Higher National Unit specification

General information

Unit title: Human Metabolism (SCQF level 8)

Unit code: H92D 35

Superclass: RH

Publication date: May 2015

Source: Scottish Qualifications Authority

Version: 02

Unit purpose

This Unit is designed to enable learners to understand key aspects of human metabolism, and its control and regulation. Learners will also develop practical skills in techniques relevant to human metabolism. The Unit is suitable for learners studying at HND level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of human metabolism 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 and explain the role of enzymes in human metabolism.
2 Describe and explain the main concepts in human metabolism.
3 Describe and explain carbohydrate metabolism.
4 Describe and explain lipid metabolism.
5 Describe and explain protein metabolism.
6 Perform practical experiments related to human metabolism.

Credit points and level

2 Higher National Unit credits at SCQF level 8: (16 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 H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills* and H922 34 *Biochemistry: Theory and Laboratory Skills*, or equivalent.

Higher National Unit Specification: General information (cont)

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Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill None

Core Skill component Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

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 role of enzymes in human metabolism.

Knowledge and/or Skills

- Enzyme structure
- Enzyme specificity and mechanism of action
- Coenzymes
- Factors affecting enzyme activity
- Enzyme thermodynamics
- Enzyme kinetics
- Enzyme inhibition
- Enzyme regulation

Outcome 2

Describe and explain the main concepts in human metabolism.

Knowledge and/or Skills

- Integration of metabolic pathways
- Role of ATP
- Endocrine regulation of metabolism

Outcome 3

Describe and explain carbohydrate metabolism.

Knowledge and/or Skills

- Glycolysis
- TCA cycle
- Glycogen metabolism
- Gluconeogenesis
- Role of hormones in control of blood glucose levels

Higher National Unit specification: Statement of standards (cont)

Unit title: Human Metabolism (SCQF level 8)

Outcome 4

Describe and explain lipid metabolism.

Knowledge and/or Skills

- Lipolysis and beta oxidation of fatty acids
- Fatty acid synthesis and lipogenesis
- Ketogenesis

Outcome 5

Describe and explain protein metabolism.

Knowledge and/or Skills

- Protein synthesis
- Protein catabolism
- Amino acid metabolism
- Urea cycle

Outcome 6

Perform practical experiments related to human metabolism.

Knowledge and/or Skills

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

Higher National Unit specification: Statement of standards (cont)

Unit title: Human Metabolism (SCQF level 8)

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1–5 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 two hours.

Written and/or oral recorded evidence for Outcome 6 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 six of the eight 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 enzymes.
- Explain enzyme specificity; describe interaction between enzymes and their substrates at the active site.
- Explain the importance of coenzymes: cofactors, prosthetic groups with named examples.
- Describe factors that affect the activity of enzymes and explain their action.
- Describe and explain enzyme thermodynamics.
- Demonstrate an understanding of kinetics using reaction rate graphs and the terms Km and Vmax.
- Identify enzyme inhibitors and explain their action on enzyme activity.
- Describe and explain ways that enzymes may be regulated.

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 and explain the integration of metabolic pathways.
- Describe and explain the role of ATP in human metabolism.
- Describe and explain endocrine regulation of metabolism.

Higher National Unit specification: Statement of standards (cont)

Unit title: Human Metabolism (SCQF level 8)

Outcome 3

The assessment will sample four 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 and explain glycolysis.
- Describe and explain the TCA cycle.
- Describe and explain glycogen metabolism.
- Describe and explain gluconeogenesis.
- Describe and explain the role of hormones in the control of blood glucose level.

Outcome 4

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 and explain lipolysis and beta oxidation of fatty acids.
- Describe and explain fatty acid synthesis and lipogenesis.
- Describe and explain ketogenesis.

Outcome 5

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 and explain protein synthesis.
- Describe and explain protein catabolism.
- Describe and explain amino acid metabolism.
- Describe and explain the urea cycle.

