

BIOTECHNOLOGY
Higher

Fifth Edition – Published March 2004

NOTE OF CHANGES TO ARRANGEMENTS
FIFTH EDITION PUBLISHED

COURSE TITLE: Biotechnology (Higher)

COURSE NUMBER: C008 12

National Course Specification

Course Details

Assessment: section inserted which clarifies details of the Instruments for Internal Assessment.

National Unit Specification:

DF5H 12 Microbiology

Statement of Standards

Outcome 3: outcome, performance criteria and evidence requirements have been amended.

Support Notes

Guidance on Approaches to Assessment for this unit includes revised guidance on Outcome 3.

NOTE OF CHANGES TO ARRANGEMENTS (cont)

COURSE TITLE: Biotechnology (Higher)

COURSE NUMBER: C008 12

D042 12 Microbiological Techniques

Statement of Standards

No change.

Support Notes

No change.

DF5J 12 Biotechnology

Statement of Standards

Outcome 2: outcome and evidence requirements have been amended.

Support Notes

Guidance on Approaches to Assessment for this unit includes revised guidance on Outcome 2.

National Course Specification

BIOTECHNOLOGY (HIGHER)

COURSE NUMBER C008 12

COURSE STRUCTURE

The course has three 40 hour units. The units cover the following content areas:

DF5H 12	Microbiology (H) <ul style="list-style-type: none">• <i>Structure of Micro-organisms</i>• <i>Microbial Metabolism</i>• <i>Genetic Engineering</i>• <i>Infection and Immunity</i>	1 credit (40 hours)
D042 12	Microbiological Techniques (H) <ul style="list-style-type: none">• <i>Growth Limitation and Sterilisation Techniques</i>• <i>Culturing Techniques</i>• <i>Identification Techniques</i>	1 credit (40 hours)
DF5J 12	Biotechnology (H) <ul style="list-style-type: none">• <i>Biotechnological Processing</i>• <i>Agriculture and Horticulture Applications</i>• <i>Clinical and Forensic Medicine Applications</i>	1 credit (40 hours)

In common with all courses, this course includes a further 40 hours over and above the 120 hours for the component units. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment. This time is an important element of the course and advice on its use is included in the course details.

Administrative Information

Superclass:	RH
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National Course Specification (cont)

COURSE Biotechnology (Higher)

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates will normally be expected to have attained one of the following:

- Intermediate 2 Biotechnology
- Standard Grade Biology at Credit level
- Intermediate 2 Biology.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* SQA, (2001).

CREDIT VALUE

The Higher Biotechnology Course is allocated 24 SCQF Credit Points at SCQF level 6*

*SCQF points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.

National Course Specification: course details

COURSE Biotechnology (Higher)

RATIONALE

Biotechnology is the use of organisms and their cellular, subcellular or molecular components in order to provide goods and services. It combines the principles of biosciences with technological expertise, and often involves the integration of a range of scientific and technological disciplines. Biotechnology is a rapidly expanding area, offering enormous benefits and challenges, and the prospect of solving many of the problems faced by the world today.

The course provides an integrated study of the biology, practical skills and production methods relevant to biotechnology. In particular, the course develops an understanding of the way microbiology is applied in industrial and commercial settings. Although the course is designed to be free standing it will be particularly appropriate in a programme of study which includes Biology or other sciences. The study of Biotechnology at Higher level contributes to the candidate's general and vocational education by building on the biotechnological knowledge and skills gained at Intermediate 2 level. The course further develops practical skills in the use of microbiological techniques and understanding of the relevance of biotechnological principles to society in preparation for, or as a contribution to, a career as a laboratory scientist in areas related to biology.

The course provides opportunities for candidates to acquire:

- knowledge and understanding of biological concepts, facts, ideas and techniques and the applications of biotechnology in society and industry
- skills in problem solving, particularly in practical contexts
- competence in microbiological techniques
- practical skills associated with biotechnology
- an awareness of the ways in which biotechnology can affect the well-being of themselves and others, and the quality of their environment.

The content reflects the need to develop a sound understanding of the structure and physiology of micro-organisms and competence in microbiological techniques. Technological advances, such as genetic engineering and the design of fermenters, on which the modern revolution in biotechnology is based, are highlighted. Specific applications, particularly in agriculture and horticulture and clinical and forensic medicine, have been chosen to illustrate the economic, social and environmental importance of biotechnology.

National Course Specification: course details (cont)

COURSE Biotechnology (Higher)

COURSE CONTENT

The Higher Biotechnology course comprises three mandatory 40 hour units. The course provides a more thorough understanding of the concepts covered at Standard Grade and Intermediate 2 level and further develops the outcomes of knowledge and understanding, problem solving and practical abilities.

