Unit 1: How do living things stay alive?

In this unit students are introduced to some of the challenges to an organism in sustaining life. Students examine the cell as the structural and functional unit of life, from the single celled to the multicellular organism, and the requirements for sustaining cellular processes in terms of inputs and outputs. They analyse types of adaptations that enhance the organism's survival in a particular environment and consider the role homeostatic mechanisms play in maintaining the internal environment. Students investigate how a diverse group of organisms form a living interconnected community that is adapted to, and utilises, the abiotic resources of its habitat. The role of a keystone species in maintaining the structure of an ecosystem is explored. Students consider how the planet's biodiversity is classified and the factors that affect the growth of a population.

A student practical investigation related to the survival of an organism or species is undertaken in Area of Study 3. The investigation draws on content from Area of Study 1 and/or Area of Study 2.

Area of study 1

How do organisms function?

In this area of study students examine the structure and functioning of cells and how the plasma membrane contributes to survival by controlling the movement of substances into and out of the cell. Although the internal structure of a cell varies, all cells require a relatively stable internal environment for optimal functioning. Whether life forms are unicellular or multicellular, or heterotrophic or autotrophic, whether they live in a deep ocean trench, a tropical rain forest, an arid desert or on the highest mountain peak, all individual organisms are faced with the challenge of obtaining nutrients and water, exchanging gases, sourcing energy and having a means of removal of waste products.

Outcome 1

On completion of this unit the student should be able to investigate and explain how cellular structures and systems function to sustain life.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 1 and the related key science skills on pages 10 and 11 of the study design.

Key knowledge

Cell size, structure and function

- cells as the basic structural feature of life on Earth, including the distinction between prokaryotic and eukaryotic cells
- surface area to volume ratio as an important factor in explaining the limitations of cell size and the need for internal compartments (organelles) with specific cellular functions
- the ultrastructure of plant and animal cells in terms of their organelles and identification of these organelles using the light microscope and electron micrographs.

Crossing the plasma membrane

- the characteristics of the plasma membrane as a semi-permeable boundary between the internal and external environments of a cell
- modes of transport of soluble substances across the plasma membrane including simple diffusion, facilitated diffusion, osmosis and active transport.

Energy transformations

- the distinction between photosynthetic autotrophs, chemosynthetic autotrophs and heterotrophs
- photosynthesis as a chemical process in which solar energy is captured and transformed to chemical energy by fixing carbon to produce a carbohydrate and releasing oxygen as a by-product
- aerobic and anaerobic cellular respiration as a chemical process that commonly uses glucose to produce energy for the cell in both autotrophs and heterotrophs.

Functioning systems

- a study of one selected vascular plant with reference to how its cells are specialised and organised (cells into tissues, and tissues into organs) for the intake, movement and loss of water from the plant
- a study of one selected mammalian system (circulatory, digestive, excretory or respiratory) with reference to how cells in the system are specialised and organised (cells into tissues, tissues into organs and organs into systems), how a specific malfunction can lead to biological consequences and how the system is interconnected to other systems for the survival of the organism.

Area of Study 2

How do living systems sustain life?

In this area of study students examine the structural, physiological and behavioural adaptations of a range of organisms that enable them to survive in a particular habitat and to maintain a viable population size over time. Students consider the distinction between the external and internal environment of an organism and examine how homeostatic mechanisms maintain the internal environment within a narrow range of values for factors including temperature, blood glucose and water balance. They explore the importance and implications of organising and maintaining biodiversity and examine the nature of an ecosystem in terms of the network of relationships within a community of diverse organisms. Students identify a keystone species, explore an organism's relationship to its habitat and evaluate the impact of abiotic factors on the distribution and abundance of organisms within the community. Factors affecting population size and growth are analysed.

Outcome 2

On completion of this unit the student should be able explain how various adaptations enhance the survival of an individual organism, investigate the relationships between organisms that form a living community and their habitat, and analyse the impacts of factors that affect population growth.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 2 and the related key science skills on pages 10 and 11 of the study design.