Higher National Unit specification: Statement of standards (cont)

Unit title: Human Metabolism (SCQF level 8)

Outcome 6

Learners will perform a minimum of four practical experiments, the content of which will be related to at least three of the Outcomes 1–5. 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 human metabolism.
- 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 should complete a laboratory diary throughout the practical experiments. Learners must report two of the four practical experiments by production of a full laboratory report, and practical experiments which are written as full laboratory reports must be commensurate with SCQF level 8. Learners may report the remaining two practical experiments 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.

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: Human Metabolism (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 80 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 and practical aspects of human metabolism.

Outcome 1 — Describe and explain the role of enzymes in human metabolism

Enzyme structure as per globular protein structure: should include amino acids, peptide bonds, levels of structure, types of intramolecular bonding, active site, isoenzymes.

Specificity: enzyme substrate interaction, examples of different types of enzyme reactions, lock and key and induced fit theories.

Coenzymes: cofactors, prosthetic groups: vitamins and minerals, their importance to the functioning of an enzyme, possible examples: zinc and magnesium ions, niacin (NAD+) Riboflavin (FAD).

Factors affecting activity: temperature, pH, substrate concentration. Link the effect of temperature and pH to their effect of the structure of the enzyme.

Thermodynamics: biological catalyst, diagram representing progress of reaction with and without enzyme including terms activation energy and transition state, metabolic importance of lowering the activation energy. The concept of ΔG (free energy change) should also be introduced.

Enzyme kinetics: Michaelis Menton and Lineweaver Burke plots. Definitions of Km and Vmax and how to estimate each from both types of plots. This knowledge can be applied in the practical element in Outcome 6.

Enzyme inhibition to include mechanism of action of different types of inhibitors: competitive, non-competitive, reversible, irreversible. The effect of both competitive and non-competitive inhibition on Km and Vmax values.

Enzyme regulation: feedback regulation, allosteric enzymes (inhibition and activation), reversible covalent modification, eg phosphorylation and dephosphorylation, regulation of enzyme synthesis and degradation, synthesis controlled by its gene induction or repression, rate of degradation of its mRNA, degradation controlled by rate of the enzyme breakdown (half-life). Proteolytic activation.

Outcome 2 — Describe and explain the main concepts in human metabolism

Integration: pathways, catabolic, anabolic, amphibolic, linear, cyclic branched, spiral, multi-enzyme complexes. Interconnectivity, key junction points (acetyl CoA, Pyruvate, glucose 6 phosphate), reciprocal regulation, compartmentation.

Role of ATP: structure, function, production, substrate level and oxidative phosphorylation (in brief), importance in metabolism.

Endocrine regulation of metabolism: general effects of insulin, glucagon, adrenaline (thyroxin and glucocorticoids briefly), how they effect their action on enzymes, eg phosphorylation, gene expression, etc (briefly).

Outcome 3 — Describe and explain carbohydrate metabolism

Glycolysis: importance, core cytoplasmic pathway of glucose metabolism, yields pyruvate, different fates depending on O_2 availability. Regulatory enzymes PFK (as main control), HK and PK.

TCA cycle: cyclic, amphibolic, centre of aerobic metabolism, pyruvate converted to Acetyl CoA by PDH, carbohydrate, fat and protein metabolites all feed in, converts acetyl CoA to CO_2 yielding NADH and $FADH_2$ reducing power and ultimately ATP, source of intermediates for biosynthesis. Regulation: substrate availability, PDH.

Glycogen metabolism: glycogen storage sites. Glycogenesis, glycogen synthase. Glycogenolysis, phosphorylase, comparison of glycogen breakdown in liver and muscle.

Gluconeogenesis: importance, glucose synthesis from non-carbohydrate sources, main substrates, reciprocal regulation with glycolysis, different enzymes for three key steps, role of glucagon.

Blood glucose levels: overview of role of hormones; central role of insulin, glucose transport, GK in liver cells, opposing action by glucagon and other hormones.

