BIOLOGY (revised)
Higher

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National Course specification

Biology (revised) Higher

COURSE CODE C274 12

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Course structure

This Course has three mandatory Units. The mandatory Units are:

FH2G 12	*DNA and the Genome* (Higher)	6 SCQF credits
FH2H 12	*Metabolism and Survival* (Higher)	6 SCQF credits
FH2J 12	*Sustainability and Interdependence* (Higher)	6 SCQF credits

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained a Biology National Qualification at SCQF level 5 or its equivalent.

Progression

This Course or its Units may provide progression to:

- Advanced Higher Biology
- Life Science Courses at SCQF level 7

National Course specification: (cont)

COURSE Biology (revised) Higher

Credit value

The Higher Course in Biology (revised) is allocated 24 SCQF credit points at SCQF level 6*.

**SCQF points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Each of the Units in this Course attracts 6 SCQF credits. Units attracting 6 credits would be 40 hours of programmed learning. This Course includes 6 SCQF credits for 40 additional programmed hours which are not tied to any specific Unit. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for Course assessment.

Core Skills

Achievement of this Course gives automatic certification of the following:

Complete Core Skill	*Problem Solving* at SCQF level 6
Core Skill component	Using Graphical Information at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of the Unit specifications for this Course.

National Course specification: Course details (cont)

COURSE Biology (revised) Higher

Rationale

The Higher Biology Course is a broad and up to date selection of concepts and ideas relevant to the central position of life science within our society. It covers all of the major themes of biology (cells, evolution, genetics, homeostasis, energy and ecosystems) and builds on previous learning.

The Course allows candidates to develop deeper understanding of the underlying themes of biology: evolution and adaptation; structure and function; genotype and niche. Within each of the three Units the scale of topics ranges from molecular through to whole organism and beyond. In addition, to increase the relevance of the Course, within each Unit the most relevant applications of biological understanding are highlighted allowing the development of capabilities associated with becoming successful candidates, confident individuals, responsible citizens and effective contributors in real life contexts.

The study of Higher Biology provides opportunities to develop investigative science and practical skills contributing to candidates' scientific literacy and to developing skills for learning, life and work. These skills prepare candidates for life in the 21st century by enabling them to adapt their learning to new situations, solve problems, make decisions based on evidence and to evaluate the impact of science developments on their own heath and well being, society and the environment.

By setting the acquisition of biological knowledge and skills in the context of Higher Biology a stimulating, relevant and enjoyable curriculum prepares candidates for further education, training or employment in areas associated with life sciences.

Course content

The content of the Higher Biology Course develops Knowledge and Understanding, skills of scientific experimentation, investigation and enquiry and skills for learning, life and work. The Knowledge and Understanding and the skills associated with the Course content should be developed in contexts related to the content and explanatory notes in the tables of the Course specification. The suggested learning activities and approaches provide contexts in which science skills and Knowledge and Understanding can be developed and are not liable for assessment although they may provide contexts for assessment items. It is not intended that candidates should cover all of these suggested learning activities and approaches, rather a selection of these may be used along with other activities and approaches to best suit candidates' needs.

Knowledge and Understanding

Through study of the biology associated with the content statements and explanatory notes in the following tables candidates should be able to:

1 Demonstrate knowledge by making accurate statements about and describing the biology of cells, organisms, relationships, processes, systems and cycles.
2 Apply their knowledge to new situations and when interpreting biological information and solving problems.
3 Demonstrate understanding by providing explanations and integrating different areas of knowledge.

Skills of scientific experimentation, investigation and enquiry

Practical work is essential in providing the contexts for the development of science skills. Through practical work candidates develop a deeper understanding of biological knowledge and acquire skills of:

1 Selecting and analysing relevant information from texts, tables, charts, keys, graphs and/or diagrams.
2 Presenting information appropriately in a variety of forms, including, extended writing, diagrams, tables and/or graphs.
3 Processing information accurately using calculations where appropriate. Calculations to include percentages, averages and/or ratios. Significant figures and units should be used appropriately.
4 Planning and designing experimental procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required.
5 Evaluating experimental procedures by commenting on the purpose or approach, the suitability and effectiveness of procedures, the control of variables, the limitations of equipment, possible sources of error and/or suggestions for improvement.
6 Drawing valid conclusions and giving explanations supported by evidence or justification. Conclusions should include reference to the overall pattern to readings or observations, trends in results or comment on the connection between variables and controls.
7 Making predictions and generalisations based on available evidence.

National Course specification: Course details (cont)

Course content (cont)

Skills for learning, life and work

By acquiring the knowledge, understanding and skills involved in the study of Biology candidates should develop capabilities that will enable them to be successful candidates, confident individuals, responsible citizens and effective contributors. By becoming scientifically literate individuals they should be able to communicate scientific knowledge by selecting and presenting relevant information. They should be able to analyse and interpret data to draw conclusions and to make predictions and generalisations. They should be able to solve problems through research, applying knowledge and through practical work in the field and laboratory. Planning and organising skills should be developed through practical work. The use of information technology should include interfacing equipment and data handling software. Candidates should be able to identify hazards, assess risk and suggest control measures and to make ethical decisions based on relevant information and the consequences of a course of action.

National Course specification: Course details (cont)

UNIT 1 — DNA and the Genome

Introduction

Through the study of DNA and the genome, this Unit explores the molecular basis of evolution and biodiversity. The universal nature of DNA as the information storage molecule is emphasised, while relevant differences in the organisation of DNA between prokaryotes and eukaryotes are highlighted. The link between the precision of replication of DNA and the complementary nature of DNA bases is central to the understanding of both DNA replication for cell division and the *in vitro* replication technology of PCR. A deeper understanding of the action of DNA polymerase is developed through the introduction of primers and the antiparallel structure of the DNA molecule.

The unity of life is emphasised again in the study of gene expression; all life shares the genetic code. Gene expression now reflects the central importance of 'one gene, many proteins'. Stages involved in gene expression include transcription, splicing, translation and post-translational modification. Splicing removes unwanted sections of RNA to form the mRNA that will be translated into an amino acid sequence. Post-translational modification can also alter the final protein expressed. The result of these processes is that a limited number of genes can be controlled to give rise to a wide array of proteins.

An understanding of gene expression at the cellular level leads to the study of the differentiation at the level of the organism. Central to this is an appreciation of the role of meristem and stem cells. The research and therapeutic value of stem cells provides an opportunity to consider ethical issues that the responsible citizen of the 21st century will have to face.

Our understanding of the evolution of the genome is one of the many growth areas of biology. The structure of the genome is introduced and genes are defined as protein-coding sequences to keep in line with common usage. The Course also puts emphasis on a range of non-protein-coding sequences. Changes to the genome are mutations, and the effects of the most important categories are included. Evolution is thoroughly considered in terms of inheritance, selection, drift and speciation. The sequencing of genomes and their comparison provides unparalleled opportunity for understanding the phylogenetic patterns of divergence. The Course encompasses the use of this evidence in classifying life into three domains and developing our understanding of the main patterns in the evolution of life from first cells to vertebrates. Genomics is also used to compare disease-causing organisms, pest species and important model organisms for research, the results of which are applicable across species boundaries given that so much of the genome is highly conserved. In addition, genomics has medical applications as it can provide personal information of benefit in assessing likelihood of disease and appropriate treatment strategies. Genomics is one of the major scientific advances of recent years and has significant implications for issues related to access to personal health information and for choices and decision making in families and communities.

National Course specification: Course details (cont)

Candidates should have a clear understanding of the following areas of content from their previous learning:

- Cell division and chromosomes
- Base sequence and base pairing of DNA
- Function of proteins
- Evolution by natural selection
- Species
- Classification of life
- Cell ultrastructure and function

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
1 The structure and replication of DNA		
(a) DNA	DNA encodes hereditary information in a chemical language. All cells store their genetic information in the base sequence of DNA. The genotype is determined by the sequence of bases.	
(i) Structure of DNA	Structure of a DNA nucleotide (deoxyribose sugar, phosphate and base). Nucleotides bond to form a sugar–phosphate backbone. Base pairs (adenine, thymine and guanine, cytosine) held by hydrogen bonds forming a double helix. Double stranded antiparallel structure with deoxyribose and phosphate at 3' and 5' ends of each strand.	Case study examining the experimental evidence of the bacterial transformation experiments of Griffiths and identification of DNA as the transforming principle by Avery *et al.*, phage experiments of Hershey and Chase, Chargaff's base ratios and the X ray crystallography of Wilkins and Franklin.
(ii) Organisation of DNA in prokaryotes and eukaryotes	DNA is a double stranded molecule that can be circular or linear. Circular chromosomal DNA and plasmids in prokaryotes. Circular plasmids in yeast. Circular chromosome in mitochondria and chloroplasts of eukaryotes. The DNA found in the linear chromosomes of the nucleus of eukaryotes is tightly coiled and packaged with associated proteins.	Watson and Crick's double helix model as an evidence based conclusion. Case study on Meselson and Stahl experiments on DNA replication. DNA gel electrophoresis. Comparison of DNA extraction from peas and kiwi fruit (false positive result in latter as DNA is obscured by pectin).

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(b) DNA can direct its own replication		
(i) Replication of DNA	Prior to cell division, DNA polymerase replicates a DNA strand precisely using DNA nucleotides. DNA polymerase needs a primer to start replication. DNA unwinds to form two template strands. DNA polymerase adds complementary nucleotides to the deoxyribose (3') end of a DNA strand. This process occurs at several locations on a DNA molecule. DNA polymerase can only add nucleotides in one direction resulting in one strand being replicated continuously and the other strand replicated in fragments. Fragments of DNA are joined together by ligase.	Virtual or physical modelling of DNA replication.
(ii) Polymerase Chain Reaction (PCR)	The polymerase chain reaction (PCR) is a technique for the amplification of DNA *in vitro*. In PCR, primers are complementary to specific target sequences at the two ends of the region to be amplified.	Case study on the use of PCR, including practical using thermal cycler or water baths. Emphasise the 'needle in a haystack' accuracy of primers and the amplification of 'a haystack from the needle' by PCR.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
	DNA is heated to separate the strands. Cooling allows primers to bind to target sequences. Heat tolerant DNA polymerase then replicates the region of DNA. Repeated cycles of heating and cooling amplify this region of DNA.	Investigating plant evolution using chloroplasmic DNA and PCR.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
2 Gene expression	The genetic code used in transcription and translation is found in all forms of life.	
	The phenotype is determined by the proteins produced as the result of gene expression, influenced by intra- and extra-cellular environmental factors.	Separation and identification of fish proteins by agarose gel electrophoresis.
(a) Expression of genes in eukaryotes	Only a fraction of the genes in a cell are expressed. Gene expression is controlled by the regulation of both transcription and translation. mRNA is transcribed from DNA in the nucleus and translated into proteins by ribosomes in the cytoplasm.	
(i) Proteins	Proteins have a large variety of structures and shapes resulting in a wide range of functions.	Investigation of the shape and structure of fibrous and globular proteins using RasMol or protein explorer software.
	Amino acids are linked by peptide bonds to form polypeptides. Polypeptide chains fold to form the three-dimensional shape of a protein. Chains are held together by hydrogen bonds and other interactions between individual amino acids.	Separation and identification of amino acids using paper chromatography.
	In covering the functions of proteins, reference should be made to the variety of proteins encountered in SCQF level 5 Courses.	

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(ii) Structure and functions of RNA	Single strand, replacement of thymine with uracil and deoxyribose with ribose compared to DNA. mRNA carries a copy of the DNA code from the nucleus to the ribosome. rRNA and proteins form the ribosome. Each tRNA carries a specific amino acid.	
(iii) Transcription of DNA into an RNA molecule	RNA polymerase moves along DNA unwinding the double helix and synthesising a primary transcript of RNA from RNA nucleotides by complementary base pairing. Eukaryotic genes have introns (non coding regions of genes) and exons (coding regions of genes). The introns of the primary transcript of mRNA are removed in RNA splicing.	Modelling transcription and translation using virtual and physical resources.
(iv) Translation of mRNA into a polypeptide	tRNA folds due to base pairing to form a triplet anticodon site and an attachment site for a specific amino acid. Triplet codons and anticodons of the genetic code. Start and stop codons. Codon recognition of incoming tRNA, peptide bond formation and exit of tRNA from the ribosome as polypeptide is formed.	

