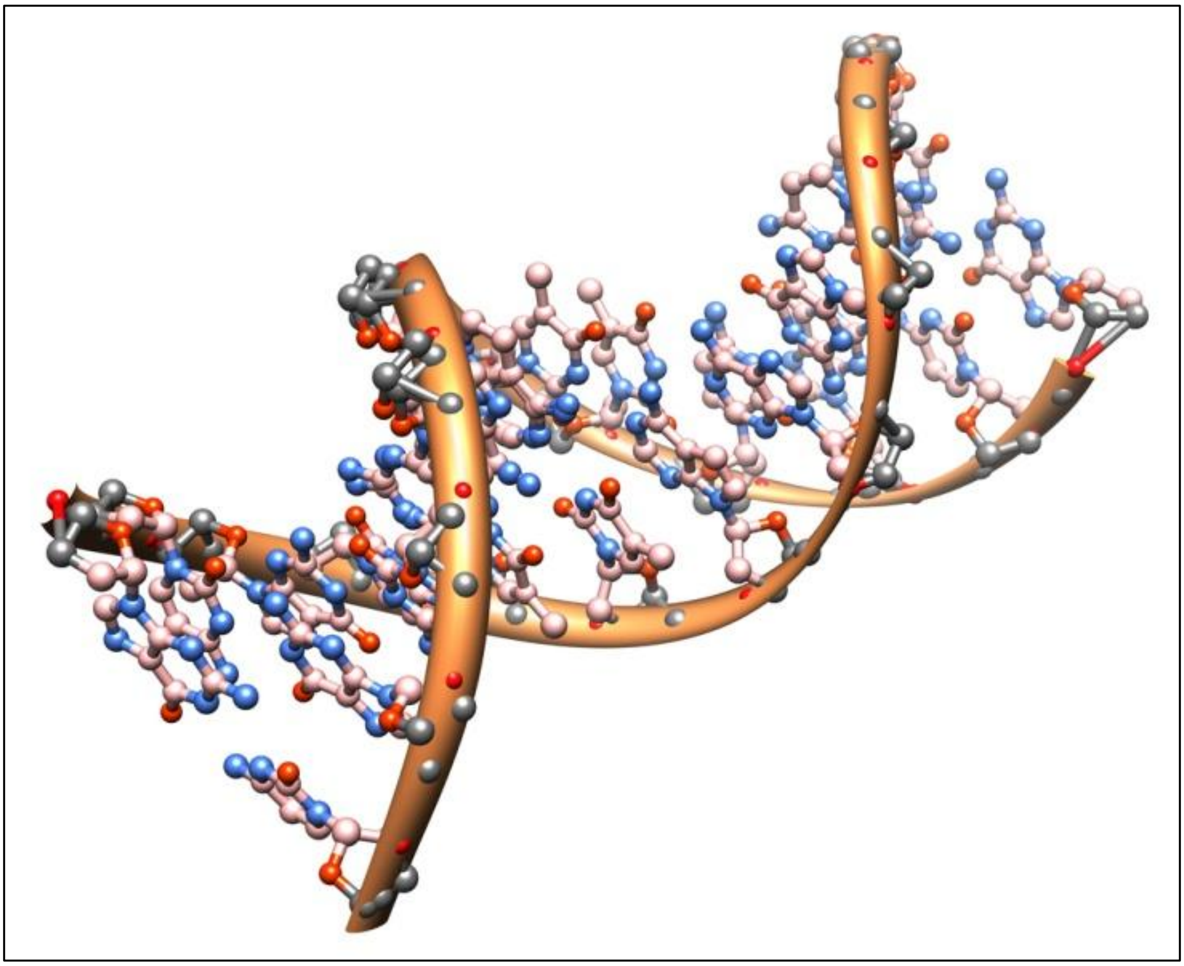
Course Support Notes

# Higher Biology Course Support Notes





Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

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# Contents

# Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Higher Biology Course. They are intended for teachers and lecturers who are delivering the Course and its Units. They should be read in conjunction with the *Course Specification*, the *Course Assessment Specification* and the Unit Specifications for the Units in the Course.

# General guidance on the Course

## Aims

As stated in the *Course Specification,* the aims of the Course are to enable learners to:

- develop and apply knowledge and understanding of biology
- develop an understanding of biology's role in scientific issues and relevant applications of biology, including the impact these could make in society and the environment
- develop scientific inquiry and investigative skills
- develop scientific analytical thinking skills, including scientific evaluation, in a biology context
- develop the use of technology, equipment and materials, safely, in practical scientific activities, including using risk assessments
- develop planning skills
- develop problem solving skills in a biology context
- use and understand scientific literacy to communicate ideas and issues and to make scientifically informed choices
- develop the knowledge and skills for more advanced learning in biology
- develop skills of independent working

## Progression into this Course

Entry to this Course is at the discretion of the centre. However, learners would normally be expected to have attained some relevant skills and knowledge through prior experience.

Skills and knowledge developed through any of the following, while **not mandatory,** are likely to be helpful as a basis for further learning in this Course:

- National 5 Biology Course

More detail is contained in the Biology Progression Framework. The Biology Progression framework shows the development of the key areas throughout the suite of Courses

## Skills, knowledge and understanding covered in the Course

Note: teachers and lecturers should refer to the *Course Assessment Specification* for mandatory information about the skills, knowledge and understanding to be covered in this Course.

## Progression from this Course

This Course or its components may provide progression for the learner to:

- Advanced Higher Biology or related areas
- further study, employment and/or training

# Hierarchies

**Hierarchy** is the term used to describe Courses and Units which form a structured sequence involving two or more SCQF levels.

It is important that any content in a Course and/or Unit at one particular SCQF level is not repeated (unless required for consolidation) if a learner progresses to the next level of the hierarchy. The skills and knowledge should be able to be applied to new content and contexts to enrich the learning experience. This is for centres to manage.

- Biology Courses from National 3 to Advanced Higher are hierarchical.
- Courses from National 3 to National 5 have Units with the same structure and titles.

National 5 gives equal progression to both Higher Biology and Higher Human Biology. Higher Biology and Higher Human Biology give equal progression to Advanced Higher Biology.

# Approaches to learning and teaching

The purpose of this section is to provide you with advice and guidance on learning and teaching. It is essential that you are familiar with the mandatory information within the Higher Biology *Course Assessment Specification*.

Teaching should involve an appropriate range of approaches to develop knowledge and understanding and skills for learning, life and work. This can be integrated into a related sequence of activities, centred on an idea, theme or application of biology, based on appropriate contexts, and need not be restricted to the Unit structure. Learning should be experiential, active, challenging and enjoyable, and include appropriate practical experiments/activities and could be learner led. The use of a variety of active learning approaches is encouraged, including peer teaching and assessment, individual and group presentations, role-playing and game-based learning, with learner-generated questions.

When developing your Biology Course there should be opportunities for learners to take responsibility for their learning. Learning and teaching should build on learners' prior knowledge, skills and experiences. The Units and the key areas identified within them may be approached in any appropriate sequence, at the centre's discretion. The distribution of time between the various Units is a matter for professional judgement and is entirely at the discretion the centre. Each Unit is likely to require an approximately equal time allocation, although this may depend on the learners' prior learning in the different key areas.

Learning and teaching, within a class, can be organised, in a flexible way, to allow a range of learners' needs to be met and to ensure progression. The new qualifications provide improved continuity between the levels. Centres can, therefore, confidently continue to organise learning and teaching strategies, in ways appropriate for their learners.

Within a class, there may be learners capable of achieving at a higher level in some aspects of the Course. Where possible, they should be given the opportunity to do so. There may also be learners who are struggling to achieve in all aspects of the Course, and may only achieve at the lower level in some areas.

Teachers/lecturers need to consider the Course and Unit Specifications, and *Course Assessment Specifications* to identify the differences between Course levels. It may also be useful to refer to the Biology Progression Framework.

When delivering this Course to a group of learners, with some working towards different levels, it may be useful for teachers to identify activities covering common key areas and skills for all learners, and additional activities required for some learners. In some aspects of the Course, the difference between levels is defined in terms of a higher level of skill.

An investigatory approach is encouraged in Biology, with learners actively involved in developing their skills, knowledge and understanding by investigating a range of relevant biological applications and issues. A holistic approach should be adopted to encourage simultaneous development of learners' conceptual understanding and skills.

Where appropriate, investigative work/experiments, in Biology, should allow learners the opportunity to select activities and/or carry out extended study. Investigative and experimental work is part of the scientific method of working and can fulfil a number of educational purposes.

