Higher National Unit specification

General information

Unit title: DNA and Genetics (SCQF level 7)

Unit code: H929 34

Superclass: RH

Publication date: May 2015

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand key aspects of DNA and genetics. Learners will study the cell cycle, gene expression, patterns of inheritance, population genetics and applications of DNA technology. The Unit is suitable for learners studying at HNC level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of molecular biology and genetics at HND level or to seek employment in science based industries.

Outcomes

On successful completion of the Unit the learner will be able to:

1 Describe the stages of the cell cycle.
2 Describe how genes are expressed.
3 Explain and apply patterns of inheritance and population genetics.
4 Describe and explain applications of DNA technology.

Credit points and level

1 Higher National Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the HN Unit H927 34 *Cell Biology: Theory and Laboratory Skills* or equivalent, or have experience of Biology or Human Biology at Higher level.

Higher National Unit specification: General information (cont)

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Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

Context for delivery

If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

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.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements.**

Higher 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 SQA.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Describe the stages of the cell cycle.

Knowledge and/or Skills

- Phases and control of the cell cycle
- Chromosome behaviour during meiosis and mitosis
- Meiotic events that give rise to variation

Outcome 2

Describe how genes are expressed.

Knowledge and/or Skills

- Gene organisation
- Control of gene expression
- Epigenetics

Outcome 3

Explain and apply patterns of inheritance and population genetics.

Knowledge and/or Skills

- Mendelian and non-Mendelian patterns of inheritance
- Linked genes
- Population genetics

Outcome 4

Describe and explain applications of DNA technology.

Knowledge and/or Skills

- Restriction enzymes
- Electrophoresis
- PCR techniques and applications

Higher National Unit specification: Statement of standards (cont)

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Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1-4 should be assessed using a holistic closed-book assessment under supervised conditions. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment be completed within 1 hour 30 minutes.

Outcome 1

The assessment will sample 2 of the 3 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Describe the phases and control of the cell cycle to include: G0/G1; S; G2; M phases.
- Describe the behaviour of chromosomes during the stages of meiosis and mitosis to include: interphase, prophase, metaphase, anaphase, telophase and cytokinesis; compare and contrast mitosis and meiosis.
- Describe the behaviour of homologous chromosomes during meiosis which gives rise to variation.

Outcome 2

The assessment will sample 2 of the 3 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Describe the organisation of genes with respect to introns and exons in eukaryotic cells and operons in bacterial cells.
- Describe initiation, elongation and termination of transcription; describe the role of enhancers and inducers on gene expression.
- Describe the effect of the environment on gene expression.

Higher National Unit specification: Statement of standards (cont)

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Outcome 3

The assessment will sample 2 of the 3 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Apply Mendel's Laws to solve genetic problems using monohybrid and dihybrid crosses; solve genetic problems using examples of incomplete and codominance; explain polygenic inheritance.
- Explain the significance of linked genes with respect to gene transmission; describe recombination events and use crossover values/recombination frequency in gene mapping techniques.
- Use the Hardy-Weinberg equation to perform calculations relating to allele frequencies within a population; describe selection pressures which influence gene frequencies within a population.

Outcome 4

The assessment will sample 2 of the 3 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Explain the action of restriction enzymes with respect to restriction sites, recognition sequences, sticky and blunt ends.
- Describe the principles of electrophoresis in DNA fragment separation based on size; describe different types of electrophoresis.
- Describe PCR techniques and applications.

Higher National Unit Support Notes

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Unit Support Notes are offered as guidance and 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 the content and context for this Unit

This Unit is intended as part of the framework for HNC/HND Applied Sciences and HND Applied Biological Sciences but may be suitable for inclusion in other HN Science awards. It is designed to develop the theoretical aspects of DNA and genetics introduced in Biology and Human Biology at Higher level.

Outcome 1 — Describe the stages of the cell cycle

Phases and control of the cell cycle to include: G0/G1; S; G2; M phases. Regulation of the cell cycle, and involvement of CdKs and cyclins. Varying levels of CdKs throughout the cell cycle. Phosphorylation of molecules by CdKs. DNA damage and spindle fibre checkpoints. Oncogenes.

Chromosome behaviour during meiosis and mitosis. Stages of meiosis: Interphase; Prophase I; Metaphase I; Anaphase I and Telophase I; Prophase II; Metaphase II; Anaphase II and Telophase II and cytokinesis. Stages of mitosis; interphase, prophase, metaphase, anaphase, telophase and cytokinesis. Comparison of meiosis and mitosis.

Meiosis as a source of variation. Description of the behaviour of homologous chromosomes which gives rise to variation and description of the events involved in crossing over.

Outcome 2 — Describe how genes are expressed

Eukaryotic DNA as consisting of exons and introns. Primary transcript mRNA spliced in nucleus. Modifications at each end of the primary transcript to include addition of a 5’ cap and poly A tail at the 3’ end, also take place in the nucleus to produce mature mRNA. Introns are absent in prokaryotes. Bacteria transcribe single piece of mRNA that encompasses several genes. Clusters of genes related in function known as operons. Lac operon as an example.

