to include the production of several organic compounds, including glycerol, lactic acid, citric acid and yeast biomass for baker's yeast
- describe strain isolation methods developed in the 1940s
- describe, using a specific example, the benefits of strain isolation methods used in biotechnology in the 20th century
- identify that developments in the 1950s led to biotransformation technologies that could produce required organic compounds such as cortisone and sex hormones

4. Cell chemistry is utilised in biotechnology

- outline, simply, the steps in the synthesis of a protein in the cell, including:
 - the difference between DNA and RNA
 - the production of messenger RNA
 - the role of transfer RNA
 - the formation of the polypeptide chain(s)
 - the formation of the protein from polypeptide chains

Students:

- gather and process information from secondary sources to:
 - identify and describe a named industrial fermentation process
 - identify the micro-organism used in the fermentation and the products of the fermentation
 - outline the use of the product of the fermentation process
 - use available evidence to assess the impact of the use of the fermentation product on society at the time of its introduction
- process and analyse information from secondary sources to demonstrate how changes in technology and scientific knowledge have modified traditional uses of biotechnology, such as fermentation
- plan and perform a first-hand investigation to test the conditions that influence the rate of enzyme activity

Students learn to:

5. Modern biotechnology includes recombinant DNA technology

- describe the three essentials of gene manipulation as:
 - cutting and joining DNA
 - monitoring the cutting and joining
 - transforming hosts, such as bacteria, with the recombinant DNA
- describe the following recombinant DNA techniques used in biotechnology, including:
 - gene splicing using restriction enzymes and ligases to produce recombinant DNA
 - polymerase chain reaction to amplify or modify DNA sequences
 - use of DNA vectors and microinjection for carrying genes into nuclear DNA in the production of transgenic multicellular organisms

6. There are many applications and areas of research in biotechnology

- outline one way that forensic scientists can use DNA analysis to help solve cases
- describe one example from the following applications of biotechnology in medicine:
 - tissue engineering using skin transplantation as an example
 - gene delivery by nasal sprays
 - production of a synthetic hormone, such as insulin
- describe one example from the following applications of animal or plant biotechnology:
 - the production of monoclonal antibodies
 - recombinant vaccines to combat virulent animal diseases
- describe one example from the following applications of aquaculture:
 - the production of a pharmaceutical from alga
 - the farming of a marine animal

Students:

- perform a first-hand investigation to extract and identify DNA from a suitable source
 - process information to produce a flow chart on the sequence of events that result in the formation of recombinant DNA
 - gather and analyse information to outline the purpose of a current application of transgenic technology, naming the organism and gene transfer technique involved
 - process and analyse secondary information to identify that complementary DNA is produced by reverse transcribing RNA or the polymerase chain reaction
-
- identify data sources, gather, analyse and process information to present one case study on the application of biotechnology in each of the following:
 - medicine
 - animal biotechnology
 - aquaculturethese case studies should:
 - give details of the process used
 - identify the organism or tissue involved
 - describe the outcome of the biotechnological process
 - evaluate the efficiency of the process and discuss advantages and disadvantages associated with either the product or the process

Students learn to:

7. Ethical issues relevant to the use of biotechnology are important and need to be considered

- explain why different groups in society may have different views about the use of DNA technology
- identify and evaluate ethical issues related to one of the following:
 - development of genetically modified organisms (GMOs)
 - animal cloning
 - gene cloning

Students:

- use available evidence to identify and discuss ethical and social issues associated with the use of biotechnology

9.7 Option — Genetics: The Code Broken?

Contextual Outline

Science has come a long way since Mendel’s important work on identifying the transmission of inherited factors across generations. The code for transmitting this genetic information has been identified and models have been developed to explain gene functioning. Transcription of the information into functional proteins is now well understood and models are being developed to test how genes direct the structure, function and development of an organism.

Modern genetics is moving towards an increased understanding of the biochemical role of individual genes. This is being enhanced by the Human Genome Project that has sequenced the entire human genome to identify all the encoded genes.

This module increases students’ understanding of the nature, practice, applications and uses of biology, the implications of biology for society and the environment, and current issues, research and developments in biology.

