SCQF level 6
Unit Specification

Biology: Sustainability and Interdependence

SCQF: level 6 (6 SCQF credit points)

Unit code: J4A8 76

Unit outline

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. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of food supply, plant growth and productivity; plant and animal breeding; crop protection; animal welfare; symbiosis; social behaviour; components of biodiversity; and threats to biodiversity.

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

Learners who complete this Unit will be able to:

1 Apply skills of scientific inquiry and draw on knowledge and understanding of the key areas of this Unit to carry out an experiment/practical investigation
2 Draw on knowledge and understanding of the key areas of this Unit and apply scientific skills

This Unit is a free-standing Unit. The *Unit Support Notes* in the Appendix provide advice and guidance on delivery, assessment approaches and development of skills for learning, skills for life and skills for work. Exemplification of the standards in this Unit is given in *Unit Assessment Support.*

Recommended entry

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 one or more of the following or equivalent qualifications and/or experience:

- National 5 Biology Course
- free-standing SCQF level 5 Biology Units

Equality and inclusion

This Unit Specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. For further information, please refer to the Appendix: *Unit Support Notes.*

Standards

Outcomes and Assessment Standards

Outcome 1

The learner will:

1 Apply skills of scientific inquiry and draw on knowledge and understanding of the key areas of this Unit to carry out an experiment/practical investigation by:

1.1 Planning an experiment/practical investigation
1.2 Following procedures safely
1.3 Making and recording observations/measurements correctly
1.4 Presenting results in an appropriate format
1.5 Drawing valid conclusions
1.6 Evaluating experimental procedures

Outcome 2

The learner will:

2 Draw on knowledge and understanding of the key areas of this Unit and apply scientific skills by:

2.1 Making accurate statements
2.2 Solving problems

Evidence Requirements for the Unit

Assessors should use their professional judgement, subject knowledge and experience, and understanding of their learners, to determine the most appropriate ways to generate evidence and the conditions and contexts in which they are used.

The key areas covered in this Unit are food supply, plant growth and productivity; plant and animal breeding; crop protection; animal welfare; symbiosis; social behaviour; components of biodiversity; and threats to biodiversity.

The following table describes the evidence for the Assessment Standards. Exemplification of assessment is provided in *Unit Assessment Support*.

Assessment Standard	Evidence required
Planning an experiment	The plan must include: ♦ a clear statement of the aim ♦ a hypothesis ♦ a dependent and independent variable ♦ variables to be kept constant ♦ measurements/observations to be made ♦ the equipment/materials ♦ a clear and detailed description of how the experiment/practical investigation should be carried out, including safety considerations
Following procedures safely	The learner must be seen to follow procedures safely.
Making and recording observations/measurements correctly	The raw data must be collated in a relevant format, for example a table.
Presenting results in an appropriate format	One format from: bar graph or line graph.
Drawing a valid conclusion	Must include reference to the aim and be supported by the results.
Evaluating experimental procedures	Provide one evaluative statement about the procedures used **and** suggest one improvement for the experiment. **or** Provide two evaluative statements about the procedures used. **or** Suggest two improvements for the experiment. Appropriate justification must also be provided, whichever option is chosen.

Assessment Standard	Evidence required
Making accurate statements and solving problems	Achieve at least 50% of the total marks available in a holistic assessment. A holistic assessment must include: ♦ an appropriate number of opportunities to make accurate statements for each key area of the Unit ♦ at least one opportunity to demonstrate each of the following problem-solving skills: — make generalisations/predictions — select information — process information, including calculations, as appropriate — analyse information

Assessment Standard thresholds

Outcome 1

Learners are not required to show full mastery of the Assessment Standards to achieve Outcome 1. Instead, five out of the six Assessment Standards for Outcome 1 must be met to achieve a pass. Learners must be given the opportunity to meet all Assessment Standards.

Outcome 2

Learners are assessed using a holistic assessment that assesses Assessment Standards 2.1 and 2.2. To gain a pass for Outcome 2, learners must achieve 50% or more of the total marks available in the assessment.

Transfer of evidence

Evidence for the achievement of Outcome 1 for this Unit can be used as evidence for the achievement of Outcome 1 in the SCQF level 6 Units: Biology: DNA and the Genome (J4A6 76) and Biology: Metabolism and Survival (J4A7 76).

Evidence for the achievement of Outcome 2 for this Unit is **not** transferable between the SCQF level 6 Units: Biology: DNA and the Genome (J4A6 76) and Biology: Metabolism and Survival (J4A7 76).

Re-assessment

SQA's guidance on re-assessment is that there should only be one or, in exceptional circumstances, two re-assessment opportunities. Re-assessment must be carried out under the same conditions as the original assessment.

