SCQF level 6
Unit Specification

Biology: Sustainability and Interdependence

SCQF: level 6 (6 SCQF credit points)

Unit code: H4KF 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; mass extinction and biodiversity; 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 also available as 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 or relevant component 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; mass extinction and biodiversity; threats to biodiversity.

Evidence can be drawn from a variety of sources and presented in a variety of formats.

The following table describes the evidence for the assessment standards which require exemplification. Evidence may be presented for individual outcomes, or gathered for the unit. If the latter approach is used, it must be clear how the evidence covers each outcome.

Assessment Standard	**Evidence required**
Planning an experiment	The plan should 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
Presenting results in an appropriate format	One format from: table, line graph, chart, key, diagram, flow chart, summary, extended text or other appropriate format
Drawing a valid conclusion	Include reference to the aim
Evaluating experimental procedures	Suggest two improvements with justification
Making accurate statements	At least half of the statements should be correct across the key areas of this Unit
Solving problems	One of each: ♦ make generalisation/prediction ♦ select information ♦ process information, including calculations, as appropriate ♦ analyse information

Exemplification of assessment is provided in Unit assessment support packs.

Advice and guidance on possible approaches to assessment is provided in the Appendix: *Unit Support Notes.*

Assessment Standard Thresholds

Outcome 1

Candidates 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. Candidates must be given the opportunity to meet all assessment standards. The threshold has been put in place to reduce the volume of re-assessment where that is required.

Transfer of evidence
Evidence of Outcome 1 in a unit is transferrable between the other units at SCQF level 6.

Re-assessment
Candidates can be given the opportunity to re-draft their original Outcome 1 report or to carry out a new experiment/practical investigation.

Outcome 2

There is no requirement to pass assessment standard 2.1 (making accurate statements) and assessment standard 2.2 (solving problems) independently. Candidates can be assessed using a single test that contains marks and a cut-off score.
A suitable unit assessment will cover all of the key areas (assessment standard 2.1) **and** assess each of the problem-solving skills (assessment standard 2.2).

Where a candidate achieves 50% or more of the total marks available in a single unit assessment, they will pass Outcome 2 for that unit. Existing unit assessment support packs (UASPs) can be used, or centres can replace the questions with suitable alternatives of a similar standard

Unit assessment support pack 1 contains questions on all of the key areas (AS 2.1) and questions covering each of the problem solving skills (AS 2.2), and may be adapted for use as a single assessment. The number of marks available for each question should be combined to give the total number of marks available. A cut-off score of 50% should be applied to the unit assessments.

Outcome 2: assessment activity 2 – tests contain questions covering assessment standards 2.1 and 2.2 in a single assessment. These do not require to be adapted.

Important note: Centres can continue to assess AS 2.1 and 2.2 separately using the existing UASPs. If this option is chosen, 50% or more of the KU statements (AS 2.1) made by candidates must be correct in the unit assessment and at least one correct response for each problem solving skill (AS 2.2) is required to pass outcome 2. However, if a candidate is given more than one opportunity in a unit assessment to provide a response for a problem solving skill, then they must answer 50% or more correctly.

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 should be carried out under the same conditions as the original assessment. It is at the teacher or lecturer's discretion how they re-assess their candidates. Candidates may be given a full re-assessment opportunity, or be re-assessed on individual key areas and/or problem-solving skills. As there is no requirement to pass assessment standard 2.1 (making accurate statements) and assessment standard 2.2 (solving problems) independently, candidates must achieve 50% of the 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:

- the *Unit Assessment Support packs*

Developing skills, knowledge and understanding

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

Approaches to learning and teaching

key areas	Suggested learning activities	Exemplification of key areas
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.	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.
(ii) 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 plant crops due to loss of energy between trophic levels. Livestock production is often possible in habitats unsuitable for growing crops.		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.

key areas	Suggested learning activities	Exemplification of key areas
(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	Examination of spectrum of visible light and artificial light sources with a simple spectroscope. Examine light transmission through extracted chlorophyll with a simple spectroscope. Investigate the action spectra of photosynthesis in plants using coloured filters. Chromatography of photosynthetic pigments. Research photosynthetic pigments in other photoautotrophs. Carry out the Hill reaction. Research the inhibition of RuBisCo by oxygen. Experiments on the synthesis of starch from	Photosynthesis traps light energy to produce carbohydrates. Absorption of particular wavelengths of light by photosynthetic pigments.

key areas	Suggested learning activities	Exemplification of key areas
glyceraldehyde-3-phosphate (G3P). G3P is used to regenerate RuBP and for the synthesis of glucose, which may be used as a respiratory substrate, synthesised into starch or cellulose or pass to other biosynthetic pathways to form a variety of metabolites.	glucose-1-phosphate by potato phosphorylase.	
(ii) Plant productivity. Net assimilation is the increase in mass due to photosynthesis minus the loss due to respiration and can be measured by the increase in dry mass per unit leaf area. Productivity is the rate of generation of new biomass per unit area per unit of time. Biological yield of a crop is the total plant biomass. Economic yield is the mass of desired product. The harvest index is calculated by dividing the dry mass of economic yield by the dry mass of biological yield.	Measure net assimilation rate in leaf samples under a variety of conditions. Carry out experimental investigations on limiting factors in photosynthesis. Analyse data on crop planting density, biological yield and economic yield using leaf area index, crop growth rates and harvest index.	
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 ability to thrive in particular environmental conditions.	Investigate resistance of potato varieties to *Phytophthera infestans.*	

