Higher National Unit specification

General information

Unit title: Protein Structure and Function (SCQF level 8)

Unit code: H92J 35

Superclass: RH

Publication date: May 2015

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to provide learners with a detailed understanding of the relationship between structure and functioning of proteins. Learners will also develop knowledge of the techniques used in analysing this relationship. The Unit is suitable for learners studying at HND level, and will provide the necessary underpinning knowledge to enable progression to further study of protein structure and function at degree 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 principles involved in keeping proteins in their native states.
2 Outline the basic principles of specific binding.
3 Outline the key principles of the regulation of protein activity.
4 Outline key aspects of proteomics.

Credit points and level

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

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the HN Units H922 34 *Biochemistry: Theory and Laboratory Skills* and H91T 34 *Applied Biochemical Techniques* or equivalent.

Higher National Unit specification: General information (cont)

Unit title: Protein Structure and Function (SCQF level 8)

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

Unit title: Protein Structure and Function (SCQF level 8)

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 principles involved in keeping proteins in their native states.

Knowledge and/or Skills

- General principles of protein denaturation
- Inactivation of functional sites
- Prevention of proteolysis
- Protein storage

Outcome 2

Outline the basic principles of specific binding.

Knowledge and/or Skills

- General characteristics of binding sites
- Interactions involved in protein-ligand binding
- Structural methods for locating the amino acid residues in binding sites
- Chemical methods for locating the amino acid residues in binding sites

Outcome 3

Outline the key principles of the regulation of protein activity.

Knowledge and/or Skills

- Role of conformational changes
- Phosphorylation and dephosphorylation
- Activation by proteolysis
- Regulation by binding proteins

Higher National Unit specification: Statement of standards (cont)

Unit title: Protein Structure and Function (SCQF level 8)

Outcome 4

Outline key aspects of proteomics.

Knowledge and/or Skills

- Use of 2D gel electrophoresis
- Interpretation of 2D gels
- Sequencing of peptides
- Protein-protein interactions

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. It is recommended that the assessment be completed within 1 hour 30 minutes.

Outcome 1

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:

- Outline the general principles of protein denaturation.
- Outline conditions which can inactivate functional sites.
- Describe methods employed to prevent proteolysis.
- Outline a common method of protein storage.

Outcome 2

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:

- Outline the general characteristics of binding sites.
- Outline the role of weak, non-covalent interactions in protein-ligand binding.
- Describe methods, based on structure, which are employed to locate amino acid residues in binding sites.
- Describe methods, based on chemical treatments, which are employed to locate amino acid residues in binding sites.

Outcome 3

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:

- Outline the role of conformational changes, in the context of multiple binding sites, in regulating protein activity.
- Outline role of kinases and phosphatases.
- Outline the process of proteolytic activation.
- Outline the principles involved in regulation by binding proteins.

Higher National Unit specification: Statement of standards (cont)

Unit title: Protein Structure and Function (SCQF level 8)

Outcome 4

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:

- Outline the principles of 2D gel electrophoresis.
- Identify 2D gel spots from the molecular weights of tryptic peptides.
- Outline the sequencing of peptides by mass spectrometry.
- Summarise the approaches used to investigate protein-protein interactions.

Higher National Unit Support Notes

Unit title: Protein Structure and Function (SCQF level 8)

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 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 protein structure and function introduced in the HN Units H922 34 *Biochemistry: Theory and Laboratory Skills* and H91T 34 *Applied Biochemical Techniques*. The Unit will provide the learner with a detailed knowledge of the relationship between the structure of a protein and its function, and it concentrates on the ability to identify how to maintain proteins in a functional state.

Outcome 1 — Describe the principles involved in keeping proteins in their native states

This Outcome concentrates on the principles involved in keeping proteins in their native states. The Knowledge and/or Skills which should be covered are:

- Denaturation: temperature; pH; detergents; urea.
- Inactivation: oxidation; protection by use of reducing agents; loss of cofactors (emphasis on metal ions).
- Proteolysis prevention: speed; cold; protease inhibitors.
- Storage: 50% glycerol at –20^{o}C.

This Outcome could include an activity which lets learners interpret data from urea gradient gels.

Higher National Unit Support Notes (cont)

Unit title: Protein Structure and Function (SCQF level 8)

Outcome 2 — Outline the basic principles of specific binding

This Outcome concentrates on enabling learners to understand the principle of specificity in the context of protein binding. The Knowledge and/or Skills which should be covered are:

- General characteristics: lock and key; induced fit; evolutionary conservation of crucial residues.
- Non-covalent interactions: ionic, hydrophobic; hydrogen bonds; van der Waals interactions; discrimination between similar molecules.
- Structural methods: data from 3D structures of complexes (without covering how the data are obtained); stable substrate analogues for enzymes.
- Chemical methods: chemical modification; pH dependence of activity.

This Outcome could include an activity which lets learners identify crucial residues (based on evolutionary conservation) by alignment of amino acid sequences.

Alternatively data from the crystal structure of a protein complex (eg between RNaseA and a non-hydrolysable substrate analogue) could be analysed to identify residues involved in the reaction mechanism.

Outcome 3 — Outline the key principles of the regulation of protein activity

This Outcome looks at the basic principles underlying the regulation of protein activity. The Knowledge and/or Skills which should be covered are:

- Conformational change: allosteric enzymes; repressor proteins; membrane receptors.
- Phosphorylation/dephosphorylation: protein kinases; phosphoprotein phosphatases; residues phosphorylated; consensus motifs.
- Proteolytic activation: specificity; pepsinogen.
- Binding proteins: cAMP dependent protein kinase.