Outcome 1

Learners can re-draft their original Outcome 1 report or carry out a new experiment/practical investigation.

Outcome 2

Learners must have a full re-assessment opportunity, ie a holistic assessment. To achieve Outcome 2, learners must achieve 50% of the total marks available in the re-assessment.

Development of skills for learning, skills for life and skills for work

It is expected that learners will develop broad, generic skills through this Unit. The skills that learners will be expected to improve on and develop through the Unit are based on SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work* and drawn from the main skills areas listed below. These must be built into the Unit where there are appropriate opportunities.

1 Literacy

1.2 Writing

2 Numeracy

2.1 Number processes
2.2 Money, time and measurement
2.3 Information handling

5 Thinking skills

5.3 Applying
5.4 Analysing and evaluating
5.5 Creating

Amplification of these is given in SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work.* The level of these skills should be at the same SCQF level of the Unit and be consistent with the SCQF level descriptor. Further information on building in skills for learning, skills for life and skills for work is given in the Appendix: *Unit Support Notes.*

Appendix: Unit Support Notes

Introduction

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

- *Unit Assessment Support*

Developing skills, knowledge and understanding

Teachers and lecturers are free to select the skills, knowledge, understanding and contexts that are most appropriate for delivery in their centres.

Approaches to learning and teaching

Sustainability and interdependence		
Key areas	**Depth of knowledge required**	**Suggested learning activities**
1 Food supply, plant growth and productivity (a) Food supply 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. Agricultural production depends on factors that control photosynthesis and 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 and competition. Livestock produce less food per unit area than crop plants due to loss of energy between trophic levels. Livestock production is often possible in habitats unsuitable for growing crops.	Food security is the ability of human populations to access food of sufficient quality and quantity. All food production is dependent ultimately upon photosynthesis. Plant crop examples include cereals, potato, roots and legumes. Breeders seek to develop crops with higher nutritional values, resistance to pests and diseases, physical characteristics suited to rearing and harvesting as well as those that can thrive in particular environmental conditions.	

Sustainability and interdependence		
Key areas	**Depth of knowledge required**	**Suggested learning activities**
(b) Photosynthesis Light energy is absorbed by photosynthetic pigments to generate ATP and for photolysis. Absorption spectra of chlorophyll a and b and carotenoids compared to action spectra for photosynthesis. Carotenoids extend the range of wavelengths absorbed and pass the energy to chlorophyll for photosynthesis. Absorbed light energy excites electrons in the pigment molecule. Transfer of these electrons through the electron transport chain 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 ions, which are transferred to the coenzyme NADP. In the carbon fixation stage (Calvin cycle), the enzyme RuBisCO fixes carbon dioxide by attaching it to ribulose bisphosphate (RuBP). The 3-phosphoglycerate (3PG) produced is phosphorylated by ATP and	Light energy not absorbed is transmitted or reflected. Each pigment absorbs a different range of wavelengths of light.	Examine the spectrum of visible light and artificial light sources with a simple spectroscope. Examine light transmission through extracted chlorophyll with a simple spectroscope. Carry out experiments to investigate the action spectra of photosynthesis in plants using coloured filters. Carry out paper or thin-layer chromatography of photosynthetic pigments. Research photosynthetic pigments in other photoautotrophs. Carry out the Hill reaction.

Sustainability and interdependence		
Key areas	**Depth of knowledge required**	**Suggested learning activities**
combined with hydrogen ions from NADPH to form glyceraldehyde-3-phosphate (G3P). G3P is used to regenerate RuBP and for the synthesis of glucose. Glucose may be used as a respiratory substrate, synthesised into starch or cellulose or passed to other biosynthetic pathways.	These biosynthetic pathways can lead to the formation of a variety of metabolites, such as DNA, protein and fat.	Carry out experiments on the synthesis of starch from glucose-1-phosphate by potato phosphorylase.
2 Plant and animal breeding (a) Plant and animal breeding to improve characteristics to help support sustainable food production	Breeders develop crops and animals with higher food yields, higher nutritional values, pest and disease resistance and ability to thrive in particular environmental conditions.	Research resistance of potato varieties to *Phytophthora infestans.*
(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.	The selection of treatments to ensure valid comparisons, the number of replicates to take account of the variability within the sample, and the randomisation of treatments to eliminate bias when measuring treatment effects.	Evaluate crop trials to draw conclusions on crop suitability, commenting on validity and reliability of trial design and the treatment of variability in results.

