Higher
Course Assessment
Specification

Higher Biology Course Assessment Specification (C707 76)

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

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Course outline

Course title:	Higher Biology
SCQF level:	6 (24 SCQF credit points)
Course code:	C707 76
Course assessment code:	X707 76

The purpose of the Course Assessment Specification is to ensure consistent and transparent assessment year on year. It describes the structure of the Course assessment and the mandatory skills, knowledge and understanding that will be assessed.

Course assessment structure

Component 1 — question paper	100 marks
Component 2 — assignment	20 marks
Total marks	**120 marks**

This Course includes six SCQF credit points to allow additional time for preparation for Course assessment. The Course assessment covers the added value of the Course.

Equality and inclusion

This Course Assessment Specification has been designed to ensure that there are no unnecessary barriers to assessment. Assessments have been designed to promote equal opportunities while maintaining the integrity of the qualification.

For guidance on assessment arrangements for disabled learners and/or those with additional support needs, please follow the link to the Assessment Arrangements web page: www.sqa.org.uk/sqa/14977.html.

Guidance on inclusive approaches to delivery and assessment of this Course is provided in the *Course Support Notes*.

Assessment

To gain the award of the Course, the learner must pass all of the Units as well as the Course assessment. Course assessment will provide the basis for grading attainment in the Course award.

Course assessment

SQA will produce and give instructions for the production and conduct of Course assessments based on the information provided in this document.

Added value

The purpose of the Course assessment is to assess added value of the Course as well as confirming attainment in the Course and providing a grade. The added value for the Course will address the key purposes and aims of the Course, as defined in the Course Rationale. It will do this by addressing one or more of breadth, challenge, or application.

In this Course assessment, added value will focus on the following:

- breadth — drawing on knowledge and skills from across the Course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in practical or theoretical contexts as appropriate

This added value consists of:

- a question paper, which requires learners to demonstrate aspects of breadth, challenge and application. Learners will apply breadth and depth of skills, knowledge and understanding from across the Course to answer questions in biology
- an assignment, which requires learners to demonstrate aspects of challenge and application. Learners will apply skills of scientific inquiry, using related knowledge, to carry out a meaningful and appropriately challenging task in biology and communicate findings

Grading

Course assessment will provide the basis for grading attainment in the Course award.

The Course assessment is graded A–D. The grade is determined on the basis of the total mark for all Course assessments together.

A learner's overall grade will be determined by their performance across the Course assessment.

Grade description for C
For the award of Grade C, learners will have demonstrated successful performance in all of the Units of the Course. In the Course assessment, learners will typically have demonstrated successful performance in relation to the mandatory skills, knowledge and understanding for the Course.

Grade description for A
For the award of Grade A, learners will have demonstrated successful performance in all of the Units of the Course. In the Course assessment, learners will typically have demonstrated a consistently high level of performance in relation to the mandatory skills, knowledge and understanding for the Course.

In addition, learners achieving a Grade A will have demonstrated a high overall level of performance by:

- retaining knowledge and understanding over a long period of time
- showing a deeper level of knowledge and understanding
- integrating and applying skills, knowledge and understanding across the three component Units of the Course
- displaying problem solving skills in less familiar and more complex contexts
- applying skills of scientific inquiry and analytical thinking in complex contexts that involve more complex data

Credit
To take account of the extended range of learning and teaching approaches, remediation, consolidation of learning and integration needed for preparation for external assessment, six SCQF credit points are available in Courses at National 5 and Higher, and eight SCQF credit points in Courses at Advanced Higher. These points will be awarded when a grade D or better is achieved.

Structure and coverage of the Course assessment

The Course assessment will consist of two Components: a question paper and an assignment. The question paper will have two Sections. The assignment will have one Section.

Component 1 — question paper
The purpose of the question paper is to assess breadth and depth of knowledge and understanding from across the Units.

The paper will assess scientific inquiry skills, analytical thinking skills and the impact of applications on society and the environment.

