Higher National Unit specification

General information

Unit title: Biotechnology: An Introduction (SCQF level 7)

Unit code: H926 34

Superclass: RH

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand key aspects of biotechnology, including how genetically modified organisms are produced, the growth vessels used for large scale synthesis of biotechnology products, and the traditional and novel applications of biotechnology. Learners will also develop awareness of ethical issues relevant to biotechnology. The Unit is suitable for learners studying at HNC level, and will provide the necessary underpinning knowledge to enable progression to further study of biotechnology 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 aspects of protein processing in prokaryotes and eukaryotes.
2 Describe the procedures used in the production of genetically modified organisms.
3 Describe the production techniques used in making a biotechnology product.
4 Describe novel and traditional applications of biotechnology.
5 Discuss bioethics regarding biotechnology.

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 experience of Biology at National 5 or Higher level or equivalent.

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 aspects of protein processing in prokaryotes and eukaryotes.

Knowledge and/or Skills

- Gene structure in prokaryotes: single circular chromosome; plasmids
- Gene structure in eukaryotes: nucleus; chromosome
- Transcription and translation of prokaryotic proteins: mRNA; translation by ribosomes
- Transcription and translation of eukaryotic proteins: premRNA; mature mRNA; translation by ribosomes
- Post-translational modification of proteins

Outcome 2

Describe the procedures used in the production of genetically modified organisms.

Knowledge and/or Skills

- Genetically modified single celled organisms: vectors; enzymes to include restriction enzymes, ligase and polymerase
- Genetically modified animals: embryo manipulation; recombinant DNA, transfection and transformation techniques
- Genetically modified plants: Ti plasmid; *Agrobacterium tumifaciens*

Outcome 3

Describe the production techniques used in making a biotechnology product.

Knowledge and/or Skills

- Batch fermentation
- Continuous flow fermentation
- Transgenic animals as growth vessels
- Downstream processing

Higher National Unit specification: Statement of standards (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Outcome 4

Describe novel and traditional applications of biotechnology.

Knowledge and/or Skills

- End products and uses of novel biotechnology applications
- End products and uses of traditional biotechnology applications

Outcome 5

Discuss bioethics regarding biotechnology.

Knowledge and/or Skills

- Ethical considerations
- Consumer concerns
- Consumer acceptance

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 one hour.

Performance evidence for Outcome 5 should be assessed by production of an assessor's observation checklist and/or a video recording.

Outcome 1

The assessment will sample three of the five 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 gene structure of prokaryotes.
- Describe the gene structure of eukaryotes.
- Describe transcription and translation in prokaryotes.
- Describe transcription and translation in eukaryotes.
- Describe post-translational modification of proteins.

Higher National Unit specification: Statement of standards (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Outcome 2

The assessment will sample two of the three 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 procedures used in the production of genetically modified single celled organisms.
- Describe the procedures used in the production of genetically modified animals.
- Describe the procedures used in the production of genetically modified plants.

Outcome 3

The assessment will sample three of the four 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 general features of a batch fermentation process.
- Describe the general features of a continuous flow fermentation process.
- Describe the use of transgenic animals as growth vessels.
- Describe downstream processes used following the production stage to isolate and purify the product.

Outcome 4

The assessment will sample one of the two 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 alternate (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 a novel biotechnology application in terms of: the organism used, the process used to generate the end product and the use of the end product.
- Describe a traditional biotechnology application in terms of: the organism used, the process used to generate the end product and the use of the end product.

Higher National Unit specification: Statement of standards (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Outcome 5

The assessment will cover all of the Knowledge and/or Skills items. A learner's response will be judged satisfactory where the evidence shows that the learner can:

- Discuss ethical considerations regarding a subject in relation to an area of biotechnology.
- Discuss consumer concerns regarding a subject in relation to an area of biotechnology.
- Discuss consumer acceptance regarding a subject in relation to an area of biotechnology.

Learners will take part in either a group discussion or deliver a presentation to an audience on a bioethical topic in relation to an area of biotechnology.

Group discussion

Learners will decide, in consultation with their lecturer, the topic to be discussed. The discussion must include all three of the Knowledge and/or Skills items listed above and could either be conducted as a class group, or the class could be divided into smaller groups. The group discussion should last approximately 60 minutes.

The assessor should ensure that all learners are actively involved in the group discussion and are able to adequately demonstrate all of the Knowledge and/or Skills items listed above. An assessor observation checklist and/or video recording should be retained as evidence of performance for each learner.