Key knowledge

Survival through adaptations and regulation

- the structural, physiological and behavioural adaptations that enhance an organism's survival and enable life to exist in a wide range of environments
- successful adaptations as models for biomimicry to solve human challenges
- how regulation of factors is needed to maintain a relatively constant internal environment, explained by the stimulus-response model and the use of homeostatic mechanisms including feedback loops
- factors regulated by homeostatic mechanisms in humans, including temperature, blood glucose and water balance
- malfunctions in homeostatic mechanisms that result in diseases, including Type 1 diabetes and hyperthyroidism in humans.

Organising biodiversity

- classification of biodiversity, past and present, into taxonomic groups based on shared morphological and molecular characteristics, and naming using binomial nomenclature
- strategies for managing Earth's biodiversity to support the conservation of species and as a reservoir for the bio-prospecting of new food sources and medicinal drugs.

Relationships between organisms within an ecosystem

- the beneficial, harmful and benign relationships between species including amensalism, commensalism, mutualism, parasitism and predation
- interdependencies between species as represented by food webs, including impact of changes to keystone species
- the distribution, density and size of a population of a particular species within an ecosystem and the impacts of factors including available resources, predation, competition, disease, chance environmental events, births, deaths and migration.

Area of Study 3

Practical investigation

Survival requires control and regulation of factors within an individual and often outside the individual. In this area of study students design and conduct a practical investigation into the survival of an individual or a species.

The investigation requires the student to develop a question, plan a course of action to answer the question, undertake an investigation to collect the appropriate primary qualitative and/or quantitative data, organise and interpret the data and reach a conclusion in response to the question. The investigation is to be related to knowledge and skills developed in Areas of Study 1 and/or 2 and is conducted by the student through laboratory work, fieldwork and/or observational studies.

Outcome 3

On completion of this unit the student should be able to design and undertake an investigation related to the survival of an organism or species, and draw conclusions based on evidence from collected data.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 3 and the related key science skills on pages 10 and 11 of the study design.

Key knowledge

- the biological concepts specific to the investigation and their significance, including definitions of key terms, and biological representations
- the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the investigation: laboratory work (microscopy), fieldwork (quadrats, transects and field guides) and/or observational studies of animal behavior; precision, accuracy, reliability and validity of data; and minimisation of experimental bias
- ethics and issues of research including identification and application of relevant health, safety and bioethical guidelines
- methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and limitations of data and methodologies
- observations and experiments that are consistent with, or challenge, current biological models or theories
- the nature of evidence that supports or refutes a hypothesis, model or theory

- options, strategies or solutions to issues related to organism or species survival
- the key findings of the selected investigation and their relationship to cytological and/or ecological concepts
- the conventions of scientific report writing including biological terminology and representations, standard abbreviations and units of measurement.

Assessment

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks that provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study, including the key knowledge and key skills listed for the outcomes, should be used for course design and the development of learning activities and assessment tasks. Assessment must be a part of the regular teaching and learning program and should be completed mainly in class and within a limited timeframe.

All assessments at Units 1 and 2 are school-based. Procedures for assessment of levels of achievement in Units 1 and 2 are a matter for school decision.

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

Suitable tasks for assessment may be selected from the following:

For Outcomes 1 and 2

- a report of a fieldwork activity
- annotations of a practical work folio of activities or investigations
- a bioinformatics exercise
- media response
- data analysis
- problem solving involving biological concepts, skills and/or issues
- a reflective learning journal/blog related to selected activities or in response to an issue
- a test comprising multiple choice and/or short answer and/or extended response.

For Outcome 3

- a report of a student-designed or adapted investigation related to the survival of an organism or a species using an appropriate format, for example a scientific poster, practical report, oral communication or digital presentation.

Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

Practical work is a central component of learning and assessment. As a guide, between 3½ and 5 hours of class time should be devoted to student practical work and investigations for each of Areas of Study 1 and 2. For Area of Study 3, between 6 and 8 hours of class time should be devoted to undertaking the investigation and communicating findings.

Unit 2: How is continuity of life maintained?

In this unit students focus on cell reproduction and the transmission of biological information from generation to generation. Students learn that all cells are derived from pre-existing cells through the cell cycle. They examine the process of DNA replication and compare cell division in both prokaryotic and eukaryotic organisms. Students explore the mechanisms of asexual and sexual reproductive strategies, and consider the advantages and disadvantages of these two types of reproduction. The role of stem cells in the differentiation, growth, repair and replacement of cells in humans is examined, and their potential use in medical therapies is considered.