Knowledge and understanding

Candidates should develop the ability to recall and understand facts and principles detailed in the course statements and supplementary notes in the following tables.

Problem solving

Problem solving skills should be developed so that candidates can generally:

- identify problems
- select relevant information from texts, tables, charts, keys, graphs and diagrams
- present information appropriately in a variety of forms, including written summaries, extended writing, tables and graphs
- process information accurately using calculations where appropriate
- plan and design problem solving procedures
- implement planned problem solving procedures
- evaluate problem solving procedures
- plan, design and evaluate experimental procedures
- draw valid conclusions and give explanations supported by evidence
- make predictions and generalisations based on available evidence.

Practical abilities

Practical work is essential in providing the contexts for the development of scientific problem solving skills. Practical work is necessary to underpin theoretical work and to develop skills. It fosters familiarity with apparatus, equipment and how it works as a useful preparation for further study or employment. As a result of engaging in practical work candidates can generally:

- carry out techniques related to microbiology
- describe experimental procedures accurately
- record relevant measurements and observations in appropriate formats
- analyse and present experimental information in appropriate formats
- draw valid conclusions
- evaluate experimental procedures with supporting argument.

The following tables contain the content and suggested learning activities through which knowledge and understanding, problem solving and practical abilities are to be developed. The content statements and the supplementary notes which provide amplification and give an indication of depth of treatment are required for the purpose of assessment.

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

Introduction

This unit outlines the biology of micro-organisms, which contributes to the development of an understanding of the major applications of biotechnology. It is not intended that a comprehensive classification system be provided; only those aspects of structure of bacteria, fungi and viruses that illustrate the uses of these micro-organisms are addressed. Energy release in respiration is studied because of its implications for cell growth and fermenter technology; DNA, its structure and function as it forms the basis for an understanding of genetic modification; and infection and immunity to help understanding of the basis of disease control.