Students learn to:

1. **The structure of a gene provides the code for a polypeptide**
 - describe the processes involved in the transfer of information from DNA through RNA to the production of a sequence of amino acids in a polypeptide

2. **Multiple alleles and polygenic inheritance provide further variability within a trait**
 - give examples of characteristics determined by multiple alleles in an organism other than humans
 - compare the inheritance of the ABO and Rhesus blood groups
 - define what is meant by polygenic inheritance and describe one example of polygenic inheritance in humans or another organism.
 - outline the use of highly variable genes for DNA fingerprinting of forensic samples, for paternity testing and for determining the pedigree of animals

Students:

- choose equipment or resources to perform a first-hand investigation to construct a model of DNA
- process information from secondary data to outline the current understanding of gene expression

- solve problems to predict the inheritance patterns of ABO blood groups and the Rhesus factor
- process information from secondary sources to identify and describe one example of polygenic inheritance

Students learn to:

3. Studies of offspring reflect the inheritance of genes on different chromosomes and genes on the same chromosomes

- use the terms 'diploid' and 'haploid' to describe somatic and gametic cells
- describe outcomes of dihybrid crosses involving simple dominance using Mendel's explanations
- predict the difference in inheritance patterns if two genes are linked
- explain how cross-breeding experiments can identify the relative position of linked genes
- discuss the role of chromosome mapping in identifying relationships between species

4. The Human Genome Project is attempting to identify the position of genes on chromosomes through whole genome sequencing

- discuss the benefits of the Human Genome Project
- describe and explain the limitations of data obtained from the Human Genome Project
- outline the procedure to produce recombinant DNA
- explain how the use of recombinant DNA technology can identify the position of a gene on a chromosome

5. Gene therapy is possible once the genes responsible for harmful conditions are identified

- describe current use of gene therapy for an identified disease

Students:

- process information from secondary sources to analyse the outcome of dihybrid crosses when both traits are inherited independently and when they are linked
- perform a first-hand investigation to model linkage

- process information from secondary sources to assess the reasons why the Human Genome Project could not be achieved by studying linkage maps

- process and analyse information from secondary sources to identify a current use of gene therapy to manage a genetic disease, a named form of cancer or AIDS

Students learn to:

6. Mechanisms of genetic change

- distinguish between mutations of chromosomes, including
 - rearrangements
 - changes in chromosome number, including trisomy, and polyploidy and mutations of genes, including
 - base substitution
 - frameshift
- outline the ability of DNA to repair itself
- describe the way in which transposable genetic elements operate and discuss their impact on the genome
- distinguish between germ line and somatic mutations in terms of their effect on species

7. Selective breeding is different to gene cloning but both processes may change the genetic nature of species

- explain, using an appropriate example from agriculture, why selective breeding has been practised
- describe what is meant by ‘gene cloning’ and give examples of the uses of gene cloning
- distinguish between gene cloning and whole organism cloning in terms of the processes and products
- discuss a use of cloning in animals or plants that has possible benefits to humans

Students:

- process and analyse information from secondary sources to describe the effect of one named and described genetic mutation on human health
- analyse and present information from secondary sources to trace the history of the selective breeding of one species for agricultural purposes and use available evidence to describe the series of changes that have occurred in the species as a result of this selective breeding
- identify data sources, choose equipment or resources, gather, process and analyse information from secondary sources to describe the processes used in the cloning of an animal and analyse the methodology to identify ways in which scientists could verify that the animal produced was a clone

8. The timing of gene expression is important in the developmental process

Students learn to:

- identify the role of genes in embryonic development
- summarise the role of gene cascades determining limb formation in birds and mammals
- describe the evidence which indicates the presence of ancestral vertebrate gene homologues in lower animal classes
- discuss the evidence available from current research about the evolution of genes and their actions

Students:

- identify data sources, gather, process and analyse information from secondary sources and use available evidence to assess the evidence that analysis of genes provides for evolutionary relationships

9.8 Option — The Human Story

Contextual Outline

Humans are a species of primate and share the characteristics of this group of animals. An examination of the classification criteria used to separate groups of organisms with a particular emphasis on the distinguishing characteristics of humans, other mammals and primates, provides some evidence to support evolutionary relationships.

Tracing the evolution of humans in detail allows increased investigation of the arbitrary nature of classification and the reasons why scientists may differ in their interpretation of evidence. The nature of science and role of technology in analysing these interpretations are further evaluated in the arena of human evolution.