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(v) One gene, many proteins	A variety of proteins can be expressed from the same gene as a result of alternative RNA splicing and post-translational modification. Different mRNA molecules are produced from the same primary transcript depending on which RNA segments are treated as exons and introns. Post translation protein structure modification by cutting and combining polypeptide chains or by adding phosphate or carbohydrate groups to the protein.	
(c) Differentiation in multicellular organisms	Cellular differentiation is the process by which a cell develops more specialised functions. Specialised cells express the genes characteristic for that type of cell.	

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(i) Meristems and stem cells	Meristems are regions of unspecialised cells in plants that are capable of cell division. Cells produced in meristems differentiate into specialised cells.	Tissue culture of plant material
	Stem cells are relatively unspecialised cells in animals that can continue to divide and can differentiate into specialised cells of one or more types. In the very early embryo, embryonic stem cells differentiate into all the cell types that make up the organism. Tissue (adult) stem cells replenish differentiated cells that need to be replaced and give rise to a more limited range of cell types. Once a cell becomes differentiated it only expresses the genes that produce the proteins characteristic for that type of cell.	Case study on use of stem cells in repair of diseased or damaged organs (eg skin grafts, bone marrow transplantation and cornea repair). Case study on ethics of stem cell research and sources of stem cells. For example, embryo cells must not be allowed to develop beyond 14 days, around the time a blastocyst would be implanted in a uterus. Sources of stem cells include embryonic stem cells, tissue stem cells and attempts to reprogramme specialised cells to an embryonic state. Ethical issues could include: regulations on the use of embryo stem cells, the use of induced pluripotent stem cells and the use of nuclear transfer techniques.
(ii) Research and therapeutic value of stem cells	Stem cell research provides information on how cell processes such as cell growth, differentiation and gene regulation work. The therapeutic uses of stem cells should be exemplified by reference to the repair of damaged or diseased organs. The ethical issues of stem cell use and the regulation of their use.	

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
3 Genome		
(a) The structure of the genome	The genome of an organism is its hereditary information encoded in DNA. DNA sequences that code for protein are defined as genes. A genome is made up of genes and other DNA sequences that do not code for proteins. Most of the eukaryotic genome consists of these non-coding sequences. Non-coding sequences include those that regulate transcription and those that are transcribed to RNA but are never translated. Some non-coding sequences have no known function.	Non translated forms of RNA include tRNA, rRNA and RNA fragments.
(b) Mutation	Mutations are random changes in the genome. Mutations can alter alleles, genes, gene expression or chromosomes.	Investigate mutant yeast or germination rates of irradiated seeds.
(i) Point mutations: nucleotide substitution, insertion and deletion	Mutation within genes and impact on protein structure. Regulatory sequence mutations can alter gene expression. Splice site mutations can alter post transcriptional processing. Importance of point mutation in evolution.	Investigate how point mutations can be silent, neutral, missense, nonsense or frame-shift. Research reasons for geographical variation in incidence of post-weaning lactose tolerance or sickle-cell trait in humans as examples of point mutation.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(ii) Chromosome structure mutations	Alterations to the structure of one or more chromosomes: duplication, deletion, translocation and inversion. Importance of gene duplication in evolution.	Analyse evidence for formation of human chromosome 2 by fusion of two ancestral chromosomes. Gene duplication and alpha and beta globins in haemoglobin.
(iii) Polyploidy	Errors during the separation of chromosomes during cell division can result in cells with whole genome duplications. Importance of polyploidy in evolution and human food crops.	Research polyploidy in plants and importance in origin of crop plants. Examples include banana (triploid) and potato (tetraploid), as well as swede, oil seed rape, wheat and strawberry. Research rarity of polyploidy in animals. Examples include tetraploidy in early vertebrate evolution and the plains viscacha rat.
(c) Evolution	The changes in organisms over generations as a result of genomic variations.	
(i) Inheritance	Genetic sequences are inherited vertically from parent to offspring as a result of sexual or asexual reproduction. Prokaryotes can exchange genetic material horizontally, resulting in rapid evolutionary change. Prokaryotes and viruses can transfer sequences horizontally into the genomes of eukaryotes.	
(ii) Selection	The non-random increase in frequency of sequences that increase survival (natural selection) or successful reproduction (sexual selection). The non-random reduction in frequency of deleterious sequences. The differences in outcome as a result of stabilising, directional and disruptive selection.	Gather data on sexual selection in brine shrimp.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(iii) Drift	The random increase and decrease in frequency of sequences, particularly in small populations, as a result of neutral mutations and founder effects.	
(iv) Speciation	Speciation is the generation of new biological species by evolution. A species is a group of organisms capable of interbreeding and producing fertile offspring, and which does not normally breed with other groups.	Research different definitions of the term species (eg biological species concept, phylogenetic species concept) and the difficulty of applying species definition to asexually reproducing organisms.
	The importance of geographical barriers in allopatric speciation. The importance of behavioural or ecological barriers in sympatric speciation.	Research the London Underground mosquito.
	The formation of hybrid zones in regions where the ranges of closely related species meet.	Collaborative data gathering of hooded crow and carrion crow hybrid zone in Scotland.
(d) Genomic sequencing	The sequence of nucleotide bases can be determined for individual genes and entire genomes. To compare sequence data, computer and statistical analyses (bioinformatics) are required.	Research how sequencing technologies use techniques such as fluorescent tagging of nucleotides to identify the base sequence.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(i) Phylogenetics and molecular clocks	The use of sequence data to study the evolutionary relatedness among groups of organisms. Sequence divergence is used to estimate time since lineages diverged. For example, comparison of sequences provides evidence for three main domains (bacteria, archaea and eukaryotes).	Case study on the evolution of bears and primates using Geneious software. Highly conserved DNA sequences are used for comparisons of distantly related genomes.
	The use of sequence data and fossil evidence to determine the main sequence of events in evolution of life: cells, last universal ancestor, photosynthesis, eukaryotes, multicellularity, animals, land plants, vertebrates.	Compare number and proportion of shared genes between organisms such as *C. elegans*, *Drosophila* and humans.
(ii) Genomics	Many genomes have been sequenced, particularly of disease-causing organisms, pest species and species that are important model organisms for research.	Research the importance of the *Fugu* genome as an example of a very small vertebrate genome with a high rate of chromosome deletion.
	Comparisons of genomes reveals that much of the genome is highly conserved across different organisms.	Comparison of human and chimp genomes reveals rapid change in genes for immune system and regulation of neural development over last 6 million years.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(iii) Personal genomics	Analysis of an individual's genome may lead to personalised medicine (pharmacogenetics) through knowledge of the genetic component of risk of disease and likelihood of success of a particular treatment. The difficulties in distinguishing between neutral and harmful mutations in both genes and regulatory sequences, and in understanding the complex nature of many diseases.	Comparison of individual's genomes focuses on point mutations, repetitive sequence errors and blocks of duplication and deletion.

National Course specification: Course details (cont)

UNIT 2 — Metabolism and Survival

Introduction

This Unit considers the central metabolic pathways of Adenosine triphosphate (ATP) synthesis by respiration. It links these reactions to the challenge of maintaining this metabolism for survival in widely different niches and to the flexibility of the environmental and genetic control of metabolism in microorganisms.

The control of metabolic pathways is essential to cell survival. Metabolism is the network of connected and integrated pathways with its reversible and irreversible steps and alternative routes. Membranes within and surrounding cells provide surfaces and compartments for the organisation and specialisation of metabolism. ATP has a key role in the transfer of energy between catabolic and anabolic reactions and in the phosphorylation of molecules. At this level it is important to understand the flexible and dynamic shape of enzymes and the functioning of the active site as well as the importance of regulatory molecules that influence enzyme shape and allow feedback inhibition.

Cellular respiration is fundamental to metabolism. The stages of glycolysis, the citric acid cycle and electron transport are introduced. There is no need to account for carbon atoms; it is the removal of hydrogen along with associated high-energy electrons and their transfer to the electron transfer chain that is critical in the cell's energy economy. A key concept in biology is the action of electron transfer chains in pumping hydrogen ions across a membrane. The return flow of these ions drives ATP synthesis by the enzyme ATP synthase. The wide range of respiratory substrates used for respiration demonstrates the connected and integrated nature of metabolic pathways.

Moving to the scale of the whole organism, adaptations for the maintenance of metabolism for survival are considered. As part of this work, the rate of metabolism of organisms can be measured in the laboratory. Oxygen delivery to tissues is essential in aerobic organisms and can be illustrated by study of the different anatomical adaptations across different vertebrate groups and physiological adaptations for low-oxygen niches. The costs and benefits of the metabolic strategies demonstrated by conformers and regulators are contrasted with particular reference to thermoregulation. Adaptations for the survival and avoidance of extreme conditions include dormancy and migration, and the latter is used as an example for understanding the challenges involved in both data gathering and in the design of experiments. In considering the design of experiments, candidates should work cooperatively and think creatively and independently to solve problems through a scientific approach. The unusual metabolic adaptations of extremophiles, organisms that live in extreme environments that would be fatal to almost all others, are also considered.

National Course specification: Course details (cont)

The manipulation of the metabolism of microorganisms is of great importance both in the laboratory and in industry. Through the manipulation of environmental conditions during culture, particular metabolic products can be generated by microorganisms. In addition, microbial metabolism can be manipulated genetically through mutagenesis, selective breeding or the use of recombinant DNA technology. A consideration of the use of microorganisms provides opportunities to identify hazards and to evaluate risks as well as to make the informed choices of a confident individual on the ethical issues of recombinant DNA technology and the use of microorganisms.

Candidates should have a clear understanding of the following areas of content from their previous learning:

- Enzymes
- Negative feedback control
- Genetic engineering
- Summary equation for respiration
- ATP and energy
- Aseptic techniques
- Microbial culture techniques

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
1 Metabolism is essential for life		
(a) Introduction to metabolism	Metabolism encompasses the integrated and controlled pathways of enzyme-catalysed reactions within a cell.	Case study on the toxic effects of venoms, toxins and poisons on metabolic pathways.
(i) Metabolic pathways (anabolism and catabolism)	Metabolic pathways involve biosynthetic processes (anabolism) and the breakdown of molecules (catabolism) to provide energy and building blocks. Synthetic pathways require the input of energy; pathways that break down molecules usually release energy. Metabolic pathways can have reversible and irreversible steps and alternative routes may exist that can bypass steps in a pathway.	
(ii) Membranes form metabolic surfaces and compartments	Membranes can form compartments to localise the metabolic activity of the cell. The roles of protein pores, pumps and enzymes embedded in phospholipid membranes. The high surface to volume ratio of small compartments allows high concentrations and high reaction rates.	Examine photomicrographs to compare ultrastructure of prokaryotes and eukaryotes and compartments and membranes in mitochondria and chloroplasts.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(b) Control of metabolic pathways	Metabolic pathways are controlled by the presence or absence of particular enzymes in the metabolic pathway and through the regulation of the rate of reaction of key enzymes within the pathway. Regulation can be controlled by intra- and extra cellular signal molecules.	Enzyme induction experiments such as ONPG and lactose metabolism in E. coli and PGlo experiments.
Enzyme action	The activity of enzymes depends on their flexible and dynamic shape. The affinity of substrate molecules for the active site of an enzyme and induced fit. The role of the active site in orientating reactants, lowering the activation energy of the transition state and the release of products with low affinity for the active site.	Activation energy experiments, comparing heat, manganese dioxide and catalase action on hydrogen peroxide.
	The effects of substrate and end product concentration on the direction and rate of enzyme reactions. Most metabolic reactions are reversible and the presence of a substrate or the removal of a product will drive a sequence of reactions in a particular direction. Enzymes often act in groups or as multi-enzyme complexes.	Experiments on reaction rate with increasing substrate concentration. DNA and RNA polymerases are part of multi enzyme complexes.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
Control of metabolic pathways through the regulation of enzyme action	Genes for some enzymes are continuously expressed. These enzymes are always present in the cell and they are controlled through the regulation of their rates of reaction. Non-competitive inhibition or stimulation of enzyme activity by the binding of molecules that change the shape of the active site. Competitive inhibition for the active site by molecules that resemble the substrate and its reversal by increasing substrate concentration. The control of metabolic pathways by feedback inhibition where an end product binds to an enzyme that catalyses a reaction early in the pathway.	Investigate the inhibition of beta galactosidase by galactose and its reversal by increasing ONPG concentration. Experiments on product inhibition with phosphatase.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(c) Cellular respiration	Cellular respiration pathways are present in cells from all three domains of life. The metabolic pathways of cellular respiration are of central importance to cells. They yield energy and are connected to many other pathways. Glucose is broken down in a series of enzyme controlled steps. Hydrogen and high energy electrons are removed by dehydrogenase enzymes and used to yield ATP.	
(i) Transfer of energy via ATP	ATP is used to transfer the energy from cellular respiration to synthetic pathways and other cellular processes where energy is required. The breakdown of ATP to ADP and phosphate releasing energy. The regeneration of ATP from ADP and phosphate using the energy released from cellular respiration. The phosphorylation of molecules to alter their reactivity.	Experiments on ATP dependent reactions, eg luciferase, luminescent reactions. Investigate a phosphorylated substrate (eg glucose-1-phosphate) using suitable positive and negative controls in the design of an experiment.
(ii) Synthesis of ATP	To synthesise the bulk of its ATP requirements, a cell uses a source of high-energy electrons to pump H ions across a membrane. The return flow of these ions rotates part of the membrane protein ATP synthase, catalysing the synthesis of ATP.	

