Higher National Unit specification

General information

Unit title: Cell Biology: Theory and Laboratory Skills (SCQF level 7)

Unit code: H927 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 cell biology. Learners will also develop practical skills in techniques relevant to cell biology. 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 biology 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 and explain the structure and function of the cell membrane.
2 Describe and explain the fates of cell proteins.
3 Describe and explain cellular communication.
4 Perform practical experiments related to cell biology.

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 H923 33 *Biology: An Introduction* or equivalent, or have experience of 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 and explain the structure and function of the cell membrane.

Knowledge and/or Skills

- Chemical structure and function of membrane lipids: phospholipids, sphingolipids, cholesterol
- Fluid nature of the cell membrane with relation to the lipid content
- Nature of common membrane proteins

Outcome 2

Describe and explain the fates of cell proteins.

Knowledge and/or Skills

- Cell cytoskeleton and movement
- Synthesis of proteins through the secretory pathway and in the cytoplasm
- Protein degradation: ubiquitination, autophagic pathway, lysosomal

Outcome 3

Describe and explain cellular communication

Knowledge and/or Skills

- Communication between neighbouring cells and the structures involved
- Chemical and electrical communication between cells that are distally located
- Disease states associated with errors in communication

Higher National Unit specification: Statement of standards (cont)

Unit title: Cell Biology: Theory and Laboratory Skills (SCQF level 7)

Outcome 4

Perform practical experiments related to cell biology.

Knowledge and/or Skills

- Cell biology experiments
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results
- Evaluation skills
- Result analysis and conclusions

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1−3 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.

Written and/or oral recorded evidence for Outcome 4 should be assessed by production of a full laboratory report, or by completion of an appropriate pro forma. An assessor's observation checklist could be used to record performance evidence of practical experiments.

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 chemical structure and function of two of the membrane lipids: phospholipids, sphingolipids, cholesterol.
- Explain the fluid nature of the cell membrane with relation to the lipid content.
- Describe the nature of common membrane proteins.

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 structure and function of two of the cytoskeleton molecules to include: the role of actin filaments in non-muscle cells, intermediate filaments, microtubules.
- Explain the synthesis of proteins on either free ribosomes or those attached to the endoplasmic reticulum.
- Describe one form of protein degradation: ubiquitination, autophagic pathway, lysosomal.

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:

- Describe cell to cell communication structures and their function in neighbouring cells.
- Describe communication between distally located cells: chemical and electrical.
- Explain the pathogenesis of diseases associated with signalling errors.

Outcome 4

Learners will perform a minimum of two practical experiments, the content of which will be related to Outcomes 1−3. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- Follow instructions to perform experiments related to cell biology.
- Work in a safe manner regarding current health and safety regulations.
- Achieve consistent and accurate results.
- Record experimental observations and results clearly and accurately.
- Evaluate validity of results in terms of sources of and values of experimental errors.
- Analyse results correctly and state valid conclusions.

An assessor observation checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

Learners may report results either by production of a full laboratory report, or by completion of an appropriate pro forma. Where a pro forma approach is deployed, the pro forma will not present information or assistance to the learners on how to correctly perform calculations, analyse experimental results or experimental errors. Learners will be expected to perform such activities independently on the basis of the experimental data.

Higher National Unit specification: Statement of standards (cont)

Unit title: Cell Biology: Theory and Laboratory Skills (SCQF level 7)

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake a different practical experiment of similar complexity. Where a laboratory report or pro forma does not meet required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

Higher National Unit Support Notes

Unit title: Cell Biology: Theory and Laboratory Skills (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 and practical aspects of cell biology.

Outcome 1 — Describe and explain the structure and function of the cell membrane

The cell membrane separates the cell from the external environment as well as forming the membranes of subcellular organelles, although the chemical composition in each case can vary. Fluid mosaic model including hydrophobic and hydrophilic regions. The main lipid molecules of the membrane are phospholipids (define as amphipathic lipid molecule with a fatty acyl hydrocarbon tail and a phosphate — based polar head), sphingolipids and cholesterol. The main class of phospholipids are phosphoglycerides. Lipids are laterally mobile in the membrane. These lipids make up the bilayer of the membrane. The cell membrane acts as a permeability barrier and serves as the attachment site for signalling molecules as well as internal structures, such as the cytoskeleton. In prokaryotes the cell membrane is crucial in cellular processes such as ATP production and DNA replication.