All learning and teaching should offer opportunities for learners to work collaboratively. Practical activities and investigative work can offer opportunities for group work, which should be encouraged. Laboratory work should include the use of technology and equipment that reflects current scientific use in Biology. Fieldwork provides an opportunity for practical work, using first-hand experience of an ecosystem to develop knowledge, understanding and problem solving. Appropriate risk assessment must be undertaken.

Learners, especially at Higher, would be expected to contribute their own time in addition to programmed learning time.

Effective partnership working can enhance the science experience. Where feasible, locally relevant contexts should be studied, with visits where this is possible. Guest speakers from eg industry, further and higher education could be used to bring the world of biology into the classroom.

Information and Communications Technology (ICT) can make a significant contribution to practical work in Higher 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 long or short periods of 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 that can then be downloaded and viewed for analysis.

Learning about Scotland and Scottish culture will enrich the learners' learning experience and help them to develop the skills for learning, life and work they will need to prepare them for taking their place in a diverse, inclusive and participative Scotland and beyond. Where there are opportunities to contextualise approaches to learning and teaching to Scottish contexts, teachers and lecturers should consider this.

Assessment should be integral to and improve learning and teaching. The approach should involve learners and provide supportive feedback. Self- and peer-assessment techniques should be encouraged, wherever appropriate. Assessment information should be used to set learning targets and next steps.

Suggestions for possible contexts and learning activities, to support and enrich learning and teaching, are detailed in the tables below.

# 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 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.

Learners 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

## DNA and the Genome

The **Mandatory Course key areas** are from the *Course Assessment Specification*. Activities in the **Suggested learning activities** are not mandatory. This offers examples of suggested activities, from which you could select a range of suitable activities. It is not expected that all will be covered. Centres may also devise their own learning activities. **Exemplification of key areas** is not mandatory. It provides an outline of the level of demand and detail of the key areas. In the **Suggested learning activities**, there are references to the use of case studies. These should be seen as a suggested approach to teaching and learning and not confused with the use of Case Study as a method of Course assessment. These case studies should make learning active, challenging and enjoyable and identify for the learner the Course content and skills that will be developed. Case studies should be developed in such a way that learners 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.

| Mandatory Course key areas | Suggested learning activities | Exemplification of key areas |
|---|---|---|
| **1 The structure and replication of DNA** | | |
| (a) Structure of DNA —nucleotides (deoxyribose sugar, phosphate and base), sugar–phosphate backbone, base pairing (adenine, thymine and guanine, cytosine), by hydrogen bonds and 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. | All cells store their genetic information in the base sequence of DNA. The genotype is determined by the sequence of bases. |
| (i) Organisation of DNA —<br>circular chromosomal DNA and plasmids in prokaryotes. Circular plasmids in yeast. Circular chromosome in mitochondria and chloroplasts of eukaryotes.<br><br>Linear chromosomes in the nucleus of eukaryotes. | Watson and Crick's double-helix model as an evidence-based conclusion.<br><br>Case study on Meselson and Stahl experiments on DNA replication.<br>DNA gel electrophoresis.<br>Comparison of DNA extraction from peas and kiwi fruit (false positive result in latter as DNA is obscured by pectin). | The DNA found in the linear chromosomes of the nucleus of eukaryotes is tightly coiled and packaged with associated proteins. |

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| (b) Replication of DNA by DNA polymerase and primer. Directionality of replication on both template strands — DNA polymerase adds complementary nucleotides to the deoxyribose (3') end of a DNA strand. Fragments of DNA are joined together by ligase. | Virtual or physical modelling of DNA replication. | Prior to cell division, DNA is replicated by a DNA polymerase. DNA polymerase needs a primer to start replication.<br><br>DNA is unwound and unzipped to form two template strands. This process occurs at several locations on a DNA molecule. DNA polymerase can only add DNA nucleotides in one direction resulting in one strand being replicated continuously and the other strand replicated in fragments. |
| (i) Polymerase chain reaction (PCR) amplification of DNA using complementary primers for specific target sequences.<br><br>DNA heated to separate strands then cooled for primer binding. Heat-tolerant DNA polymerase then replicates the region of DNA. Repeated cycles of heating and cooling amplify this region of DNA. | Case study on the use of PCR, including practical using thermal cycler or water baths.<br><br>Emphasise the ‘needle in a haystack’ accuracy of primers and the amplification of ‘a haystack from the needle’ by PCR.<br><br>Investigating plant evolution using chloroplast DNA and PCR. | The polymerase chain reaction (PCR) is a technique for the amplification of DNA *in vitro*.<br><br>In PCR, primers are complementary to specific target sequences at the two ends of the region to be amplified.<br><br>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. |

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| **2 Gene expression**<br>The phenotype is determined by the proteins produced as the result of gene expression, influenced by intra- and extra-cellular environmental factors.<br>Only a fraction of the genes in a cell are expressed. | Separation and identification of fish proteins by agarose gel electrophoresis. | The genetic code used in transcription and translation is found in all forms of life. |
| (a) Gene expression is controlled by the regulation of transcription and translation. | | mRNA is transcribed from DNA in the nucleus and translated into proteins by ribosomes in the cytoplasm. |
| (i) Structure and functions of RNA<br>Single strand, replacement of thymine with uracil and deoxyribose with ribose compared to DNA. mRNA (messenger) carries a copy of the DNA code from the nucleus to the ribosome. rRNA (transfer) and proteins form the ribosome. Each tRNA carries a specific amino acid. | | |
| (ii) Transcription of DNA into primary and mature RNA transcripts to include the role of RNA polymerase and complementary base pairing.<br>The introns of the primary transcript of mRNA are non-coding and are removed in RNA splicing. The exons are coding regions and are joined together to form mature transcript. This process is called RNA splicing. | Modelling transcription and translation using virtual and physical resources. | RNA polymerase moves along DNA unwinding and unzipping the double helix and synthesising a primary transcript of RNA from RNA nucleotides by complementary base pairing.<br>Introns (non-coding regions of genes) and exons (coding regions of genes). |

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| (iii) Translation of mRNA into a polypeptide by tRNA at the ribosome. tRNA folds due to base pairing to form a triplet anticodon site and an attachment site for a specific amino acid. Triplet codons on mRNA and anticodons translate the genetic code into a sequence of amino acids. Start and stop codons exist. Codon recognition of incoming tRNA, peptide bond formation and exit of tRNA from the ribosome as polypeptide is formed.<br><br>(iv) One gene, many proteins as a result of RNA splicing and post-translational modification.<br>Different mRNA molecules are produced from the same primary transcript depending on which RNA segments are treated as exons and introns.<br>Post-translation protein structure modification by cutting and combining polypeptide chains or by adding phosphate or carbohydrate groups to the protein. | | |
| (v) Proteins are held in a three-dimensional shape — peptide bonds, folded polypeptide chains, hydrogen bonds, interactions between individual amino acids. | Investigation of the shape and structure of fibrous and globular proteins using RasMol or protein explorer software.<br><br>Separation and identification of amino acids using paper chromatography. | Proteins have a large variety of structures and shapes resulting in a wide range of functions. Amino acids are linked by peptide bonds to form polypeptides. Polypeptide chains fold to form the three-dimensional shape of a protein, held together by hydrogen bonds and other interactions between individual amino acids. |

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| (b) Cellular differentiation is the process by which a cell develops more specialised functions by expressing the genes characteristic for that type of cell. | | |
| Differentiation into specialised cells from meristems in plants; embryonic and tissue (adult) stem cells in animals. | Tissue culture of plant material. | Meristems are regions of unspecialised cells in plants that are capable of cell division. 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. |
| (i) Research and therapeutic uses of stem cells by reference to the repair of damaged or diseased organs or tissues.<br>Stem cell research provides information on how cell processes such as cell growth, differentiation and gene regulation work. Stem cells can be used as model cells to study how diseases develop or for drug testing. The ethical issues of stem cell use and the regulation of their use. | Case study on use of stem cells in repair of diseased or damaged organs (eg skin grafts, bone marrow transplantation and cornea repair).<br><br>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 (adult) stem cells and attempts to reprogram 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. | Tissue (adult) stem cells replenish differentiated cells that need to be replaced and give rise to a more limited range of cell types, eg red bone marrow produces various blood cell types. Once a cell becomes differentiated it only expresses the genes that produce the proteins characteristic for that type of cell.<br><br>The therapeutic uses of stem cells should be exemplified by reference to the repair of damaged or diseased organs, eg corneal transplants, and skin grafts for burns. |