The question paper will give learners an opportunity to demonstrate the following skills, knowledge and understanding by:

- demonstrating knowledge and understanding of biology by making statements, describing information, providing explanations and integrating knowledge
- applying knowledge of biology to new situations, analysing information and solving problems
- planning or designing experiments/practical investigations to test given hypotheses or to illustrate particular effects, applying safety measures
- selecting and presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- identifying a source of error and suggesting improvements to experiments/practical investigations

The mandatory skills and knowledge are specified in the 'Further mandatory information on Course coverage' section at the end of this *Course Assessment Specification*.

The question paper will have 100 marks.

The question paper will have two Sections.

Section 1, titled 'Objective Test', will have 20 marks.

Section 2, titled 'Paper 2', will contain restricted and extended response questions and will have 80 marks.

Marks will be distributed approximately proportionately across the Units. The majority of the marks will be awarded for applying knowledge and understanding. The other marks will be awarded for applying scientific inquiry, scientific analytical thinking and problem solving skills.

Component 2 — assignment
The purpose of the assignment is to assess the application of skills of scientific inquiry and related biology knowledge and understanding.

The assignment requires learners to apply skills, knowledge and understanding to investigate a relevant topic in biology. The topic should draw on one or more of the key areas of the Course, and should be chosen with guidance from the assessor.

The assignment will give learners an opportunity to demonstrate the following skills, knowledge and understanding by:

- applying knowledge of biology to new situations and analysing information
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing the information (using calculations and units, where appropriate)
- drawing valid conclusions and giving explanations supported by evidence/justification
- communicating findings/information

The assignment will have 20 marks out of a total of 120 marks.

The majority of the marks will be awarded for applying scientific inquiry and analytical thinking skills. The other marks will be awarded for applying knowledge and understanding related to the topic chosen.

The assignment offers challenge by requiring skills, knowledge and understanding to be applied in a context that is one or more of the following:

- unfamiliar
- familiar but investigated in greater depth
- integrates a number of familiar contexts

This assignment has two stages:

- a research stage
- a communication stage

In the course of their assignment, learners are required to:

- choose a relevant topic in biology (the assessor must review the appropriateness of the topic chosen)
- state appropriate aim(s)
- research the topic by selecting relevant data/information
- process and present relevant data/information
- analyse data/information
- state conclusion(s)
- evaluate their investigation
- explain the underlying biology of the topic researched
- present the findings of the research in a report

Setting, conducting and marking of assessment

Question paper

This question paper will be set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA. Learners will complete this in 2 hours and 30 minutes.

Controlled assessment — assignment

This assignment is:

- set by centres within SQA guidelines
- conducted under a high degree of supervision and control

Evidence will be submitted to SQA for external marking.

All marking will be quality assured by SQA.

Setting the assessment

Set by centres within SQA guidelines.

Conducting the assessment

The **research** stage will be conducted under some supervision and control.

The **communication** stage will be conducted under a high degree of supervision. SQA will provide Assignment General assessment information and Assignment Assessment task documents. SQA will specify the material to be taken into the communication stage of the assignment.

The production of the report will be carried out:

- in time to meet a submission date set by SQA
- independently by the learner

Further mandatory information on Course coverage

The following gives details of mandatory skills, knowledge and understanding for the Higher Biology Course. Course assessment will involve sampling the skills, knowledge and understanding. This list of skills, knowledge and understanding also provides the basis for the assessment of Units of the Course.

The following gives details of the skills:

- demonstrating knowledge and understanding of biology by making statements, describing information, providing explanations and integrating knowledge
- applying biology knowledge to new situations, analysing information and solving problems
- planning and designing experiments/practical investigations to test given hypotheses or to illustrate particular effects
- carrying out experiments/practical investigations safely, recording detailed observations and collecting data
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations from evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experiments/practical investigations and suggesting improvements
- communicating findings/information effectively

These skills will be assessed, across the Course, in the context of the mandatory knowledge.

The following table specifies the mandatory knowledge for the Higher Biology Course.