CONTENT	NOTES	LEARNING ACTIVITIES
<p>a) Structure of micro-organisms</p> <p>i Prokaryotes and eukaryotes.</p> <p>ii Bacteria.</p> <p>Structure and function.</p>	<p>Prokaryotes are cells whose genomes are not contained within a nucleus.</p> <p>Eukaryotes have internal membranes and membrane-bound nuclei within which the genome is stored as chromosomes.</p> <p>The structure and function of the characteristic organelles of eukaryotes to include mitochondria (cristae and central matrix), chloroplasts (grana, stroma, and lamellae), endoplasmic reticulum, Golgi apparatus and lysosomes.</p> <p>Prokaryotes, single-celled. Lack of nuclei organised within membranes and of membrane-bound organelles. Presence of: circular chromosome; plasmids; gelatinous capsule; cell wall; ribosomes; sometimes a flagellum may be present in motile bacteria.</p>	<p>Identify micro-organisms using keys.</p> <p>Identify a range of bacteria from prepared slides and flowcharts of identifying characteristics.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>Shape.</p> <p>Gram positive and Gram negative bacteria.</p> <p>Uses.</p> <p>iii Fungi.</p> <p>Structure.</p> <p>Reproduction.</p>	<p>Cocci (round), bacilli (rod-shaped), spirilla (spiral).</p> <p>Bacteria are Gram positive if they retain crystal violet in the Gram stain and Gram negative if they do not. Gram positive bacteria cell walls have over 40% peptidoglycans, Gram negative bacteria cell walls have significantly less. The antibiotic penicillin is more active against Gram positive bacteria than Gram negative bacteria.</p> <p>Genetic engineers insert genes for useful substances into plasmids; plasmids introduced into bacteria. Such bacteria used for large scale production of these substances.</p> <p>The structure of unicellular fungi as exemplified by yeast.</p> <p>Multinucleate cytoplasm of hyphal fungi as exemplified by <i>Mucor</i>.</p> <p>Asexual reproduction by in yeast.</p> <p>Asexual reproduction by spore bearing structures (sporangia) arising from the mycelium in <i>Mucor</i>.</p> <p>Sexual reproduction in <i>Mucor</i> to produce a zygospore.</p>	<p>Identify a range of bacteria using reaction to Gram stain and morphology.</p> <p>Examine conjugation in <i>Mucor</i>.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>Uses</p> <p>iv Viruses.</p> <p>The nature of viruses and their invasion of cells.</p> <p>Alteration of cell instructions to produce more viruses.</p> <p>Types.</p> <p>Uses.</p>	<p>Yeasts used commercially for brewing and baking; other fungal species used for large-scale production of enzymes and other useful substances including antibiotics.</p> <p>Viruses do not have a cellular structure. Presence of central core of DNA or RNA, capsid (protein coat) and envelope in some viruses.</p> <p>Ability of viruses to enter cells and alter host cell metabolism so that replication of viral DNA/RNA can take place, resulting in the formation and release of a large number of viruses (eg bacteriophage lytic cycle). Ability of viruses to transfer viral nucleic acid to host's chromosome.</p> <p>Animal, plant and bacteriophage.</p> <p>Grown in large numbers for the production of vaccines (eg vaccines against small pox, polio, rubella and measles; these are named examples only ie production details of each are not required) or for use in genetic engineering as cloning vectors.</p>	<p>Demonstrate plaque formation in bacteria using bacteriophage.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>b) Microbial metabolism</p> <p>1 Energy release</p> <p>The role and production of adenosine triphosphate (ATP):</p> <p>i ATP as a means of transferring chemical energy. Regeneration of ATP from ADP and inorganic phosphate.</p> <p>ii Glycolysis: the breakdown of glucose to pyruvic acid with a net production of ATP in the cytoplasm.</p> <p>iii Krebs (citric acid, tricarboxylic acid) cycle and cytochrome system. The location of these reactions within the cristae and matrix of the mitochondrion in eukaryotes. Relationship of folding of inner membrane to activity of mitochondrion. The production of ATP, carbon dioxide, hydrogen and reduced co-enzyme.</p>	<p>In the teaching of energy release the principles of the process should be emphasised.</p> <p>Only the intermediates pyruvic acid, tricarboxylic acid and acetyl-CoA need be known by name. It is more important to follow the fate of the carbon atoms and hydrogen in the process. The importance of the cytochrome system in the step-by-step release of energy via transfer of electrons and hydrogen combined with reduced co-enzyme should be emphasised.</p>	<p>Design and carry out an investigation to show the activity of dehydrogenase enzymes in yeast.</p> <p>Examine published electron micrographs of mitochondria.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>iv The distinction between anaerobic and aerobic phases of respiration with reference to location, level of ATP produced and final metabolic products.</p> <p>v Fermentation.</p> <p>2 Patterns of growth</p> <p>i Factors affecting growth.</p> <p>ii The bacterial growth curve in liquid media.</p>	<p>In industry the term fermentation is used to describe aerobic and anaerobic growth of micro-organisms.</p> <p>Candidates should be familiar with the terms: obligate aerobes, obligate anaerobes, and facultative anaerobes.</p> <p>Alcohol fermentation results in production of ethanol. Lactate fermentation results in production of lactic acid.</p> <p>Temperature, oxygen concentration, pH, external concentration of solutes and water, pressure, nutrient availability.</p> <p>Phase 1: lag, latent or initial stationary phase. Phase 2: exponential or log phase. Phase 3: stationary phase. Phase 4: final, death or senescent phase. Candidates are expected to be able to explain events that occur within each of the phases.</p>	<p>Analyse data on different fermentation processes.</p> <p>Demonstrate fermentation and/or lactic acid production in souring milk.</p> <p>Design and carry out an experiment to examine the effects of temperature/pH/glucose concentration on the growth of a named micro-organism.</p> <p>Analyse data on bacterial population count.</p> <p>Determine doubling time and growth rate constant of yeast in a liquid culture.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>3 Copying and translating genes</p> <p>i DNA structure.</p> <p>ii Single circular chromosome in prokaryotes.</p> <p>iii Plasmids.</p>	<p>Double helix (deoxyribose sugar- phosphate backbone, weak hydrogen bonds between strands), nucleotides and bases, pairing of named bases.</p> <p>Anti parallel strands with 3' end of one strand opposite 5' end of the other strand, sense (the strand which acts as the template for mRNA production) and anti sense strands of the DNA double helix.</p> <p>Genes as regions of chromosomal DNA. DNA replication and its importance.</p> <p>DNA polymerases add nucleotides only to the free 3' end of a DNA molecule being synthesised.