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| **3 Genome**<br>(a) The structure of the genome — coding and 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. | 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-translated forms of RNA include tRNA, rRNA and RNA fragments. |
| (b) Mutations are changes in the genome that can result in no protein or an altered protein being expressed. | Investigate mutant yeast or germination rates of irradiated seeds. | |
| (i) Single gene mutations involve the alteration of a DNA nucleotide sequence as a result of the substitution, insertion or deletion of nucleotides. Single-nucleotide substitutions include: missense, nonsense and splice-site mutations. Nucleotide insertions or deletions result in frame-shift mutations or an expansion of a nucleotide sequence repeat. | 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. | Regulatory sequence mutations can alter gene expression. Splice site mutations can alter post-transcriptional processing. |
| (ii) Chromosome structure mutations — duplication, deletion and translocation.<br><br>(iii) The importance of mutations and 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. | Alterations to the structure of one or more chromosomes.<br>Importance of gene duplication in evolution. |

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| (iv) Polyploidy — errors during the separation of chromosomes during cell division can result in cells with whole genome duplications.<br>Importance of polyploidy in evolution and human food crops<br><br>(c) Evolution — the changes in organisms over generations as a result of genomic variations.<br><br>(i) Gene transfer.<br>Vertical (inheritance) - from parent to offspring as a result of sexual or asexual reproduction.<br>Horizontal - prokaryotes and viruses can exchange genetic material in this way.<br><br>(ii) Selection.<br>Natural selection is the non-random increase in frequency of DNA sequences that increase survival. Sexual selection is an increase in successful reproduction.<br><br>(iii) Genetic drift. The random increase and decrease in frequency of sequences, particularly in small populations, as a result of neutral mutations and founder effects. | Research polyploidy in plants and importance in origin of crop plants.<br>Research rarity of polyploidy in animals.<br><br>Gather data on sexual selection in brine shrimp. | Polyploidy examples include banana (triploid) and potato (tetraploid), as well as swede, oil seed rape, wheat and strawberry.<br><br>Prokaryotes can exchange genetic material horizontally, resulting in rapid evolutionary change. Prokaryotes and viruses can transfer sequences horizontally into the genomes of eukaryotes.<br><br>The non-random reduction in frequency of deleterious DNA sequences.<br>The differences in outcome as a result of stabilising, directional and disruptive selection. |

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| (iv) Speciation is the generation of new biological species by evolution.<br>The importance of geographical barriers in allopatric speciation. The importance of behavioural or ecological barriers in sympatric speciation. Hybrid zones. | Research different definitions of the term species (e.g. biological species concept, phylogenetic species concept) and the difficulty of applying species definition to asexually reproducing organisms.<br><br>Research the London Underground mosquito.<br><br>Collaborative data gathering of hooded crow and carrion crow hybrid zone in Scotland. | A species is a group of organisms capable of interbreeding and producing fertile offspring, and which does not normally breed with other groups.<br><br>The formation of hybrid zones in regions where the ranges of closely related species meet. |
| (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. | |
| (i) Evidence from phylogenetics and molecular clocks to determine the main sequence of events in evolution. | Case study on the evolution of bears and primates using Geneious software.<br>Highly conserved DNA sequences are used for comparisons of distantly related genomes. | 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). |
| | Compare number and proportion of shared genes between organisms such as *C. elegans*, *Drosophila* and humans. | The use of sequence data and fossil evidence to determine the main sequence of events in evolution of life: cells, last universal ancestor, photosynthetic organisms, eukaryotes, |

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| | | multicellularity, animals, land plants, vertebrates. |
| (ii) Comparison of genomes from different species.<br>Comparison of genomes reveals that many genes are highly conserved across different organisms | Research the importance of the *Fugu* genome as an example of a very small vertebrate genome with a high rate of chromosome deletion.<br><br>Comparison of human and chimp genomes reveals rapid change in genes for immune system and regulation of neural development over last 6 million years. | Many genomes have been sequenced, particularly of disease-causing organisms, pest species and species that are important model organisms for research. |
| (iii) Personal genomics and health.<br><br>Analysis of an individual's genome may lead to personalised medicine through knowledge of the genetic component of risk of disease and likelihood of success of a particular treatment. | Comparison of individual's genomes focuses on point mutations, repetitive sequence errors and blocks of duplication and deletion. | Pharmacogenetics.<br><br>The difficulties in distinguishing between neutral and harmful mutations in both genes and regulatory sequences, and in understanding the complex nature of many diseases. |

# 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, learners should work co-operatively 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.

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.

Learners 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

## Metabolism and Survival

The **Mandatory Course key areas** are from the *Course Assessment Specification*. Activities in the **Suggested learning activities** are not mandatory. This offers examples of suggested activities, from which you could select a range of suitable activities. It is not expected that all will be covered. Centres may also devise their own learning activities. **Exemplification of key areas** is not mandatory. It provides an outline of the level of demand and detail of the key areas. In the **Suggested learning activities**, there are references to the use of case studies. These should be seen as a suggested approach to teaching and learning and not confused with the use of Case Study as a method of Course assessment. These case studies should make learning active, challenging and enjoyable and identify for the learner the Course content and skills that will be developed. Case studies should be developed in such a way that learners 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.

| Mandatory Course key areas | Suggested learning activities | Exemplification of key areas |
|---|---|---|
| **1 Metabolism is essential for life**<br>(a) Introduction to metabolic pathways — 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) Anabolic (energy requiring) and catabolic (energy releasing) pathways — can have reversible and irreversible steps and alternative routes. | | Metabolic pathways involve biosynthetic processes (anabolism) and the breakdown of molecules (catabolism) to provide energy and building blocks. |
| (ii) Membranes form surfaces and compartments for metabolic pathways — protein pores, pumps and enzymes embedded in phospholipid membranes. | Examine photomicrographs to compare ultrastructure of prokaryotes and eukaryotes and compartments and membranes in mitochondria and chloroplasts. | Membranes can form compartments to localise the metabolic activity of the cell. The high surface to volume ratio of small compartments allows high concentrations and high reaction rates. |

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| (b) Control of metabolic pathways (presence or absence of particular enzymes and the regulation of the rate of reaction of key enzymes within the pathway<br><br>(i) Induced fit and the role of the active site of enzymes including shape and substrate affinity. Activation energy. The effects of substrate and end product concentration on the direction and rate of enzyme reactions. Enzymes often act in groups or as multi-enzyme complexes.<br><br>(ii) Control of metabolic pathways through competitive, non-competitive and feedback inhibition. | Enzyme induction experiments such as ONPG and lactose metabolism in *E. coli* and PGlo experiments.<br><br>Activation energy experiments, comparing heat, manganese dioxide and catalase action on hydrogen peroxide.<br><br>Experiments on reaction rate with increasing substrate concentration.<br><br>Investigate the inhibition of beta galactosidase by galactose and its reversal by increasing ONPG concentration.<br><br>Experiments on product inhibition with phosphatase. | Regulation can be controlled by intra- and extra cellular signal molecules.<br><br>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.<br><br>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.<br><br>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.<br>Competitive inhibition (binds to active site), non-competitive inhibition (changes shape of active site) and feedback inhibition (end product binds to an enzyme, catalysing a reaction earlier in the pathway).<br>Competitive inhibition can be reversed by increasing substrate concentration. |

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| (c) Cellular respiration — glucose broken down, hydrogen electrons removed by dehydrogenase enzymes, releasing ATP. | | 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. |
| (i) The role of ATP in the transfer of energy and the phosphorylation of molecules by ATP. | Experiments on ATP dependent reactions, eg luciferase, luminescent reactions.<br><br>Investigate a phosphorylated substrate (eg glucose-1-phosphate) using suitable positive and negative controls in the design of an experiment. | ATP is used to transfer energy to synthetic pathways and other cellular processes where energy is required.<br><br>The return flow of H ions rotates part of the membrane protein ATP synthase, catalysing the synthesis of ATP. |
| (ii) Metabolic pathways of cellular respiration. | | |
| The breakdown of glucose to pyruvate in the cytoplasm in glycolysis, and the progression pathways in the presence or absence of oxygen (fermentation). | | 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 $CO_2$. |
| The formation of citrate. 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 | Research how Hans Krebs discovered the citric acid cycle.<br><br>Experiments on inhibition of citric acid cycle | |