Students use chromosome theory and terminology from classical genetics to explain the inheritance of characteristics, analyse patterns of inheritance, interpret pedigree charts and predict outcomes of genetic crosses. They explore the relationship between genes, the environment and the regulation of genes in giving rise to phenotypes. They consider the role of genetic knowledge in decision making about the inheritance of autosomal dominant, autosomal recessive and sex-linked genetic conditions. In this context the uses of genetic screening and its social and ethical issues are examined.

A student-directed research investigation into, and communication of, an issue related to genetics and/or reproductive science is to be undertaken in Area of Study 3. The investigation draws on content from Area of Study 1 and/or Area of Study 2.

Area of Study 1

How does reproduction maintain the continuity of life?

In this area of study students consider the need for the cells of multicellular organisms to multiply for growth, repair and replacement. They examine the main events of the cell cycle in prokaryotic and eukaryotic cells. Students become familiar with the key events in the phases of the cell cycle, and focus on the importance of the processes involved in a cell's preparation for cell division. Students investigate and use visualisations and modelling to describe the characteristics of each of the phases in mitosis. Cytokinesis is explained for both plant and animal cells. Students describe the production of gametes in sexual reproduction through the key events in meiosis and explain the differences between asexual and sexual reproduction in terms of the genetic makeup of daughter cells. Students consider the role and nature of stem cells, their differentiation and the consequences for human prenatal development and their potential use to treat injury and disease.

Outcome 1

On completion of this unit the student should be able to compare the advantages and disadvantages of asexual and sexual reproduction, explain how changes within the cell cycle may have an impact on cellular or tissue system function and identify the role of stem cells in cell growth and cell differentiation and in medical therapies.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 1 and the related key science skills on pages 10 and 11 of the study design.

Key knowledge

The cell cycle

- derivation of all cells from pre-existing cells through completion of the cell cycle
- the rapid procession of prokaryotic cells through their cell cycle by binary fission
- the key events in the phases (G1, S, G2, M and C) of the eukaryotic cell cycle, including the characteristics of the sub-phases of mitosis (prophase, metaphase, anaphase and telophase) and cytokinesis in plant and animal cells.

Asexual reproduction

- the types of asexual reproduction including fission, budding, vegetative propagation and spore formation
- the biological advantages and disadvantages of asexual reproduction
- emerging issues associated with cloning, including applications in agriculture and horticulture.

Sexual reproduction

- how an offspring from two parents has a unique genetic identity
- the key events in meiosis that result in the production of gametes from somatic cells including the significance of crossing over of chromatids between homologous chromosomes in Prophase 1 and the non-dividing of the centromere in Metaphase 1
- the biological advantage of sexual reproduction, specifically the genetic diversity in offspring.

Cell growth and cell differentiation

- the types and function of stem cells in human development, including the distinction between embryonic and adult stem cells and their potential use in the development of medical therapies
- the consequences of stem cell differentiation in human prenatal development including the development of germ layers, types of tissues formed from germ layers and the distinction between embryo and foetus
- the disruption of the regulation of the cell cycle through genetic predisposition or the action of mutagens that gives rise to uncontrolled cell division including cancer and abnormal embryonic development.

Area of Study 2

How is inheritance explained?

In this area of study students build on their understanding of the nature of genes and the use of genetic language to read and interpret patterns of inheritance and predict outcomes of genetic crosses. They gain an understanding that a characteristic or trait can be due solely to one gene and its alleles, or due to many genes acting together, or is the outcome of genes interacting with external environmental or epigenetic factors. Students apply their genetic knowledge to consider the social and ethical implications of genetic applications in society including genetic screening and decision making regarding the inheritance of autosomal and sex-linked conditions.

Outcome 2

On completion of this unit the student should be able to apply an understanding of genetics to describe patterns of inheritance, analyse pedigree charts, predict outcomes of genetic crosses and identify the implications of the uses of genetic screening and decision making related to inheritance.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 2 and the related key science skills on pages 10 and 11 of the study design.