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(iii) Metabolic pathways of cellular respiration		
Glycolysis	The breakdown of glucose to pyruvate during glycolysis. The phosphorylation of intermediates in glycolysis in an energy investment phase and the direct generation of ATP in an energy pay off stage. Pyruvate progresses to the citric acid cycle if oxygen is available. In the absence of oxygen, the pyruvate undergoes a fermentation to either lactate or ethanol and CO_2.	
Citric acid cycle	Pyruvate is broken down to an acetyl group that combines with coenzyme A to be transferred to the citric acid cycle as acetyl coenzyme A. Acetyl coenzyme A combines with oxaloacetate to form citrate, followed by the enzyme-mediated steps of the citric acid cycle with some generation of ATP, the release of carbon dioxide and the regeneration of oxaloacetate.	Research how Hans Krebs discovered the citric acid cycle. Experiments on inhibition of citric acid cycle with malonic acid and DCPIP as an indicator of dehydrogenase activity.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
Electron transport chain	The electron transport chain as a collection of proteins attached to a membrane. At certain steps in the glycolytic and citric acid pathways, dehydrogenase enzymes remove hydrogen ions from the substrate along with associated high-energy electrons. These hydrogen ions and high-energy electrons are passed to the coenzymes NAD or FAD forming NADH or $FADH_2$. NADH and $FADH_2$ release the high-energy electrons to the electron transport chain where they cascade down the chain, releasing energy. The energy is used to pump H ions across the inner mitochondrial membrane. The return flow of H ions drives ATP synthase and produces the bulk of the ATP generated by cellular respiration. The final electron acceptor is oxygen, which then combines with hydrogen ions and electrons to form water.	Experiments with yeast dehydrogenase, eg using resazurin.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(ii) Substrates for respiration	Starch and glycogen are broken down to glucose for use as a respiratory substrate. Other sugar molecules can be converted to glucose or glycolysis intermediates for use as respiratory substrates. Proteins can be broken down to amino acids and converted to intermediates of glycolysis or the citric acid cycle for use as respiratory substrates. Fats can also be broken down to intermediates of glycolysis and the citric acid cycle.	Investigation of different sugars as respiratory substrates in yeast. Research different use of substrates during exercise and starvation.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
2 Maintaining metabolism		
(a) Metabolic rate	Comparison of metabolic rates of different organisms at rest through measurement of oxygen consumption, carbon dioxide production and heat production.	Investigate metabolic rate using oxygen, carbon dioxide and temperature probes.
(i) Oxygen delivery	As oxygen is consumed during aerobic respiration, high metabolic rates require efficient delivery of oxygen to cells. Arrangement of heart chambers and circulation in fish, amphibians/reptiles and mammals/birds and the complexity of lungs in amphibians, reptiles, mammals and birds to cope with aerobic demand of metabolic rates. Physiological adaptations for low-oxygen niches (eg high altitude, deep diving). The variation in atmospheric oxygen concentration over geological timescale and maximum terrestrial body size. The use of maximum oxygen uptake as a measure of fitness in humans.	Case study on adaptations to survive low-oxygen niches.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(b) Metabolism in conformers and regulators	The ability of an organism to maintain its metabolic rate is affected by external abiotic factors such as temperature, salinity and pH.	
	A conformer's internal environment is dependent upon its external environment. Metabolic costs may be low. Conformers may have a narrow ecological niche unless they can tolerate or resist variation in their external environment. Behavioural responses may help to maintain optimum metabolic rate.	Case study on the response of a conformer to a change in an environmental factor. Comparisons of marine and estuarine invertebrates and their response to variation in salinity.
	Regulators control their internal environment, which increases the range of possible ecological niches. Regulation requires energy to achieve homeostasis. The principle of negative feedback control to maintain a relatively stable internal environment.	
Thermoregulation in mammals	The importance of regulating temperature for optimal enzyme-controlled reaction rates and diffusion rates for maintenance of metabolism.	

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
	The role of the hypothalamus as a temperature monitoring centre; nerve communication between the hypothalamus and effectors; the skin and its role in temperature regulation.	Experiments using thermisters or infra red thermometers on skin temperature and its regulation in humans.
(c) Maintaining metabolism during environmental change	Many environments vary beyond the tolerable limits for normal metabolic activity for any particular organism. To survive these cyclic or unpredictable fluctuations, organisms must have adaptations to survive and/or avoid adverse conditions.	
(i) Surviving adverse conditions	To allow survival during a period when the costs of continued normal metabolic activity would be too high, the metabolic rate can be reduced.	Research and scientific presentation on aspects of surviving adverse conditions.
	Dormancy is part of an organism's lifecycle and may be predictive or consequential. Examples of dormancy include hibernation and aestivation. Hibernation is often defined in terms of mammals. Aestivation allows survival in periods of high temperature or drought. Daily torpor as a period of reduced activity in organisms with high metabolic rates.	Seed dormancy experiments. Research seed banks and the practicalities of maintaining viable stocks.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(ii) Avoiding adverse conditions	Migration avoids metabolic adversity by expending energy to relocate to a more suitable environment. The use of specialised techniques in studies of long-distance migration, such as individual marking and types of tracking to overcome the difficulties involved in the study of migratory vertebrates and invertebrates. The design of experiments to investigate the innate and learned influences on migratory behaviour.	Evaluate procedures and results of studies investigating triggers for migration, navigation adaptations. Research the genetic control of migratory behaviour in studies of populations of the blackcap.
(d) Extremophiles	Some species have enzymes that are extremely tolerant and allow them to thrive in environments that would be lethal to almost all other species. Use of heat tolerant DNA polymerase from thermophilic bacterium in PCR. Some species living in hot springs or seabed vents generate their ATP by removing high-energy electrons from inorganic molecules.	Research different types of extremophiles. Research use of H_2 in methanogenic bacteria and H_2S in sulphur bacteria.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
3 Investigating metabolism in microorganisms	Microorganisms include archaea, bacteria and some species of eukaryotes. Microorganisms include species that use a wide range of substrates for metabolism and produce a wide range of products from their metabolic pathways. As a result of their adaptability microorganisms are found in a wide range of ecological niches and can be used for a variety of research and industrial uses because of their ease of cultivation and speed of growth.	
(a) Environmental control of metabolism		
(i) Culture conditions	The growth of microorganisms is influenced by the composition of the growth medium and environmental conditions. Microorganisms require an energy source and raw materials for biosynthesis. Energy is derived either from chemical substrates or from light in photosynthetic microorganisms. Many microorganisms can produce all the complex molecules required for biosynthesis (including all the amino acids required for protein synthesis) from simple chemical compounds in growth media. Other microorganisms require complex compounds such as vitamins or fatty acids. Growth media can be composed of specific substances or can contain complex ingredients such as beef extract.	Investigate the growth of microbes under different cultural and environmental conditions using standard laboratory equipment and simple fermenters. Isolate yeast from grapes using selective media and appropriate growing conditions.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
	Culture conditions include sterility to eliminate any effects of contaminating microorganisms, control of temperature, control of oxygen levels by aeration and control of pH by buffers or the addition of acid or alkali.	
(ii) Patterns of growth	Doubling or generation time of exponential growth. Appearance of exponential growth on normal and semi logarithmic graph paper. Lag phase of growth where microorganisms adjust to the conditions of the culture by inducing enzymes that metabolise the available substrates. Log or exponential phase of growth. Stationary phase where the culture medium becomes depleted and metabolites accumulate and secondary metabolites are produced. Death phase where lack of substrate and the toxic accumulation of metabolites causes death of cells.	
(iii) Controlling metabolism	Some fermentations may require the addition of metabolic precursors, inducers or inhibitors to control metabolism to give the required product. Secondary metabolism produces substances, not associated with growth, which may confer an ecological advantage.	Experiments on the induction of enzymes in micro-organisms. Research industrial processes that use microorganisms. Suitable processes that involve underpinning biology include: Citric acid production, Glutamic acid production, Penicillin production and therapeutic proteins such as insulin, human growth hormone and erythropoietin.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
(b) Genetic control of metabolism		
(i) Genetic variation	Wild strains of microorganisms can be improved by mutagenesis, selective breeding and culture or recombinant DNA technology. Exposure to ultra violet (UV) light, radiation or mutagenic chemicals results in mutations some of which may produce an improved strain. Mutant strains are often genetically unstable and revert to the wild type in continuous culture. Some bacteria can transfer plasmids or pieces of chromosomal DNA to each other or take up DNA from their environment to produce new strains. In fungi and yeast, new genotypes can be brought about by sexual reproduction between existing strains.	Investigate transfer of DNA using bacteria. Experiments investigating the effects of UV radiation on UV sensitive yeast.
(ii) Recombinant DNA technology	Plant or animal gene sequences can be transferred to microorganisms to produce plant or animal proteins. Genes that remove inhibitory controls or amplify specific metabolic steps in a pathway can be introduced to increase yield. As a safety mechanism, genes are often introduced that prevent the survival of the microorganism in an external environment.	Case study on bacterial transformation.

National Course specification: Course details (cont)

Content	Notes	Suggested learning activities and approaches
Plasmids and artificial chromosomes	Extra-chromosomal DNA molecules can be transferred to microorganisms. They contain marker genes and restriction sites in addition to genes for self-replication and regulatory sequences to allow the control of gene expression. Restriction endonucleases cut target sequences of DNA leaving sticky ends. Treatment of vectors with the same restriction endonuclease forms complementary sticky ends that are then combined using DNA ligase to form recombinant DNA. Plant or animal recombinant DNA in bacteria may result in polypeptides that are folded incorrectly or lack post-translational modifications. These proteins may be produced more successfully in a recombinant yeast cell.	
(c) Ethical considerations in the use of microorganisms	The development of biotechnology products raises ethical issues and the consideration of hazards and control of risks.	Research the development of a microbiological product from discovery to market.

National Course specification: Course details (cont)

UNIT 3 — Sustainability and Interdependence

Introduction

The study of biology often involves the attempt to model and understand complex interactions between many interdependent entities. Our human population is dependent upon sufficient and sustainable food production from the harvest of a narrow range of crop and livestock species. The importance of both plant productivity and the manipulation of genetic diversity in maintaining food security is emphasised. Many individual organisms are also interdependent, whether as symbiotic partners or as members of a social group. Biodiversity studies attempt to catalogue and understand the human impact on patterns of diversity and extinction in our biosphere.

Food production is an area of vital importance for biological research. An understanding of photosynthesis lies at its core. Studies should focus on the energy gathering process and the transfer of high-energy electrons through an electron transfer chain to generate ATP. The action of RuBisCO as part of the Calvin cycle should be included as this is the carbohydrate-forming stage. The measurement of productivity can be carried out as part of a practical exercise. In food production, we are dependent on the success of plant and animal breeding to provide appropriate crops and stock for cultivation. Through the use of selection, inbreeding, outbreeding and crossbreeding, as well as the use of genetic and reproductive technology, new strains and varieties are generated for production. Responsible citizens should understand the importance of maintaining biodiversity while protecting crops and maintaining the genetic resources for plant and animal breeding. Considering the conflict associated with these issues provides opportunity to make reasoned evaluations and to develop and communicate the candidate's own beliefs. The UK is a world leader in developing standards for the welfare of livestock. As well as addressing ethical issues, a study of animal welfare provides contexts to study ethology and to develop skills of experimental design.