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| A combines with oxaloacetate to form citrate followed by the enzyme mediated steps of the cycle. This cycle results in the generation of ATP, release of $CO_2$, and the regeneration of oxaloacetate in the matrix of the mitochondria. | with malonic acid and DCPIP as an indicator of dehydrogenase activity. | |
| Dehydrogenase enzymes remove H ions and electrons, which are passed to coenzymes NAD or FAD (forming NADH or FADH2) in glycolysis and citric acid pathways. The high energy electrons are passed to the electron transport chain on the inner mitochondrial membrane and results in the synthesis of ATP. | Experiments with yeast dehydrogenase, eg using resazurin. | The electron transport chain as a collection of proteins attached to a membrane.<br><br>Energy is released and ATP synthase generates ATP. |
| iii) ATP synthesis - high energy electrons are used to pump H ions across a membrane and the flow of these ions synthesises ATP by the membrane protein ATP synthase.<br>Oxygen is the final electron acceptor, which combines with H ions and electrons, forming water. | | |
| (iv) Substrates for respiration (starch and glycogen, other sugar molecules, amino acids and fats). | Investigation of different sugars as respiratory substrates in yeast. Research different use of substrates during exercise and starvation. | 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. |

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| **2 Maintaining Metabolism** | | |
| (a) Metabolic rate | | |
| (i) Measurement of oxygen consumption, carbon dioxide and heat production. | Investigate metabolic rate using oxygen, carbon dioxide and temperature probes. | Comparison of metabolic rates of different organisms at rest. |
| (ii) High metabolic rates require efficient delivery of oxygen to cells. Comparative physiology of heart chambers, circulation and lung arrangement in amphibians, reptiles, mammals and birds, and heart and circulation in fish. | | |
| (iii) Physiological adaptations of animals for low oxygen niches. | | Low oxygen niches, eg high altitude, deep diving. The variation in atmospheric oxygen concentration over a long geological timescale and how this relates to maximum terrestrial body size. |
| (iv) The use of maximum oxygen uptake as a measure of fitness in humans. | Case study on adaptations to survive low-oxygen niches. | |
| (b) Metabolism in conformers and regulators. | | |
| (i) The ability of an organism to maintain its metabolic rate is affected by external abiotic factors. | | Abiotic factors such as temperature, salinity and pH. |

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| (ii) Conformers internal environment is dependent upon external environment. Conformers may have low metabolic costs and a narrow ecological niche. Behavioural responses to maintain optimum metabolic rate.<br><br>(iii) Regulators control their internal environment, which increases the range of possible ecological niches. Regulation requires energy to achieve homeostasis. | 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. | Conformers may have a narrow ecological niche unless they can tolerate or resist variation in their external environment. |
| (iv) Negative feedback control and thermoregulation in mammals including the role of the hypothalamus, nerves, effectors and skin. | Experiments using thermistors or infra-red thermometers on skin temperature and its regulation in humans. | The importance of regulating temperature for optimal enzyme-controlled reaction rates and diffusion rates for maintenance of metabolism. |
| (c) Maintaining metabolism during environmental change. | | Organisms must have adaptations to survive and/or avoid adverse conditions. Many environments vary beyond the tolerable limits for normal metabolic activity for any particular organism. |
| (i) Surviving adverse conditions<br><br>Dormancy is part of some organisms' 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 | Research and scientific presentation on aspects of surviving adverse conditions.<br><br>Seed dormancy experiments. Research seed banks and the practicalities of maintaining viable stocks. | To allow survival during a period when the costs of continued normal metabolic activity would be too high, the metabolic rate can be reduced. |

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| in periods of high temperature or drought. Daily torpor as a period of reduced activity in organisms with high metabolic rates. | | |
| (ii) Avoiding adverse conditions by migration. Migration avoids metabolic adversity by expending energy to relocate to a more suitable environment. Long-distance migration studies. 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. | 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.<br><br>The design of experiments to investigate the innate and learned influences on migratory behaviour. |
| (d) Extremophiles<br>Some species have enzymes that are extremely tolerant and allow them to thrive in environments that would be lethal to almost all other species. Examples of extremophiles include thermophilic bacteria living in hot springs or seabed vents. | Research different types of extremophiles.<br><br>Research use of $H_2$ in methanogenic bacteria and $H_2S$ in sulphur bacteria. | 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. |

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| **3 Metabolism in microorganisms**<br>Microorganisms to include archaea, bacteria and some species of eukaryota.<br><br>(a) Environmental control of metabolism. | | 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. |
| (i) Variations in growth media and control of environmental factors.<br>Microorganisms require an energy source (chemical or light) and simple chemical compounds for biosynthesis. Many microorganisms can produce all the complex molecules required. Other microorganisms require more complex compounds to be added to the growth media.<br>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. | 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. | Energy is derived either from chemical substrates or from light in photosynthetic microorganisms. 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. |
| (ii) Phases of growth and doubling or generation time of exponential growth and changes in culture conditions. | | Interpretation of exponential growth on normal and semi-logarithmic scales.<br>Lag phase of growth where microorganisms |

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| Phases to include lag, log/exponential, stationary and death. | | 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) Control of metabolism through the addition of metabolic precursors, inducers or inhibitors to give a required product.<br><br>Secondary metabolism can confer an ecological advantage.<br><br>(b) Genetic control of metabolism. | Experiments on the induction of enzymes in microorganisms. 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. | |
| (i) Wild strains of microorganisms can be improved by mutagenesis, selective breeding and culture or recombinant DNA. | | Exposure to UV light and other forms of 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. |
| | Investigate transfer of DNA using bacteria. Experiments investigating the effects of UV radiation on UV sensitive yeast. | Some bacteria can transfer plasmids or pieces of chromosomal DNA to each other (horizontal transfer) or take up DNA from their environment to produce new strains. In fungi |

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| | | and yeast, new genotypes can be brought about by sexual reproduction between existing strains. |
| (ii) Recombinant DNA technology, plasmids and artificial chromosomes.<br>Restriction endonucleases. Use of ligase in recombinant DNA. Gene introduction to increase yield or to prevent the survival of the microorganism in an external environment.<br>Control of gene expression in recombinant plasmids and artificial chromosomes.<br>Use of recombinant yeast cells. | Case study on bacterial transformation. | Restriction endonucleases cut target sequences of DNA and can leave sticky ends. Vectors with complementary sticky ends are then combined with target sequences using ligase. 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.<br>Recombinant plasmids and artificial chromosomes contain marker genes and restriction sites in addition to genes for self-replication and regulatory sequences to allow the control of gene expression.<br>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, hazards and control of risks. | Research the development of a microbiological product from discovery to market. | |

# 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 learner'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 learners to simple models of behaviour. Living with other organisms of the same species also requires some interesting adaptations as shown by many primate species.

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.

Learners 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

## Sustainability and Interdependence

The **Mandatory Course key areas** are from the *Course Assessment Specification*. Activities in the **Suggested learning activities** are not mandatory. This offers examples of suggested activities, from which you could select a range of suitable activities. It is not expected that all will be covered. Centres may also devise their own learning activities. **Exemplification of key areas** is not mandatory. It provides an outline of the level of demand and detail of the key areas. In the **Suggested learning activities**, there are references to the use of case studies. These should be seen as a suggested approach to teaching and learning and not confused with the use of Case Study as a method of Course assessment. These case studies should make learning active, challenging and enjoyable and identify for the learner the Course content and skills that will be developed. Case studies should be developed in such a way that learners 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.

| Mandatory Course key areas | Suggested learning activities | Exemplification of key areas |
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| **1 The science of food production**<br><br>(a) Food supply.<br>(i) Food security and sustainable food production.<br><br>Increase in human population and concern for food security leads to a demand for increased food production. Food production must be sustainable and not degrade the natural resources on which agriculture depends.<br><br>(ii) Agricultural production depends on factors that control plant growth.<br>The area to grow crops is limited. Increased food production will depend on factors that control plant growth: breeding of higher yielding cultivars, protecting crops from pests, diseases, competition. | Case study on challenge of providing food for the global human population. Contribution of biological science to interdisciplinary approaches to food security. | Food security is the ability of human populations to access food of sufficient quality and quantity.<br><br>Most human food comes from a small number of plant crops. All food production is dependent ultimately upon photosynthesis. Plant crops examples include cereals, potato, roots and legumes.<br>Breeders seek to develop crops with higher nutritional values, resistance to pests and |