The lipid bilayer is a fluid structure (fluid mosaic model). Membrane fluidity can be affected by altering the lipid content. Cholesterol decreases fluidity. Many internal membranes have a different composition to the cell membrane. Polyunsaturated/saturated lipids of varying molecule length can alter membrane fluidity. Convey fluid nature of the membrane. The composition of the outer layer of the membrane is different than the inside.

Proteins in the membrane can be integral (span membrane) or peripheral (do not span the membrane). Membrane spanning proteins usually have one or more membrane spanning α helices and hydrophilic regions that reach into the external and intracellular environment. Functions often include transport across the membrane, cell recognition, signal transduction (receptors) etc.

Outcome 2 — Describe and explain the fates of cell proteins

An introduction may be required to revise basic cell biology (including organelles, size and distinction between cell types).

The role of the cytoskeleton in the cell to include cell shape, cell function and transport of organelles, and other cellular components.

Actin filaments have a role in cell crawling in amoeba and animal cells. Actin filaments support cell structures, such as microvilli. Actin filaments influence the mobility of cell membrane proteins, ie 'walking' structures along filaments to their destination — Tread milling.

Microtubules constructed of tubulin are polar structures that grow rapidly at the plus end. Flagella and Cilia of eukaryotes are composed of microtubules. Microtubules are used to transport organelles around the cell.

Expression of intermediate filaments in a tissue specific manner with examples. Keratin filaments are differentially expressed in the epidermis. Differentiated cells at the outer layer of the skin express different keratin molecules than cells in the lower layers.

Proteins synthesised by free ribosomes remain within the cytoplasm, others are embedded in membranes or secreted. Proteins are sorted in two main ways; signal based targeting and vesicle based trafficking. Some proteins that are destined for secretion from the cell or to be embedded in a membrane are often translated in ribosomes associated with the endoplasmic reticulum. These proteins contain a signal peptide that dictates their fate. Often these proteins are inserted in the ER membrane during translation and have distinct hydrophobic and hydrophilic regions. The signal peptide is often removed in the ER and there are specific molecules that insert membrane spanning sections in to the ER membrane (translocons and signal peptidase). Cytoplasmic proteins are often sorted by signalling sequences that determine their final destination including the nucleus and mitochondria.

Proteins are removed from the cell in various ways. The most common include ubiquitination, autophagosomes and lysosome degradation.

Outcome 3 — Describe and explain cellular communication

Cells can communicate with neighbouring cells by direct contact. The structures that facilitate these communication pathways include gap junctions (composed of a tubular structure of six connexins on each cell joining to directly link the cytoplasm), tight junctions, plasmodesmata and desmosomes. Local signalling can also be distributed between neighbouring cells through second messengers (including cAMP and Ca^{2+}) and cytokines. This Outcome should also convey the idea of summation of these structures in the junctional nexus.

Signals can be passed to distally located cells through electrical impulses carried by neurones (general information on nerve structure and function and communication) or chemically by hormone receptor interactions. Examples for hormone signalling could include anti-diuretic hormone (ADH), insulin and growth hormone. For electrical signalling specific neurotransmitters could be discussed; examples may be noradrenaline or acetylcholine.

Many disease conditions arise due to problems in signalling. Three different disease types must be covered and their pathogenesis explained. Centres may choose the diseases at their discretion. The following is an example; Diabetes mellitus — insulin, a signalling hormone involved in the regulation of blood sugar level is produced by β cells in the Islets of Langerhans of the pancreas. It binds to insulin receptors (integral membrane proteins) of various cell types including hepatocytes, muscle cells and specialised brain cells causing them to store excess glucose maintaining blood glucose levels at 5mM. Type 1 diabetes is caused by destruction of the Islets of Langerhans, therefore there is reduced/loss of insulin secretion resulting in loss of control of blood glucose rising to type 1 diabetes mellitus. Other examples could include type 2 diabetes, cancers, Parkinson's disease, multiple sclerosis and deafness associated with connexon mutations.