All species are dependent upon the existence of others. Symbiotic species are a particularly striking example of this as they require intimate contact. Both parasitism and mutualism provide rich illustrations of dependence and interdependence. There is also interesting science underlying social behaviour. The study of altruism and kin selection can introduce candidates to simple models of behaviour. Living with other organisms of the same species also requires some interesting adaptations as shown by many primate species.

National Course specification: Course details (cont)

The study of biodiversity should begin with an examination of past patterns of biodiversity and mass extinction. The difficulties of measuring biodiversity should be covered in terms of assessing both genetic diversity and species diversity. This would be an appropriate area for practical fieldwork. Much of the current science of biodiversity is concerned with measuring and addressing threats to biodiversity. In covering overexploitation, habitat loss, introduced non-native species and conservation, the underlying themes are genetic diversity and ecosystem stability. In the study of anthropogenic climate change it would be appropriate to consider the difficulties associated with data gathering, modelling and predictions.

Candidates should have a clear understanding of the following areas of content from their previous learning:

- Photosynthesis
- Plant biology
- Inheritance
- Extinction
- Food webs and chains
- Biodiversity and conservation
- Climate change

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
1 The science of food production (a) Food supply (i) Food security	Food security is the ability of human populations to access food of sufficient quality and quantity. As a result of the increase in human population and concern for food security there is a continuing demand for increased food production. There is also a demand that food production is sustainable and does not degrade the natural resources on which agriculture depends.	Case study on challenge of providing food for the global human population. Contribution of biological science to interdisciplinary approaches to food security.
(ii) Agricultural production	All food production is dependent ultimately upon photosynthesis. Most human food comes from a small number of plant crops (cereals, potato, roots, legumes). If the area to grow crops is limited, increased food production will depend on the factors that control plant growth, the breeding of higher yielding cultivars and protecting crops from pests, diseases and competition. Livestock produce less food per unit area than plant crops due to loss of energy between trophic levels. Livestock production may be possible in managed and wild habitats unsuitable for cultivation of crops.	

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(b) Plant growth and productivity (i) Photosynthesis	Photosynthesis traps light energy to produce carbohydrates.	
Energy capture	Absorption of particular wavelengths of light by photosynthetic pigments. Transmission and reflection of light that is not absorbed by pigments. The absorption spectra of Chlorophyll a and b and carotenoids compared to the action spectra for photosynthesis. Carotenoids extend the range of wavelengths absorbed by photosynthesis and pass the energy to chlorophyll. Absorbed energy excites electrons in the pigment molecule. Transfer of these high-energy electrons through electron transport chains releases energy to generate ATP by ATP synthase. Energy is also used for photolysis, in which water is split into oxygen, which is evolved, and hydrogen, which is transferred to the coenzyme NADP.	Examination of spectrum of visible light and artificial light sources with a simple spectroscope. Examine light transmission through extracted chlorophyll with a simple spectroscope. Investigate the action spectra of photosynthesis in plants using coloured filters. Chromatography of photosynthetic pigments. Research photosynthetic pigments in other photoautotrophs. Carry out the Hill reaction.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
	The enzyme RuBisCO fixes carbon dioxide by attaching it to ribulose bisphosphate (RuBP) in the Calvin cycle. The intermediate produced is phosphorylated by ATP and combined with hydrogen from NADPH to form glyceraldehyde-3-phosphate (G3P). G3P is used to regenerate RuBP and for the synthesis of sugars. These sugars may be synthesised into starch or cellulose or pass to other biosynthetic pathways to form a variety of metabolites.	Research the inhibition of RuBisCO by oxygen. Experiments on the synthesis of starch from glucose-1-phosphate by photato phosphorylase.
(ii) Plant productivity	Net assimilation is the increase in mass due to photosynthesis minus the loss due to respiration and can be measured by the increase in dry mass per unit leaf area. Productivity is the rate of generation of new biomass per unit area per unit of time. Biological yield of a crop is the total plant biomass. Economic yield is the mass of desired product. The harvest index is calculated by dividing the dry mass of economic yield by the dry mass of biological yield.	Measure net assimilation rate in leaf samples under a variety of conditions. Carry out experimental investigations on limiting factors in photosynthesis. Analyse data on crop planting density, biological yield and economic yield using leaf area index, crop growth rates and harvest index.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(c) Plant and animal breeding for sustainable food production	Plant and animal breeding involves the manipulation of heredity to develop new and improved organisms to provide sustainable food sources. Breeders seek to develop crops and stock with higher yields, higher nutritional values, resistance to pests and diseases, physical characteristics suited to rearing and harvesting as well as those that can thrive in particular environmental conditions.	Investigate resistance of potato varieties to *Phytophthera infestans*.
Variation	Continuous variation may be due to polygenic inheritance, which refers to the interaction of multiple genes and/or environmental influences. Inherited characteristics that show discrete variation are usually controlled by a single gene.	Examine patterns of inheritance and pedigrees that show continuous and discrete variation.
Field trials	Plant field trials are carried out in a range of environments to compare the performance of different cultivars or treatments. In designing field trials account has to be taken of: the selection of treatments (to ensure fair comparisons); the number of replicates (to take account of the variability within the sample) and the randomisation of treatments (to eliminate bias when measuring treatment effects).	Evaluate crop trials to draw conclusions on crop suitability, commenting on validity and reliability of trial design and the treatment of variability in results.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(i) Selecting and breeding	Animals and cross pollinating plants are naturally outbreeding. In inbreeding, selected plants or animals are bred for several generations until the population breeds true to the desired type due to the elimination of heterozygotes. Test crosses can be used to identify unwanted individuals with heterozygous recessive alleles. Inbreeding depression is the accumulation of recessive, deleterious homozygous alleles. Self pollinating plants are naturally inbreeding and less susceptible to inbreeding depression due to the elimination of deleterious alleles by natural selection. In outbreeding species inbreeding depression is avoided by selecting for the desired characteristic while maintaining an otherwise genetically diverse population.	Analyse patterns of inheritance in inbreeding and outbreeding species (monohybrid cross, F_1 and F_2 from two true breeding parental lines, back cross, test cross). Case studies on the development of particular crop cultivars and livestock breeds.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(ii) Cross breeding and F_1 hybrids	New alleles can be introduced to plant and animal lines by crossing a cultivar or breed with an individual with a different, desired genotype. In animals, individuals from different breeds may produce a new crossbreed population with improved characteristics. As a F_2 population will have a wide variety of genotypes a process of selection and backcrossing is required to maintain the new breed. Alternatively the two parent breeds can be maintained to produce crossbreed animals for production. In plants F_1 hybrids, produced by the crossing of two different inbred lines, creates a relatively uniform heterozygous crop. F_1 hybrids often have increased vigour and yield. The F_2 generation is genetically variable and of little use for further production although it can provide a source of new varieties.	Case histories of plant mutations in breeding programmes. Mutation breeding has brought about improvement to a number of crops in disease resistance, dwarf habit (eg in cereals) and chemical/nutritional composition (eg low euricic acid in rape seed).

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(iii) Genetic technology	As a result of genome sequencing, organisms with desirable genes can be identified and then used in breeding programmes. Genetic transformation techniques allow a single gene to be inserted into a genome and this genome can then used in breeding programmes.	Genetic transformations in plant breeding include *Bt* toxin gene for pest resistance, glyphosate resistance gene for herbicide tolerance and golden rice, a cultivar that contains a pre cursor of vitamin A.
(d) Crop protection	Agricultural ecosystems are greatly simplified in their community structure. In these conditions weed competitors and pest and disease populations can multiply rapidly, reducing sustainability.	
(i) Weeds, pests and diseases	The properties of annual plants that make them successful weeds include rapid growth, short life cycle, high seed output and long-term seed viability. Perennial weeds have competitive adaptations, storage organs and vegetative reproduction. Most of the pests of crop plants are invertebrate animals such as insects, nematode worms and molluscs. Plant diseases can be caused by fungi, bacteria or viruses.	

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(ii) Control of weeds, pests and diseases	Control of weeds, pests and diseases by cultural means. The advantages of plant protection chemicals that are selective or systemic. Protective applications of fungicide based on disease forecasts are often more effective than treating a diseased crop.	Investigate the incidence and viability of potato cyst nematode cysts in samples of soil continuously cropped with potatoes and in samples of soil cropped with potatoes as part of a rotation.
(iii) Problems with plant protection chemicals	Plant protection chemicals may also be toxic to animal species. Some may also be persistent in the environment and accumulate or be magnified in food chains. The use of pesticides may also result in a population selection pressure producing a resistant population.	Case study on the control of weeds, pests and or diseases of agricultural crops by cultural and chemical means.
(iv) Biological control and integrated pest management	In biological control the control agent is a natural predator or parasite of the pest. Integrated pest management combines chemical and biological control.	Case studies on, for example, control of glasshouse whitefly with the parasitic wasp *Encarsia*, control of glasshouse red spider mite with the predatory mite *Phytoseiulus* and/or control of butterfly caterpillars with the bacterium *Bacillus thuringiensis*. Investigate the chemical and biological control of red spider mite.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(e) Animal welfare	The costs, benefits and ethics of providing different levels of animal welfare in livestock production. Behavioural indicators of poor welfare (stereotypes, misdirected behaviour, failure in sexual or parental behaviour and altered levels of activity).	Research the five freedoms for animal welfare.
(i) Observing behaviour (ethology)	The observed behaviours (ethograms) of domesticated animals in natural or semi-natural settings. This data can be used to form hypotheses on their behaviour in production surroundings that can then be tested. The use of preference tests and measurements of motivation in animal welfare studies.	Interpret and evaluate ethograms to form hypotheses and draw conclusions on animals' behaviour needs and to develop an awareness of scientific evidence rather than anthropomorphism when creating an environment for domestic animals.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
2 Interrelationships and dependence		
(a) Symbiosis	Symbiotic relationships are coevolved intimate relationships between members of two different species.	
(i) Parasitism	A parasite benefits in terms of energy or nutrients, whereas its host is harmed by the loss of these resources. Parasites often have more limited metabolism so often cannot survive out of contact with a host. Transmission of parasites to new hosts using direct contact, resistant stages and vectors. Evolution of parasitic lifecycles involving secondary hosts.	Observe microscope slides of parasites.
(ii) Mutualism	Both mutualistic partner species benefit in an interdependent relationship. Examples include the cellulose-digesting protozoa/bacteria in the guts of many herbivores and the photosynthetic algae in the polyps of coral. Evidence for the symbiotic origin of chloroplasts and mitochondria.	Research the links between these symbioses and anthropogenic climate change.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(b) Social behaviour	Many animals live in social groups and have behaviours that are adapted to group living such as social hierarchy or cooperative hunting and defence. Cooperative hunting may benefit subordinate animals as well as dominant, as the subordinate animal may gain more food than by foraging alone; also food sharing will occur as long as the reward for sharing exceeds that for foraging individually.	
(i) Altruism and kin selection	An altruistic behaviour harms the donor individual but benefits the recipient. Reciprocal altruism, where the roles of donor and recipient later reverse, often occurs in social animals. The prisoner's dilemma as a simple model of altruism. Behaviour that appears to be altruistic can be common between a donor and a recipient if they are related (kin). The donor will benefit in terms of the increased chances of survival of shared genes in the recipient's offspring or future offspring.	Investigate reciprocal altruism using the prisoner's dilemma. Analyse data on helper behaviour and relatedness.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(ii) Social insects	Evolution of the societies of insects such as bees, wasps, ants and termites, in which only some individuals contribute reproductively. Most members of the colony are workers who cooperate with close relatives to raise relatives. Social insects are often keystone species within their ecosystems. Some species are of economic importance to humans providing ecosystem services such as pollination and pest control.	
(iii) Primate behaviour	Long period of parental care in primates gives an opportunity to learn complex social behaviours. To reduce unnecessary conflict, social primates use ritualistic display and appeasement behaviours. Grooming, facial expression, body posture and sexual presentation important in different species. In some monkeys and apes, alliances form between individuals which are often used to increase social status within the group. Complexity of social structure related to ecological niche, resource distribution and taxonomic group.	Case study on primate behaviour.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
3 Biodiversity		
(a) Mass extinction	Fossil evidence indicates that there have been several mass extinction events in the past. Following each mass extinction event, biodiversity has been regained slowly and some surviving taxonomic groups radiate. The difficulties in estimating past and current species extinction rates. The extinction of megafauna correlated with the spread of humans. The escalating rate of ecosystem degradation caused by humans is causing the rate of species extinction to be much higher than the natural background rate.	Research the Permian, Cretaceous and Holocene mass extinction events.
(b) Measuring biodiversity	Measurable components of biodiversity include genetic diversity and species diversity and ecosystem diversity.	Research the importance of producing a central database of all known species and the difficulties involved in ensuring its accuracy. It is estimated that there are about 2 million known species. Of these, about half are animals, most of which are insects. Of the vertebrate animals, most are fish. There are about 0.25 million species of flowering plants.
(i) Genetic diversity	Genetic diversity comprises the genetic variation represented by the number and frequency of all the alleles in a population. If one population dies out then the species may have lost some of its genetic diversity, and this may limit its ability to adapt to changing conditions.	