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| <br><br><br><br>Livestock produce less food per unit area than plant crops due to loss of energy between trophic levels.<br><br>(b) Plant growth and productivity.<br><br>(i) Photosynthesis.<br>Energy capture by photosynthetic pigments to generate ATP and for photolysis.<br>Transmission and reflection of light that is not absorbed by pigments.<br><br>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.<br><br>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. | <br><br><br><br><br><br><br><br><br><br><br>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.<br><br><br><br><br>Carry out the Hill reaction. | diseases, physical characteristics suited to rearing and harvesting as well as those that can thrive in particular environmental conditions.<br>Livestock production may be possible in managed and wild habitats unsuitable for cultivation of crops. |

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| 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.<br><br>(ii) Plant productivity<br>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.<br><br>(c) Plant and animal breeding by manipulation of heredity: for improved plant crops, improved animal stock, to support sustainable food production. | Research the inhibition of Rubisco by oxygen.<br><br>Experiments on the synthesis of starch from glucose-1-phosphate by potato phosphorylase.<br><br>Measure net assimilation rate in leaf samples under a variety of conditions. Carry out experimental investigations on limiting factors in photosynthesis.<br>Analyse data on crop planting density, biological yield and economic yield using leaf area index, crop growth rates and harvest index.<br><br>Investigate resistance of potato varieties to *Phytophthera infestans*. | 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 |

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| | | values, resistance to pests and diseases, physical characteristics suited to rearing and harvesting as well as those that can thrive in particular environmental conditions. |
| (i) Plant field trials are carried out in a range of environments to compare the performance of different cultivars or treatments and to evaluate GM crops. In designing field trials account has to be taken of: the selection of treatments, the number of replicates and the randomisation of treatments. | Evaluate crop trials to draw conclusions on crop suitability, commenting on validity and reliability of trial design and the treatment of variability in results. | 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). |
| (ii) Selecting and breeding<br>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, F1 and F2 from two true breeding parental lines, back cross, test cross).<br><br>Case studies on the development of particular crop cultivars and livestock breeds. | |

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| (iii) Cross breeding and $F_1$ hybrids<br>In animals, individuals from different breeds may produce a new crossbreed population with improved characteristics. As an F2 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 crossbred animals for production.<br><br>(iv) Test cross. Test crosses can be used to identify unwanted individuals with heterozygous recessive alleles.<br>In plants F1 hybrids, produced by the crossing of two different inbred lines, creates a relatively uniform heterozygous crop. F1 hybrids often have increased vigour and yield. The F2 generation is genetically variable and of little use for further production although it can provide a source of new varieties.<br>Genetic transformation techniques allow one or more genes to be inserted into a genome and this genome can then be used in breeding programmes.<br><br>(v) Genetic technology<br>As a result of genome sequencing, organisms with desirable genes can be identified and then used in breeding programmes. | 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).<br><br>Research/study of self-pollinating plants- naturally inbreeding and less susceptible to inbreeding depression due to the elimination of deleterious alleles by natural selection.<br><br>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. | New alleles can be introduced to plant and animal lines by crossing a cultivar or breed with an individual with a different, desired genotype.<br><br>. |

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| (d) Crop protection<br><br>(i) Weeds, pests and disease populations compete with crops reducing productivity. Properties of annual weeds include rapid growth, short life cycle, high seed output, long-term seed viability.<br>Properties of perennial weeds with competitive adaptations — storage organs and vegetative reproduction.<br>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, which are often carried by invertebrates. | | |
| (ii) Control of weeds, pests and diseases by cultural means.<br>The advantages of plant protection chemicals which 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 may include toxicity to animal species, persistence in the environment, can accumulate or be magnified in food chains, produce resistant populations. | Case study on the control of weeds, pests and or diseases of agricultural crops by cultural and chemical means. | The use of pesticides may also result in a population selection pressure producing a resistant population. |

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| (iv) Biological control and integrated pest management.<br><br><br><br><br><br><br><br>(e) Animal welfare and behavioural indicators of poor welfare.<br>The costs, benefits and ethics of providing different levels of animal welfare in livestock production. Behavioural indicators include stereotypes, misdirected behaviour, failure in sexual or parental behaviour, altered levels of activity.<br><br>(i) Observing behaviour (ethology)<br>The observed behaviours of domesticated animals in natural or semi-natural settings. Information from these studies can be used to improve the environment for domesticated animals. The use of preference tests and measurements of motivation in animal welfare studies. | 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*.<br>Investigate the chemical and biological control of red spider mite.<br><br>Research the five freedoms for animal welfare.<br><br><br><br><br><br><br>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. | In biological control the control agent is a natural predator or parasite of the pest. Integrated pest management combines chemical and biological control. |

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| **2 Interrelationships and dependence**<br>(a) Symbiosis — relationships between members of two different species. | | Symbiotic relationships are coevolved and intimate. |
| (i) Parasitic relationships and transmission — a parasite benefits in terms of energy or nutrients, whereas its host is harmed by the loss of these resources.<br>Transmission of parasites to new hosts using direct contact, resistant stages and vectors.<br>Some parasitic lifecycles involve secondary hosts. | Observe microscope slides of parasites.<br><br>Research the links between these symbioses and anthropogenic climate change. | Parasites often have more limited metabolism so often cannot survive out of contact with a host. |
| (ii) Mutualism including evolution of mitochondria and chloroplasts. 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. |
| (b) Social behaviour<br>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 and its influence on survival.<br>An altruistic behaviour harms the donor individual but benefits the recipient.<br>Behaviour that appears to be altruistic can be | Investigate reciprocal altruism using the prisoner's dilemma.<br><br>Analyse data on helper behaviour and relatedness. | 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. |

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| 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.<br><br>(ii) Social insects, the structure of their society and their ecological importance —<br>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.<br>Ecological importance — social insects are often keystone species within their ecosystems.<br>Some species are of economic importance to humans providing ecosystem services such as pollination and pest control. | | |
| (iii) Primate behaviour<br>Complex behaviours that support social structure to reduce unnecessary conflict, group behaviour, the influence of external factors such as the complexity of social structure include ecological niche, resource distribution and taxonomic group. | Case study on primate behaviour. | Long period of parental care in primates gives an opportunity to learn complex social behaviours.<br><br>To reduce unnecessary conflict, social primates use ritualistic display and appeasement behaviours. Grooming, facial expression, body posture and sexual presentation important in different species. |

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| | | In some monkeys and apes, alliances form between individuals which are often used to increase social status within the group. |
| **3 Biodiversity**<br><br>(a) Mass extinction, and the regaining of biodiversity.<br>Fossil evidence indicates that there have been several mass extinction events in the past. Following each mass extinction event, biodiversity has been regained slowly as some surviving taxonomic groups radiate.<br>The difficulties in estimating past and current species extinction rates. The extinction of mega fauna correlated with the spread of humans.<br>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.<br><br>(b) Measuring biodiversity.<br>Measurable components of biodiversity include genetic diversity, species diversity and ecosystem diversity.<br>(i) The number and frequency of alleles in a population as a measure of genetic diversity.<br>Genetic diversity comprises the genetic variation represented by the number and frequency of all the alleles in a population. | <br><br>Research the Permian, Cretaceous and Holocene mass extinction events.<br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>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. | <br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>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. |

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| (ii) 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). The effects of isolation and area on the species diversity of habitat islands.<br><br>(iii) Ecosystem diversity refers to the number of distinct ecosystems within a defined area. | Case study using fieldwork to compare biodiversity indices 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).<br><br>Analyse data on island biogeography. Compare ecosystem diversity in different land areas. | A community with a dominant species has a lower species diversity than one with the same species richness but no particularly dominant species. |
| (c) Threats to biodiversity<br>(i) Exploitation and recovery of populations and the impact on their genetic diversity. Small populations may lose the genetic variation necessary to enable evolutionary responses to environmental change (the bottleneck effect).<br><br>(ii) Habitat loss, habitat fragments and their impact on species richness. 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. | Analyse data on exploitation of whale or fish populations. Use of gel electrophoresis in monitoring harvest species.<br><br>Research impact of naturally low genetic diversity within cheetah populations.<br><br>Research impact of habitat fragmentation and benefits of habitat corridors for tiger populations. | Reduction of a population to a level that can still recover. 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. |

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| (iii) Introduced, naturalised and invasive species and their impact on indigenous populations.<br>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, out-compete them for resources or hybridise with them. | Case study on invasive species. | |
| (iv) Analysing climate change and its impact on biodiversity. | Use climate change modelling software. | 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. |

# Developing skills for learning, skills for life and skills for work

Learners are expected to develop broad generic skills as an integral part of their learning experience. The *Course Specification* lists the skills for learning, skills for life and skills for work that learners should develop through this Course. These are based on SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work* and must be built into the Course where there are appropriate opportunities. The level of these skills will be appropriate to the level of the Course.

