SCOTTISH
QUALIFICATIONS
AUTHORITY

National Unit Specification: general information

UNIT Genetics and Adaptation (Higher)

NUMBER D030 12

COURSE Biology (Higher)

SUMMARY

The unit seeks to develop knowledge and understanding and problem solving in the context of variation, selection and speciation, and animal and plant adaptations. This is a component unit of Higher Biology.

OUTCOMES

1 Demonstrate knowledge and understanding related to genetics and adaptation.
2 Solve problems related to genetics and adaptation.
3 Collect and analyse information related to Higher Biology obtained by experiment.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Biology with Knowledge and Understanding and Problem Solving at Credit level
- Intermediate 2 Biology.

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In particular, candidates should have a clear understanding of the Standard Grade Biology topics of mitosis, nature of inheritance, monohybrid crosses, fertilisation and chromosome number, sex determination, and applications of genetic engineering, transport systems in plants, gas exchange in plants, photosynthesis, kidney structure and function, and the effects of environmental factors on behaviour. Alternatively, candidates should have achieved the units: *Living Cells (Int 2), Environmental Biology and Genetics (Int 2),* and *Animal Physiology (Int 2).*

CREDIT VALUE

1 credit at Higher.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

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

OUTCOME 1

Demonstrate knowledge and understanding related to genetics and adaptation.

Performance criteria
(a) Variation is described correctly in terms of meiosis and the dihybrid cross, linkage and crossing over, and mutation.
(b) Selection and speciation is described correctly in terms of natural and artificial selection.
(c) Animal and plant adaptations are described correctly with respect to maintaining a water balance, obtaining food and coping with dangers.

Evidence requirements
Evidence of an appropriate level of achievement must be generated from a closed-book test with items covering all the above performance criteria.

OUTCOME 2

Solve problems related to genetics and adaptation.

Performance criteria
(a) Relevant information is selected and presented in an appropriate format.
(b) Information is accurately processed, using calculations where appropriate.
(c) Conclusions drawn are valid and explanations given are supported by evidence.
(d) Experimental procedures are planned, designed and evaluated appropriately.
(e) Predictions and generalisations made are based on available evidence.

Evidence requirements
Evidence of an appropriate level of achievement must be generated from a closed-book test with items covering all the above performance criteria. Problems must be set in the context of variation selection and speciation, or animal and plant adaptations.

National Unit Specification: statement of standards (cont)

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OUTCOME 3

Collect and analyse information related to Higher Biology obtained by experiment.

Performance criteria
(a) The information is collected by active participation in the experiment.
(b) The experimental procedures are described accurately.
(c) Relevant measurements and observations are recorded in an appropriate format.
(d) Recorded experimental information is analysed and presented in an appropriate format.
(e) Conclusions drawn are valid.
(f) The experimental procedures are evaluated with supporting argument.

Evidence requirements

A report of one experimental activity is required, covering the above performance criteria in relation to the contents and notes specified for Higher Biology.

The teacher/lecturer responsible must attest that the report is the individual work of the candidate derived from active participation in an experiment involving the candidate in planning the experiment; deciding how it is managed; identifying and obtaining the necessary resources, some of which must be unfamiliar; and carrying out the experiment. Depending on the activity, the collection of the information may be group work.

Evidence submitted in support of attainment of PC (d) must be in the format of a table or graph(s) as appropriate. Conclusions drawn should be justified by reference to supporting evidence.

The evaluation should cover all stages of the experiment, including the initial analysis of the situation and planning and organising the experimental procedure.

National Unit Specification: support notes

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

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

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

Outcome 1

a)   Variation
1   Meiosis and the dihybrid cross.
    i   Sexual reproduction as a means of enabling genetic variation to be maintained in the population and its importance in long-term evolutionary change.
    ii   Outline of meiosis: haploid gamete production.
       Crossing over and independent assortment of chromosomes during meiosis: a means of producing new phenotypes.
    iii   The dihybrid cross: expected F_2 phenotypic ratio.

2   Linkage and crossing over.
    i   The existence of linked genes and its effect on the F_2 generation.
       Comparison of the distance between linked genes and the frequency of recombination.
    ii   Crossing over of genes at chiasmata during meiosis resulting in recombinant gametes.
       Separation of linked genes as a source of variation.
    iii   Sex linkage.

3   Mutation.
    i   Characteristics of mutant alleles, to include random occurrence and low frequency.
    ii   Mutagenic agents.
    iii   Changes in the number of chromosomes through non-disjunction.
    iv   Polyploidy: advantages in crop production.
    v   Change in the structure of one chromosome (duplication, translocation, deletion, inversion).
    vi   Alteration of base type or sequence (substitution, insertion, deletion, inversion).

b)   Selection and speciation
1   Natural selection
    i   The survival of those organisms best suited to their environment.
    ii   The concept of the species.
    iii   The importance of isolating mechanisms as barriers to gene exchange leading to evolution of new species.
    iv   Adaptive radiation.
    v   The high-speed evolution of organisms such as antibiotic resistant bacteria and the melanic peppered moth.
    vi   The conservation of species through wildlife reserves, captive breeding and cell banks. The maintenance of genetic diversity.