Sustainability and interdependence		
Key areas	**Depth of knowledge required**	**Suggested learning activities**
(c) Inbreeding In inbreeding, selected related plants or animals are bred for several generations until the population breeds true to the desired type due to the elimination of heterozygotes. A result of inbreeding can be an increase in the frequency of individuals who are homozygous for recessive deleterious alleles. These individuals will do less well at surviving to reproduce. This results in inbreeding depression.	Analysis of patterns of inheritance in inbreeding using monohybrid crosses	Analyse patterns of inheritance in inbreeding and outbreeding species (monohybrid cross, F_1 and F_2 from two true breeding parental lines). Research the development of particular crop cultivars and livestock breeds. Research self-pollinating plants — naturally inbreeding and less susceptible to inbreeding depression due to the elimination of deleterious alleles by natural selection.
(d) Cross breeding and F_1 hybrids In animals, individuals from different breeds may produce a new crossbreed population with improved characteristics. The two parent breeds can be maintained to produce more crossbred animals showing the improved characteristic. In plants, F_1 hybrids produced by the crossing of two different inbred lines, create a relatively uniform heterozygous crop. F_1 hybrids often have increased vigour and yield.	New alleles can be introduced to plant and animal lines by crossing a cultivar or breed with an individual with a different, desired genotype. Plants with increased vigour may have increased disease resistance or increased growth rate.	

Sustainability and interdependence		
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In inbreeding animals and plants, F_1 hybrids are not usually bred together as the F_2 produced shows too much variation.		
(e) Genetic technology As a result of genome sequencing, organisms with desirable genes can be identified and then used in breeding programmes. Breeding programmes can involve crop plants that have been genetically modified using recombinant DNA technology.	Single genes for desirable characteristics can be inserted into the genomes of crop plants, creating genetically modified plants with improved characteristics. Details of recombinant DNA technology techniques in improving crop plants are not required, for example the use of Agrobacterium. Recombinant DNA technology in plant breeding includes insertion of Bt toxin gene into plants for pest resistance, glyphosate resistance gene inserted for herbicide tolerance.	Research plant mutations in breeding programmes, for example, mutation breeding has brought about improvement to a number of crops in disease resistance, dwarf habit (for example in cereals), and chemical or nutritional composition (for example low erucic acid in rapeseed).
3 Crop protection (a) Weeds compete with crop plants, while other pests and diseases damage crop plants, all of which reduce productivity.		

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Properties of annual weeds — rapid growth, short life cycle, high seed output and 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, other pests and diseases by cultural methods	Ploughing, weeding and crop rotation	Research the incidence and viability of potato cyst nematodes in samples of soil continuously cropped with potatoes and in samples of soil cropped with potatoes as part of a rotation.
(c) The advantages of pesticides, which are either selective or systemic	Pesticides include herbicides to kill weeds, fungicides to control fungal diseases, insecticides to kill insect pests, molluscicides to kill mollusc pests and	Research the control of weeds, pests and/or diseases of agricultural crops by cultural and chemical means.

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Problems with pesticides: toxicity to non-target species, persistence in the environment, bioaccumulation or biomagnification in food chains, producing resistant populations of pests	nematicides to kill nematode pests. Selective herbicides have a greater effect on certain plant species (broad leaved weeds). Systemic herbicide spreads through vascular system of plant and prevents regrowth. Systemic insecticides, molluscicides and nematicides spread through the vascular system of plants and kill pests feeding on plants. Applications of fungicide based on disease forecasts are more effective than treating diseased crops. Bioaccumulation is a build-up of a chemical in an organism. Biomagnification is an increase in the concentration of a chemical moving between trophic levels.	
(d) Control of weeds, other pests and diseases by biological control and integrated pest management	In biological control, the control agent is a natural predator, parasite or pathogen of the pest.	Research methods of biological control, for example control of glasshouse whitefly with the parasitic wasp *Encarsia*, red

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	Integrated pest management is a combination of chemical, biological and cultural control.	spider mite with the predatory mite *Phytoseiulus* and butterfly caterpillars with the bacterium *Bacillus thuringiensis*.
Risks with biological control	The control organism may become an invasive species, parasitise, prey on or be a pathogen of other species.	Compare the chemical and biological control of the red spider mite.
4 Animal welfare The costs, benefits and ethics of providing different levels of animal welfare in livestock production	Intensive farming is less ethical than free-range farming due to poorer animal welfare. Free-range requires more land and is more labour intensive but can be sold at a higher price and animals have a better quality of life. Intensive farming often creates conditions of poor animal welfare but is often more cost effective, generating higher profit as costs are low.	Research the five freedoms for animal welfare.
Behavioural indicators of poor animal welfare are stereotypy, misdirected behaviour, failure in sexual or parental behaviour and altered levels of activity.	Very low (apathy) or very high (hysteria) levels of activity.	

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5 Symbiosis Symbiosis — co-evolved intimate relationships between members of two different species	Types of symbiotic relationship — parasitism and mutualism Knowledge of commensalism is not required.	
(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. Parasites often have limited metabolism and cannot survive out of contact with a host. Transmission of parasites to new hosts using direct contact, resistant stages and vectors. Some parasitic life cycles involve intermediate (secondary) hosts to allow them to complete their life cycle.		Observe microscope slides of parasites.