</p> <p>Presence of exons (expressed, coding regions of DNA) and introns (intervening, non-coding regions of DNA) in eukaryotes.</p> <p>Mutations as alterations of base type or sequence (substitution, insertion, deletion, inversion).</p> <p>Genes with related functions clustered together as operons.</p> <p>Self replicating double-stranded circles of DNA in prokaryotes; carry genes that may be advantageous but are not essential: as illustrated by antibiotic resistance; can be passed from one bacterium to another.</p>	<p>Obtain information from a variety of sources on the nature of DNA and RNA and their roles in protein synthesis. Sources may include appropriate models, computer simulations and published materials.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>iv The structure of protein.</p> <p>v RNA structure and function in protein synthesis.</p> <p>The role of cellular organelles in protein synthesis.</p>	<p>The structure of protein should be given an elementary treatment. Amino acid chains are linked by strong peptide bonds; further linkages such as weak hydrogen bonds produce secondary and tertiary structures that are important in the functioning of protein.</p> <p>Single strand, replacement of thymine with uracil and deoxyribose with ribose.</p> <p>mRNA synthesis: The mRNA exported from the nucleus consists of exon sequences only. The remaining RNA transcribed from the gene (intron sequence) is removed by splicing. RNA is transcribed from the sense strand of DNA.</p> <p>Function of mRNA and tRNA in synthesis of proteins, triplet code, codons and anti-codons. Ribosomes organised on membranes in eukaryotes, free in cytoplasm in prokaryotes.</p> <p>The effect of gene mutation on amino acid sequences should be noted.</p> <p>Ribosomes and rough endoplasmic reticulum. Distribution within the cell and function as site of translation in protein synthesis; role of endoplasmic reticulum in transporting proteins; role of Golgi apparatus in processing molecules for secretion.</p>	<p>Carry out electrophoresis of proteins from different sources.</p> <p>Investigate the effect of lactose on the activity of β-galactosidase in <i>E coli</i>.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>vi An introduction to the Jacob-Monod hypothesis of gene action in bacteria.</p> <p>c) Genetic engineering</p> <p>i Extraction and preparation of DNA sequences.</p> <p>Purification of DNA.</p> <p>Use of restriction endonucleases in isolation of gene sequences.</p> <p>Separation of DNA fragments by gel electrophoresis and use of probes.</p>	<p>As illustrated by lactose metabolism in <i>Escherichia coli</i> and the <i>lac</i> operon. The terms repressor molecule, regulator gene, inducer, operator and structural gene should be known.</p> <p>Breakdown of cell wall of plant and bacterial sources; removal of protein.</p> <p>Enzymes, extracted from bacteria, cut DNA at specific recognition sites consisting of 4-8 paired nucleotide sequences.</p> <p>Details of gel electrophoresis: use of agarose, the higher the concentration of agarose the slower that rate of movement of DNA fragments. DNA fragments move towards the anode because of negative charge. DNA fragments separated according to size, smaller fragments moving further than larger fragments. DNA is visualised by staining. Transfer of DNA fragments to membrane filter. Desired DNA fragment located by use of labelled probe with some of its base sequences complementary to the base sequence of desired DNA fragment. Probe can be either single stranded DNA or RNA, with radioactive or chemiluminescent label.</p>	<p>Isolate DNA from plant cells.</p> <p>Carry out, or analyse data on, the restriction and electrophoresis of DNA.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>cDNA production.</p> <p>ii Transformation and cloning.</p> <p>Advantages and disadvantages of using the bacterium <i>E. coli</i> and the yeast <i>S. cerevisiae</i> as recipients for foreign DNA.</p> <p>Cloning vectors.</p>	<p>Desired gene synthesised from its template mRNA using the enzyme reverse transcriptase. DNA-RNA hybrid formed and RNA removed by alkali. Single stranded DNA used to make double stranded DNA with DNA polymerase. Many copies of complementary DNA (cDNA) results when cDNA is cloned.</p> <p>To include: unicellular, quick growing micro-organisms, ideal for large scale production methods. <i>E. coli</i>: foreign DNA can account for 60% of total protein production. Advantages of <i>E. coli</i>: fast growing, easy to manipulate, easy to transform. Disadvantages of <i>E. coli</i>: post translational modifications to proteins not performed. Advantages of yeast: performs post translational modifications to protein, such as addition of sugar residues. Disadvantages of yeast: difficult to transform, yields less protein, plasmid vectors can be lost from yeast if there is no selective advantage to yeast in having the plasmid.</p> <p>Have a means of replicating in its host cell. Bacteriophage and plasmids are used as cloning vectors. They are genetically engineered so that foreign DNA can be inserted into them using DNA ligase; they contain antibiotic resistance marker genes and they contain part of the <i>lac</i> operon which is used to control expression of the foreign DNA.</p>	<p>Carry out bacterial transformation using kits approved for educational use.</p> <p>Produce a flow diagram to show the production process using <i>E. coli</i> and <i>S. cerevisiae</i>.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>Transformation.</p> <p>Cloning.</p> <p>d) Infection and immunity</p> <p>i Micro-organisms as pathogens.</p> <p>ii Production of antibodies and the role of blood cells.</p> <p>Cell-mediated response by T-lymphocytes.</p> <p>Production of humoral antibodies by B-lymphocytes.</p>	<p>The taking up of DNA. Transformed cells are grown in a media containing an antibiotic. Only cells which have taken up the cloning vector will grow on the antibiotic.</p> <p>Transformed bacteria are isolated, then grown and multiplied to produce genetically identical offspring called clones.</p> <p>Antibodies are proteins synthesised in response to foreign antigens. Natural immunity should be treated as the ability of the body to recognise foreign material and mobilise cells (cellular response) and cell products (humoral response) to deal with that foreign material</p> <p>The involvement of T-lymphocytes and B-lymphocytes in these responses should be taught, but no attempt made to distinguish between the structure of these cells. Mention should be made of the various ways in which T-lymphocytes and B-lymphocytes function, without naming the different sub-groups of these cells. The variety of antibody-antigen reactions need not be covered.</p>	<p>Obtain and present information on the way the HIV 1 (Human Immunodeficiency Virus) disrupts the mechanisms of the immune system.</p> <p>Carry out an investigation into antibody/antigen reaction using animal anti-sera.</p>

