Higher National Unit specification

General information

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

Unit code: H922 34

Superclass: RH

Publication date: May 2015

Source: Scottish Qualifications Authority

Version: 02, March 2019

Unit purpose

This Unit is designed to enable learners to understand key aspects of biochemistry, in terms of the structures and functions of the major classes of biological molecules, the chemical nature of enzymes, and energy production within cells. Learners will also develop practical skills in techniques relevant to biochemistry. 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 biochemistry 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 structures and functions of the major classes of biological molecules.
2 Describe the chemical nature of enzymes.
3 Describe cellular respiration and photosynthesis.
4 Perform practical experiments related to biochemistry.

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 structures and functions of the major classes of biological molecules.

Knowledge and/or Skills

- Proteins
- Carbohydrates
- Lipids
- Nucleic Acids

Outcome 2

Describe the chemical nature of enzymes.

Knowledge and/or Skills

- Structure and function of enzymes
- Enzyme kinetics
- Regulation of enzyme activity

Outcome 3

Describe cellular respiration and photosynthesis.

Knowledge and/or Skills

- Role of ATP as an energy currency
- Cellular Respiration
- Photosynthesis

Higher National Unit specification: Statement of standards (cont)

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

Outcome 4

Perform practical experiments related to biochemistry.

Knowledge and/or Skills

- Biochemistry 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, completion of an appropriate pro forma or a laboratory diary entry. An assessor's observation checklist could be used to record performance evidence of practical experiments.

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 structure of proteins in terms of amino acid structure, peptide bond formation and levels of structure in protein molecules.
- Describe the structure of carbohydrates in terms of monosaccharides and formation and structure of disaccharides and polysaccharides.
- Describe the formation of lipids and specific structure of triglycerides, phospholipids and glycolipids.
- Describe the structure of nucleic acids in terms of the bonds involved in formation of RNA and DNA.
- Describe a function for two of the following four classes of biological molecules: proteins; carbohydrates; lipids; nucleic acids.

Higher National Unit specification: Statement of standards (cont)

Unit title: Biochemistry: Theory and Laboratory Skills (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 relationship between the structure and function in enzymes in terms of the molecular nature of enzymes.
- Describe enzyme kinetics in terms of the relationship between reaction rate and substrate concentration (Michaelis-Menten Equation) and the calculation of K_m and V_{max} (Lineweaver and Burk plots).
- Describe the regulation of enzyme activity by one of the following mechanisms: the effects of enzyme inhibitors on enzyme activity and enzyme kinetics; the effects of environmental conditions on enzyme activity; the regulation of enzyme function by covalent and non-covalent modifications.

Outcome 3

The assessment should 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:

- Describe how the structure of ATP relates to its function as an energy currency.
- Describe three of the following items relating to aerobic and anaerobic cellular respiration: Glycolysis; TCA cycle; electrochemical gradient and ATP synthase; fermentation; energy yields; limiting factors.
- Describe two of the following items relating to oxygenic photosynthesis in plants: the light dependent phase (photolysis); carbon-fixation phase (Calvin cycle); limiting factors.

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 biochemistry.
- 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, completion of an appropriate pro forma or a laboratory diary entry. 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. Where a laboratory diary approach is deployed, the laboratory diary must meet all of the requirements of a pro forma (in particular an evaluation of experimental errors), as set out in the Understanding Standards materials.

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, pro forma or laboratory diary does not meet the 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: Biochemistry: 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 biochemistry in order to enable learners to progress to the HN Unit H92J 35 *Protein Structure and Function*.

Outcome 1 — Describe the structures and functions of the major classes of biological molecules

The structure of proteins to include: the structure and classes of amino acids, formation of peptide bonds, levels of structure in proteins including the bonds involved in determining secondary, tertiary and quaternary structure. The presence of loops, motifs and domains within proteins. The functions of proteins. Learners would be expected to draw and label protein structures and draw bond formations.

The structure of carbohydrates to include: structure of monosaccharides, types of glycosidic bonding, structure of dissacharides and polysaccharides, reducing and non-reducing sugars. The functions of carbohydrates. Learners would be expected to draw and label carbohydrate structures and draw bond formations.

The structure of lipids to include: the structure of fatty acids and glycerol, structure and formation of triglycerides, formation of ester bonds, structure and formation of phospholipids and glycolipids. The functions of lipids. Learners would be expected to draw and label lipid structures and draw bond formation.

The structure of nucleic acid to include: structure and formation of nucleotides, the bonds involved in formation of RNA and DNA, formation of double helix in DNA, secondary structure in RNA. The functions of nucleic acids. Learners would be expected to draw and label nucleic acid structures, and draw bond formations.