DNA and the Genome

1 The structure 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 respectively, forming a double helix.
(b) Organisation of DNA - circular chromosomal DNA and plasmids in prokaryotes. Circular plasmids in yeast. Circular chromosome in mitochondria and chloroplasts of eukaryotes. DNA in the linear chromosomes of the nucleus of eukaryotes is tightly coiled and packaged with associated proteins.

2 Replication of DNA
(a) 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.
(b) Polymerase chain reaction (PCR) amplification of DNA using complementary primers for specific target sequences. 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. Practical applications of PCR.

3 Control of gene expression
(a) The phenotype is determined by the proteins produced as the result of gene expression, influenced by intra- and extra-cellular environmental factors. Only a fraction of the genes in a cell are expressed.
Gene expression is controlled by the regulation of transcription and translation.
(b) Structure and functions of RNA. 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 (ribosomal) and proteins form the ribosome. Each tRNA (transfer) carries a specific amino acid.
(c) Transcription of DNA into primary and mature RNA transcripts to include the role of RNA polymerase and complementary base pairing. 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.
(d) 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.
(e) Different proteins can be expressed from one gene as a result of alternative RNA splicing and post-translational modification. Different mRNA molecules are produced from the same primary transcript depending on which RNA segments are treated as exons and introns.
Post translation protein structure modification by cutting and combining polypeptide chains or by adding phosphate or carbohydrate groups to the protein.
(f) Proteins are held in a three-dimensional shape — peptide bonds, folded polypeptide chains, hydrogen bonds, interactions between individual amino acids.

4 Cellular differentiation
(a) 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. Stem cells are relatively unspecialised cells in animals that can continue to divide and can differentiate into specialised cells.
(b) Embryonic and tissue (adult) stem cells. Research and therapeutic uses of stem cells by reference to the repair of damaged or diseased organs or tissues. 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.

5 The structure of the genome

The genome of an organism is its hereditary information encoded in DNA. DNA sequences that code for protein are genes.
The structure of the genome — coding and non-coding sequences. A genome is made up of genes and other DNA sequences that do not code for proteins. 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.

6 Mutations

(a) Mutations are random changes in the genome that can result in no protein or an altered protein being expressed.
(b) 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.
(c) Chromosome structure mutations — duplication, deletion, inversion and translocation.
(d) The importance of mutations and gene duplication in evolution
(e) Polyploidy - errors during the separation of chromosomes during cell division can result in cells with whole genome duplications. Importance of polyploidy in evolution and human food crops.

7 Evolution

(a) Evolution — the changes in organisms over generations as a result of genomic variations.
(b) Gene transfer. Vertical (inheritance) - from parent to offspring as a result of sexual or asexual reproduction. Prokaryotes can exchange genetic material horizontally, resulting in rapid evolutionary change. Prokaryotes and viruses can transfer sequences horizontally into the genomes of eukaryotes.
(c) Selection. Natural selection is the non-random increase in frequency of DNA sequences that increase survival. Sexual selection is the non-random increase in frequency of DNA sequences that increase reproduction. The differences in outcome as a result of stabilising, directional and disruptive selection.
(d) Genetic drift. The random increase and decrease in frequency of sequences, particularly in small populations, as a result of neutral mutations and founder effects.
(e) Speciation is the generation of new biological species by evolution as a result of isolation, mutation and selection.
The importance of geographical barriers in allopatric speciation. The importance of behavioural or ecological barriers in sympatric speciation. Hybrid zones.

8 Genomic sequencing

(a) 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.
(b) Evidence from phylogenetics and molecular clocks to determine the main sequence of events in evolution: last universal ancestor, prokaryotes, photosynthesis, eukaryotes, multicellular organisms. The sequence of events can be determined using sequence data and fossil evidence. Comparison of sequences provides evidence of the three domains (bacteria, archaea and eukaryotes).
(c) Comparison of genomes from different species. Comparison of genomes reveals that many genes are highly conserved across different organisms.
(d) Personal genomics and health. 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. Difficulties with personalised medicine.