key areas	Suggested learning activities	Exemplification of key areas
(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.	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).
(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.	Analyse patterns of inheritance in inbreeding and outbreeding species (monohybrid cross, F1 and F2 from two true breeding parental lines, back cross, test cross). Case studies on the development of particular crop cultivars and livestock breeds.	
d) Cross breeding and F1 hybrids. In animals, individuals from different breeds may produce a new crossbreed population	Case histories of plant mutations in breeding programmes. Mutation breeding has brought about improvement to a number of crops in	New alleles can be introduced to plant and animal lines by crossing a cultivar or breed with an individual with a different, desired

key areas	Suggested learning activities	Exemplification of key areas
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.	disease resistance, dwarf habit (eg in cereals) and chemical/nutritional composition (eg low euricic acid in rape seed).	genotype.
(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.	Research/study of self-pollinating plants-naturally inbreeding and less susceptible to inbreeding depression due to the elimination of deleterious alleles by natural selection.	
(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.	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.	
3 Crop protection (a) Weeds compete with crop plants, while		

key areas	Suggested learning activities	Exemplification of key areas
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.	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.	Control of weeds, pests and diseases by farming methods.
(c) Problems with plant protection chemicals may include toxicity to animal species, persistence in the environment, accumulation or magnification in food chains, producing 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.
(d) Biological control and integrated pest	Case studies on, for example, control of	In biological control the control agent is a

key areas	Suggested learning activities	Exemplification of key areas
management. Risks with biological control.	glasshouse whitefly with the parasitic wasp *Encarsia*, control of glasshouse red spider mite with the predatory mite *Phytoseiulus* and/or control of butterfly caterpillars with the bacterium *Bacillus thuringiensis*. Investigate the chemical and biological control of red spider mite.	natural predator or parasite of the pest. Integrated pest management combines chemical and 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.	Research the five freedoms for animal welfare.	
(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.	Interpret and evaluate data 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.	
5 Symbiosis Symbiosis — co-evolved intimate relationships between members of two different species.		
(a) Parasitic relationships and transmission —	Observe microscope slides of parasites.	

key areas	Suggested learning activities	Exemplification of key areas
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.	Research the links between these symbioses and anthropogenic climate change.	
(b) 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. Evidence for the symbiotic origin of chloroplasts and mitochondria.
6 Social behaviour (a) Many animals live in social groups and have behaviours that are adapted to group living such as social hierarchy, cooperative hunting and social 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.
(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	Investigate reciprocal altruism using the prisoner's dilemma. 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.

key areas	Suggested learning activities	Exemplification of key areas
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 (queens and drones) contribute reproductively. Most members of the colony are sterile 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 conflict (ritualistic display and appeasement behaviour, 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.	Case study on primate behaviour.	Long period of parental care in primates gives an opportunity to learn complex social behaviours. To reduce unnecessary conflict, social primates use ritualistic display and appeasement behaviours. Grooming, facial expression, body posture and sexual presentation important in different species. In some monkeys and apes, alliances form between individuals which are often used to increase social status within the group.

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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.	Research the Permian, Cretaceous and Holocene mass extinction events.	
b) Measuring biodiversity. Measurable components of biodiversity include genetic diversity, species diversity and ecosystem diversity.	Research the importance of producing a central database of all known species and the difficulties involved in ensuring its accuracy. It is estimated that there are about 2 million known species. Of these, about half are animals, most of which are insects. Of the vertebrate animals, most are fish. There are about 0.25 million species of flowering plants.	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. Species richness and relative abundance as a measure of species diversity.
(i) The number and frequency of alleles in a population as a measure of genetic diversity. Genetic diversity comprises the genetic		

key areas	Suggested learning activities	Exemplification of key areas
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). Effect of dominant species on species diversity. The effects of degree of isolation and size of habitat islands on their species diversity.	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).	A community with a dominant species has a lower species diversity than one with the same species richness but no particularly dominant species.
(iii) Ecosystem diversity refers to the number of distinct ecosystems within a defined area.	Analyse data on island biogeography.	
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); inbreeding in small populations resulting in poor reproductive rates.	Analyse data on exploitation of whale or fish populations. Use of gel electrophoresis in monitoring harvest species. Research impact of naturally low genetic diversity within cheetah populations.	Exploitation and recovery of populations of particular species. 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.
(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	Research impact of habitat fragmentation and benefits of habitat corridors for tiger populations.	

key areas	Suggested learning activities	Exemplification of key areas
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 move between habitat fragments and 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.	Case study on invasive species.	
(d) 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

key areas	Suggested learning activities	Exemplification of key areas
		change on species and ecosystem diversity.

Administrative information

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Superclass: RH

History of changes to National Unit Specification

Version	Description of change	Authorised by	Date
2.0	Page 1 – the description of key areas under 'Unit outline' has been revised to give more information Page 3 – in Outcome 1.3, the word 'accurately' has been replaced by 'correctly'. Pages 3-4 – the Evidence requirements have been rewritten to better explain what is required Page 4 – information has been added on Transfer of Evidence	Qualifications Development Manager	April 2014
3.0	Assessment Standards 2.2 & 2.3 removed	Qualifications Development Manager	June 2014
3.1	'Threats to biodiversity' added as key area in this Unit	Qualifications Manager	April 2015
4.0	Level changed from Higher to SCQF level 6. Unit support notes added. Assessment standard threshold added.	Qualifications Manager	September 2018