Initiation, elongation and termination of transcription including the role of promoters in increasing efficiency of RNA polymerase binding. Transcription factors binding DNA in promoter sequence to increase or decrease the likelihood of a gene expressing. Transcription factors binding to enhancers. Transcription stops at a specific transcription termination sequence on the DNA at the 5’ end of the gene.

Oncogenes as mutant forms of normal proto-oncogenes. The normal products of tumour suppresser genes block abnormal growth and malignant transformation. These genes only contribute to malignancy when the function of both alleles is lost — mutations in these genes are recessive.

Environmental factors that influence chemical reactions that lead to stable long term alterations in DNA and gene expression. The impact of these changes on the activation/deactivation of genes.

Outcome 3 — Explain and apply patterns of inheritance and population genetics

Solve various genetic problems to include autosomal recessive, autosomal dominant, sex/X linked, monohybrid and dihybrid crosses, incomplete and co-dominance, lethal alleles and polygenic inheritance.

Genes on the same chromosome are linked. Genes on a single chromosome form a linkage group. Genes belonging to the same linkage group usually do not show independent assortment. Linked genes not displaying 9:3:3:1. Two or more genes linked when phenotypes with new gene combinations (recombinants) occur less frequently than the parental phenotypes. The role of crossing over in linkage. Recombination frequency calculations and crossover values to construct gene maps.

Hardy-Weinberg calculations to calculate frequency of alleles within a population. Selection as the process by which fitter organisms survive and reproduce. Selection pressure is a result of population size combined with environmental limiting factors.

Gene flow as the movement of individuals between different population groups, with interbreeding between the migrants and their new group. Genetic drift as chance events occur to greater extents in smaller populations and may influence the evolution of the population. Founder effect as a small gene pool resulting from a population bottleneck.

Stabilising selection operates when phenotypic features coincide with optimal environmental conditions and competition is not severe. Directional selection operates in response to gradual changes in environmental conditions. Disruptive selection when fluctuating conditions within an environment may favour the presence of more than one phenotype within a population.

Outcome 4 — Describe and explain applications of DNA technology

Restriction enzymes as endonucleases cut DNA at points called restriction sites unique to each enzyme. Recurring feature of recognition sequences is that they are palindromic. Specific examples of enzymes, frequency of restriction sites, blunt ends and sticky ends. Significance of production of sticky ends.

Separation of DNA fragments using DNA gel electrophoresis. Techniques for visualisation of DNA fragments in gel. Calculation of fragment size. Advantages and disadvantages of acrylamide in comparison to agarose.

Basic PCR technique, before covering RT-PCR and q-PCR. Reverse transcriptase PCR creates cDNA (complementary DNA) by reverse transcribing RNA to DNA using reverse transcriptase. In qPCR (quantitative PCR or real time PCR) the DNA or RNA molecules are tagged using fluorescent probes, so that the concentration of amplified products can be monitored and quantified in real-time by tracking the level of fluorescence. Applications of PCR should be discussed to include paternity testing, crime scene analysis, disease diagnosis and comparison of evolutionary similarities and differences between species.

Guidance on approaches to delivery of this Unit

There is no particular order in which Outcomes 1−4 would be best delivered.

It is envisaged that the delivery of Outcome 1 could commence with a recap on DNA structure and replication. Simple DNA extraction could be performed as an introduction to the Unit. The stages of the cell cycle should then be covered. In the teaching of the cell cycle, the importance of the varying levels of CdKs at various points should be emphasised. The significance of the different checkpoints, and their role in the cell cycle should also be covered. There are many resources online, including games and animations which would support the delivery of this Outcome.

In the delivery of meiosis and mitosis learners would be expected to name and understand events in the stages of both types of cell division. Comparisons and similarities between the two types of cell division should be made, as well as highlighting the differences. This topic presents a good opportunity for the learners to research and present this information to the rest of the class. Meiosis as a source of variation should also be covered, to specifically look at behaviour of chromosomes during meiosis in independent assortment, and the events involved in crossing over.

It is recommended that the delivery of Outcome 2 could commence with a revision on protein synthesis. Primary transcript mRNA splicing and the splicing process and modifications which also take place at each end of the mRNA to assist the ribosome in attaching to and detaching from the molecule should be covered. The addition of a 5’ cap and a poly A tail at the 3’ end also take place in the nucleus to produce the mature mRNA that will exit the nucleus and be used in translation in the cytoplasm. The role of snRNA to mediate the processing of primary transcript mRNA should also be covered. Bacterial cells do not contain introns and exons, but have sets of related genes called operons. Practical work to support this concept would be beneficial, for example the transformation of E. coli using pGLO plasmid to introduce fluorescence genes. The Ara operon is important in this practical.