Outcome 4 — Perform practical experiments related to cell biology

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1−3.

In carrying out such activities, learners should follow Good Laboratory Practice (GLP) and carry out or be familiar with the risk and Control of Substances Hazardous to Health (COSHH) assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

There is no particular order in which Outcomes 1−3 would be best delivered. It is envisaged that laboratory work and demonstrations will feature across each of the Outcomes.

It is envisaged that delivery of this Unit would commence with a brief revision of the basics of cell biology, including the organelles, their function, cell size and cell type. A practical experiment may be integrated at this point to aid learning and to introduce basic microscopy techniques.

Outcome 1 is intended to cover the molecular structure of the cell membrane. It is suggested that this section begins with a brief description of the cell membrane and its role in separating the cytoplasm from the external environment and as a permeability barrier. This could then be followed by a section describing the chemical structure of the main membrane lipids. These should include phospholipids, sphingolipids and cholesterol. Practical work in this section could be used to illustrate the functions of the membrane as a permeable barrier.

The next section can be delivered as a continuation of the lipid structure and begins to establish that the cell membrane is a bi-layer and that these lipid molecules are laterally mobile in the membrane and that the membrane is asymmetric. This could then lead on to a description of the role of polyunsaturated/saturated lipids with varying lengths in altering membrane fluidity.

Higher National Unit Support Notes(cont)

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The final stage of Outcome 1 should give a general description of common membrane proteins. This should cover integral and peripheral proteins and an explanation that the distribution of these proteins is asymmetric across the bi layer. A general overview of the main types should be given, and may include transport proteins, receptor and cell signalling molecules. This Outcome could finish off with a full description of the fluid mosaic model as a summary of the three sections. Learners could be asked to spend some time drawing a detailed diagram of the fluid mosaic model with high levels of detail and labelling.

The delivery of Outcome 2 could begin with a general introduction to the cell cytoskeleton and its basic functions including cell shape, strength and transport of proteins and organelles. This Outcome should then cover the three main types of protein structures that make up the cytoskeleton, including their size and grouping into microfilaments, microtubules and intermediate filaments. Beginning with the actin filaments in non-muscle cells, areas that could be covered include the structure and role of actin filaments in cell crawling (in animal cells and amoeba) and their role as support for cell structures such as microvilli. This could then lead on to the role actin microfilaments play in transporting proteins in the cell and the process of tread milling in actin assembly.

Microtubules could then be discussed. These should be described as polar molecules and should include that there is rapid growth at the plus end. A description should be given of what these microtubules are composed of and how they can transport vesicles and other structures throughout the cell and their size.

Intermediate filaments should be explained including common types and their size. The crucial point of this section is the differential expression of intermediate filaments in different cell types and their specific function.

The processing of proteins destined to be inserted in to the membrane or to be excreted from the cell, the secretory pathway, could then be covered. The role of membrane bound ribosomes and protein synthesis should be described. These proteins are often inserted into the membrane during translation. The role of the signal peptide should be discussed as well as the post translational removal of this signal peptide in many proteins. Specific examples could be used to deliver the main concepts. Reference should be made to translocons and signal peptidase enzymes. For each section learners may want to investigate specific examples and follow the pathway of specific proteins.

The majority of proteins in the cell are synthesised in ribosomes that are not associated with a membrane. These proteins often remain in the cytoplasm but others contain signal peptides that determine their fate within the cell. These proteins can be targeted to specific organelles. Specific examples could be used to convey the main concepts such as ovalbumin and prolactin.

When no longer needed, these proteins must be degraded. There are various methods for this, including; ubiquitination, the autophagosome pathway and lysosome degradation.

Higher National Unit Support Notes(cont)

Unit title: Cell Biology: Theory and Laboratory Skills (SCQF level 7)

Outcome 3 provides an opportunity for learner research or as lecturer led lessons. The structures described in cell to cell communication are widely documented and there are many examples of each. Work could include group work tasked with providing details on the structure and function of specific communication molecules, which cell types they are associated with and what effect they have on cell communication. There are many diseases associated with structures involved in cell to cell communication, examples may be included at this point as a link to the section covering communication disease types. All the learner work could then be brought together and the idea that these communication structures work together to regulate cell function.