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(b) Mutualism 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, co-operative hunting and social defence.	Social hierarchy is a rank order within a group of animals consisting of dominant and subordinate members. In a social hierarchy, dominant individuals carry out ritualistic (threat) displays while subordinate animals carry out appeasement behaviour to reduce conflict. Social hierarchies increase the chances of the dominant animal's favourable genes being passed on to offspring. Animals often form alliances in social hierarchies to increase their social status within the group. Co-operative hunting may benefit subordinate animals as well as dominant ones, as they may gain more food than by foraging alone. Less energy is used per individual. Co-operative hunting enables	View video clips of orca, wolves, lions and chimpanzees co-operatively hunting.

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	larger prey to be caught and increases the chance of success. Social defence strategies increase the chance of survival as some individuals can watch for predators while others can forage for food. Groups adopt specialised formations when under attack, protecting their young.	 View video clips of social defence in musk oxen, meerkats and starlings.
(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 kin selection in terms of the increased chances of survival of shared genes in the recipient's offspring or future offspring.	 Reciprocal altruism, where the roles of donor and recipient later reverse, often occurs in social animals.	 Research reciprocal altruism using the prisoner's dilemma. Analyse data on helper behaviour and relatedness.

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(c) Social insects and the structure of their society in which only some individuals (queens and drones) contribute reproductively Most members of the colony are sterile workers who co-operate with close relatives to raise relatives.	Social insects include bees, wasps, ants and termites. Other examples of workers' roles include defending the hive, collecting pollen and carrying out waggle dances to show the direction of food. Sterile workers raise relatives to increase survival of shared genes.	View video clips of the queen's role and workers' roles in termite and honey bee colonies.
(d) Primate behaviour Primates have a long period of parental care to allow learning of complex social behaviour. Complex social behaviours support the social hierarchy. This reduces conflict through ritualistic display and appeasement behaviour. Alliances form between individuals, which are often used to increase social status within the group.	Grooming, facial expression, body posture and sexual presentation	View video clips of primate behaviour.

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7 Components of biodiversity Components of biodiversity are genetic diversity, species diversity and ecosystem diversity. Genetic diversity is the number and frequency of all the alleles within a population. 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). Ecosystem diversity refers to the number of distinct ecosystems within a defined area.	If one population of a species dies out then the species may have lost some of its genetic diversity, and this may limit its ability to adapt to changing conditions. A community with a dominant species has a lower species diversity than one with the same species richness but no particularly dominant species.	Research the importance of producing a central database of all known species and the difficulties involved in ensuring its accuracy. Use fieldwork studies to compare biodiversity indices of different areas, for example: polluted versus unpolluted river, an ecosystem with invasive species versus an ecosystem with native species, a disturbed habitat versus an undisturbed habitat. Analyse data on island biogeography.
8 Threats to biodiversity (a) Exploitation and recovery of populations and the impact on their genetic diversity	With overexploitation, populations can be reduced to a low level but may still recover. Some species have a naturally low genetic diversity in their population and yet remain viable.	Analyse data on exploitation of whale or fish populations.

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The bottleneck effect — small populations may lose the genetic variation necessary to enable evolutionary responses to environmental change.	In small populations, this loss of genetic diversity can be critical for many species, as inbreeding can result in poor reproductive rates.	Research impact of naturally low genetic diversity within cheetah populations.
(b) Habitat loss, habitat fragments and their impact on species richness The clearing of habitats has led to habitat fragmentation. Degradation of the edges of habitat fragments results in increased competition between species as the fragment becomes smaller. This may result in a decrease in biodiversity. To remedy widespread habitat fragmentation, isolated fragments can be linked with habitat corridors.	More isolated fragments and smaller fragments exhibit a lower species diversity. The corridors allow movement of animals between fragments, increasing access to food and choice of mate. This may lead to recolonisation of small fragments after local extinctions.	Research impact of habitat fragmentation and benefits of habitat corridors for tiger populations.
(c) Introduced, naturalised and invasive species and their impact on native populations Introduced (non-native) species are those that humans have moved either		

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Key areas	**Depth of knowledge required**	**Suggested learning activities**
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, therefore reducing species diversity. Invasive species may well be free of the predators, parasites, pathogens and competitors that limit their population in their native habitat. Invasive species may prey on native species, out-compete them for resources or hybridise with them.		

Administrative information

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Superclass: RH

History of changes to National Unit Specification

Version	Description of change	Authorised by	Date

Note: readers are advised to check SQA's website: www.sqa.org.uk to ensure they are using the most up-to-date version of the Unit Specification.