Metabolism and Survival

1 Metabolism pathways and their control
(a) Introduction to metabolic pathways - integrated and controlled pathways of enzyme-catalysed reactions within a cell.
(i) Anabolic (energy requiring) and catabolic (energy releasing) pathways — can have reversible and irreversible steps and alternative routes.
(ii) Membranes form surfaces and compartments for metabolic pathways to allow high concentrations and reaction rates. Protein pores, pumps and enzymes embedded in phospholipid membranes.
(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).
(i) Induced fit and the role of the active site of enzymes including shape and substrate affinity and orientation of reactants. Products have a low affinity for the active site. 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.
(ii) Control of metabolic pathways through competitive, non-competitive and feedback inhibition of enzymes.

2 Cellular respiration
(a) Glucose is broken down, hydrogen ions and electrons are removed by dehydrogenase enzymes and ATP is released.
(b) The role of ATP in the transfer of energy and the phosphorylation of molecules by ATP.
(c) Metabolic pathways of cellular respiration. The breakdown of glucose to pyruvate in the cytoplasm in glycolysis. The phosphorylation of intermediates in glycolysis in an energy investment phase leading to the direct generation of more ATP in an energy pay-off stage giving a net gain of ATP. In the presence of oxygen, pyruvate is broken down to an acetyl group that combines with coenzyme A to be transferred to the citric acid cycle as acetyl coenzyme A. Acetyl coenzyme A combines with oxaloacetate to form citrate followed by the enzyme mediated steps of the cycle. This cycle results in the generation of ATP, release of CO_2, and the regeneration of oxaloacetate in the matrix of the mitochondria. In the absence of oxygen, pyruvate undergoes fermentation to lactate or ethanol and carbon dioxide.
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.
(d) 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. Oxygen is the final electron acceptor, which combines with H ions and electrons, forming water.
(e) Substrates for respiration -starch and glycogen are broken down to glucose; other sugars are converted to glucose or glycolysis intermediates; fats and proteins can be converted to intermediates of glycolysis and the citric acid cycle.

3 Metabolic rate
(a) Measurement of oxygen consumption, carbon dioxide and heat production to compare metabolic rates.
(b) High metabolic rates require efficient delivery of oxygen to cells. Comparative anatomy and physiology of heart chambers, circulation and lung arrangement in amphibians, reptiles, mammals and birds, and heart and circulation in fish.

(c) Physiological adaptations of animals for low oxygen niches.
(d) The use of maximum oxygen uptake as a measure of fitness in humans.

4 Metabolism in conformers and regulators
(a) The ability of an organism to maintain its metabolic rate is affected by external abiotic factors.
(b) 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.
(c) Regulators use metabolism to control their internal environment, which increases the range of possible ecological niches. Regulation requires energy to achieve homeostasis.
(d) Negative feedback control and thermoregulation in mammals including the role of the hypothalamus, nerves, effectors and skin.
(e) Importance of regulating temperature for optimal enzyme controlled reaction rates and diffusion rates to maintain metabolism.

5 Metabolism and adverse conditions
(a) Surviving adverse conditions. Metabolic rate is reduced. 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 in periods of high temperature or drought. Daily torpor as a period of reduced activity in organisms with high metabolic rates.
(b) 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.
(c) Extremophiles. Some species have enzymes that are extremely tolerant and allow them to thrive in environments that would be lethal to almost all other species. Examples of extremophiles include thermophilic bacteria living in hot springs or seabed vents.

6 Environmental control of metabolism
Microorganisms to include archaea, bacteria and some species of eukaryota.
(a) Variations in growth media and control of environmental factors.
Microorganisms require an energy source (chemical or light) and simple chemical compounds for biosynthesis. Many microorganisms can produce all the complex molecules required, including amino acids required for protein synthesis. Other microorganisms require more complex compounds to be added to the growth media, including vitamins and fatty acids. 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.
(b) Phases of growth and doubling or generation time of exponential growth and changes in culture conditions. Phases to include lag (enzymes induced), log/exponential, stationary (culture depleted and secondary metabolites produced) and death (lack of substrate and toxic accumulation of metabolites). Viable and total cell count.
(c) Control of metabolism through the addition of metabolic precursors, inducers or inhibitors to give a required product. Secondary metabolism can confer an ecological advantage by producing substances not associated with growth.