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(ii) Species diversity	Species diversity comprises the number of different species in an ecosystem (the species richness) and the proportion of each species in the ecosystem (the relative abundance). A community with a dominant species has a lower species diversity than one with the same species richness but no particularly dominant species. The effects of isolation and area on the species diversity of habitat islands.	Case study using fieldwork to compare biodiversity indicies of different areas (eg polluted versus unpolluted river, monoculture versus set-aside, an ecosystem with invasive species versus an ecosystem with native species, a disturbed habitat versus an undisturbed habitat). Analyse data on island biogeography.
(c) Threats to biodiversity		
(i) Overexploitation	Exploitation and recovery of populations of particular species. Reduction of a population to a level that still can recover. Small populations may lose the genetic variation necessary to enable evolutionary responses to environmental change (the bottleneck effect). This loss of genetic diversity can be critical for many species, as inbreeding results in poor reproductive rates. Some species have a naturally low genetic diversity in their population and yet remain viable.	Analyse data on exploitation of whale or fish populations. Use of gel electrophoresis in monitoring harvest species. Research impact of naturally low genetic diversity within cheetah populations.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(ii) Habitat loss	Habitat fragments typically support lower species richness than a large area of the same habitat. Habitat fragments suffer from degradation at their edges and this may further reduce their size; species adapted to the habitat edges may invade the habitat at the expense of interior species. To remedy widespread habitat fragmentation, isolated fragments can be linked with habitat corridors allowing species to feed, mate and recolonise habitats after local extinctions.	Research impact of habitat fragmentation and benefits of habitat corridors for tiger populations.
(iii) Introduced, naturalised and invasive species	Introduced (non native) species are those that humans have moved either intentionally or accidentally to new geographic locations. Those that become established within wild communities are termed naturalised species. Invasive species are naturalised species that spread rapidly and eliminate native species. Invasive species may well be free of the predators, parasites, pathogens and competitors that limit their population in their native habitat. They may prey on native species or out-compete them for resources.	Case study on invasive species.

National Course specification: Course details (cont)

Content	Notes	Learning activities and suggested approaches
(iv) Anthropogenic climate change	Biological and other sources of data for analysing the effects of climate change on biodiversity. The challenges associated with modelling the impact of climate change on species and ecosystem diversity.	Use climate change modelling software.

Assessment

To achieve the Course award the candidate must achieve the Units as well as pass the Course assessment. The candidate's grade is based on the Course assessment.

Assessment objectives

Candidates will be assessed on their Knowledge and Understanding of the content column and notes column in the tables for each Unit. The suggested learning activities and approaches column in the tables for each Unit provides advice and suggests contexts and activities for learning and will not be liable for sampling in assessment.

Candidates will be assessed on their skills of scientific experimentation, investigation and enquiry and skills for learning, life and work. These skills should be developed in contexts related to the content and notes columns in the tables for each Unit.

Advice on developing the capabilities associated with knowledge, understanding and skills is given in the section G*uidance on Learning and Teaching Approaches for this Course* (page 61).

Unit assessment

Unit assessment will be a closed-book test with items based on the statement of standards for each Unit and a report of one experimental activity set in the context of the Unit based on the statement of standards. Only one report of an experimental activity is required to meet the Course specification for Higher Biology. This report can then be used as evidence of the statement of standards for the other Units of the Course. The report can be in the format of a traditional lab report or alternatives such as a conference poster, scientific paper, Power Point presentation, video presentation or web page that cover the Performance Criteria.

Further details about Unit assessment for this Course can be found in the Unit specifications and the National Assessment Bank (NAB) materials.

Course assessment

The external Course assessment will be based on the Knowledge and Understanding, skills of scientific experimentation, investigation and enquiry and skills for learning, life and work described in the Course content.

The examination will consist of one paper of 2 hours 30 minutes with a total of 130 marks. The paper will consist of three sections:

National Course specification: Course details (cont)

Section A

This section will contain 30 multiple-choice questions. Between 9 and 11 of these will test science skills and skills for learning, life and work, the remainder will test Knowledge and Understanding. Section A will have an allocation of 30 marks. Candidates will be expected to answer all the questions.

Section B

This section will contain structured questions and data handling questions with an allocation of 80 marks. Between 25 and 30 marks will test science skills and skills for learning, life and work, the remainder will test Knowledge and Understanding. Candidates will be expected to answer all the questions.

Section C

This section will consist of four extended response questions to test the candidates ability to select, organise and present relevant knowledge. Section C will have an allocation of 20 marks and will include:

- two structured extended response questions each with an allocation of 10 marks. Candidates will be expected to answer one of these questions.
- two open extended response questions for 10 marks (1 mark for relevance, 1 mark for coherence and 8 marks for Knowledge and Understanding). Candidates will be expected to answer one of these questions.

Further details of the Course assessment are given in the Course Assessment specification and in the Specimen Question Paper.

Complexity of data

The following advice is intended as general guidelines in setting the complexity of data to be used in science skills Problem Solving questions.

At Higher, typically two sources of data (text, tables, charts, keys, diagrams or graphs) should be provided from which the problem has to be solved. It is, however, recognised that extracting data from one source could be more demanding than extracting data from two sources for example, depending on the nature of the data.

Where there are not two separate sources of data, the provided data should normally have two to three patterns, trends, conditions, variables or sets of results from which information has to be selected and presented, or which have to be used as sources of evidence for conclusions, explanations, predictions or generalisations. The analysis of data should involve comparisons between two or more of these sets of data.

The planning, designing and evaluation of experimental procedures should involve one to two of the following: purpose, one or two treatments, adequate controls, limitations of equipment, sources of error and possible improvements as appropriate.

National Course specification: Course details (cont)

Link between Unit and Course assessment/added value

Course assessment requires candidates to demonstrate abilities beyond Unit assessment by:

- retaining knowledge and skills over an extended period of time
- integrating Knowledge and Understanding and skills from different Units
- applying knowledge, understanding and skills in contexts less familiar and more complex than in the component Units.

National Course specification: Course details (cont)

Grade Descriptions at A and C

The candidate's grade will be based on the total score obtained from the Course assessment. The descriptions below indicate the nature of achievement required for an award at Grade C and A in the Course.

For an award at Grade C, candidates should be able to:

- retain knowledge and skills over an extended period of time
- integrate Knowledge and Understanding, science skills and skills for learning life and work acquired across component Units
- apply Knowledge and Understanding, science skills and skills for learning life and work in contexts similar to those in the component Units.

For an award at Grade A, candidates should be able to:

- retain an extensive range of knowledge and skills over an extended period of time
- integrate an extensive range of Knowledge and Understanding, science skills and skills for learning life and work acquired across component Units
- apply Knowledge and Understanding, science skills and skills for learning life and work in contexts less familiar and more complex than in the component Units.

Estimates and appeals

Detailed advice and guidance is issued to centres in the publication *Estimates, Absentees and Assessment Appeals: Guidance on Evidence Requirements.*

Estimates

In preparing estimates, evidence must take account of performance across the Course and must be judged against the grade descriptions. Further advice on the preparation of estimates is given in the Course Assessment specification.

Appeals

Evidence to support appeals for the Course must show sufficient breadth of coverage of the content, cover each of the seven science skills areas and must relate to the Course grade descriptions at A and C. Approximately 30% of the assessment items in the evidence to support appeals should relate to the Course grade descriptions at A to ensure that candidates who are graded at A are gaining marks in A grade items.

The evidence to support appeals should reflect the structure of the Course Assessment specification and the standards set out in the Specimen Question Paper. Centres must ensure that the instrument of assessment has not been seen previously by candidates.

An analysis of the evidence to support appeals showing the content and skills covered by assessment items along with marking instructions with cut off scores should be included with ***all*** evidence submitted in support of an appeal.

National Course specification: Course details (cont)

Quality Assurance

All National Courses are subject to external marking and/or verification. Externals Markers, visiting Examiners and Verifiers are trained by SQA to apply national standards.

The Units of all Courses are subject to internal verification and may also be chosen for external verification. This is to ensure that national standards are being applied across all subjects.

Courses may be assessed by a variety of methods. Where marking is undertaken by a trained Marker in their own time, Markers meetings are held to ensure that a consistent standard is applied. The work of all Markers is subject to scrutiny by the Principal Assessor.

To assist centres, external assessment and internal assessment reports are published on SQA's website **www.sqa.org.uk**.

National Course specification: Course details (cont)

Guidance on learning and teaching approaches for this Course

In delivering the Course, teachers should be building on candidates' previously acquired knowledge and skills. Candidates' experiences should include a variety of approaches to develop Knowledge and Understanding, science skills and skills for learning life and work. Where possible these experiences should be integrated into a related sequence of activities centered on an idea, theme or application of biology based on contexts related to the Course content. Such case studies should make learning active, challenging and enjoyable and identify for the candidate the Course content and skills that will be developed. Case studies should be developed in such a way that candidates have the opportunity to select activities where appropriate and present the opportunity to pursue further study. Case studies need not necessarily be restricted to one Unit but could include biology drawn from different Units. Advice on the capabilities that could be included in such case studies to develop the knowledge, understanding and skills of the Course content is provided below.

Practical experimental work is a key part of the scientific method of working and as such is an essential component of Biology Courses. In addition to being part of the way scientists work, practical work can fulfill a number of educational purposes including:

- Developing Problem Solving skills and analytical thinking
- Working collaboratively and thinking independently
- Illustrating concepts as an aid to understanding
- Developing experimental designs that are valid and reliable
- Testing hypotheses and drawing conclusions based on evidence
- Generating data for subsequent analysis
- Developing competence in practical techniques

Information and Communication Technology (ICT) makes a significant contribution to practical work in Biology in addition to the use of computers as a learning tool. Computer interfacing equipment can detect and record small changes in variables allowing experimental results to be recorded over short periods of time completing experiments in class time. Results can also be displayed in real time helping to improve understanding. Data logging equipment and video cameras can be set up to record data and make observations over periods of time longer than a class lesson which can then be subsequently downloaded and viewed for analysis. Developments in the mapping and analysing of DNA sequences and bioinformatics have made computing an essential tool in scientific investigations of evolutionary biology, inheritance and personalised medicine.

National Course specification: Course details (cont)

Knowledge and Understanding

The following capabilities related to demonstrating knowledge, applying knowledge and demonstrating understanding should be developed in Course work.

1 Demonstrating knowledge

Candidates should be able to:

- Make accurate statements about biological organisms, relationships, processes, systems and cycles
- Use biological terms, symbols, abbreviations and units correctly
- Describe the properties and structure and function of organisms
- Describe the properties of and relationships in biological processes, systems and cycles.

2 Applying knowledge

Candidates should be able to:

- Use knowledge when interpreting biological information in textual, tabular or graphical forms
- Use a relationship, equation or formula to find a qualitative or quantitative solution to a biological problem
- Use existing knowledge in new situations
- Appreciate and understand the impact of science and technology on everyday life
- Make and justify personal decisions about things that involve biological science.

3 Demonstrating understanding

Candidates should be able to:

- Demonstrate understanding of the properties and structure and function of organisms
- Demonstrate understanding of the properties of and relationships in biological processes, systems and cycles
- Give examples to illustrate a concept or relationship or to support an observation, hypothesis or point of view
- Explain an observation or phenomenon demonstrating understanding of the underlying concept, principle or theory
- Use knowledge to demonstrate understanding of cause and effect
- Combine knowledge with evidence from observation, experience and investigation to provide explanations, formulate hypotheses and make predictions about the effects of change on biological systems and processes
- Integrate knowledge in different areas of biology.