Outcome 4 — Describe and explain lipid metabolism

Lipolysis: degradation of TAGs, hormone sensitive lipase, rate limiting, regulation. Beta oxidation: mitochondrial matrix, spiral metabolic pathway, sequence of four reactions (brief).

Fatty acid synthesis: two main stages, carboxylation of acetyl CoA, rate limiting step, regulation, and fatty acid synthase, multi enzyme complex, chain elongation
Synthesis of triglycerides: (TAGs): TAGs suitability for energy storage, adipose tissue, sources of glycerol phosphate.

Ketogenesis: importance, ketone bodies, regulation, diabetes, effect of diet.

Outcome 5 — Describe and explain protein metabolism

Protein synthesis: transcription (brief), translation: initiation, elongation termination.

Protein catabolism: protein turnover, protein half-life, ubiquitin/proteasome pathway.

Amino acid metabolism: transanimation, deamination (glutamate dehydrogenase), αketoglutaric acid, glutamic acid, glucogenic and ketogenic amino acids.

Urea cycle: nitrogen balance, nitrogen excretion, link with deamination, compare properties of ammonia and urea, carbamoyl phosphate, links with TCA cycle.

Outcome 6 — Perform practical experiments related to human metabolism

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 1–5.

In carrying out such activities, students 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

Outcomes 1 and 2 are best delivered early in the Unit as they provide some of the basic concepts for the study of human metabolism. These concepts should be reinforced in the teaching of the other Outcomes. It is envisaged that laboratory work and demonstrations will feature across the delivery of each of the Outcomes, and that the assessed practical experiments for Outcome 6 will be undertaken in similar timeframe to the underpinning theory.

For Outcome 1 learners should be encouraged to construct a glossary of terms used in the study of enzymes. In the study of enzyme kinetics learners should be taught to interpret rate of reaction graphs. It would be beneficial for them to construct Michaelis Menton and Lineweaver Burke plots from data provided. Learners can also apply this knowledge when they carry out the practical experiments related to enzymes in Outcome 6. In enzyme regulation it is recommended that examples given of the various types of regulation are relevant to and support the study of Outcomes 3, 4 and 5.

Higher National Unit Support Notes (cont)

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In Outcome 2 maps, charts and posters of metabolic pathways, particularly those illustrating human metabolism, should be used for the topic of integration of metabolism. There are also online interactive versions available. In the teaching of the importance of hormones in the control of metabolism, detailed information on cell signalling pathways should be avoided.

For Outcomes 3–5 it is not envisaged that learners learn pathways step by step. A holistic approach should be taken with emphasis on entry and exit points, control and regulation and how a particular pathway integrates with other pathways. A useful exercise is for learners, either individually or as part of a group, to draw up their own version of a human metabolism poster illustrating the main pathways and how they interconnect and the points of the main control enzymes etc. Learners would benefit from a guest lecture from a qualified dietician or a specialist in metabolic diseases.

For Outcomes 1–5 there are numerous online video clips and interactive programmes that will assist in the illustration and explanation of many of the concepts.

It is envisaged that Outcome 6 will be delivered alongside the theoretical based Outcomes 1–5. A range of practical experiments could be utilised to both support understanding of the underlying theory and to prepare learners for undertaking the four assessed practical experiments. Aspects suitable for experimental investigation might include various features of enzyme activity, qualitative and/or or quantitative analysis of biomolecules related to human metabolism, and factors affecting blood glucose level.

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 1–5 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 two hours.

When evidence of Outcomes 1–5 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 6 learners are required to undertake four assessed practical experiments, the content of which will be related to at least three of the Outcomes 1–5. 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.

Higher National Unit Support Notes (cont)

Unit title: Human Metabolism (SCQF level 8)

Suitable practical experiments are:

Outcome 1

- Determination of Km and Vmax for a named enzyme, eg alkaline phosphatase with 4-nitrophenyl phosphate as substrate (spectrophotometry).
- Determination of the effects of an inhibitor on enzyme activity, eg using phosphate as the inhibitor in the above reaction.
- Ca^{2+}/Mg^{2+} ions in milk — titration.
- The effect of 'Lactaid' on milk, compare milks from different sources, etc.
- Activity of lipase over range of temperatures or pH.