7 Genetic control of metabolism
(a) Wild strains of microorganisms can be improved by mutagenesis, selective breeding and culture or recombinant DNA. Some bacteria can transfer plasmids or chromosomal DNA to each other or take up DNA from the environment to produce

new strains. Fungi and yeast can produce new phenotypes by sexual reproduction.
(b) Recombinant DNA technology, plasmids and artificial chromosomes.
Restriction endonucleases, marker genes, restriction sites, origin of replication, selective markers and regulatory sequences. Use of ligase in recombinant DNA. Genes can be introduced to confer an advantage. As a safety mechanism, genes are often introduced that prevent the survival of the microorganism in an external environment. Control of gene expression in recombinant plasmids and artificial chromosomes. Use of recombinant yeast cells to avoid polypeptides being folded incorrectly or lacking post translational modifications.

8 Ethical considerations in the use of microorganisms, hazards and control of risks

Sustainability and Interdependence

1 Food supply, plant growth and productivity
(a) Food supply.
(i) Food security and sustainable food production.
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.
(ii) Agricultural production depends on factors that control plant growth.
The area to grow crops is limited. Increased food production will depend on factors that control plant growth: breeding of higher yielding cultivars, use of fertiliser, protecting crops from pests, diseases, competition. Livestock produce less food per unit area than plant crops due to loss of energy between trophic levels.
(b) Plant growth and productivity.
(i) Photosynthesis. Energy capture by photosynthetic pigments to generate ATP and for photolysis. Transmission and reflection of light that is not absorbed by pigments. Absorption spectra of chlorophyll a and b and carotenoids compared to the action spectra for photosynthesis. Carotenoids extend the range of wavelengths absorbed by photosynthesis and pass the energy to chlorophyll.
Absorbed energy excites electrons in the pigment molecule. Transfer of these high-energy electrons through electron transport chains releases energy to generate ATP by ATP synthase. Energy is also used for photolysis, in which water is split into oxygen, which is evolved, and hydrogen, which is transferred to the coenzyme NADP. The enzyme RuBisCO fixes carbon dioxide by attaching it to ribulose bisphosphate (RuBP) in the Calvin cycle. The 3-phosphoglycerate 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 glucose, which may be synthesised into starch or cellulose or pass to other biosynthetic pathways to form a variety of metabolites.
(ii) Plant productivity. Net assimilation is the increase in mass due to photosynthesis minus the loss due to respiration and can be measured by the increase in dry mass per unit leaf area. Productivity is the rate of generation of new biomass per unit area per unit of time. Biological yield of a crop is the total plant biomass. Economic yield is the mass of desired product. The harvest index is calculated by dividing the dry mass of economic yield by the dry mass of biological yield.

2 Plant and animal breeding(a) Plant and animal breeding by manipulation of heredity: for improved plant crops, improved animal stock, to support sustainable food production. Breeders develop improved crops and animals with higher food yields, higher nutritional values, pest and disease resistance and the ability to thrive in particular environmental conditions.
(b) 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.
(c) Selecting and breeding. Animals and cross pollinating plants are naturally outbreeding. In inbreeding, selected plants or animals are bred for several generations until the population breeds true to the desired type due to the elimination of heterozygotes. 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.
(d) Cross breeding and F_1 hybrids. 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.
(e) 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. Test crosses can be used to identify unwanted individuals with heterozygous recessive alleles. (f) Genetic technology. As a result of genome sequencing, organisms with desirable genes can be identified and then used in breeding programmes. Using genetic transformation techniques a single gene can be inserted into a genome which can then be used in breeding programmes.