The control of gene expression should be covered by discussing the role of promoters in increasing efficiency of RNA polymerase binding. Transcription factors binding DNA in promoter sequence to increase or decrease the likelihood of a gene expressing and transcription factors binding to enhancers. Transcription stops at a specific transcription termination sequence on the DNA at the 5’ end of the gene.

Environmental factors such as diet, gestational diabetes and smoking can influence the addition of chemical tags to DNA. These epigenetic tags can influence gene expression. There are various web activities which support the teaching of these concepts.

Higher National Unit Support Notes (cont)

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Outcome 3 will have a large problem solving component. Learners will be expected to successfully solve various genetic problems to include autosomal recessive, autosomal dominant, sex/X linked, monohybrid and dihybrid crosses, incomplete and co-dominance, lethal alleles and polygenic inheritance.

Linked gene examples should be covered, and learners should be able to construct a gene map by using recombination frequency calculations and crossover values. Hardy-Weinberg calculations should be used to calculate the frequency of alleles within a population. The significance of selection as the process by which fitter organisms survive and reproduce should be discussed, and selection pressure is a result of population size combined with environmental limiting factors.

In Outcome 4, specific features of restriction enzymes such as unique cutting sites for each enzyme, and the significance of blunt and sticky ends should be covered. The basic PCR process should be covered, before moving on to RT-PCR and qPCR. The differences and similarities of each process should be covered, and the applications of PCR. Whilst Outcome 4 does not have an assessed practical experiment, learners would benefit from practical experiments to reinforce theoretical concepts. Learners could carry out a PCR, but it is unlikely delivering centres would have resources to carry out RT-PCR and qPCR. However, delivering centres could access online laboratory simulations of PCR.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Outcomes 1−4 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Assessments should be carried out in supervised conditions, and it is recommended that the assessment be completed within 90 minutes.

Where evidence of Outcomes 1−4 is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment must be included in the alternative (re-sit) assessment.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 7.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Higher National Unit Support Notes (cont)

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Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The delivery and assessment of this Unit will provide learners with the opportunity to develop the Core Skills of *Numeracy* at SCQF level 5 and *Information and Communication Technology (ICT)* at SCQF level 4.

Numeracy — Using Number at SCQF level 5

Learners will be required to successfully complete genetic calculations when doing mono and dihybrid calculations, as well as Hardy-Weinberg equations.

Information and Communication Technology (ICT) — Providing/Creating Information at SCQF level 4

Leaners may be required to use internet search engines to source information on research topics.

Sustainability

Sustainability can be embedded in delivery of the Unit in a variety of ways. For example, by encouraging minimum usage, correct disposal procedures and possibly recycling during any practical experiments which may be carried out.

Citizenship

Citizenship will be encouraged by developing learners who are scientifically literate on topics such as DNA technologies and their uses.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: DNA and Genetics (SCQF level 7)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This is a 1 credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of an HNC/HND science programme. Before progressing to this Unit it would be beneficial to have completed the HN Unit H927 34 *Cell Biology: Theory and Laboratory Skills* or have experience of Biology or Human Biology at Higher level.

On completion of the Unit you should be able to:

1 Describe the stages of the cell cycle.
2 Describe how genes are expressed.
3 Explain and apply patterns of inheritance and population genetics.
4 Describe and explain applications of DNA technology.

Outcome 1

In this Outcome you will cover the cell cycle. The cell cycle is a carefully synchronised sequence of events, leading to cell division. You will look at the stages of the cell cycle, and how these events are controlled. The events involved in meiosis and mitosis will also be covered, and the differences and similarities between the two events will be discussed. You will also learn how the events in meiosis give rise to genetic variation.

Outcome 2

In this Outcome you will gain an understanding of gene expression. You will learn how the information contained in eukaryotic DNA is processed and translated into information the cell can use to make protein. You will also consider the organisation of genes in prokaryotes. The factors which control transcription of genes will be discussed, along with the impact of the environment on gene expression.

Outcome 3

In this Outcome you will learn about patterns of inheritance, which will consist of solving various genetic problems. You will cover Mendelian and Non-Mendelian patterns of inheritance. Gene mapping calculations will also be performed. You will learn about population genetics and you will solve problems relating to frequency of genes in population. You will also investigate what can affect the frequency of an allele within a population.

Outcome 4

In this Outcome you will learn about DNA technology. You will learn about the different kinds of restriction enzymes which exist, and how they can be used. You will also cover different methods of PCR and gel electrophoresis.

Assessment

For Outcomes 1 to 4 you will take a closed-book, end of Unit assessment.

General information for learners

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Core Skills

Although there is no automatic certification of Core Skills in the Unit, you will have opportunities to develop the Core Skills of *Numeracy* at SCQF level 5, and *Information and Communication Technology (ICT)* at SCQF level 4.