Outcome 2

- Investigate ATP and muscle contraction.

Outcome 3

- Measuring blood glucose levels using glucometer — test variables, time of day, fasting, exercise, etc.
- Perform qualitative testing on carbohydrates, fats and proteins.
- Analysis of milk components — qualitative and quantitative.
- The effect of 'Lactaid' on milk, compare milks from different sources, etc.

Outcome 4

- Perform qualitative testing on carbohydrates, fats and proteins.
- Analysis of milk components — qualitative and quantitative.
- Activity of lipase over range of temperatures or pH.

Outcome 5

- Preparation of a calibration graph, eg Bradford Assay using BSA for the calibration line, include unknown concentrations for learners to identify (spectrophotometry).
- Perform qualitative testing on carbohydrates, fats and proteins.
- Analysis of milk components — qualitative and quantitative.

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 of achievement at SCQF level 8.

Higher National Unit Support Notes (cont)

Unit title: Human Metabolism (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* and *Problem Solving* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 4.

Numeracy — Using Number at SCQF level 6

Learners will have to decide on steps and operations to solve complex problems, eg performing calculations for serial dilutions, using scientific notation, plotting and interpolating and extrapolating information from graphs.

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.

Information and Communication Technology — 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. Packages used will likely include word processing, spreadsheets, and graph drawing software. They 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 minimising the use of disposable materials (such as plastic tips and paper towels) as well as recycling where appropriate.

This Unit has the Critical Thinking component of Problem Solving embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6.

History of changes to Unit

Version	Description of change	Date
02	Core Skills Component Critical Thinking at SCQF level 5 embedded.	28/07/2015

General information for learners

Unit title: Human Metabolism (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 2 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 H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills* and H922 34 *Biochemistry: Theory and Laboratory Skills*, where you will have learned underpinning aspects of biomolecules and enzymes.

On completion of the Unit you should be able to:

1 Describe and explain the role of enzymes in human metabolism.
2 Describe and explain the main concepts in human metabolism.
3 Describe and explain carbohydrate metabolism.
4 Describe and explain lipid metabolism.
5 Describe and explain protein metabolism.
6 Perform practical experiments related to human metabolism.

Outcome 1

In this Outcome you will gain an overview of the role of enzymes to include their structure and function and aspects of their activity and regulation. You will also be introduced to the study of enzyme kinetics.

Outcome 2

In this Outcome you will gain an understanding of the main concepts in human metabolism such as the integration of metabolic pathways and the role of ATP. The importance of the endocrine system in the regulation of metabolism will also be covered.

Outcome 3

In this Outcome the metabolism of carbohydrates will be studied. You will cover pathways such as glycolysis, TCA cycle and gluconeogenesis. Glycogen metabolism will also be included along with how each of the pathways are linked and regulated.

Outcome 4

In this Outcome the metabolism of lipids will be studied. You will cover the anabolic and catabolic pathways, including ketogenesis, in the metabolism of triglycerides. Links to other pathways and regulation will be included too.

Outcome 5

In this Outcome the metabolism of proteins will be studied. You will cover anabolic and catabolic pathways in the metabolism of proteins. You will also be introduced to amino acid metabolism, nitrogen balance and the urea cycle.

General information for learners (Cont)

Unit title: Human Metabolism (SCQF level 8)

Outcome 6

In this Outcome you will undertake practical experiments, the content of which will be related to at least three of the Outcomes above.

During this practical work, you will also be expected to 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 5 you will take a closed-book, end of Unit assessment.

Outcome 6 will be assessed after you have learned the necessary practical skills, and will take the form of four practical experiments, for which you will record your observations and results either in full laboratory reports, or by completion of pro forma reports.

Core Skills

You will have opportunities to develop the Core Skills of *Numeracy* and *Problem Solving* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 4.