Humans have taken a very different path in their recent evolution as the ongoing development of culture has restricted and redirected the role of natural selection as a tool for guiding the evolution of a species. The polymorphic nature of the human species is considered in light of our distribution on Earth and the different environments that we occupy.

This module increases students' understanding of the history, nature, practice, applications and uses of biology, and current issues, research and developments in biology.

Students learn to:

Students:

1. Humans have characteristics that can be used to classify them with other organisms

- outline the general classification hierarchy from phylum to species
 - define the term species and outline criteria used to identify a species
 - outline features that classify humans as:
 - mammal
 - primate
 - hominid
 - hominin
 - discuss the use of the terms hominin and hominid in terms of the arbitrary nature of classification systems
 - describe primate characteristics, including:
 - hand/foot structure and function, including opposable thumb or toe
 - skull shape and function
 - brain size relative to body size
 - arrangement of the vertebral column to the degree of upright stance
 - vision, including degree of stereoscopic vision, colour vision
 - reproductive features, including single live young and relatively long gestation
 - parenting and group bonding
 - describe primate characteristics in:
 - prosimians
 - new and old world monkeys
 - apes
 - humans
- identify data sources, gather, process and analyse information from secondary sources to illustrate the classification process by identifying features of humans that classifies them as:
 - Animal
 - Chordate
 - Mammal
 - Primate
 - Hominid
 - *Homo*
 - *Homo sapiens*
 - process information to summarise and analyse the similarities and differences between prosimians, monkeys, apes and humans
 - analyse information and use available evidence to identify technological advances and resulting new information that have changed scientists' opinions about the classification of primates

2. Fossil and other biological evidence assists in the clarification of the relationships between humans and other primates

Students learn to:

- outline the conditions under which fossils may form
- relate the age of the Earth to the way in which geological time is described
- distinguish between and describe some relative and absolute techniques used for dating fossils
- describe relative dating techniques using fossil sequence in strata
- discuss the difficulty of interpreting the past from the fossil record alone, including:
 - conflicting dates based on different technologies
 - the paucity of the fossil record
 - different interpretations of the same evidence
- compare living primates to hypothesise about relationships between groups of primates using evidence from:
 - karyotype analysis
 - DNA–DNA hybridisation
 - comparison of haemoglobins
 - DNA sequencing
 - mitochondrial DNA as a molecular clock

Students:

- process and analyse information from secondary sources to model karyotype analysis
- process information from secondary sources to model DNA–DNA hybridisation in order to demonstrate its use in determining relationships between organisms
- identify data sources, gather, process and present information from secondary sources about the maternal inheritance of mitochondrial DNA and its importance in tracing human evolution

Students learn to:

Students:

3. Debate continues on the relationships between hominid species

- examine at least two alternative views of human evolutionary relationships using the same fossil evidence, including:
 - *Ardipithecus ramidus*
(*Australopithecus ramidus*)
 - *Australopithecus afarensis*
 - *Paranthropus robustus*
(*Australopithecus robustus*)
 - *Paranthropus boisei*
(*Australopithecus boisei*)
 - *Australopithecus africanus*
 - *Homo habilis*
 - *Homo ergaster*
 - *Homo erectus*
 - *Homo heidelbergensis*
 - *Homo neanderthalensis*
 - *Homo sapiens*
- compare the above species, including comparisons of:
 - body structure
 - cranial capacity
 - fossil ages and regional locations
 - inferred culture
- outline and examine the evidence for the pattern of human migration and evolution based on:
 - the ‘Out of Africa’ model
 - the theory of regional continuity (multi-regional hypothesis)

- gather, process, present and analyse information to provide an overview of the similarities and differences of any two species used in tracing human evolutionary relationships
- process secondary information and use available evidence to assess the contribution of one of the following to our increased understanding of human evolution:
 - the Leakey family
 - Johanson
 - Broom
 - Tobias
 - Dart
 - Goodall
- gather and process information from secondary sources to analyse and evaluate the evidence for two different models of human evolution

4. How humans have adapted to their environment

- outline the mechanisms that led to human diversity
- explain the differences between polymorphism and clinal gradation using at least one appropriate example from human phenotypes

- gather and process information from secondary sources to describe two examples of polymorphism in humans and analyse the evolutionary significance of the phenotypes displayed