3 Crop protection
(a) Weeds compete with crop plants, while pests and diseases damage them all, reducing productivity. Properties of annual weeds include rapid growth, short life cycle, high seed output, long-term seed viability. Properties of perennial weeds with competitive adaptations — storage organs and vegetative reproduction.
Most of the pests of crop plants are invertebrate animals such as insects, nematode worms and molluscs. Plant diseases can be caused by fungi, bacteria or viruses, which are often carried by invertebrates.
(b) Control of weeds, pests and diseases by cultural means.
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.
(c) 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.
(d) Biological control and integrated pest management. Risks with biological control.

4 Animal welfare(a) The costs, benefits and ethics of providing different levels of animal welfare in livestock production. Behavioural indicators include stereotypy, misdirected behaviour, failure in sexual or parental behaviour, altered levels of activity.
(b) Observing behaviour (ethology). 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.

5 Symbiosis
Symbiosis — co-evolved intimate relationships between members of two different species.
(a) Parasitic relationships and transmission — a parasite benefits in terms of energy or nutrients, whereas its host is harmed by the loss of these resources.
Transmission of parasites to new hosts using direct contact, resistant stages and vectors. Some parasitic lifecycles involve secondary hosts. Parasites often have limited metabolism and cannot survive out of contact with a host.
(b) Mutualism including evolution of mitochondria and chloroplasts. Both mutualistic partner species benefit in an interdependent relationship.

6 Social behaviour
(a) Many animals live in social groups and have behaviours that are adapted to group living such as social hierarchy or cooperative hunting and defence.
(b) Altruism and kin selection and its influence on survival. An altruistic behaviour harms the donor individual but benefits the recipient. Behaviour that appears to be altruistic can be common between a donor and a recipient if they are related (kin). The donor will benefit in terms of the increased chances of survival of shared genes in the recipient's offspring or future offspring.
(c) Social insects, the structure of their society and their ecological importance - 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.
Ecological importance — social insects are often keystone species within their ecosystems. Some species are of economic importance to humans providing ecosystem services such as pollination and pest control.
(d) Primate behaviour (long period of parental care allows learning of complex social behaviour). Complex behaviours that support social structure to reduce unnecessary conflict, group behaviour (alliances to increase social status), the influence of external factors such as the complexity of social structure include ecological niche, resource distribution and taxonomic group.

7 Mass extinction and biodiversity
(a) Mass extinction and the regaining of biodiversity. Fossil evidence indicates that there have been several mass extinction events in the past. Following each mass extinction event, biodiversity has been regained slowly due to speciation of survivors. The difficulties in estimating past and current species extinction rates. The extinction of mega fauna correlated with the spread of humans. The escalating rate of ecosystem degradation caused by humans is causing the rate of species extinction to be much higher than the natural background rate.
(b) Measuring biodiversity. Measurable components of biodiversity include genetic diversity, species diversity and ecosystem diversity.
(i) The number and frequency of alleles in a population as a measure of genetic diversity. Genetic diversity comprises the genetic variation represented by the number and frequency of all the alleles in a population.
(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 degree of isolation and area of habitat islands on their species diversity.
(iii) Ecosystem diversity refers to the number of distinct ecosystems within a defined area.

8 Threats to biodiversity
(a) 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).
(b) 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 (edge species) 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.
(c) Introduced, naturalised and invasive species and their impact on indigenous populations. 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.
(d) Climate change and its impact on biodiversity.

Administrative information

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History of changes to Course Assessment Specification

Course details	Version	Description of change	Authorised by	Date
	2.0	Page 2 – the number of marks awarded for the assignment has changed. Pages 5 and 6 – the descriptions of the skills to be assessed have been rewritten to better explain what is required. Page 7 – Conducting the assessment: this has been rewritten to clarify how stages will be assessed. Suggested timings for each stage have been removed. Page 8 –the details of the skills to be assessed have been rewritten for clarity Page 9 onwards – Further mandatory knowledge: these tables have been substantially revised to aid understanding	Qualifications Development Manager	April 2014

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Note: You are advised to check SQA's website (**www.sqa.org.uk**) to ensure you are using the most up-to-date version of the Course Assessment Specification.

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