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    2   Artificial selection.
        i   The evolution of a wide variety of crops and domesticated animals through selective breeding and hybridisation as undertaken by humans.
        ii   The contribution of genetic engineering to the development of new varieties.
        iii   Somatic fusion in plants to produce new species.

c) **Animal and plant adaptations**
    1   Maintaining a water balance.

        Animals
        i   Osmoregulation in freshwater fish and saltwater bony fish.
        ii   Adaptations associated with salmon and eel migration.
        iii   Water conservation in the desert mammal.

        Plants
        i   The transpiration stream.
        ii   Stomatal mechanism.
        iii   Adaptations in xerophytes and hydrophytes.

    2   Obtaining food.

        Animals
        i   Foraging behaviour and search patterns in animals.
        ii   Economics of foraging behaviour.
        iii   Examples of interspecific and intraspecific competition arising from scarcity of resources.
        iv   Dominance hierarchy and cooperative hunting within the social group.
        v   Territorial behaviour in relation to competition for food.

        Plants
        i   Comparison of the sessility of plants and the mobility of animals.
        ii   Competition in plants mainly for light and soil nutrients.
        iii   The effect of grazing by herbivores on species diversity.
        iv   Comparison of the compensation point in sun and shade plants.

    3   Coping with dangers.

        Animals
        i   Avoidance behaviour and habituation.
        ii   Learning as a long-term modification of response.
        iii   Individual and social mechanisms for defence.

        Plants
        i   Structural defence mechanisms.
        ii   Ability to tolerate grazing.

Further detail is given in the supplementary notes in the course contents section of the course specification.

National Unit Specification: support notes (cont)

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Outcome 2

Examples of learning activities which provide suitable contexts for the development of problem solving skills include:

- design and carry out an investigation to examine the phenotypes arising from dihybrid crosses
- obtain and interpret information relating to linkage from examination of appropriate material, for example, *Drosophila*, corn cobs
- obtain and present information relating to mutation from the examination of appropriate material, for example normal/spelt wheat, popcorn/podcorn cobs, normal/albino mice
- obtain and present information on the distribution of British buttercup species
- obtain and present information on heavy metal resistance in grasses, calcicole/calcifuge pairs in *Viola* species or the bladder campions
- analyse and interpret current data on distribution of peppered moths
- analyse information on selective breeding by means of suitable computer simulation
- obtain and present information about osmoregulation in fresh and saltwater bony fish
- obtain and present information about osmoregulation in a desert mammal
- design and carry out an investigation to compare transpiration rates.

Outcome 3

Examples of suitable experiments in the context of this unit include:

- comparison of transpiration rates
- the escape response, including habituation
- learning using a finger maze
- examining the phenotypes from a dihybrid cross in *Drosophila*
- examining the phenotypes from a dihybrid cross in tomato plants
- stomatal opening and closing in *Commelina communis L*
- planarian activity in presence and absence of food
- the response of sun and shade plants to green light
- the relationship of the number of spines on holly leaves to the height above the ground.

Candidates or centres could devise other appropriate experiments in the context of variation, selection and speciation, or animal and plant adaptations.

The experiments chosen should allow all the performance criteria for this outcome to be achieved within any single report.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Details of suitable approaches are detailed in the course specification.

National Unit Specification: support notes (cont)

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GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

It is recommended that a holistic approach is taken to assessment, eg Outcomes 1 and 2 could be assessed by an integrated end of unit test with questions covering all the performance criteria for knowledge and understanding and problem solving.

Outcome 2
Test items should be constructed to allow candidates to generate evidence relating to the performance criteria as follows:

a) Selecting and presenting information:

- sources of information to include: texts, tables, charts, graphs and diagrams
- formats of presentation to include: written summaries, extended writing, tables and graphs.

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

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

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

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

National Unit Specification: support notes (cont)

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Outcome 3

Type of experimental activity

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

Assessment of Outcome 3

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

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

National Course Specification: support notes (cont)

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

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

National Unit Specification: support notes (cont)

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

Conditions required to complete the report

Candidates may complete their reports outwith class time provided reasonable measures are taken to ensure that the report is the individual work of the candidate.

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

Use of IT

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

Transfer of evidence

Candidates may transfer evidence for Outcome 3 from one level to the one below provided the experiment is in the context of the course concerned.

Candidates, who are repeating a course, may carry forward evidence of an appropriate standard, generated in a previous year.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).