Students learn to:

Students:

5. Cultural development has been a significant feature of human evolution

- describe the cultural changes that occurred as humans developed into efficient hunters in organised cooperative groups
- discuss possible impacts of this cultural development

- process and analyse information from secondary sources to compare humans with other primates in terms of:
 - care of young
 - length of juvenile stage
 - development of, and size of, social groups
 - the development and use of tools
 - communication systemsand assess the evolutionary significance of the similarities and differences identified

6. Current and future trends in biological evolution and cultural development

- analyse the possible effects on human evolution of the following factors:
 - increased population mobility
 - modern medicine
 - genetic engineering

- gather, process, present and analyse information from secondary sources to account for changes in human population numbers in the last 10 000 years and to discuss the potential impact of named examples of modern technologies on future human populations
- process information from secondary sources to outline the purpose of the Human Genome Project and briefly discuss its implications

9.9 Option — Biochemistry

Contextual Outline

Examining a dead organism tells biologists a little about its structure and very little about its function. The great challenge to biologists has been to identify and describe not only the structure and function of living organisms but to describe how their metabolism works.

It has been difficult for the biologist to fully understand cell function in particular, because microanalysis of living tissue has never been easy. When biologists have technologies at their disposal to watch intact structures operating, the complete story will be told.

The history of photosynthesis tells the story of the progression of knowledge that follows closely the improvements in technology that allowed new strategies to be implemented for the study of living materials.

This module increases students' understanding of the history, nature, practice, applications and uses of biology.

Students learn to:

1. Photosynthesis is one of the most important biochemical reactions that can be studied

- discuss reasons for studying photosynthesis, including:
 - its production of food resources and the need to increase crop yields
 - understanding of photosynthesis may lead to better methods of harvesting solar energy
 - photosynthesis can provide raw materials for a range of human needs
 - the importance of the role of photosynthesis in reducing carbon dioxide levels in the atmosphere
 - the importance of generating oxygen

Students:

- gather, process and summarise information from secondary sources to identify the products of photosynthesis and describe the function of these compounds in living organisms
- analyse information from secondary sources to discuss and evaluate the potential uses of photosynthesis in replacing at least three named materials presently obtained from other non-renewable resources

Students learn to:

2. The notion that plants obtain nourishment from water, light and air took nearly two centuries to evolve

- outline the progress that occurred in the 17th and 18th centuries towards understanding plant growth by identifying:
 - the observation of van Helmont that soil was not primarily responsible for a plants change in mass as it grew
 - Stephen Hales’ proposal that plants extract some of their matter from air
 - the work of Priestley in identifying that plants could ‘restore the air’ used by a candle and his subsequent discovery of oxygen
 - Ingen-Housz’s demonstration of the importance of sunlight for oxygen production by plants
 - Senebier’s demonstration of the use of carbon dioxide during photosynthesis
 - Saussure’s conclusion that water was also necessary for photosynthesis
- explain that, building on the evidence from earlier investigations, Mayer concluded that plants convert light energy to chemical energy
- identify that Blackman and Mathgel hypothesised that photosynthesis was a two-step process

Students:

- identify data sources, choose equipment or resources to plan and perform a first-hand investigation that could test the observations of one of:
 - van Helmont
 - Hales
 - Priestley
 - Ingen-Housz
 - Senebier
 - Saussure
- gather and process information from secondary sources to identify and describe one example of a modern technology other than microscopy not available to the above people that would have assisted them in their investigations
- process information from secondary sources to identify observations and conclusions from the observations that led to the hypothesis of Blackman and Mathgel

3. Chloroplasts were proposed as the site of photosynthesis in the late 19th century

Students learn to:

- explain that Sachs proved that chlorophyll is located in special bodies within plant cells and relate his finding to the site where glucose is made
- describe homogenisation as a process that breaks up cells and allows study of cell fractions, suspensions and solutions
- outline the role of centrifugation in removing cell debris and sedimenting cell organelles, such as chloroplasts
- outline the discoveries of Englemann and explain why Englemann's work led to the description of the action spectrum of photosynthesis
- explain how the role of pigments, other than chlorophyll, in photosynthesis was inferred

Students:

- identify data sources, plan and choose equipment or resources to perform a first-hand investigation to gather data to determine the effect of light intensity and temperature on gas production in a suitable pond weed
- gather information from secondary sources to produce a time-line indicating improvements in microscopy that would have assisted Englemann in his work with *Spirogyra*
- process information from secondary sources to outline the importance of Tswett's invention of chromatography for the separation of leaf pigments
- perform a first-hand investigation to:
 - extract the mixture of pigments from leaves
 - examine the absorption spectrum of these pigments
 - separate the pigments using chromatography

Students learn to:

4. By the middle of the 20th century, a description of the light dependent reaction was developing

- describe and discuss the importance of Van Niel's hypothesis that water was the source of oxygen given out in photosynthesis
- outline the classic experiments of Emerson and Arnold and their interpretation by Gaffron and Wahl that led to the hypothesis of a photosynthetic unit consisting of chlorophyll and photoenzyme molecules
- identify the light dependent reaction as that which traps light energy and converts it to chemical energy stored in ATP
- identify the role of chlorophylls in the light reactions
- explain the significance of the difference in function of photosystems I and II
- identify the role of the coenzymes ADP and NADP in the light reactions

5. The use of isotopes made the tracing of biochemical reactions much easier

- explain why the tracking of biochemical reactions is difficult
- identify that isotopes of some elements may be unstable and emit radiation
- define what is meant by the half-life of an isotope and explain how this would affect its use in biochemistry
- outline the evidence provided by:
 - Hill and Scarisbruck
 - Rubento confirm that the oxygen released by photosynthesis originated from water

Students:

- present information that describes the repetitive flash technique first used by Emerson and Wahl and account for its subsequent importance in the study of photosynthesis
- gather and process information from secondary sources to trace the light dependent reaction of photosynthesis on a suitable biochemical pathways flow chart
- gather and process information from secondary sources to outline the range of isotopes that have been useful in studying photosynthesis and explain how radioactive tracers can be incorporated into plants to follow a biochemical pathway, such as photosynthesis

Students learn to:

6. The discovery of C14 in the mid-20th century allowed a detailed study of the role of carbon dioxide in photosynthesis

- identify that Kamen and Ruben discovered C14 and demonstrated that radioactive carbon dioxide could be used to investigate the chemical transformations of carbon dioxide during photosynthesis in 1940
- describe the experiments, using paper chromatography, that Calvin carried out to deduce the products of photosynthesis
- outline the main steps of the Calvin cycle as:
 - the production of phosphoglycerate from the combining of carbon dioxide with an acceptor molecule
 - the reduction of phosphoglycerate into glyceraldehyde phosphate in two reactions that use ATP and NADPH produced in the light reactions
 - the regeneration of the initial carbon dioxide acceptor
- explain why the Calvin cycle is now called the light independent stage of photosynthesis

7. ATP is the energy source of every living cell

- identify that adenosine triphosphate is used as an energy source for nearly all cellular metabolic processes
- explain that the biologically important part of the molecule contains three phosphate groups linked by high energy phosphodiester bonds
- outline the discovery of ATP synthesis in the mid 20th century in terms of:
 - the discovery of photophosphorylation in chloroplasts of plants
 - the discovery that ATP synthesis involves an electron transfer reaction occurring across a membrane

Students:

- gather and process information to use a biochemical pathways chart to trace the steps in the Calvin cycle

- gather and process information from a diagram or model of the structure of the adenosine triphosphate molecule to discuss the nature and organisation of the phosphodiester bonds between the phosphate groups

Students learn to:

8. The development of the electron microscope in increasingly sophisticated forms has increased understanding of chloroplast structure

- describe the structure of a chloroplast as seen under a transmission electron microscope
- identify the average size of a chloroplast and describe the range of sizes observed across species
- describe the thylakoids as flattened, hollow discs with chlorophyll dissolved in the lipid layers of the membrane
- describe the stroma as matrix lying within the inner membrane containing DNA, ribosomes, lipid droplets and starch granules

Students:

- gather and present information from secondary sources, including electron micrographs to:
 - draw and label the structure of a chloroplast
 - compare the size, shape and distribution of chloroplasts in a named alga, terrestrial angiosperm and aquatic angiosperm
- gather and process information from secondary sources to identify and explain the location of the sites of light absorption and the site of the Calvin cycle

10 Course Requirements

For the Preliminary course:

- 120 indicative hours are required to complete the course
- the content in each module must be addressed over the course
- experiences over the course must cover the scope of each skill as described in Section 8.1
- practical experiences should occupy a minimum of 45 indicative hours of course time
- at least one open-ended investigation integrating skill and knowledge outcomes must be included in the course.