National Course Specification: course details (cont)

Unit 1: Microbiology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>iii The function of macrophages.</p> <p>Phagocytosis and the function of lysosomes.</p> <p>iv Immunity.</p> <p>Innate immunity.</p> <p>Acquired immunity: natural and artificial.</p> <p>Active and passive immunity.</p>	<p>The principles of vaccination should be understood in the context of artificially-acquired immunity as, for example, in vaccination against tetanus. Natural passive immunity is obtained via the placenta and breast milk. Artificial passive immunity can be given, eg with the injection of the tetanus antitoxin to someone suffering from tetanus.</p>	<p>Analyse data on the success of vaccination programmes in the global eradication of specified diseases.</p>

National Course Specification: course details (cont)

Unit 2: Microbiological Techniques (Higher)

Introduction

This unit is designed to allow candidates to develop competence in the laboratory procedures and techniques of microbiology and biotechnology. Along with the competencies developed *Working with Micro-organisms (Int. 2)*, the candidate should achieve a level of competence appropriate to working in a microbiology laboratory with minimum supervision.

CONTENT	NOTES	LEARNING ACTIVITIES
<p>a) Microbiological techniques</p> <p>1 Growth limitation and sterilisation techniques</p> <p>i Sterilisation and disinfection.</p> <p>Comparison of autoclaving, use of dry heat and gamma irradiation.</p> <p>Chemical disinfectants.</p> <p>Filtration methods.</p>	<p>Reference to good laboratory practice should be made throughout.</p> <p>Biocidal and biostatic effects.</p> <p>Sterilisation by autoclaving (typically 121°C for 15 minutes or 126°C for 10 minutes), dry heat (160°C for 2 hours) and gamma irradiation. Need for use of Browne's tubes or test strips to check sterilisation after autoclaving or dry heat. Suitability of sterilisation methods for different materials.</p> <p>The effects of exposure time and concentration. Uses of chlorine, phenolic, alcohol and multi-oxidising based disinfectants. Preparation and use of disinfectants for bench swabbing, surface sterilisation and disposal</p> <p>Filters trap micro-organisms due to small pore size/adsorption. Used to sterilise materials which cannot be sterilised by other methods.</p>	<p>Sterilise instruments, equipment and media by autoclaving and or dry heat.</p> <p>Use materials sterilised by gamma irradiation.</p> <p>Carry out an investigation to compare the effect of boiling and autoclaving on sporing and non-sporing bacteria.</p> <p>Use Browne's tubes to check sterilisation.</p> <p>Prepare and use disinfectants for bench swabbing, surface sterilisation and disposal.</p>

National Course Specification: course details (cont)

Unit 2: Microbiological Techniques (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>ii Risk assessment and coping with spillages.</p> <p>The difference between hazard and risk.</p> <p>Different types of risk assessment.</p> <p>The principles of control measures.</p> <p>Procedures for dealing with small-scale spillages of broths and containment of large scale spillages from fermenters.</p> <p>2 Culturing techniques</p>	<p>Hazard as source of risk/potential harm. Risk as probability of harm being realized.</p> <p>Description of simple (familiar hazard, well known control measures), generic (use of authoritative source of advice/code of practice) and novel (unfamiliar, from first principles) risk assessments.</p> <p>Choice of micro-organism (source and control of organism); selection of media; method of culture (growth conditions); choice of handling procedures including prevention of aerosol formation (scale of operation, degree of containment, likelihood of contamination); protective equipment.</p> <p>Reference to good working/laboratory practice including preparation of work-space, use of personal protective equipment, aseptic technique (to include flame sterilisation of equipment), disinfection and disposal on completion of work.</p>	<p>Study and use of an appropriate code of practice.</p> <p>Prepare risk assessments.</p> <p>Clear up simulated spillages in accordance with an appropriate code of practice.</p>

National Course Specification: course details (cont)