Higher National Unit Support Notes (cont)

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

Outcome 2 — Describe the chemical nature of enzymes

The relationship between structure and function in enzymes in terms of the molecular nature of enzymes, to include co-enzymes and prosthetic groups. The relationship between amino acid sequence and 3D structure in proteins and its role in forming the active site, the role of amino acid side chains in enzyme-substrate binding and enzyme specificity.

Enzyme kinetics in terms of the interaction between enzymes and substrates, the role of enzymes acting as biological catalysts to lower the activation energy of reactions, the relationship between reaction rate and substrate concentration (Michaelis-Menten Equation), the use of Lineweaver and Burk plots in the calculation of K_m and V_{max}

The action of enzyme inhibitors and their effect on enzyme kinetics, to include reversible and irreversible inhibitors, difference between action of competitive, non-competitive and uncompetitive inhibitors, effects of inhibitors on K_m and V_{max}, the effects of pH and temperature on enzyme activity, the effects of non-covalent interactions (eg reversible binding of regulatory molecules) and reversible covalent interactions (phosphorylation, methylation, creation and reduction of disulphide bonds) and irreversible covalent interactions.

Outcome 3 — Describe cellular respiration and photosynthesis

The structure of ATP and how this relates to its function as an energy currency.

The processes of aerobic and anaerobic cellular respiration to include: steps involved in cellular respiration; location in cell of each stage; mitochondrial structure and function; glycolysis; fate of pyruvate in aerobic and anaerobic conditions; fermentation; Krebs Cycle; electron acceptors; formation of electrochemical gradient, ATP synthase and generation of ATP; energy yields, limiting factors.

The processes of oxygenic photosynthesis in plants to include: location of reactions in plant cells, structure of chloroplasts, the light dependent phase (photolysis); light harvesting pigments (primary and antenna complexes); reaction centres; electrochemical gradients and generation of ATP, products of light-dependent phase; carbon-fixation phase (Calvin cycle); limiting factors.

Outcome 4 — Perform practical experiments related to biochemistry

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.

Higher National Unit Support Notes (cont)

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

Guidance on approaches to delivery of this Unit

Outcomes 1–3 would best be delivered in order. It is envisaged that laboratory work and demonstrations will feature across the delivery of each of the Outcomes, and that the assessed practical experiment will be undertaken in a similar timeframe to the underpinning theory.

It is envisaged that delivery of Outcome 1 would commence with an introduction to the basic classes of biological molecules. The emphasis should be on understanding the structures of the building blocks and how they are linked together to form larger functional molecules. Learners would be expected to draw and label the basic building blocks for each class and to draw the bonds formed, for example, amino acids linked by peptide bonds to form proteins. The use of molecular model sets or online modelling programmes could be used to demonstrate structure and bonding. Learners would also be expected to understand the functions of each of the classes of biological molecules. Learners could also carry out practical experiments relating to the Outcome. For example, the learner could undertake a practical experiment where they are required to identify unknown carbohydrates by comparing their properties to known standards.

Outcome 2 is intended to introduce learners to enzyme structure and function and to investigate enzyme kinetics, ideally by carrying out practical experiments to enable calculations of enzyme reaction rates. Learners should be introduced to the structure and nature of enzymes. Brief mention should be made of the catalytic activities of RNA but the emphasis should be on protein enzymes. In terms of the 3D structure of enzymes and the formation of the active site, there are many online models available showing the 3D structures of enzymes and how these determine the structure of the active site and the specificity of enzyme-substrate interactions.

To enable the learners to develop a better understanding of enzyme kinetics, it is recommended that they undertake practical experiments which generate quantitative data on enzyme reaction rates. An example would be the use of an assay to investigate the activity of the alkaline phosphatase enzyme to allow calculation of the reaction rate and specific activity. This would then enable learners to more clearly understand the concepts relating to calculations of K_m and V_{max}. Learners would be expected to calculate both of these values using either data generated during practical experiments or using data provided for them. This should also enable learners to understand the effects of inhibitors on enzyme kinetics by studying competitive, non-competitive and uncompetitive inhibitors.

Outcome 3 is intended to expand on existing knowledge from Higher Biology and Higher Human Biology on cellular respiration. The emphasis should be on a more detailed understanding of the metabolic pathways involved, the structure of ATP and its function as energy currency, the role of electrochemical gradients and the components of the electron transport chain in generation of ATP. Practical experiments could include investigating yeast dehydrogenase activity in the presence of different substrates. The use of electron micrographs or models showing mitochondrial structure could be used to develop understanding of the location of the electron transport chain and of how electrochemical gradients are formed at the mitochondrial membranes.

