Maribyrnong College

VCE Biology Units 3 and 4 – 2015

The following is from the *Biology Victorian Certificate of Education Study Design 2013 – 2016*.

Units 1 to 4: Key Skills

Investigate and inquire scientifically

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

Apply biological understandings

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

Communicate biological information and understandings

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

Unit 3: Signatures of life

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

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

Students investigate how cells communicate with each other at molecular level in regulating cellular activities; how they recognise 'self' and 'non-self' in detecting possible agents of attack; and how physical barriers and immune responses can protect the organism against pathogens.
Students consider the technological advances that have contributed to our knowledge and understanding of molecular biology and thereby appreciate the dynamic nature of science.
Students apply concepts related to the structure, function, activities, needs and regulated death of cells.

Area of study 1
Molecules of life

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

Students gain an understanding that DNA and proteins are the key molecules of life forms, and that DNA codes for the production of proteins. Students explore applications of molecular biology in medical diagnosis.

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

Outcome 1

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

Key knowledge

- the nature and importance of biomacromolecules in the chemistry of the cell:
  - synthesis of biomacromolecules through the condensation reaction
  - lipids and their sub-units; the role of lipids in the plasma membrane
  - examples of polysaccharides and their glucose monomer
  - structure and function of DNA and RNA, their monomers, and complementary base pairing
  - the nature of the proteome; the functional diversity of proteins; the structure of proteins in terms of primary, secondary, tertiary and quaternary levels of organisation
- the structure and function of the plasma membrane and the movement of substances across it:
  - the fluid-mosaic model of a plasma membrane
  - the packaging, transport, import and export of biomacromolecules (specifically proteins)
  - the role played by organelles including ribosomes, endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of proteins
- the nature of biochemical processes within cells:
  - catabolic and anabolic reactions in terms of reactions that release or require energy
  - the role of enzymes as protein catalysts, their mode of action and the inhibition of the action of enzymes both naturally and by rational drug design
  - the role of ATP and ADP in energy transformations
  - requirements for photosynthesis – excluding differences between CAM, C3 and C4 plants –including: the structure and function of the chloroplast; the main inputs and outputs of the light dependent and light independent stages
  - requirements for aerobic and anaerobic cellular respiration: the location, and main inputs and outputs, of glycolysis; the structure of the mitochondrion and its function in aerobic cellular respiration including main inputs and outputs of the Krebs Cycle and the electron transport chain.

AREA OF STUDY 2
Detecting and Responding

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

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

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

Outcome 2

On completion of this unit the student should be able to describe and explain the use of the stimulus-response model in coordination and regulation and how components of the human immune system respond to antigens and provide immunity.

Key knowledge

- co-ordination and regulation at the cellular level:
  - the nature of the stimulus-response model and the roles of the nerve pathway and chemical signals in the transmission of information from receptor to effector
  - types of signalling molecules: neurotransmitters; animal hormones; pheromones; plant growth regulators
  - a generalised view of how information received by a cell's receptor is transducted to an effector to initiate various cellular responses including the position of receptors for protein-based and lipid-based signalling molecules
  - apoptosis (regulated cell death) as an example of a cellular response to specific signals
  - the nature of antigens and their sources: 'self' and 'non-self', including non-cellular agents, and cellular pathogens and non-cellular agents (viruses and prions)
- the role of the human immune system in detecting and responding to antigens:
  - the nature of physical and chemical barriers in plants and animals (including humans) to invading pathogens
  - the structure and role of the lymphatic system in the innate and adaptive immune response
  - the nature, characteristics and roles of components in the innate (non-specific) immune response including the inflammatory response
  - the nature, characteristics and components of the adaptive immune response including the role and actions of B cells and their antibodies in humoral immunity and the role and actions of T helper cells and T cytotoxic cells in cell-mediated immunity
  - disorders of the human immune response including the allergic response and autoimmune diseases
  - acquired immunity through natural and passive strategies, including the nature and production of vaccines and antibody serums and their importance in maintaining immunity for a particular disease in the human population.

Unit 4: Organisms and their environment

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

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

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

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

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

Area of study 1

Heredity

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

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

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

Outcome 1
On completion of this unit the student should be able to analyse evidence for the molecular basis of heredity, and patterns of inheritance.

Key knowledge
- cell reproduction:
  - binary fission in prokaryotes
  - the phases of the cell cycle in eukaryotes including DNA replication, the division of the nucleus (mitosis), and cytokinesis
  - the key events that result in the production of haploid sex cells from a diploid cell (meiosis)
- molecular genetics:
  - the nature of genomes, genes and the genetic code
  - gene expression: the genetic code and roles of RNA in transcription, RNA processing in eukaryotes, and translation
  - the concept of gene regulation (the switching on and off of genes by factors expressed by regulator genes and environmental factors)
- DNA tools and techniques: gel electrophoresis; DNA amplification; DNA sequencing; making a recombinant plasmid; bacterial transformations; DNA profiling; gene cloning; and using plasmids as gene delivery systems
- inheritance:
  - the nature of chromosomes, alleles, genotype and phenotype
  - the causes of phenotypic variation: mutations; recombination of parental alleles in sexual reproduction; polygenes; and interactions of environmental factors with genes
  - continuous and discontinuous variation
  - patterns of inheritance involving the monohybrid cross: dominance; recessiveness; co-dominance; multiple alleles
  - dihybrid crosses as independent or linked; use of the test cross
  - pedigree analysis: autosomal and sex-linked.

AREA OF STUDY 2
Change over time
This area of study focuses on change to genetic material that occurs over time and the changing nature and reliability of evidence that supports the concept of evolution of life forms. Students investigate changes to species and examine the process of natural selection as a mechanism for evolution. Students examine how evolutionary biology has been based upon changes in evidence obtained by accumulation of information over time, changes in interpretation and more recently from molecular biology. Students investigate technological advances that have increased understanding of evolutionary processes and phylogenetic relationships.

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

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

Outcome 2

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

Key knowledge

- a qualitative treatment of changing allele frequencies in a population and the consequences:
  - the concept of the gene pool
  - environmental selection pressures, gene flow, genetic drift (founder and bottleneck effects)
  - natural selection as a mechanism for biological evolution
- evidence for biological evolution over time:
  - the geological time scale; relative and absolute dating techniques
  - the fossil record; biogeography; comparative morphology; molecular homology
- determination of evolutionary relationships: comparison of DNA sequences; comparative genomics; mitochondrial DNA; phylogeny
- patterns of biological change:
  - allopatric speciation
  - divergent and convergent evolution
  - extinctions
- hominin evolution:
  - shared characteristics which define primates, hominoids and hominins
  - major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo* including morphological, structural and cognitive development resulting in cultural evolution and the rise of technologies
- human intervention in evolutionary processes:
  - application of gene technologies including gene cloning, bacterial transformations, stem cell differentiation, genetic screening, gene therapy and DNA profiling
  - selective breeding as a method of affecting and limiting the gene pool.