Unit 2: Microbiological Techniques (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>i Media preparation and sterilisation.</p> <p>Preparation of plates, slopes and broths for inoculation.</p> <p>Sterilisation and pouring of media.</p> <p>Suitability of media for inoculation.</p> <p>Types of media.</p> <p>ii Isolating and culturing micro-organisms.</p> <p>Loop and pipette transfer of micro-organisms.</p> <p>Use of selective and differential media and discrete growth characteristics to separate mixed cultures into component organisms and obtain pure cultures.</p> <p>Growth conditions of a range of micro-organisms.</p>	<p>Suitability of medium for inoculation to include dry, flat and smooth agar. Suitability of medium for growth of specific micro-organism.</p> <p>Nutrient components of complex and synthetic media. The use of agar and buffers. General purpose media. Selective media and their diagnostic use. Differential media and its use to distinguish between different organisms.</p> <p>From solid or liquid to solid or liquid. Steak plate inoculation.</p> <p>Growth characteristics to include range of temperature, pH, salt concentration, oxygen. Nature of pure cultures.</p> <p>Growth conditions to include temperature, pH, salt concentration, requirement of oxygen</p>	<p>Prepare media from a ready- made formula and from a recipe and autoclave.</p> <p>Prepare plates, slopes and broths for inoculation.</p> <p>Isolate pure cultures given mixed cultures.</p>

National Course Specification: course details (cont)

Unit 2: Microbiological Techniques (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>iii Enumerating micro-organisms.</p> <p>Total count.</p> <p>Serial dilutions.</p> <p>Viable count.</p> <p>Plaque assay</p> <p>iv Preparing a bacterial lawn.</p>	<p>Use of colorimeter/ spectrophotometer to determine turbidity (indirect count) and standard curves generated from known cell concentrations and used to determine unknowns. Use of haemocytometer for direct count. Possible sources of error.</p> <p>Procedure for dilution of cells to a number that can be easily counted.</p> <p>Plating of known volumes from serial dilutions, plate count and calculation of number of cells per unit volume.</p> <p>Serial dilution of bacteriophage followed by mixing known volume of greatest dilution of bacteriophage with bacterial broth culture, transferring known volume of mixture to agar plate, incubating and counting areas of clearing (plaques) caused by lysis of susceptible bacteria. Possible sources of error.</p> <p>The use of bacterial lawns in assay work to provide uniform growth across plate surface, eg response to antibiotic discs.</p>	<p>Use a haemocytometer to measure total cell count of a yeast culture.</p> <p>Use colorimeter to measure turbidity of broth culture.</p> <p>Plot a calibration curve of turbidity against total cell numbers.</p> <p>Estimate viable bacterial numbers by serial dilution and plate count.</p> <p>Estimate viable bacterial numbers by serial dilution and plate count.</p> <p>Prepare a bacterial lawn.</p>

National Course Specification: course details (cont)

Unit 2: Microbiological Techniques (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>v Tissue culture</p> <p>Callus culture: apical meristem culture.</p> <p>b) Identification of micro-organisms</p> <p>1 Microscopy.</p> <p>i Gram stain.</p>	<p>Description of micropropagation from (a) explants that produce callus tissue and from (b) apical meristems. Position of apical meristem. Need for sterile conditions.</p> <p>Importance of carbon source, plant growth substances (auxins and cytokinins) and vitamins in media to promote cell differentiation and subsequent plant development. Purpose to produce pathogen free clones of plants and rapid production of cloned offspring.</p> <p>Candidates are expected to be able to identify a range of micro-organisms from provided information related to Gram stain, morphology and results from biochemical tests.</p> <p>Use and purposes of Gram stain.</p>	<p>Carry out an investigation into the effects of different levels of plant growth substances on the development of explants.</p>

National Course Specification: course details (cont)

Unit 2: Microbiological Techniques (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
ii Morphology	Size, shape and arrangement of structures of micro-organisms. To include cocci, bacilli, spirilla, flagella, capsule, cell wall, sporangia.	Identify a range of bacteria using reaction to Gram stain and morphology.
2 Biochemical tests. Presence of specific micro-organisms identified using appropriate diagnostic tests.	Micro-organisms grown on media with diagnostic indicators to characterise and identify the micro-organisms.	Test for the presence of specific micro-organisms using a range of diagnostic tests.
i Extra cellular degradation.	Examples to include hydrolysis of starch, caesin, gelatin and fat to determine presence of these enzymes.	
ii Fermentation of carbohydrate.		
iii Tests measuring other biochemical reactions.	Examples to include: breakdown of hydrogen peroxide to determine catalase activity; presence of cytochrome c to determine oxidase activity.	

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

Introduction

This unit explores the technological advances in biotechnological processing methods, particularly the use of large scale cell and tissue culture, and enzyme production. Applications of biotechnology in the areas of agriculture and horticulture and clinical and forensic medicine are included to illustrate the economic, social and environmental importance of biotechnology. The sustainable nature of biotechnology is emphasised in relation to the recycling of materials and energy conservation.