For this Course, it is expected that the following skills for learning, skills for life and skills for work will be significantly developed:

### Literacy

Writing means the ability to create texts which communicate ideas, opinions and information, to meet a purpose and within a context. In this context, 'texts' are defined as word-based materials (sometimes with supporting images) which are written, printed, Braille or displayed on screen. These will be technically accurate for the purpose, audience and context.

**1.2 Writing**
Learners develop the skills to effectively communicate key areas of biology, make informed decisions and describe, clearly, biological issues in various media forms. Learners will have the opportunity to communicate applied knowledge and understanding throughout the Course, with an emphasis on applications and environmental/ethical/social impacts.

There will be opportunities to develop the literacy skills of listening and reading, when gathering and processing information in biology.

### Numeracy

This is the ability to use numbers in order to solve problems by counting, doing calculations, measuring, and understanding graphs and charts. This is also the ability to understand the results.
Learners will have opportunities to extract, process and interpret information presented in numerous formats including tabular and graphical. Practical work will provide opportunities to develop time and measurement skills.

**2.1 Number processes**
Number processes means solving problems arising in everyday life through carrying out calculations, when dealing with data and results from experiments/investigations and everyday class work, making informed decisions based on the results of these calculations and understanding these results.

**2.2 Money, time and measurement**
This means using and understanding time and measurement to solve problems and handle data in a variety of biology contexts, including practical and investigative.

**2.3 Information handling**
Information handling means being able to interpret biological data in tables, charts and other graphical displays to draw sensible conclusions throughout the Course. It involves interpreting the data and considering its reliability in making reasoned deductions and informed decisions. It also involves an awareness and understanding of the chance of events happening.

## Thinking skills

This is the ability to develop the cognitive skills of remembering and identifying, understanding and applying.
The Course will allow learners to develop skills of applying, analysing and evaluating. Learners can analyse and evaluate practical work and data by reviewing the process, identifying issues and forming valid conclusions. They can demonstrate understanding and application of key areas and explain and interpret information and data.

**5.3 Applying**
Applying is the ability to use existing information to solve biological problems in different contexts, and to plan, organise and complete a task such as an investigation.

**5.4 Analysing and evaluating**
This covers the ability to identify and weigh-up the features of a situation or issue in biology and use judgement of them in coming to a conclusion. It includes reviewing and considering any potential solutions.

**5.5 Creating**
This is the ability to design something innovative or to further develop an existing thing by adding new dimensions or approaches. Learners can demonstrate their creativity, in particular, when planning and designing biology experiments or investigations. Learners have the opportunity to be innovative in their approach. Learners also have opportunities to make, write, say or do something new.

In addition, learners will also have opportunities to develop working with others and citizenship.

## Working with others

Learning activities provide many opportunities, in all areas of the Course, for learners to work with others. Practical activities and investigations, in particular, offer opportunities for group work, which is an important aspect of biology and should be encouraged.

## Citizenship

Learners will develop citizenship skills, when considering the applications of biology on our lives, as well as environmental and ethical implications.

# Approaches to assessment

Assessment should cover the mandatory skills, knowledge and understanding of the Course. Assessment should be integral to and improve learning and teaching. The approach should involve learners and provide supportive feedback. Self- and peer-assessment techniques should be used, whenever appropriate.

See the *Unit Support Notes* for guidance on approaches to assessment of the Units of the Course.

### Skills of scientific experimentation, investigation and enquiry

Learners should acquire scientific skills through a series of learning experiences, investigations and experimental work. 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 analysing 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 learners' learning. Further details on the skills that should be developed in Course work are given below.

### 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. Learners will often deal with more complex information than they can produce. Learners 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

### 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. Learners 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. Learners 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 learners 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.

### Processing information

Process information accurately using calculations where appropriate. Learners 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. Learners 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

### 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. Learners 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. Learners 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 wellbeing 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.

### Evaluating experimental procedures

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. Learners 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

### 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. Learners 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

### Making predictions and generalisations

Make predictions and generalisations based on available evidence. Learners should be able to:

- predict the outcome in experimental situations from supplied information
- make generalisations from a range of biological information
- use modelling 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

See the *Unit Support Notes* for guidance on approaches to assessment of the Units of the Course.

# Added value

At Higher, the added value will be assessed in the Course assessment.

Information given in the *Course Specification* and the *Course Assessment Specification* about the assessment of added value is mandatory.

If the Unit is being taken as part of the Higher Biology Course, the learner will be required to draw on, extend and apply the skills and knowledge they have developed during this Unit within the *Course Assessment* (Question Paper and Assignment).

# Preparation for Course assessment

Each Course has additional time which may be used at the discretion of the teacher or lecturer to enable learners to prepare for Course assessment. This time may be used near the start of the Course and at various points throughout the Course for consolidation and support. It may also be used for preparation for Unit assessment, and towards the end of the Course, for further integration, revision and preparation and/or gathering evidence for Course assessment.

During delivery of the Course, opportunities should be found:

- for identification of particular aspects of work requiring reinforcement and support
- to practise skills of scientific inquiry and investigation in preparation for the Assignment
- to practise Question Paper techniques

# Combining assessment across Units

If an integrated approach to Course delivery is chosen then there may be opportunities for combining assessment across Units. If this approach is used, then it is necessary to be able to track evidence for individual Outcomes and Assessment Standards.

Transfer of evidence: Outcome 1 in a Unit may be used as evidence of the achievement of Outcome 1 in other Units of this Course.

# Equality and inclusion

The following should be taken into consideration:

| Situation | Reasonable adjustment |
|---|---|
| Carrying out practical activities. | Use could be made of practical helpers for learners with:<br>♦ physical disabilities, especially manual dexterity, when carrying out practical activities<br>♦ visual impairment who have difficulty distinguishing colour changes or other visual information |
| Reading, writing and presenting text, symbolic representation, tables, graphs and diagrams. | Use could be made of ICT, enlarged text, alternative paper and/or print colour and/or practical helpers for learners with visual impairment, specific learning difficulties and physical disabilities. |
| Process information using calculations. | Use could be made of practical helpers for learners with specific cognitive difficulties (eg dyscalculia). |
| Draw a valid conclusion, giving explanations and making generalisation/predictions. | Use could be made of practical helpers for learners with specific cognitive difficulties or autism. |

As far as possible, reasonable adjustments should be made for the Question Paper and/or Assignment, where necessary. All adjustments currently available for the Question Paper would be available for Component 1. Learners will have a choice of Assignment topic for Component 2, for which reasonable adjustments can be made. This includes the use of 'practical helpers', readers, scribes, adapted equipment or assistive technologies.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in these *Course Support Notes* is designed to sit alongside these duties but is specific to the delivery and assessment of the Course.

It is important that centres are aware of and understand SQA's assessment arrangements for disabled learners, and those with additional support needs, when making requests for adjustments to published assessment arrangements. Centres will find more guidance on this in the series of publications on Assessment Arrangements on SQA's website: www.sqa.org.uk/sqa/14977.html.

# Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- Overview of Qualification Reports
- *Principles and practice papers for curriculum areas*
- *Research Report 4 — Less is More: Good Practice in Reducing Assessment Time*
- Course*work Authenticity — a Guide for Teachers and Lecturers*
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- *Skills for Learning, Skills for Life and Skills for Work: Using the Curriculum Tool*
- SQA Guidelines on e-assessment for Schools
- SQA Guidelines on Online Assessment for Further Education
- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

# Administrative information

**Published:** April 2012 (version 1.0)

**Superclass:** to be advised

## History of changes to Course Support Notes

| Course details | Version | Description of change | Authorised by | Date |
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Unit Support Notes

# Unit Support Notes — Biology: DNA and the Genome (Higher)



Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

# Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Biology: DNA and the Genome (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the *Unit Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support Notes*
- appropriate assessment support materials

# General guidance on the Unit

## Aims

The general aim of this Unit is to develop skills of scientific inquiry, investigation and analytical thinking, along with knowledge and understanding of DNA and the genome.

Learners will apply these skills when considering the applications of DNA and the genome on our lives, as well as the implications on society/the environment. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of: structure and replication of DNA, gene expression and the genome.

Learners will research issues, apply scientific skills and communicate information related to their findings, which will develop skills of scientific literacy.

## Progression into this Unit

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience:

- National 5 Biology Course

## Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Biology *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

## Progression from this Unit

This Unit may provide progression to:

- other qualifications in Biology or related areas
- further study, employment and/or training

# Approaches to learning and teaching

Approaches to learning and teaching and suggested learning activities are covered in the *Course Support Notes*.