For the HSC course:

- the Preliminary course is a prerequisite
- 120 indicative hours are required to complete the course
- the content in each module of the core and one option must be addressed over the course
- experiences over the course must cover the scope of each skill as described in Section 9.1
- practical experiences should occupy a minimum of 35 indicative hours of course time
- at least one open-ended investigation integrating skill and knowledge outcomes must be included in the course.

11 Post-school Opportunities

The study of Biology Stage 6 provides students with knowledge, understanding and skills that form a valuable foundation for a range of courses at university and other tertiary institutions.

In addition, the study of Biology Stage 6 assists students to prepare for employment and full and active participation as citizens. In particular, there are opportunities for students to gain recognition in vocational education and training. Teachers and students should be aware of these opportunities.

Recognition of Student Achievement in Vocational Education and Training (VET)

Wherever appropriate, the skills and knowledge acquired by students in their study of HSC courses should be recognised by industry and training organisations. Recognition of student achievement means that students who have satisfactorily completed HSC courses will not be required to repeat their learning in courses in TAFE NSW or other Registered Training Organisations (RTOs).

Registered Training Organisations, such as TAFE NSW, provide industry training and issue qualifications within the Australian Qualifications Framework (AQF).

The degree of recognition available to students in each subject is based on the similarity of outcomes between HSC courses and industry training packages endorsed within the AQF. Training packages are documents that link an industry's competency standards to AQF qualifications. More information about industry training packages can be found on the National Training Information Service (NTIS) website (www.ntis.gov.au).

Recognition by TAFE NSW

TAFE NSW conducts courses in a wide range of industry areas, as outlined each year in the TAFE NSW Handbook. Under current arrangements, the recognition available to students of Biology in relevant courses conducted by TAFE is described in the HSC/TAFE Credit Transfer Guide. This guide is produced by the Board of Studies and TAFE NSW and is distributed annually to all schools and colleges. Teachers should refer to this guide and be aware of the recognition available to their students through the study of Biology Stage 6. This information can be found on the HSC / TAFE Credit Transfer website (www.det.nsw.edu.au/hstafe).

Recognition by other Registered Training Organisations

Students may also negotiate recognition into a training package qualification with another RTO. Each student will need to provide the RTO with evidence of satisfactory achievement in Biology Stage 6 so that the degree of recognition available can be determined.

12 Assessment and Reporting

Advice on appropriate assessment practice in relation to the Biology syllabus is contained in *Assessment and Reporting in Biology Stage 6*. That document provides general advice on assessment in Stage 6 as well as the specific requirements for the Preliminary and HSC courses. The document contains:

- suggested components and weightings for the internal assessment of the Preliminary course
- mandatory components and weightings for the internal assessment of the HSC course
- the HSC examination specifications, which describe the format of the external HSC examination.

The document and other resources and advice related to assessment in Stage 6 Biology are available on the Board's [website](http://www.boardofstudies.nsw.edu.au/syllabus_hsc) (www.boardofstudies.nsw.edu.au/syllabus_hsc).

13 Appendix

The following information clarifies terminology used in the syllabus.

Allelopathy	The production of specific biomolecules by one plant that can be detrimental to, or give benefit to, another plant. This concept suggests that biomolecules (allelochemicals) produced by a plant escape into the environment and subsequently influence the growth and development of other neighbouring plants.
Archaea	Archaea are microscopic, single-celled organisms. They have no membrane-bound organelles within their cells. They differ from both eukaryotes and bacteria in that their membrane lipids are ether-linked not ester-linked and in that they are capable of methanogenesis. Although many books and articles still refer to them as 'Archaeobacteria', that term has been abandoned because they aren't bacteria.
Enantiostasis	Maintenance of metabolic and physiological functions (as distinct from states), in response to variations in the environment.
sound shadow	Since the head will absorb high frequencies more easily than low ones, it will create a sound shadow for the ear farthest away from the sound source, and therefore the phenomenon plays a role in sound localization.