National Course specification: Course details (cont)

Skills of scientific experimentation, investigation and enquiry

Candidates should acquire scientific skills through a series of learning experiences, investigations and experimental work set in the contexts described in the content statements and supplementary notes of the Course specification. These skills should be developed throughout the Course using a variety of case studies, practical activities and other learning experiences as appropriate. Some activities and experiences will lend themselves to developing particular skills more than others. For example some practical activities will be particularly suitable for developing planning and designing skills, some for presenting and analyzing data skills and others for the skill of drawing conclusions. In selecting appropriate activities and experiences teachers and lecturers should identify which skills are best developed in each activity to ensure the progressive development of all skills and to support candidates' learning. Further details on the skills that should be developed in Course work are given below.

1 Selecting Information

Select and analyse relevant information from texts, tables, charts, keys, graphs and/or diagrams.

The study of biology involves dealing with written and visual information. Candidates will often deal with more complex information than they can produce.

Candidates should be able to:

- work with quantitative and qualitative data, discrete and continuous data and sampled data
- deal with experimental data presented in tables, pie and bar charts, line graphs, lines of best fit, graphs with semi logarithmic scales, graphs with error bars and information presented as box plots
- analyse and interpret typically two interconnected tables, charts, keys, graphs or diagrams or a single source of graphical information with two to three patterns, trends, conditions, variables or sets of results
- deal with statistical concepts such as the mean, range and standard deviation of data and statistically significant differences (as shown by error bars in graphs and plus and minus values in tables of results)
- deal with text to analyse its content, select appropriate information, identify and evaluate evidence, explain relationships, draw conclusions and display related knowledge
- use computers and software applications to search and retrieve relevant information.

2 Presenting Information

Present information appropriately in a variety of forms, including summaries and extended text, flow charts, keys, diagrams, tables and/or graphs.

(a) Representing data

Candidates should be able to:

- present variables from experimental or other data in an appropriate form including tables, charts, keys, graphs and diagrams
- distinguish between dependant and independent variables.

(b) Communication

Candidates should be able to:

- select, organise and present relevant information, including presenting alternative points of view, on a biological issue
- produce scientific reports which describe experimental procedures, record relevant observations and measurements, analyse and present results, draw conclusions and evaluate procedures with supporting argument
- produce extended text presenting relevant ideas clearly, coherently and logically using specialist vocabulary where appropriate
- use word processing and graphics packages, spreadsheets and other data handling software.

(c) Oral communication

Through discussion and presentations candidates should be able to:

- convey information clearly and logically using specialist vocabulary where appropriate
- use images including charts, models, graphs, diagrams, illustrations or video in conveying information
- respond to others by answering questions, clarifying points, contributing points of view and asking questions to clarify or explore in greater depth.

3 Processing Information

Process information accurately using calculations where appropriate.

Candidates should be able to:

- perform calculations involving whole numbers, decimals and fractions
- calculate ratios and percentages including percentage increase and decrease
- round answers to an appropriate degree of accuracy (eg to two decimal places or three significant figures)
- deal with a range of units in accordance with Society of Biology recommendations. Candidates will be expected to be able to convert between, eg μg and mg

- deal with calculations involving negative numbers, numbers represented by symbols and scientific notation
- work with data to find the mean and range of the data
- calculate genetic ratios based on probability
- substitute numerical values into equations and changing the subject of an equation
- use software packages to carry out statistical and other data handling processes.

4 Planning, Designing and Carrying Out

Plan, design and carry out experimental procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required.

(a) Planning and designing

Candidates should be able to:

- state the aim of an investigation
- suggest a hypotheses for investigation based on observation of biological phenomena
- plan experimental procedures and select appropriate techniques
- suggest suitable variables that could be investigated in a given experimental set up
- identify dependent and independent variables in an investigation
- decide on the experimental designs required to ensure the validity of experimental procedures
- decide on the measurements and observations required to ensure reliable results
- modify procedures in the light of experience.

(b) Carrying Out

Candidates should be able to:

- identify component tasks in practical work and plan a procedure (to include timings and allocation of tasks where appropriate)
- identify, obtain and organise the resources required for practical work
- carry out work in a methodical and organised way with due regard for safety and with appropriate consideration for the well-being of organisms and the environment where appropriate
- follow procedures accurately
- make and record observations and measurements accurately
- capture experimental data electronically using a range of devices
- modify procedures and respond to sources of error.

National Course specification: Course details (cont)

5 Evaluating

Evaluate experimental procedures by commenting on the purpose or approach, the suitability and effectiveness of procedures, the control of variables, the limitations of equipment, possible sources of error and/or suggestions for improvement.

Candidates should be able to:

- identify and comment on variables that are not controlled in experimental situations and distinguish between dependent and independent variables
- identify sources of error in measurements and observations
- identify and comment on the reliability of results
- identify and comment on the validity of experimental designs
- suggest possible improvements to experimental set ups
- use observations and collected data to make suggestions for further work.

6 Drawing conclusions

Draw valid conclusions and give explanations supported by evidence or justification. Conclusions should include reference to the aim of the experiment, overall pattern to readings or observations, trends in results or comment on the connection between variables and controls.

Candidates should be able to:

- analyse and interpret experimental data to select relevant information from which conclusions can be drawn
- state the results of the investigation
- draw conclusions on the relationships between the dependent and independent variables
- take account of controls when drawing conclusions
- analyse and interpret experimental data to identify patterns, trends and rates of change

7 Making predictions and generalisations

Make predictions and generalisations based on available evidence.

Candidates should be able to:

- predict the outcome in experimental situations from supplied information
- make generalisations from a range of biological information
- use modeling and simulation software to test predictions and answer questions related to biological and experimental phenomena
- use evidence to support a personal decision or point of view on a current scientific, technological, environmental or health issue.

National Course specification: Course details (cont)

Skills for learning, life and work

As a result of their study of biology candidates should have the opportunity to and further develop their capabilities to:

- Use their literacy, communication and numeracy skills to demonstrate their Knowledge and Understanding of biology
- Solve problems by thinking creatively, working with others and planning and managing tasks related to biological laboratory and field work
- Develop competence in the use of laboratory and fieldwork equipment and the use of information and communication technology
- Identify hazards, assess their risk in different situations and suggest control measures
- Make ethical decisions based on researching relevant information and a consideration of the consequences for different courses of action

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

History of changes

Version	Description of change	Date

National Unit specification: general information

Unit title: DNA and the Genome (SCQF level 6)

Unit code: FH2G 12

Superclass: RH

Publication date: March 2011

Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit is a mandatory Unit of the Biology (revised) Higher Course and has been designed to be taken as part of that Course. It can also be taken as a free-standing Unit.

This Unit seeks to develop Knowledge and Understanding, Problem Solving and practical skills related to the structure and replication of DNA, gene expression and the genome.

Successful candidates will be able to describe and explain aspects of DNA and the genome and apply their knowledge in new situations and when interpreting related biological information. They will be able to collect, analyse and present scientific data and information; plan, design and carry out practical work; draw conclusions, evaluate and make predictions and generalisations based on scientific evidence. They will be able to write a scientific report on an experimental activity related to DNA and the genome that they have carried out.

This Unit is suitable for candidates who have studied cell biology and evolution as part of a Course or Unit at SCQF level 5.

Outcomes

1 Demonstrate Knowledge and Understanding related to DNA and the genome.
2 Solve problems related to DNA and the genome using scientific skills.
3 Collect and analyse information related to DNA and the genome by experiment.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained a Biology National Qualification at SCQF level 5 or its equivalent.

General information (cont)

Credit points and level

1 SQA credit at SCQF level 6: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill *Problem Solving* at SCQF level 6

Core Skill component Using Graphical Information at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit specification: statement of standards

Unit title: DNA and the Genome (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Demonstrate Knowledge and Understanding related to DNA and the genome.

Performance Criteria

(a) Make accurate statements and give clear descriptions about the biology of DNA and the genome.
(b) Apply relevant knowledge of DNA and the genome in new situations and appreciate its significance when interpreting biological information.
(c) Explain the biology of DNA and the genome with reasons or supporting evidence.

Outcome 2

Solve problems related to DNA and the genome using scientific skills.

Performance Criteria

(a) Select and present relevant information in an appropriate format.
(b) Process information accurately using calculations where appropriate.
(c) Draw valid conclusions and give explanations supported by evidence.
(d) Plan, design and evaluate experimental procedures appropriately.
(e) Make predictions and generalisations based on evidence.

Outcome 3

Collect and analyse information related to DNA and the genome by experiment.

Performance Criteria

(a) Participate actively in the collection of information by experiment.
(b) Describe the experimental procedures accurately.
(c) Record relevant measurements and observations in an appropriate format.
(d) Analyse and present the recorded experimental information in an appropriate format.
(e) Draw valid conclusions.
(f) Evaluate the experimental procedures with supporting argument.

National Unit specification: statement of standards (cont)

Unit title: DNA and the Genome (SCQF level 6)

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have achieved all Outcomes and Performance Criteria.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

Evidence of an appropriate level of achievement must be generated from a closed-book instrument of assessment under controlled conditions covering the Performance Criteria for Outcome 1 and Outcome 2 set in the context of the structure and replication of DNA, gene expression and the genome, with a time limit of 45 minutes.

In the evidence for planning and designing experimental procedures in Outcome 2 PC (d) candidates must be able to develop and justify a hypothesis to be investigated or the aim of an experiment.

A report of one experiment is required covering the Performance Criteria for Outcome 3 set in the context of the structure and replication of DNA, gene expression and the genome. The report can be in the format of a traditional lab report or alternative that covers the Performance Criteria for the Unit including conference poster format, scientific paper format, Power Point presentation, video presentation or web page.

The teacher/lecturer responsible must attest that the report is the individual work of the candidate derived from active participation in an experiment in which the candidate plans the experiment; decides how it is managed; identifies and obtains the necessary resources, some of which must be unfamiliar; and carries out the experiment. Depending on the activity, the collection of the information may be group work.

Evidence submitted in support of attainment of PC (d) must be in the format of a table or graph(s) as appropriate. Conclusions drawn should be justified by reference to supporting evidence and comment on trends or patterns and/or connections between variables and controls.

The evaluation should cover all stages of the experiment, including the initial analysis of the situation and planning and organising the experimental procedure. In carrying out the experiment candidates should consider modifying procedures and respond to sources of error.

National Unit specification: support notes

Unit title: DNA and the Genome (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

1 The structure and replication of DNA

(a) DNA:
  (i) Structure of DNA
  (ii) Organisation of DNA in prokaryotes and eukaryotes

(b) DNA can direct its own replication:
  (i) Replication of DNA
  (ii) Polymerase Chain Reaction (PCR)

2 Gene expression

(a) Expression of genes in eukaryotes:
  (i) Proteins
  (ii) Structure and functions of RNA
  (iii) Transcription of DNA into an RNA molecule
  (iv) Translation of mRNA into a polypeptide
  (v) One gene, many proteins
  b) Differentiation in multicellular organisms:
  (i) Meristems and stem cells
  (ii) Research and therapeutic value of stem cells

3 Genome

(a) The structure of the genome

(b) Mutation:
  (i) Point mutations: nucleotide substitution, insertion and deletion
  (ii) Chromosome structure mutations
  (iii) Polyploidy

(c) Evolution:
  (i) Inheritance
  (ii) Selection
  (iii) Drift
  (iv) Speciation

(d) Genomic sequencing:
  (i) Phylogentics and molecular clocks
  (ii) Genomics
  (iii) Personal genomics

Further guidance on the content and context for this Unit is provided in the Course content tables for DNA and the Genome in the Course specification for Biology (revised) Higher. The suggested learning activities and approaches column in these tables provides contexts in which the Knowledge and Understanding and skills of this Unit can be developed and are not liable for assessment although they may provide contexts for assessment items.

National Unit specification: support notes (cont)

Unit title: DNA and the Genome (SCQF level 6)

Guidance on learning and teaching approaches for this Unit

Guidance on learning and teaching approaches for this Unit are provided in the guidance on learning and teaching approaches in the Course specification for Biology (revised) Higher.

Opportunities for developing Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes of this Unit specification. The guidance on learning and teaching approaches for this Unit provided in the Course specification for Biology (revised) Higher highlights opportunities to develop *Using Number* when processing information and Oral and Written Communication when presenting information. In addition the guidance on learning and teaching approaches highlights opportunities to develop *Working with Others* when carrying out practical experimental work and in using *Information and Communication Technology* in practical experimental work and for data analysis.

Guidance on approaches to assessment for this Unit

A holistic approach is taken to assessment, ie Outcomes 1 and 2 are assessed by an integrated end of Unit test with questions covering all the Performance Criteria for Knowledge and Understanding and Problem Solving.