It is recommended that a basic introduction to photosynthesis is provided. This should describe the structure of chloroplasts and the location of the different stages within the chloroplast. Appropriate practical experiments could include an investigation into the light dependent reaction in photosynthesis by measuring reduction of DCPIP by isolated chloroplasts.

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 experiment. Aspects suitable for experimental investigation might include identifying unknown carbohydrates by comparing their properties to known standards, the use of an assay to investigate the activity of the alkaline phosphatase enzyme to allow calculation of the reaction rate and specific activity, or investigating yeast dehydrogenase activity in the presence of different substrates.

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 1 hour.

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 practical 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 are:

Outcome 1

- Identify an unknown biological molecule from its chemical and physical properties. For example, identification of an unknown carbohydrate using a variety of biochemical tests.
- Extraction of nucleic acid from animal or plant cells.

Outcome 2

- Perform an enzyme assay (eg alkaline phosphatase) using visible/UV spectrophotometry to follow enzyme reactions directly or through coupled reactions.

Higher National Unit Support Notes (cont)

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

Outcome 3

- Investigate the light dependent reaction in photosynthesis by measuring reduction of DCPIP.
- Investigate yeast dehydrogenase activity in the presence of different substrates.

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 *Information and Communication Technology (ICT)* at SCQF level 4, *Numeracy* at SCQF level 5 and *Problem Solving* at SCQF level 6.

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

Learners may make effective and appropriate use of ICT packages to produce a laboratory report in an appropriate format. 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.

Numeracy — Using Number at SCQF level 5

During practical experiments, learners might be required to solve simple equations and perform data analysis, eg calculation of enzyme reaction rates, K_m and $V_{max.}$

Higher National Unit Support Notes (cont)

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

Problem Solving — Reviewing and Evaluating at SCQF level 6

Following assessed practical experiments learners will be required to review and evaluate the effectiveness of the exercise with a thorough interpretation of random and systematic sources of error. Learners will be required to reach sound conclusions on the basis of the data collected and the inherent errors.

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 possible recycling during practical experiments.

History of changes to Unit

Version	Description of change	Date
2	Both experiments can be reported by production of a full laboratory report, completion of an appropriate pro forma or a laboratory diary entry.	07/03/2019

General information for learners

Unit title: Biochemistry: 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 completed the HN Unit H927 34 *Cell Biology: Theory and Laboratory Skills*, where you will have learned underpinning aspects of cell structure and function and developed your practical skills.

On completion of the Unit you should be able to:

1 Describe the structures and functions of the major classes of biological molecules.
2 Describe the chemical nature of enzymes.
3 Describe cellular respiration and photosynthesis.
4 Perform practical experiments related to biochemistry.

Outcome 1

In this Outcome you will study the four main classes of biological molecules: proteins, carbohydrates, lipids and nucleic acids. The emphasis in this Outcome will be on the structure of the building blocks for each class and how they are linked together to form functional biological macromolecules. You will gain an understanding of the basic chemical structures of each class and the bonds involved in linking components together. You will also gain an understanding of the functions of each of the four main classes of biological molecules.

Outcome 2

In this Outcome you will study the structure and functions of enzymes, enzyme kinetics and how enzyme function can be regulated. The emphasis will be on protein enzymes although RNA will be mentioned as it can also act as an enzyme. You will look at the structure of enzymes and how this determines the conformation of the active site and controls enzyme specificity. In the second part of the Outcome, you will look at enzyme kinetics and you will learn how to determine reaction rates and specific activity of enzymes. It is likely that you will carry out specific practical experiments to allow you to generate quantitative data on enzyme kinetics. You will also look at how enzyme activity can be regulated in cells either by enzyme inhibitors or by modifications carried out within cells.

Outcome 3

In this Outcome you will investigate cellular respiration and photosynthesis. For both processes you will look at the cellular locations where the different stages occur. You will then look in more detail at each step in the pathway and the products generated at each stage. You will also look at how the processes can be regulated by environmental factors. It is likely that you will carry out practical experiments relating to cellular respiration and photosynthesis to help you better understand the theory.

General information for learners (cont)

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

Outcome 4

In this Outcome you will undertake assessed 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.

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, pro forma reports or laboratory diary entries

Core Skills

Although there is no automatic certification of Core Skills in the Unit, you will have opportunities to develop the Core Skills of *Information and Communication Technology (ICT)* at SCQF level 4, *Numeracy* at SCQF level 5 and *Problem Solving* at SCQF level 6.