Presentation

Learners will decide, in consultation with their lecturer, the topic to be presented. The presentation must include all three of the Knowledge and/or Skills items listed above, and should last a minimum of 5 minutes.

An assessor observation checklist and/or video recording should be retained as evidence of performance for each learner.

Where a learner does not perform an assessed topic to the required standard, they will be given the chance to either reattempt the same topic, or to undertake a different topic of similar complexity. If the required standard is still not attained, then an alternative topic will be set.

Higher National Unit Support Notes

Unit title: Biotechnology: An Introduction (SCQF level 7)

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, HND Applied Biological Sciences and HND Applied Chemical Sciences but may be suitable for inclusion in other HN Science awards. It is designed to develop the theoretical aspects of cell biology introduced in the HN Unit H927 34 *Cell Biology: Theory and Laboratory Skills*, and also to introduce learners to ethical issues regarding biotechnology.

Outcome 1 — Describe aspects of protein processing in prokaryotes and eukaryotes

- Prokaryotic gene structure to include — the possession of a single circular chromosome with genes clustered together as operons, as exemplified by the structure and control of the lac operon. Prokaryotes possess plasmids which are self-replicating circles of DNA that carry genes which may be advantageous to survival but not essential.
- Eukaryotic gene structure to include — packaging of DNA into chromosomes within a nucleus. Eukaryotic genes possess introns, exons, promoter sequences, start and stop codons.
- Transcription and translation in prokaryotes in terms of: RNA polymerase binding to a promoter, producing a mRNA transcript until the terminator sequence is reached, then its translation by ribosomes directly in the cytoplasm.
- Transcription and translation in eukaryotes in terms of: RNA polymerase binding to a promoter, producing a pre-mRNA transcript until the terminator sequence is reached, processing of the pre-mRNA by alternative splicing to produce mature mRNA which leaves the nucleus to be translated by ribosomes in the cytoplasm.

Only eukaryotic cells perform post-translational modifications of proteins once they are synthesised. These modifications could include protein cleavage and the addition of chemical groups such as phosphates and carbohydrates.

Higher National Unit Support Notes (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Outcome 2 — Describe the procedures used in the production of genetically modified organisms

The production of genetically modified single celled organisms as exemplified by bacteria and *Saccharomyces cerivisiae*. The features of bacterial and yeast plasmids with multiple cloning sites, inducible promoters, selectable marker genes (eg antibiotic resistance or GFP) and ori sites, which make them useful vectors for recombinant DNA techniques. The role of restriction and ligase enzymes to insert DNA into the vector. Bacterial transformation techniques (such as calcium chloride) and yeast transfection techniques (such as precipitation or electroporation).

Transfection is the term used to produce genetically modified animal cells and it refers to non-viral methods such as the use of liposomes, calcium phosphate precipitation, DEAE dextran or electroporation. Viral methods can also be used to create genetically modified animal cells.

In each case, exemplification will help to contextualise the science discussed. These examples could include:

- genetically modified yeast used in winemaking allowing a wider range of fermentation techniques to be employed.
- genetically modified bacteria used to produce medicines, food additives and biofuels.

Genetically modified animals used in medical research of the basis of certain diseases (eg oncomouse used to study cancer), in the production of medicines such as antithrombin in goat milk as well as those genetically modified animals which allow higher meat or milk yield in agriculture.

Genetically modified plants that are frost, disease or herbicide resistant or those genetically modified to increase yield in agriculture.

Through the discussion of these examples, the relative advantages and disadvantages of genetically modified animals and plants will naturally evolve.

The production of genetically modified animals by the most common approach of microinjection (viral infection can be used) of DNA into fertilised eggs. The product can then be secreted into the milk produced by the animal, or in the case of chickens in the egg white.

Plants do not possess natural plasmids, but the Ti plasmid from *Agrobacterium tumifaciens* (a species of bacteria which naturally infects plants) can be modified by recombinant DNA techniques to be used as a vector. Protoplasts and bacteria can be cultivated together to produce transgenic plant cells which can be propagated in plant tissue culture.

Higher National Unit Support Notes (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Outcome 3 — Describe the production techniques used in making a biotechnology product

Batch fermentation techniques to include — closed system, allows all phases of growth to occur, physical factors controlled during the process (temperature, pressure and pH), chemical factors controlled during the process (oxygen distribution or exclusion and nutrients) and the importance of maintenance of sterility. In addition, the advantages of batch fermentation.