Outcome 1

Test items should be constructed to allow candidates to meet all of the Performance Criteria in the context of the structure and replication of DNA, gene expression and the genome.

Outcome 2

Test items should be constructed to allow candidates to generate evidence relating to the Performance Criteria as follows:

(a) Selecting and presenting information:
- sources of information to include: texts, tables, charts, keys, graphs and diagrams
- formats of presentation to include: written summaries, extended writing, tables and graphs.

(b) Calculations to include: percentages, averages, ratios. Significant figures and units should be used appropriately.

(c) Conclusions drawn should include some justification, and explanations should be reported by evidence. Conclusions could contain a comment on trends or patterns and/or connections between variables and controls.

(d) Candidates could plan and design procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required. The evaluation of given experimental procedures may include situations which are unfamiliar to candidates and could test the candidates' ability to comment on the purpose of approach or the suitability of given experimental procedures. Candidates could comment on the limitations of the set-up, apparatus, suggested measurements or observations, limitations of equipment, appropriateness of controls, sources of error and possible improvements.

(e) Candidates could make predictions and generalisations from given experimental results or, given situations, predict what the results might be.

Outcome 3

Type of experimental activity

The teacher/lecturer should ensure that the experimental activity to be undertaken in connection with Outcome 3 affords opportunity for the candidate to demonstrate the ability to undertake the planning and organising of an experimental activity at an appropriate level of demand. The activity must relate to the Course content and candidates should be made aware of the range of skills which must be demonstrated to ensure attainment of Outcome 3.

Assessment of Outcome 3

Candidates are only required to produce one report for Outcome 3 in relation to the contents and notes specified for Higher (revised) Biology. This report can then be used as evidence for Outcome 3 for the other Units of the Course.

In relation to PC (a), the teacher/lecturer checks by observation that the candidate participates in the collection of the experimental information by playing an active part in planning the experiment, deciding how it will be managed, identifying and obtaining resources (some of which must be unfamiliar to the candidate), and carrying out the experiment.

Candidates should provide a report with an appropriate title. The report should relate to the Performance Criteria as follows:

(b) The experimental procedures are described accurately.	A clear statement of the aim of the experiment. A few brief concise sentences including as appropriate: ♦ a labelled diagram or brief description of apparatus or ♦ instruments used ♦ how the independent variable was altered ♦ control measure used ♦ how measurements were taken or observations made. There is no need for a detailed description. The use of the impersonal passive voice is to be encouraged as an example of good practice but this is not mandatory for meeting the Performance Criteria.
(c) Relevant measurements and observations are recorded in an appropriate format.	Readings or observations (raw data) must be recorded in a clear table with correct headings, appropriate units and results/readings entered correctly.

(d) Recorded experimental information is analysed and presented in an appropriate format.	Data should be analysed and presented in tabular, graphical format or as a scatter diagram or equivalent, as appropriate: ♦ For a tabular presentation this may be an extension of the table used for PC (c) above, and must include: suitable headings and units showing averages or other appropriate computations ♦ For a graphical presentation this must include: data presented as a histogram, bar chart, connected points or line of best fit as appropriate, with suitable scales and axes labelled with variable and units and with data correctly plotted.
(e) Conclusions drawn are valid.	Conclusions should use evidence from the experiment and relate back to the aim of the experiment. At least one of the following should be included: ♦ overall pattern to readings or observations (raw data) ♦ trends in analysed information or results ♦ connection between variables and controls.
(f) The experimental procedures are evaluated with supporting argument.	The evaluation could cover all stages of the activity including preparing for the activity, analysis of the activity and the results of the activity. The evaluation must include supporting argument in at least one of the following: ♦ effectiveness of procedures ♦ control of variables ♦ limitations of equipment ♦ possible sources of error ♦ possible improvements.

The bullet points under each Performance Criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the experiment. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to external verification) against the Performance Criteria. It is appropriate to support candidates in producing a report to meet the Performance Criteria. Re-drafting of a report after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting and resubmission is only required for the specific Performance Criterion identified in need of further attention, ie the entire report does not need to be rewritten.

Conditions required to complete the report

Candidates may complete their work outwith class time provided reasonable measures are taken to ensure that the report is the individual work of the candidate. Teachers and lecturers may wish candidates to write up reports under their direct supervision so that they can provide appropriate advice and support. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidate's response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Use of IT

Candidates may, if they wish, present their reports in a word-processed format. Candidates may use Excel (or any other suitable data analysis software) when tackling Outcome 3. However, candidates must not be given a spreadsheet with pre-prepared column headings nor formulae, as they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. The use of clip art or images captured by digital camera may also be used in recording details of experimental methods.

Transfer of evidence

Candidates may transfer evidence for Outcome 3 from one level to the one below provided the experiment is in the context of the Course concerned. Candidates, who are repeating a Course, may carry forward evidence of an appropriate standard, generated in a previous year.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

History of changes

Version	Description of change	Date

National Unit specification: general information

Unit title: Metabolism and Survival (SCQF level 6)

Unit code: FH2H 12

Superclass: RH

Publication date: March 2011

Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit is a mandatory Unit of the Biology (revised) Higher Course and has been designed to be taken as part of that Course. It can also be taken as a free-standing Unit.

This Unit seeks to develop Knowledge and Understanding, Problem Solving and practical skills related to metabolism being essential for life, maintaining metabolism and investigating metabolism in microorganisms.

Successful candidates will be able to describe and explain aspects of metabolism and survival and apply their knowledge in new situations and when interpreting related biological information. They will be able to collect, analyse and present scientific data and information; plan, design and carry out practical work; draw conclusions, evaluate and make predictions and generalisations based on scientific evidence. They will be able to write a scientific report on an experimental activity related to metabolism and survival that they have carried out.

This Unit is suitable for candidates who have studied enzymes, negative feedback, respiration and microorganisms as part of a Course or Unit at SCQF level 5.

Outcomes

1 Demonstrate Knowledge and Understanding related to metabolism and survival.
2 Solve problems related to metabolism and survival using scientific skills.
3 Collect and analyse information related to metabolism and survival by experiment.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained a Biology National Qualification at SCQF level 5 or its equivalent.

General information (cont)

Credit points and level

1 SQA credit at SCQF level 6: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill *Problem Solving* at SCQF level 6

Core Skill component Using Graphical Information at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit specification: statement of standards

Unit title: Metabolism and Survival (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Demonstrate Knowledge and Understanding related to metabolism and survival.

Performance Criteria

(a) Make accurate statements and give clear descriptions about the biology of metabolism and survival.
(b) Apply relevant knowledge of metabolism and survival in new situations and appreciate its significance when interpreting biological information.
(c) Explain the biology of metabolism and survival with reasons or supporting evidence.

Outcome 2

Solve problems related to metabolism and survival using scientific skills.

Performance Criteria

(a) Select and present relevant information in an appropriate format.
(b) Process information accurately using calculations where appropriate.
(c) Draw valid conclusions and give explanations supported by evidence.
(d) Plan, design and evaluate experimental procedures appropriately.
(e) Make predictions and generalisations based on evidence.

Outcome 3

Collect and analyse information related to metabolism and survival by experiment.

Performance Criteria

(a) Participate actively in the collection of information by experiment.
(b) Describe the experimental procedures accurately.
(c) Record relevant measurements and observations in an appropriate format.
(d) Analyse and present the recorded experimental information in an appropriate format.
(e) Draw valid conclusions.
(f) Evaluate the experimental procedures with supporting argument.

National Unit specification: statement of standards (cont)

Unit title: Metabolism and Survival (SCQF level 6)

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have achieved all Outcomes and Performance Criteria.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

Evidence of an appropriate level of achievement must be generated from a closed-book instrument of assessment under controlled conditions covering the Performance Criteria for Outcome 1 and Outcome 2 set in the context of metabolism being essential for life, maintaining metabolism and investigating metabolism in microorganisms.

In the evidence for planning and designing experimental procedures in Outcome 2 PC (d) candidates must be able to develop and justify a hypothesis to be investigated or the aim of an experiment.

A report of one experiment is required covering the Performance Criteria for Outcome 3 set in the context of metabolism being essential for life, maintaining metabolism and investigating metabolism in microorganisms. The report can be in the format of a traditional lab report or alternative that covers the Performance Criteria for the Unit including conference poster format, scientific paper format, Power Point presentation, video presentation or web page.

The teacher/lecturer responsible must attest that the report is the individual work of the candidate derived from active participation in an experiment in which the candidate plans the experiment; decides how it is managed; identifies and obtains the necessary resources, some of which must be unfamiliar; and carries out the experiment. Depending on the activity, the collection of the information may be group work.

Evidence submitted in support of attainment of PC (d) must be in the format of a table or graph(s) as appropriate. Conclusions drawn should be justified by reference to supporting evidence and comment on trends or patterns and/or connections between variables and controls.

The evaluation should cover all stages of the experiment, including the initial analysis of the situation and planning and organising the experimental procedure. In carrying out the experiment candidates should consider modifying procedures and respond to sources of error.

National Unit specification: support notes

Unit title: Metabolism and Survival (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

1 Metabolism is essential for life

(a) Introduction to metabolism:
  (i) Metabolic pathways (anabolism and catabolism)
  (ii) Membranes form metabolic surfaces and compartments

(b) Control of metabolic pathways:
  (i) Enzyme action
  (ii) Control of metabolic pathways through the regulation of enzyme action

(c) Cellular respiration:
  (i) Transfer of energy via ATP
  (ii) Synthesis of ATP
  (iii) Metabolic pathways of cellular respiration (glycolysis, citric acid cycle and electron transport chain)
  (iv) Substrates for respiration

2 Maintaining metabolism

(a) Metabolic rate:
  (i) Oxygen delivery

(b) Metabolism in conformers and regulators:
  (i) Thermoregulation in mammals

(c) Maintaining metabolism during environmental change:
  (i) Surviving adverse conditions
  (ii) Avoiding adverse conditions

(d) Extremophiles

3 Investigating metabolism in microorganisms

(a) Environmental control of metabolism:
  (i) Culture conditions
  (ii) Patterns of growth
  (iii) Controlling metabolism

(b) Genetic control of metabolism:
  (i) Genetic variation
  (ii) Recombinant DNA technology
  Plasmids and artificial chromosomes

(c) Ethical considerations in the use of microorganisms

Further guidance on the content and context for this Unit is provided in the Course content tables for Metabolism and Survival in the Course specification for Biology (revised) Higher. The suggested learning activities and approaches column in these tables provides contexts in which the Knowledge and Understanding and skills of this Unit can be developed and are not liable for assessment although they may provide contexts for assessment items.

National Unit specification: support notes (cont)

Unit title: Metabolism and Survival (SCQF level 6)

Guidance on learning and teaching approaches for this Unit

Guidance on learning and teaching approaches for this Unit are provided in the guidance on learning and teaching approaches in the Course specification for Biology (revised) Higher.

Opportunities for developing Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes of this Unit specification. The guidance on learning and teaching approaches for this Unit provided in the Course specification for Biology (revised) Higher highlights opportunities to develop *Using Number* when processing information and Oral and Written Communication when presenting information. In addition the guidance on learning and teaching approaches highlights opportunities to develop *Working with Others* when carrying out practical experimental work and in using *Information and Communication Technology* in practical experimental work and for data analysis.

Guidance on approaches to assessment for this Unit

A holistic approach is taken to assessment, ie Outcomes 1 and 2 are assessed by an integrated end of Unit test with questions covering all the Performance Criteria for Knowledge and Understanding and Problem Solving.

Outcome 1

Test items should be constructed to allow candidates to meet all of the Performance Criteria in the context of metabolism being essential for life, maintaining metabolism and investigating metabolism in microorganisms.

Outcome 2

Test items should be constructed to allow candidates to generate evidence relating to the Performance Criteria as follows:

(a) Selecting and presenting information:
- sources of information to include: texts, tables, charts, keys, graphs and diagrams
- formats of presentation to include: written summaries, extended writing, tables and graphs.

(b) Calculations to include: percentages, averages, ratios. Significant figures and units should be used appropriately.

(c) Conclusions drawn should include some justification, and explanations should be reported by evidence. Conclusions could contain a comment on trends or patterns and/or connections between variables and controls.