CONTENT	NOTES	LEARNING ACTIVITIES
<p>a) Biotechnological processing</p> <p>1 Large scale cell and tissue culture production.</p> <p>i Laboratory models.</p> <p>ii Scaling up.</p>	<p>Candidates are expected to be able to analyse and produce flow diagrams of production processes.</p> <p>Used to determine optimum conditions (oxygen, temperature, pH and nutrient supply) for growth and reproduction of material to be cultured and/or product formation; mean generation time; range of substrates that can be used; rate at which nutrients used up; the stage when useful product produced; volume of gas consumed by cells or tissues as they grow.</p> <p>Production models used to scale up from laboratory fermenters to pilot plant to industrial plant (trial or investigative stage). Factors taken into account include cost, technical specification, containment of micro-organisms, exclusion of contaminants, control systems to allow temperature, pH and fluid volume to be maintained.</p>	<p>Produce a flow diagram of a production process.</p> <p>Obtain and present information on growth curves of industrial processes.</p> <p>Set up a small-scale laboratory fermenter and monitor and control various conditions such as pH and temperature.</p>

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>iii Industrial fermenters.</p> <p>2 Downstream processing as the extraction and purification of the desired end product (cells, solvent or solute).</p> <p>i Extracting cells from liquid culture.</p> <p>ii Obtaining solvent and solute.</p>	<p>Both aerobic and anaerobic used for large-scale fermentations as illustrated by continuous stirred tank bioreactor and anaerobic digesters. Features and functions of: stainless steel container, paddles, baffles, electrically-operated probes, anti-foaming agents water-jacket, sparger, air filter, pressure gauge, inoculation/sampling port, safety valve and harvest pipe.</p> <p>Flocculation/precipitation, and filtration as illustrated by yeast in alcohol production; freeze-drying of bacterial cells. Centrifugation less widely used due to cost.</p> <p>Flocculation/precipitation, ultrafiltration or centrifugation, distillation, drying and purification. Solvent extraction of Penicillin; distillation of alcohol. Citric and lactic acid precipitation by addition of lime or chalk. Protein purification using column chromatography on basis of size, charge or shape.</p>	<p>Visit a local fermentation plant.</p> <p>Autolyse yeast and test viability at different stages in a downstream process.</p> <p>Carry out protein purification by column chromatography.</p>

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>3 Comparison of batch and continuous flow processes.</p> <p>4 Enzymes in production.</p> <p>i Different processing techniques for production of intracellular and extracellular enzymes.</p> <p>ii Immobilisation of enzymes.</p>	<p>Batch culture: closed system, organism multiplies and changes conditions in medium by using up nutrients and producing waste, conditions become unfavourable. Useful for production of secondary metabolites such as Penicillin. Advantages of batch culture to include short fermentation time, ease of control, allows all stages of growth to occur.</p> <p>Continuous flow culture: fresh medium (substrate) supplied and product removed throughout, optimum conditions such as temperature and pH maintained. Used for production of metabolites such as lactic acid and vitamin C. Advantages to include increased productivity and continuous supply of product.</p> <p>Enzymes are produced by fungi or bacteria usually in batch cultures. Intracellular enzymes: break down of cell walls and membranes with enzymes or detergents; filtration and precipitation. Extracellular enzymes: filtration to remove cells and concentration by drying or column chromatography depending on purity required.</p> <p>Description of bonding (covalent), adsorption (non-covalent), and entrapment. Advantages: enzymes can be recycled, reduces cost, easier and cheaper separation of enzyme and product, improved stability of enzymes, reduces effluent disposal problems, ideal for continuous flow production.</p>	<p>Investigate methods of removing immobilised enzyme beads from the substrate.</p> <p>Carry out an investigation into the effects of immobilized β-galactosidase in milk.</p>

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>iii Uses of enzymes.</p> <p>5 Production of transgenic organisms.</p> <p>i Transgenic animals.</p> <p>ii Transgenic plants.</p>	<p>Wide range of uses as therapeutic and catalytic agents as illustrated by pectinase (clarifying fruit juice); urokinase (removal of fibrin clots after heart attacks); cellulase (manufacture of feedstock from waste material); and lysozyme (disruption of bacterial and yeast cells).</p> <p>Defined as genetically modified animals into which foreign DNA is inserted by microinjection or by viral infection into a fertilized egg. (Details of these techniques are not required.) Genetically modified organisms known as GMOs.</p> <p>Also known as GMOs: genetically modified plants into which DNA is inserted as exemplified by use of <i>Agrobacterium tumefaciens</i>. Foreign DNA carrying genes for desired characteristics inserted into bacterial plasmid. Plant cell protoplasts incubated with bacteria containing genetically engineered plasmid in medium which allows only those plant cells which have taken up the foreign DNA to grow.</p>	<p>Investigate the effect of pectinase, amylase, cellulase and RGase on the production and clarity of fruit juice.</p> <p>Investigate the action of cellulase on cellulose.</p> <p>Discuss case studies of the use of transgenic plants and animals.</p> <p>Inoculate plant tissue with <i>A. tumefaciens</i> and observe growth and development.</p>
<p>6 New breeding techniques.</p> <p>i Embryo manipulation.</p>	<p>Purpose is to produce a number of identical animals with desired characteristics.</p> <p>Fertilised egg bisected at the two-cell stage, each half transplanted into uterus results in double reproductive rate.</p>	