Key knowledge

Genomes, genes and alleles

- the distinction between a genome, gene and allele
- the genome as the sum total of an organism's DNA measured in the number of base pairs contained in a haploid set of chromosomes
- the role of genomic research since the Human Genome Project, with reference to the sequencing of the genes of many organisms, comparing relatedness between species, determining gene function and genomic applications for the early detection and diagnosis of human diseases.

Chromosomes

- the role of chromosomes as structures that package DNA, their variability in terms of size and the number of genes they carry in different organisms, the distinction between an autosome and a sex chromosome and the nature of a homologous pair of chromosomes (one maternal and one paternal) as carrying the same gene loci
- presentation of an organism's set of chromosomes as a karyotype that can be used to identify chromosome number abnormalities including Down's, Klinefelter's and Turner's syndromes in humans.

Genotypes and phenotypes

- the use of symbols in the writing of the genotypes for the alleles present at a particular gene locus
- the distinction between a dominant and recessive phenotype
- the relative influences of genetic material, environmental factors and interactions of DNA with other molecules (epigenetic factors) on phenotypes
- qualitative treatment of polygenic inheritance as contributing to continuous variation in a population, illustrated by the determination of human skin colour through the genes involved in melanin production or by variation in height.

Pedigree charts, genetic cross outcomes and genetic decision-making

- pedigree charts and patterns of inheritance including autosomal dominant, autosomal recessive, X-linked and Y-linked traits
- the determination of genotypes and prediction of the outcomes of genetic crosses including monohybrid crosses, and monohybrid test crosses
- the inheritance of two characteristics as either independent or linked, and the biological consequence of crossing over for linked genes
- the nature and uses of genetic testing for screening of embryos and adults, and its social and ethical implications.

Area of Study 3

Investigation of an issue

The increasing uses and applications of genetics knowledge and reproductive science in society both provide benefits for individuals and populations and raise social, economic, legal and ethical questions. Human cloning, genetic modification of organisms, the use of forensic DNA databanks, assisted reproductive technologies and prenatal and predictive genetic testing challenge social and ethical norms. In this area of study students apply and extend their knowledge and skills developed in Areas of Study 1 and/or 2 to investigate an issue involving reproduction and/or inheritance.

They communicate the findings of their investigation and explain the biological concepts, identify different opinions, outline the legal, social and ethical implications for the individual and/or species and justify their conclusions. Material for the investigation can be gathered from laboratory work, computer simulations and modelling, literature searches, global databases and interviews with experts.

Outcome 3

On completion of this unit the student should be able to investigate and communicate a substantiated response to a question related to an issue in genetics and/or reproductive science.

To achieve this outcome the student will draw on key knowledge outlined in Area of Study 3 and the related key science skills on pages 10 and 11 of the study design.

Key knowledge

- the characteristics of effective science communication: accuracy of biological information; clarity of explanation of biological concepts, ideas and models; contextual clarity with reference to importance and implications of findings; conciseness and coherence; and appropriateness for purpose and audience
- the biological concepts specific to the investigation: definitions of key terms; use of appropriate biological terminology, conventions and representations
- the use of data representations, models and theories in organising and explaining observed phenomena and biological concepts, and their limitations
- the nature of evidence and information: distinction between opinion, anecdote and evidence, weak and strong evidence, and scientific and non-scientific ideas; and validity, reliability and authority of data including sources of possible errors or bias
- the influence of social, economic, legal and ethical factors relevant to the selected biological issue.

Assessment

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- data analysis
- problem solving involving biological concepts, skills and/or issues
- a reflective learning journal/blog related to selected activities or in response to an issue
- a test comprising multiple choice and/or short answer and/or extended response.

For Outcome 3

- a report of an investigation into genetics and/or reproductive science using an appropriate format, for example, digital presentation, oral communication or written report.

Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

Practical work is a central component of learning and assessment. As a guide, between 3½ and 5 hours of class time should be devoted to student practical work and investigations for each of Areas of Study 1 and 2. For Area of Study 3, between 6 and 8 hours of class time should be devoted to undertaking the investigation and communicating findings.