## Developing skills for learning, skills for life and skills for work

Information about developing skills for learning, skills for life and skills for work in this Unit, is given in the relevant *Course Support Notes*.

## Approaches to assessment and gathering evidence

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and, where possible, enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.
There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

The table below gives guidance and advice on possible approaches to assessment and gathering evidence:

| **Strategies for gathering evidence** |
|---|
| There may be opportunities in the day-to-day delivery of the Units in a Course to observe learners providing evidence, which satisfies completely, or partially, a Unit or Units. This is naturally occurring evidence and can be recorded as evidence for an Outcome or parts of an Outcome. In some cases, additional evidence may also be required to supplement and confirm the naturally occurring evidence.<br><br>Approaches to assessment might cover the whole Unit or be combined across Outcomes. A holistic approach can enrich the assessment process for the learner by bringing together different Outcomes and/or Assessment Standards. |

If a holistic approach is used, then it is necessary to be able to track individual Assessment Standard evidence.

Strategies for gathering evidence and ensuring that the learners' work is their own could include:

- personal interviews during which the teacher or lecturer can ask additional questions about completed work
- an oral presentation on their work
- writing reports in supervised conditions
- checklists to record the authenticity
- supplementary sources of evidence, such as witness testimony, film or audio clips

Evidence can be gathered from classwork, experiments, investigations and/or research carried out in this Unit. It can be obtained using one or more of the strategies outlined above or by alternative methods, which could include a test of knowledge, understanding and skills.

# Combining assessment within Units

See *Course Support Notes*.

# Equality and inclusion

The *Course Support Notes* provide full information on equality and inclusion for this Unit.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in this document is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and that the alternative approaches to assessment will, in fact, generate the necessary evidence of achievement.

# Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- Overview of Qualification Reports
- Principles and practice papers for sciences curriculum area
- Science: A Portrait of current practice in Scottish Schools (2008)
- Research Report 4 — Less is More: Good Practice in Reducing Assessment Time
- Coursework Authenticity — a Guide for Teachers and Lecturers
- *SCQF Handbook: User Guide (published 2009)* and
  SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- *Skills for Learning, Skills for Life and Skills for Work: Using the Curriculum Tool*
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- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

# Administrative information

**Published:** April 2012 ( version 1.0)

**Superclass:** to be advised

## History of changes to Unit Support Notes

| Unit details | Version | Description of change | Authorised by | Date |
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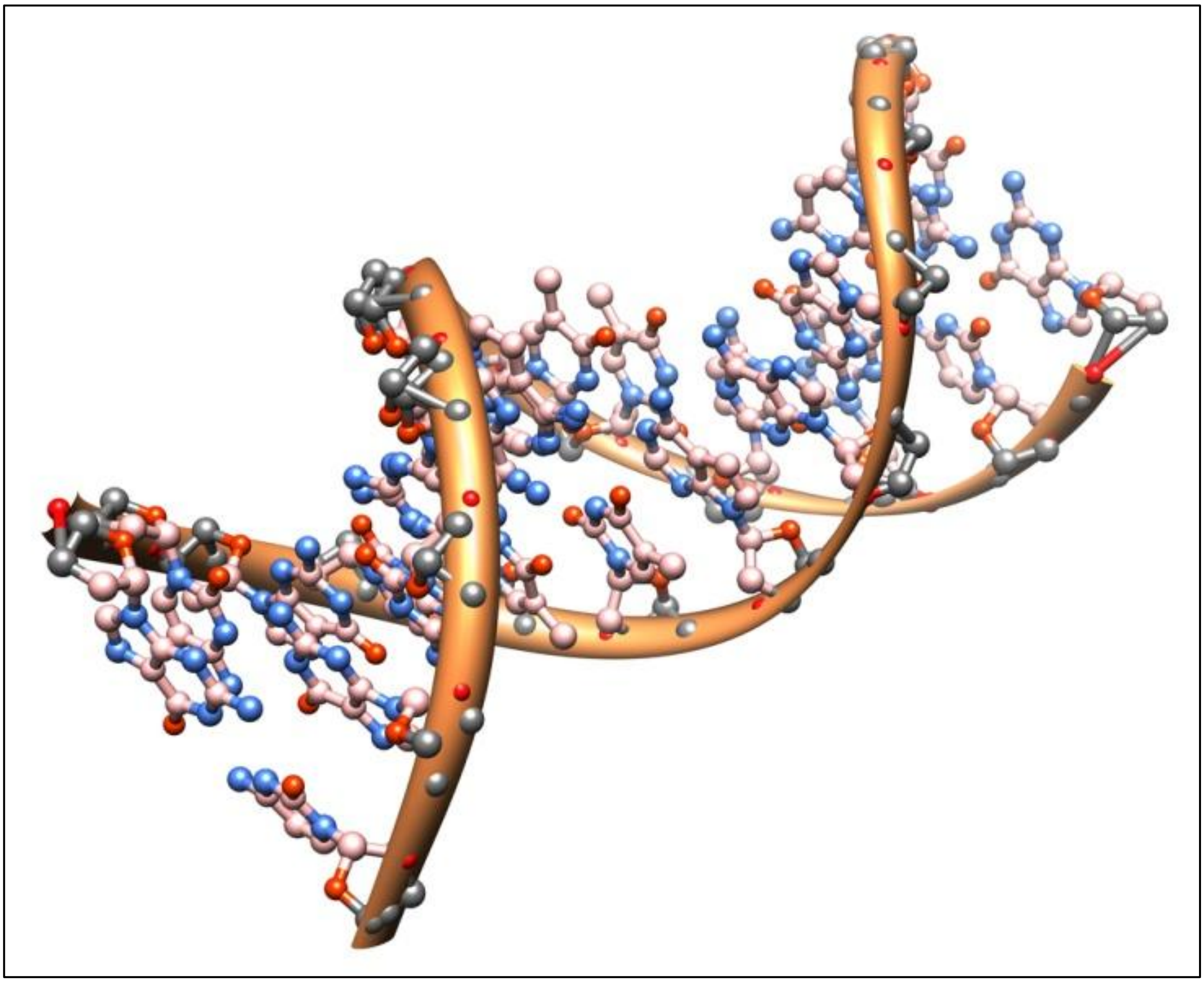
**Unit Support Notes**

# Unit Support Notes — Biology: Metabolism and Survival (Higher)





Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

# Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Biology: Metabolism and Survival (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the *Unit Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support N*otes
- appropriate assessment support materials

# General guidance on the Unit

## Aims

The general aim of this Unit is to develop skills of scientific inquiry, investigation and analytical thinking, along with knowledge and understanding of metabolism and survival.

Learners will apply these skills when considering the applications of metabolism and survival on our lives, as well as the implications on society/the environment. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of:

- Metabolism is essential for life
- Maintaining metabolism
- Metabolism in microorganisms

Learners will research issues, apply scientific skills and communicate information related to their findings, which will develop skills of scientific literacy.

## Progression into this Unit

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience:

- National 5 Biology Course

## Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Biology *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

## Progression from this Unit

This Unit may provide progression to:

- other qualifications in Biology or related areas
- further study, employment and/or training

# Approaches to learning and teaching

Approaches to learning and teaching and suggested learning activities are covered in the *Course Support Notes*.

## Developing skills for learning, skills for life and skills for work

Information about developing skills for learning, skills for life and skills for work in this Unit, is given in the relevant *Course Support Notes*.

## Approaches to assessment and gathering evidence

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and, where possible, enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.

There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

The table below gives guidance and advice on possible approaches to assessment and gathering evidence:

| **Strategies for gathering evidence** |
| --- |
| There may be opportunities in the day-to-day delivery of the Units in a Course to observe learners providing evidence, which satisfies completely, or partially, a Unit or Units. This is naturally occurring evidence and can be recorded as evidence for an Outcome or parts of an Outcome. In some cases, additional evidence may also be required to supplement and confirm the naturally occurring evidence.<br><br>Approaches to assessment might cover the whole Unit or be combined across Outcomes. A holistic approach can enrich the assessment process for the |

learner by bringing together different Outcomes and/or Assessment Standards. If a holistic approach is used, then it is necessary to be able to track individual Assessment Standard evidence.

Strategies for gathering evidence and ensuring that the learners' work is their own could include:

- personal interviews during which the teacher or lecturer can ask additional questions about completed work
- an oral presentation on their work
- writing reports in supervised conditions
- checklists to record the authenticity
- supplementary sources of evidence, such as witness testimony, film or audio clips

Evidence can be gathered from classwork, experiments, investigations and/or research carried out in this Unit. It can be obtained using one or more of the strategies outlined above or by alternative methods, which could include a test of knowledge, understanding and skills.