Communication over distance should focus on general principles of nerve cell communication. Cell structure, sensory/motor neurones, neurotransmitters and regulation should be covered. For hormone signalling, specific examples could be used to describe receptor mediated signalling with reference to its specificity.

The final section is a description of disease states associated with communication errors. The disease states taught are at the discretion of the centre. Common disease types could include diabetes (relationship between ligand and receptor and the differences between type 1 and type 2 diabetes mellitus), pituitary dwarfism (lack of human growth hormone can lead to this disease) and Parkinson's disease (progressive disease state due to lack of a specific neurotransmitter).

It is envisaged that Outcome 4 will be delivered alongside the theoretical based Outcomes 1−3. A range of practical experiments could be utilised to both support understanding of the underlying theory and to prepare learners for undertaking the assessed practical experiments.

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 1−3 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 that the assessment be completed within 60 minutes.

Where evidence of Outcomes 1−3 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 4 learners are required to undertake two assessed practical experiments, the content of which will be related to Outcomes 1−3. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments for Outcome 4 are:

- Haematoxylin and Eosin staining of tissue sections.
- Comparing structure and size of plant, animal and bacterial cells.
- Identification of secretory pathway organelles on electron micrographs.
- Gram-stain of bacteria samples.

Assessed practical experiments will usually be performed individually. However, there may be some experiments that are suitable to be undertaken in pairs or small groups. If this is the case then the assessor should ensure that all participants are actively involved and are able to adequately demonstrate the required skills.

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.

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

Numeracy — Using Number at SCQF level 6

Learners will be required to decide on the steps and operations to solve complex problems, carrying out sustained and complex calculations, eg performing calculations related to cell size.

Higher National Unit Support Notes(cont)

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

Learners could make effective and appropriate use of ICT packages to produce laboratory reports or pro formas in an appropriate format as well as preparing group results from investigation. Packages used will likely include word processing, spreadsheets, and graph drawing software. Learners will also be required to utilise 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 practical experiments.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Cell Biology: Theory and Laboratory Skills (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 Higher level or to have completed the HN Unit H923 33 *Biology: An Introduction*, where you will have learned underpinning aspects of cell biology and developed your practical skills.

On completion of the Unit you should be able to:

1 Describe and explain the structure and function of the cell membrane.
2 Describe and explain the fates of cell proteins.
3 Describe and explain cellular communication.
4 Perform practical experiments related to cell biology.

Outcome 1

In this Outcome you will learn that the cell membrane separates the cell from the external environment as well as forming the barrier of internal organelles, serving as a permeability barrier. You will also learn about the main lipid molecules and the fluid mosaic model. In addition, you will cover the key features of proteins in the membrane.

Outcome 2

In this Outcome you will learn about the role of the cytoskeleton in the cell to include; cell shape, cell function and transport of organelles and other cellular components, as well as the various roles of different tubules; actin, micro and intermediate. You will also discover how proteins are folded and transported to the cell surface when synthesised in the rough ER as well as the fate of proteins synthesised in the cytoplasm. In addition, you will cover how proteins are removed from the cell in various ways.

Outcome 3

In this Outcome you will focus on how cells communicate with both neighbouring cells and those distally located. Cells can communicate over distances using electrical impulses (through neurones) or chemical messengers. You will also learn that many disease conditions arise due to problems in signalling.

Outcome 4

In this Outcome you will undertake practical experiments, based on the content of Outcomes 1−3.

During this practical work, you will also be expected to develop good laboratory practices as well as improve your skills of manipulation, observation and measurement. You will also be encouraged to develop safe working practices and to strive constantly to improve the accuracy and reliability of your results. The reporting and analysis of experimental data is an important aspect of the practical sessions.

General information for learners (cont)

Unit title: Cell Biology: Theory and Laboratory Skills (SCQF level 7)

Assessment

For Outcomes 1 to 3 you will take a closed-book, end of Unit assessment.

Outcome 4 will be assessed after you have learned the necessary practical skills, and will take the form of two practical experiments, for which you will report your results either in full laboratory reports, or by completion of pro forma reports.

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