Continuous flow fermentation to include — growth substrates supplied and product removed throughout. Physical factors controlled during the process (temperature, pressure and pH), chemical factors controlled during the process (nutrients and oxygen distribution or exclusion) and the importance of maintenance of sterility. In addition, the advantages of continuous flow fermentation.

The use of transgenic animals to include — the cost effectiveness of the process as there is no large scale investment for industrial production vessels or maintenance of equipment and the use of a eukaryotic organism carrying out the protein processing. Product can be isolated from milk (goats, sheep) or egg white (chickens).

Downstream processing to include — the extraction of cells (flocculation, filtration, centrifugation), extraction of solvent or solute depending on the product (distillation, ultrafiltration, precipitation, drying and protein purification). If the product is intracellular an additional step of cell lysis is necessary.

Outcome 4 — Describe novel and traditional applications of biotechnology

Novel applications could include genetically modified plant, bacterial and animal cells that produce, for example: a human therapeutic or resistant plants for food security, genetically modified animals for animal pharming, production of alternative fuels and stem cells for blood production.

Traditional applications could include brewing, antibiotics and food products such as soy sauce and vinegar.

In each case, the organism used, the process used to generate the end product and its use must be taught for the chosen examples.

Outcome 5 — Discuss bioethics regarding biotechnology

Ethical considerations could include those relating to the production of transgenic animals and plants by manipulation of DNA, cloning techniques using embryo manipulation and stem cell production, plus their therapeutic use.

Consumer concerns could include the safety of the product to humans and the environment, the control of pollen from transgenic plants, animal welfare and effects of transgenic plants and animals on biodiversity.

Consumer acceptance could relate to issues concerning food security and animal (including human) health.

Higher National Unit Support Notes (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Guidance on approaches to delivery of this Unit

Outcomes 1–5 would best be delivered in order. Whilst there are no prescribed practical experiments for this Unit, suggestions have been included in order to highlight opportunities to develop practical skills.

Outcome 1

Throughout Outcome 1 it is important to emphasise the differences in protein production in prokaryotes and eukaryotes to enable understanding of organism choice for a biotechnology process. These differences should begin with the discussion of gene structure, in that eukaryotic genes posses coding and non-coding sequences, which in turn influence the way in which mRNA molecules are processed in each cell type, for example splicing of introns and the joining of exons in eukaryotes. This leads naturally to the discussion of 'one gene many proteins', where exon shuffling in eukaryotes can bring about the production of protein variants.

In discussing protein production in prokaryotes, the presence of gene clusters (operons) should be mentioned. These cell types only produce the proteins necessary for metabolism depending on the environmental conditions, for example diauxic growth of *E.coli*. In eukaryotes, post-translational modification is necessary for the production of functional proteins in many cases. Prokaryotes do not carry out this process, which may have an impact on which cell type is chosen to make the recombinant protein. This area allows the teaching of this topic through the use of case studies and problem solving activities.

There are opportunities to develop practical skills by looking at galactosidase induction in *E.coli*. Online animations are particularly useful to illustrate processes such as transcription and translation.

Outcome 2

The emphasis in Outcome 2 is that the chemical nature of DNA is universal so it can be transferred between species. It is recommended that the transformation process to produce genetically modified bacteria is taught first. Practical experiments could include using the BioRad pGlo kit to produce genetically modified bacteria, which could be used to illustrate the use of plasmids as vectors and the selection of genetically modified organisms. Practical experiments such as restriction digests and gel electrophoresis could also be carried out.

This would allow progression to the discussion of the different techniques employed to produce genetically modified yeast, animals and plants. Other practical experiments could include the preparation of plant protoplasts and plant tissue culture.

This Outcome reinforces why the choice of organism to make the product is important.

Higher National Unit Support Notes (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Outcome 3

In this Outcome the three main types of growth vessels are taught, and it is important that these are dealt with holistically, by emphasising the advantages and disadvantages of each growth vessel. Maintenance of sterility is essential to prevent contaminants overtaking the culture when dealing with cell growth in fermenters. The choice of growth vessel is determined by the necessary properties of the end product. For example, animal cells or whole organisms may be beneficial in producing a human protein where post-translational modification is important for protein function. Another example would be that batch cultures are necessary for products like penicillin because it is only produced at a particular stage of growth. Opportunities for practical experiments could include production of ethanol by immobilised yeast or the production of sauerkraut.

Outcome 4

Outcome 4 could be introduced as a discussion of examples of traditional and novel biotechnology processes — examples of which are given elsewhere in this document.