# Combining assessment within Units

See *Course Support Notes*.

# Equality and inclusion

The *Course Support Notes* provide full information on equality and inclusion for this Unit.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in this document is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and that the alternative approaches to assessment will, in fact, generate the necessary evidence of achievement.

# Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- Overview of Qualification Reports
- Principles and practice papers for sciences curriculum area
- Science: A Portrait of current practice in Scottish Schools (2008)
- Research Report 4 — Less is More: Good Practice in Reducing Assessment Time
- Coursework Authenticity — a Guide for Teachers and Lecturers
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- *Skills for Learning, Skills for Life and Skills for Work: Using the Curriculum Tool*
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- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

# Administrative information

**Published**: April 2012 ( version 1.0)

**Superclass**: to be advised

## History of changes to Unit Support Notes

| Unit details | Version | Description of change | Authorised by | Date |
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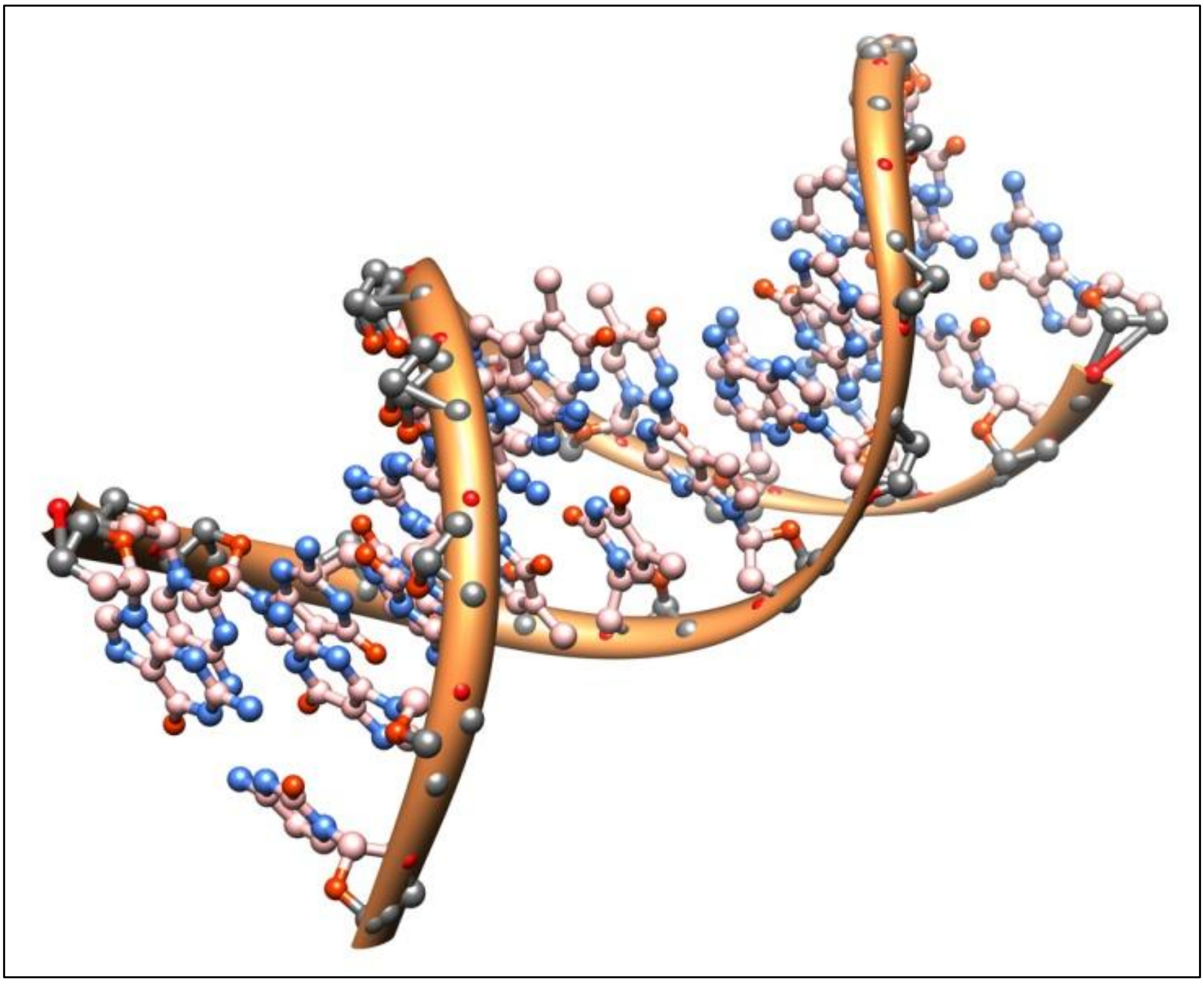
Unit Support Notes

# Unit Support Notes — Biology: Sustainability and Interdependence (Higher)





Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

# Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Biology: Sustainability and Interdependence (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the *Unit Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support Notes*
- appropriate assessment support materials

# General guidance on the Unit

## Aims

The general aim of this Unit is to develop skills of scientific inquiry, investigation and analytical thinking, along with knowledge and understanding of sustainability and interdependence.

Learners will apply these skills when considering the applications of sustainability and interdependence on our lives, as well as the implications on society/the environment. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of:

- The science of food production
- Interrelationships and dependence
- Biodiversity

Learners will research issues, apply scientific skills and communicate information related to their findings, which will develop skills of scientific literacy.

## Progression into this Unit

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained some relevant skills, knowledge and understanding through prior learning such as:

- National 5 Biology Course

## Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Biology *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

## Progression from this Unit

This Unit may provide progression to:

- other qualifications in Biology or related areas
- further study, employment and/or training

# Approaches to learning and teaching

Approaches to learning and teaching and suggested learning activities are covered in the *Course Support Notes*.

## Developing skills for learning, skills for life and skills for work

Information about developing skills for learning, skills for life and skills for work in this Unit, is given in the relevant *Course Support Notes*.

Learners are expected to develop broad generic skills as an integral part of their learning experience. The *Unit Specification* lists the skills for learning, skills for life and skills for work that learners should develop through this Course. These are based on SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work* and must be built into the Unit where there are appropriate opportunities. The level of these skills will be appropriate to the level of the Unit.

## Approaches to assessment and gathering evidence

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and, where possible, enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.

There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

The table below gives guidance and advice on possible approaches to assessment and gathering evidence:

| **Strategies for gathering evidence** |
|---|
| There may be opportunities in the day-to-day delivery of the Units in a Course to observe learners providing evidence, which satisfies completely, or partially, a Unit or Units. This is naturally occurring evidence and can be recorded as |

evidence for an Outcome or parts of an Outcome. In some cases, additional evidence may also be required to supplement and confirm the naturally occurring evidence.

Approaches to assessment might cover the whole Unit or be combined across Outcomes. A holistic approach can enrich the assessment process for the learner by bringing together different Outcomes and/or Assessment Standards. If a holistic approach is used, then it is necessary to be able to track individual Assessment Standard evidence.

Strategies for gathering evidence and ensuring that the learners' work is their own could include:

- personal interviews during which the teacher or lecturer can ask additional questions about completed work
- an oral presentation on their work
- writing reports in supervised conditions
- checklists to record the authenticity
- supplementary sources of evidence, such as witness testimony, film or audio clips

Evidence can be gathered from classwork, experiments, investigations and/or research carried out in this Unit. It can be obtained using one or more of the strategies outlined above or by alternative methods, which could include a test of knowledge, understanding and skills.

# Combining assessment within Units

See *Course Support Notes*.

# Equality and inclusion

The *Course Support Notes* provide full information on equality and inclusion for this Unit.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in this document is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and that the alternative approaches to assessment will, in fact, generate the necessary evidence of achievement.

# Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- Overview of Qualification Reports
- Principles and practice papers for sciences curriculum area
- Science: A Portrait of current practice in Scottish Schools (2008)
- Research Report 4 — Less is More: Good Practice in Reducing Assessment Time
- Coursework Authenticity — a Guide for Teachers and Lecturers
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- *Skills for Learning, Skills for Life and Skills for Work: Using the Curriculum Tool*
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- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

# Administrative information

**Published:** April 2012 (version 1.0)

**Superclass:** to be advised

## History of changes to Unit Support Notes

| Unit details | Version | Description of change | Authorised by | Date |
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