An ideal opportunity exists in this Outcome to engage learners in data-handling activities. This could be through the use of calculations to allow the determination of K_d for repressor proteins in the presence and absence of effectors.

Outcome 4 — Outline key aspects of proteomics

This Outcome looks at the key aspects of proteomics. Learners should become familiar with the following features:

- 2D gel electrophoresis: SDS-PAGE; isoelectric focusing; automated comparison of gels.
- Interpretation: trypsin specificity; mass spectrometry; database searches.
- Sequencing: fragmentation of amide linkages; mass differences between peaks.
- Interactions: techniques used to identify and analyse proteins bound by the target protein.

This Outcome could include an activity which lets learners use data to locate the exact site of tryptic cleavage in the full structure of an oligopeptide.

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 delivery of Outcome 1 could include simple investigations of the effect of manipulating environmental parameters such as temperature, or the presence of chemicals such as detergents, on the activity of a protein. The emphasis should be on how easy it is to lose protein function, and therefore the need to consider practical methods to prevent denaturation.

Outcome 2 focuses on why proteins are specific for certain tasks and learners should develop an understanding of the various types of chemical bonds. Delivery could then focus on learners applying their knowledge of the various types of chemical bonds used to identify the types of interactions amino acid side chains participate in, specifically those required to maintain proteins in their native state, and in interactions with substrates/ligands.

Outcome 3 should cover the main post translational modifications that are used to activate or deactivate proteins. In delivery of this Outcome links could be made to other HN Science related Units, such as H928 35 *Cellular Signalling* or H92D 35 *Human Metabolism*, to explain the consequences of such modulation in a cellular context.

Outcome 4 is intended to introduce learners to the key techniques used in the study of proteomics: namely gel electrophoresis to separate proteins in a mix (proteome) and mass spectrometry to analyse them. A possible context to deliver this Outcome is the use of proteomics in personalised medicine, eg to identify proteins associated with a disease such as cancer, which computer software can then use as targets for potential new drugs.

Due to the huge computational component in the study of proteomics, Outcome 4 presents an ideal opportunity to engage learners in utilising the accessible protein databases available on the internet, as well as computer graphics of structures of proteins and protein-ligand complexes.

Higher National Unit Support Notes (cont)

Unit title: Protein Structure and Function (SCQF level 8)

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. Assessment should be carried out in supervised conditions, and is recommended that the assessment be completed within 90 minutes. Evidence could be generated by case studies and/or problem solving activities, and where possible Knowledge and/or Skills should be assessed in an integrated manner.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 8.

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

Numeracy — Using Number at SCQF level 6

Learners will be required to work with number throughout the Unit. For example, in Outcome 1 learners may be required to interpret data on urea gradient gels. Outcome 3 also lends itself to engaging learners in data-handling activities. This could be through the use of calculations to allow the determination of K_d for repressor proteins in the presence and absence of effectors.

Problem Solving — Critical Thinking at SCQF level 6

Outcome 4 provides an ideal opportunity for learners to apply Problem Solving skills in an activity requiring the use of data to locate the exact site of tryptic cleavage in the full structure of an oligopeptide.

Higher National Unit Support Notes (cont)

Unit title: Protein Structure and Function (SCQF level 8)

Information and Communication Technology (ICT) — Providing/Creating Information at SCQF level 6

In delivery of this Unit an ideal opportunity exists to engage learners in making effective and appropriate use of ICT to access protein databases on the internet, as well as computer graphics of structures of proteins and protein-ligand complexes. For example, Outcome 2 could include an activity which lets learners identify crucial residues (based on evolutionary conservation) by alignment of amino acid sequences.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Protein Structure and Function (SCQF level 8)

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 8, which you are likely to be studying as part of the second year of an HND Science programme. Before progressing to this Unit it would be beneficial to have completed the HN Units H922 34 *Biochemistry: Theory and Laboratory Skills* and H91T 34 *Applied Biochemical Techniques*, where you will have learned underpinning aspects of protein structure and function and developed your practical skills. The Unit is designed to provide you with an understanding of, and appreciation for, the link between a protein's structure and its ability to function in a specific way.

On completion of this Unit you should be able to:

1 Describe the principles involved in keeping proteins in their native states.
2 Outline the basic principles of specific binding.
3 Outline the key principles of the regulation of protein activity.
4 Outline key aspects of proteomics.

Outcome 1

In this Outcome you will be introduced to the principles involved in keeping proteins in their natural state. You will learn about environmental conditions which may lead to denaturation, protection methods to prevent denaturation, and effective storage methods.

Outcome 2

In this Outcome you will focus on the concept of specific binding. The characteristics shared by protein binding sites will be outlined, and you will also learn about chemical and structural methods which are utilised in trying to identify the actual amino acid residues which contribute to a binding site.

Outcome 3

In this Outcome you will look at regulation of protein activity. You will learn about such principles, namely: conformational changes, reversible phosphorylation, proteolysis and the role of binding proteins.

Outcome 4

In this Outcome you will be introduced to the concept of proteomics. You will focus on particular aspects such as the various biochemical techniques involved as well as how to interpret the data produced.

Assessment

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

General information for learners (cont)

Unit title: Protein Structure and Function (SCQF level 8)

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