It is highly recommended, but not mandatory, that learners visit a local company which uses a biotechnology process in order to investigate and collect information. As an alternative, online research could be applicable. Following either a visit or the use of IT for research purposes groups of learners could work together to investigate a process of interest to them to produce a report (eg poster, PowerPoint, structured report) and disseminate it to the rest of the group. This would develop their skills of team working, researching and presenting relevant information. Centres are free to select processes relevant to their learners in order to allow flexibility and for specific local examples to be taught.

Outcome 5

This Outcome consolidates the Knowledge and/or Skills covered in Outcomes 1–4, where the underlying science is discussed.

Learners, in discussion with their lecturer, should select their topic to be discussed/presented and they should be given time to prepare and research the information prior to the assessment event.

If the group discussion approach is taken, it is recommended that the class is divided into smaller discussion groups, and the groups may discuss the same topic or different topics.

Suggested topics to be discussed/presented are given elsewhere in this document, however, it is envisaged that the lecturer will facilitate the discussion, which will be learner led.

Higher National Unit Support Notes (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

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. Assessment should be carried out in supervised conditions, and it is recommended to last for 60 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.

In Outcome 5 learners are required to take part in either a group discussion or deliver a presentation on a bioethical topic in relation to an area of biotechnology. Learners will discuss ethical considerations, consumer concerns and consumer acceptance.

If the group discussion approach is taken, assessed activities will usually be performed in small groups. The assessor should ensure that all learners are actively involved in the group discussion and are able to adequately demonstrate all of the Knowledge and/or Skills items.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achieve 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.

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**.

Higher National Unit Support Notes (cont)

Unit title: Biotechnology: An Introduction (SCQF level 7)

Guidance on approaches to assessment of this Unit

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 *Problem Solving* at SCQF level 6 and *Information and Communication Technology (ICT)* at SCQF level 4.

Problem Solving — Reviewing and Evaluating at SCQF level 6

Although this Unit does not contain any prescribed practical experiments, there are opportunities for experiments to be carried out. Therefore, skills of reviewing and evaluating procedures, identifying sources of error and reaching conclusions based on the collected data can be developed.

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

Learners could use ICT to research information for Outcomes 4 and 5. In addition, depending on the resources learners use to disseminate information, skills in using PowerPoint or word processing packages could be utilised.

Team Working and Citizenship

Team working and citizenship can be developed through the bioethical discussion in Outcome 5.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Biotechnology: An Introduction (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 experience of Biology at National 5 or Higher level or equivalent. There will be emphasis on the areas important to the biotechnology industry which ranges from food and drink production to the growth of stem cells used to make artificial blood.

On completion of the Unit you should be able to:

1 Describe aspects of protein processing in prokaryotes and eukaryotes.
2 Describe the procedures used in the production of genetically modified organisms.
3 Describe the production techniques used in making a biotechnology product.
4 Describe novel and traditional applications of biotechnology.
5 Discuss bioethics regarding biotechnology.

Outcome 1

In this Outcome you will study the underlying biology regarding the structure of genes in prokaryotes (bacteria) and eukaryotes (animals, yeast and plants) and the way in which proteins are made in each cell type. This Outcome sets the scene for your understanding as to why the cell type you choose to make your product is important.

Outcome 2

In this Outcome you will cover the techniques used to make a genetically modified organism. You will learn about the different techniques that are used to make genetically modified bacteria, animals, yeast and plants.

Outcome 3

This Outcome follows on from the construction of the genetically modified organism itself to the isolation and perhaps mass production of the end product. In this Outcome you will learn about fermenters, the use of animals as growth vessels and the processes involved in the product purification before it goes to market.

Outcome 4

In this Outcome you will learn about novel and traditional applications of biology. You will cover brewing and baking (traditional), and stem cell technology and the use of organisms such as bacteria and plants to produce drugs to treat human diseases (novel).

Outcome 5

In this Outcome you will take part in either a group discussion or deliver a presentation on ethical considerations, consumer concerns and consumer acceptance regarding an area of biotechnology. The topic will be chosen by you, in agreement with your lecturer, and it gives you the opportunity to learn more about the area of bioethics.

General information for learners

Unit title: Biotechnology: An Introduction (SCQF level 7)

Assessment

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

In Outcome 5, the assessment involves you taking part in either a group discussion or delivering a presentation on a bioethical topic in relation to an area of biotechnology.

Core Skills

Although there is no automatic certification of Core Skills in the Unit, you will have opportunities to develop the Core Skills of *Problem Solving* at SCQF level 6 and *Information and Communication Technology (ICT)* at SCQF level 4.