(d) Candidates could plan and design procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required. The evaluation of given experimental procedures may include situations which are unfamiliar to candidates and could test the candidates' ability to comment on the purpose of approach or the suitability of given experimental procedures. Candidates could comment on the limitations of the set-up, apparatus, suggested measurements or observations, limitations of equipment, appropriateness of controls, sources of error and possible improvements.

(e) Candidates could make predictions and generalisations from given experimental results or, given situations, predict what the results might be.

Outcome 3

Type of experimental activity

The teacher/lecturer should ensure that the experimental activity to be undertaken in connection with Outcome 3 affords opportunity for the candidate to demonstrate the ability to undertake the planning and organising of an experimental activity at an appropriate level of demand. The activity must relate to the Course content and candidates should be made aware of the range of skills which must be demonstrated to ensure attainment of Outcome 3.

Assessment of Outcome 3

Candidates are only required to produce one report for Outcome 3 in relation to the contents and notes specified for Higher (revised) Biology. This report can then be used as evidence for Outcome 3 for the other Units of the Course.

In relation to PC (a), the teacher/lecturer checks by observation that the candidate participates in the collection of the experimental information by playing an active part in planning the experiment, deciding how it will be managed, identifying and obtaining resources (some of which must be unfamiliar to the candidate), and carrying out the experiment.

Candidates should provide a report with an appropriate title. The report should relate to the Performance Criteria as follows:

(b) The experimental procedures are described accurately.	A clear statement of the aim of the experiment. A few brief concise sentences including as appropriate: ♦ a labelled diagram or brief description of apparatus or ♦ instruments used ♦ how the independent variable was altered ♦ control measure used ♦ how measurements were taken or observations made.

National Unit specification: support notes (cont)

Unit title: Metabolism and Survival (SCQF level 6)

	There is no need for a detailed description. The use of the impersonal passive voice is to be encouraged as an example of good practice but this is not mandatory for meeting the Performance Criteria.
(c) Relevant measurements and observations are recorded in an appropriate format.	Readings or observations (raw data) must be recorded in a clear table with correct headings, appropriate units and results/readings entered correctly.
(d) Recorded experimental information is analysed and presented in an appropriate format.	Data should be analysed and presented in tabular, graphical format or as a scatter diagram or equivalent, as appropriate: ♦ For a tabular presentation this may be an extension of the table used for PC (c) above, and must include: suitable headings and units showing averages or other appropriate computations ♦ For a graphical presentation this must include: data presented as a histogram, bar chart, connected points or line of best fit as appropriate, with suitable scales and axes labelled with variable and units and with data correctly plotted.
(e) Conclusions drawn are valid.	Conclusions should use evidence from the experiment and relate back to the aim of the experiment. At least one of the following should be included: ♦ overall pattern to readings or observations (raw data) ♦ trends in analysed information or results ♦ connection between variables and controls.
(f) The experimental procedures are evaluated with supporting argument.	The evaluation could cover all stages of the activity including preparing for the activity, analysis of the activity and the results of the activity. The evaluation must include supporting argument in at least one of the following: ♦ effectiveness of procedures ♦ control of variables ♦ limitations of equipment ♦ possible sources of error ♦ possible improvements.

National Unit specification: support notes (cont)

Unit title: Metabolism and Survival (SCQF level 6)

The bullet points under each Performance Criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the experiment. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to external verification) against the Performance Criteria. It is appropriate to support candidates in producing a report to meet the Performance Criteria. Re-drafting of a report after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting and resubmission is only required for the specific Performance Criterion identified in need of further attention, ie the entire report does not need to be rewritten.

Conditions required to complete the report

Candidates may complete their work outwith class time provided reasonable measures are taken to ensure that the report is the individual work of the candidate. Teachers and lecturers may wish candidates to write up reports under their direct supervision so that they can provide appropriate advice and support. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidate's response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Use of IT

Candidates may, if they wish, present their reports in a word-processed format. Candidates may use Excel (or any other suitable data analysis software) when tackling Outcome 3. However, candidates must not be given a spreadsheet with pre-prepared column headings nor formulae, as they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. The use of clip art or images captured by digital camera may also be used in recording details of experimental methods.

Transfer of evidence

Candidates may transfer evidence for Outcome 3 from one level to the one below provided the experiment is in the context of the Course concerned. Candidates, who are repeating a Course, may carry forward evidence of an appropriate standard, generated in a previous year.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

National Unit specification: support notes (cont)

Unit title: Metabolism and Survival (SCQF level 6)

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

History of changes

Version	Description of change	Date

National Unit specification: general information

Unit title: Sustainability and Interdependence (SCQF level 6)

Unit code: FH2J 12

Superclass: RH

Publication date: March 2011

Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit is a mandatory Unit of the Biology (revised) Higher Course and has been designed to be taken as part of that Course. It can also be taken as a free-standing Unit.

This Unit seeks to develop Knowledge and Understanding, Problem Solving and practical skills related to the science of food production, interrelationships and dependence and biodiversity.

Successful candidates will be able to describe and explain aspects of sustainability and interdependence and apply their knowledge in new situations and when interpreting related biological information. They will be able to collect, analyse and present scientific data and information; plan, design and carry out practical work; draw conclusions, evaluate and make predictions and generalisations based on scientific evidence. They will be able to write a scientific report on an experimental activity related to sustainability and interdependence that they have carried out.

This Unit is suitable for candidates who have studied plant biology, inheritance and ecology as part of a Course or Unit at SCQF level 5.

Outcomes

1 Demonstrate Knowledge and Understanding related to sustainability and interdependence.
2 Solve problems related to sustainability and interdependence using scientific skills.
3 Collect and analyse information related to sustainability and interdependence by experiment.

General information (cont)

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained a Biology National Qualification at SCQF level 5 or its equivalent.

Credit points and level

1 SQA credit at SCQF level 6: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill	*Problem Solving* at SCQF level 6
Core Skill component	Using Graphical Information at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit specification: statement of standards

Unit title: Sustainability and Interdependence (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Demonstrate Knowledge and Understanding related to sustainability and interdependence.

Performance Criteria

(a) Make accurate statements and give clear descriptions about the biology of sustainability and interdependence.
(b) Apply relevant knowledge of sustainability and interdependence in new situations and appreciate its significance when interpreting biological information.
(c) Explain the biology of sustainability and interdependence with reasons or supporting evidence.

Outcome 2

Solve problems related to sustainability and interdependence using scientific skills.

Performance Criteria

(a) Select and present relevant information in an appropriate format.
(b) Process information accurately using calculations where appropriate.
(c) Draw valid conclusions and give explanations supported by evidence.
(d) Plan, design and evaluate experimental procedures appropriately.
(e) Make predictions and generalisations based on evidence.

Outcome 3

Collect and analyse information related to sustainability and interdependence by experiment

Performance Criteria

(a) Participate actively in the collection of information by experiment.
(b) Describe the experimental procedures accurately.
(c) Record relevant measurements and observations in an appropriate format.
(d) Analyse and present the recorded experimental information in an appropriate format.
(e) Draw valid conclusions.
(f) Evaluate the experimental procedures with supporting argument.

National Unit specification: statement of standards (cont)

Unit title: Sustainability and Interdependence (SCQF level 6)

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have achieved all Outcomes and Performance Criteria.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

Evidence of an appropriate level of achievement must be generated from a closed-book instrument of assessment under controlled conditions covering the Performance Criteria for Outcome 1 and Outcome 2 set in the context of the science of food production, interrelationships and dependence and biodiversity.

In the evidence for planning and designing experimental procedures in Outcome 2 PC (d) candidates must be able to develop and justify a hypothesis to be investigated or the aim of an experiment.

A report of one experiment is required covering the Performance Criteria for Outcome 3 set in the context of the science of food production, interrelationships and dependence and biodiversity. The report can be in the format of a traditional lab report or alternative that covers the Performance Criteria for the Unit including conference poster format, scientific paper format, Power Point presentation, video presentation or web page.

The teacher/lecturer responsible must attest that the report is the individual work of the candidate derived from active participation in an experiment in which the candidate plans the experiment; decides how it is managed; identifies and obtains the necessary resources, some of which must be unfamiliar; and carries out the experiment. Depending on the activity, the collection of the information may be group work.

Evidence submitted in support of attainment of PC (d) must be in the format of a table or graph(s) as appropriate. Conclusions drawn should be justified by reference to supporting evidence and comment on trends or patterns and/or connections between variables and controls.

The evaluation should cover all stages of the experiment, including the initial analysis of the situation and planning and organising the experimental procedure. In carrying out the experiment candidates should consider modifying procedures and respond to sources of error.

National Unit specification: support notes

Unit title: Sustainability and Interdependence (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

1 The science of food production

(a) Food supply:
  (i) Food security
  (ii) Agricultural production

(b) Plant growth and productivity:
  (i) Photosynthesis (energy capture)
  (ii) Plant productivity

(c) Plant and animal breeding for sustainable food production (variation, field trials):
  (i) Selecting and breeding
  (ii) Cross breeding and F1 hybrids
  (iii) Genetic technology

(d) Crop protection:
  (i) Weeds, pests and diseases
  (ii) Control of weeds, pests and diseases
  (iii) Problems with plant protection chemicals
  (iv) Biological control and integrated pest management

(e) Animal welfare:
  (i) Observing behaviour (ethology)

2 Interrelationships and dependence

(a) Symbiosis:
  (i) Parasitism
  (ii) Mutualism

(b) Social behaviour:
  (i) Altruism and kin selection
  (ii) Social insects
  (iii) Primate behaviour

3 Biodiversity

(a) Mass extinction

(b) Measuring biodiversity:
  (i) Genetic diversity
  (ii) Species diversity

(c) Threats to biodiversity:
  (i) Overexploitation
  (ii) Habitat loss
  (iii) Introduced, naturalised and invasive species
  (iv) Anthropogenic climate change

National Unit specification: support notes (cont)

Unit title: Sustainability and Interdependence (SCQF level 6)

Further guidance on the content and context for this Unit is provided in the Course content tables for sustainability and interdependence in the Course specification for Biology (revised) Higher. The suggested learning activities and approaches column in these tables provides contexts in which the Knowledge and Understanding and skills of this Unit can be developed and are not liable for assessment although they may provide contexts for assessment items.

Guidance on learning and teaching approaches for this Unit

Guidance on learning and teaching approaches for this Unit are provided in the guidance on learning and teaching approaches in the Course specification for Biology (revised) Higher.

Opportunities for developing Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes of this Unit specification. The guidance on learning and teaching approaches for this Unit provided in the Course specification for Biology (revised) Higher highlights opportunities to develop Using Number when processing information and Oral and Written Communication when presenting information. In addition the guidance on learning and teaching approaches highlights opportunities to develop *Working with Others* when carrying out practical experimental work and in using *Information and Communication Technology* in practical experimental work and for data analysis.

Guidance on approaches to assessment for this Unit

A holistic approach is taken to assessment, ie Outcomes 1 and 2 are assessed by an integrated end of Unit test with questions covering all the Performance Criteria for Knowledge and Understanding and Problem Solving.

Outcome 1

Test items should be constructed to allow candidates to meet all of the Performance Criteria in the context of the science of food production, interrelationships and dependence and biodiversity.

Outcome 2

Test items should be constructed to allow candidates to generate evidence relating to the Performance Criteria as follows:

(a) Selecting and presenting information:
- sources of information to include: texts, tables, charts, keys, graphs and diagrams
- formats of presentation to include: written summaries, extended writing, tables and graphs.

(b) Calculations to include: percentages, averages, ratios. Significant figures and units should be used appropriately.

(c) Conclusions drawn should include some justification, and explanations should be reported by evidence. Conclusions could contain a comment on trends or patterns and/or connections between variables and controls.

(d) Candidates could plan and design procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required. The evaluation of given experimental procedures may include situations which are unfamiliar to candidates and could test the candidates' ability to comment on the purpose of approach or the suitability of given experimental procedures. Candidates could comment on the limitations of the set-up, apparatus, suggested measurements or observations, limitations of equipment, appropriateness of controls, sources of error and possible improvements.

(e) Candidates could make predictions and generalisations from given experimental results or, given situations, predict what the results might be.

Outcome 3

Type of experimental activity

The teacher/lecturer should ensure that the experimental activity to be undertaken in connection with Outcome 3 affords opportunity for the candidate to demonstrate the ability to undertake the planning and organising of an experimental activity at an appropriate level of demand. The activity must relate to the Course content and candidates should be made aware of the range of skills which must be demonstrated to ensure attainment of Outcome 3.

Assessment of Outcome 3

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