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>ii Embryo cloning.</p> <p>iii Somatic cell cloning.</p>	<p>Used to conserve desired features for future generations. Allows many genetically identical copies of an animal to be produced. Outline of process in mice to include egg from donor grown to blastocyst stage, undifferentiated cells isolated, nuclear transfer (nuclei removed and injected into donor egg cell from which nuclear material is removed), cells cultured to blastocyst stage and transplanted into surrogate mother.</p> <p>Similar process to embryo cloning except nuclear transfer from an adult cell (differentiated). As exemplified by Dolly the sheep and other mammalian examples.</p>	<p>Review newspaper articles on cloning.</p>
<p>b) Biotechnology applications</p> <p>1 Agriculture and horticulture applications.</p> <p>i Crop protection.</p> <p>Microbial pesticides.</p> <p>Transfer of gene for bacterial toxin into plants.</p>	<p>Micro-organisms introduced into an area plagued by insects as illustrated by the bacterium <i>Bacillus thuringiensis</i> which when it sporulates produces a crystalline protein toxin (Bt toxin) which kills, for example Gypsy Moth caterpillars, selectively.</p> <p>As an alternative to using the bacterium, transgenic tobacco and tomato plants which carry the gene have effective protection from insect damage.</p>	<p>View and discuss a video on the use of microbial pesticides on cotton plants.</p> <p>Examine photographs showing method of gene transfer.</p> <p>Discuss the benefits of biological methods of crop protection over chemical methods.</p>

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>Herbicide resistance.</p> <p>ii Plant production.</p> <p>2 Clinical and forensic medicine applications.</p> <p>i Producing vaccines by genetic engineering.</p> <p>Advantages over conventional production methods.</p> <p>Production of Hepatitis vaccine.</p> <p>ii Monoclonal antibodies.</p> <p>Production.</p>	<p>Wheat and maize can be transformed with genes that increase resistance to herbicides such as glyphosate. Gene codes for protein which degrades and detoxifies the herbicide.</p> <p>Use of tissue culture to produce large number of identical plants with desired characteristics, grown cheaply.</p> <p>As exemplified by plants producing vaccine.</p> <p>DNA coding for surface antigens of the virus are cloned in yeast cells which secrete the viral surface antigen. These viral antigens are purified and used as vaccine.</p> <p>B-lymphocytes fused with cancer cells to produce hybrid cells. The hybrid cells which produce the desired antibody are selected and cloned.</p>	

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
<p>Uses.</p> <p>iii Transgenic animals.</p> <p>Production of medical products by transgenic animals.</p> <p>Advantages and disadvantages over the use of micro-organisms.</p> <p>iv Stem cell culture.</p>	<p>Research tool, tissue-typing before organ transplantation, pregnancy testing, identifying infective agents such as HIV and glandular fever. Therapeutic uses eg monoclonal antibody medicines used as anti-cancer drugs.</p> <p>As illustrated by transgenic sheep and cattle with their genome altered by recombinant DNA technology. The required gene, eg for interferon or blood-clotting factors is inserted close to the gene that codes for milk production. Results in the secretion of the required protein in the animals' milk as exemplified by alpha-1-antitrypsin (AAT) production in milk of sheep. The social and ethical issues related to the use of transgenic animals.</p> <p>To include: more cost effective since there is no need for expensive large scale production culture vessels, continuous monitoring of equipment and maintenance; animals can add sugar residue to proteins; ability to secrete a required protein can be passed from one generation to next.</p> <p>Embryo cloning technique used to produce stem cells for use in treatment of disease and potential organ production. Social and ethical issues related to use of embryonic tissue.</p>	<p>Investigate meat types in different sausages by ELISA technique which uses species specific antibodies.</p> <p>Discuss the social and ethical issues related to the use of transgenic animals.</p>

National Course Specification: course details (cont)

Unit 3: Biotechnology (Higher)

CONTENT	NOTES	LEARNING ACTIVITIES
v DNA profiling.	Allows identification of individuals from the lengths of their DNA fragments after samples of their DNA have been treated with restriction endonucleases. Detection of genetic disorders.	Carry out DNA fingerprinting. Analyse data on DNA profiling.
3 Environmental applications.		
i Biosensors as pollution detectors.	Biosensors consist of a transducer with either an enzyme, antibody or cell that will react with the material to be detected. The signal produced can be electrical, in the form of a dye or luminescence. No further detail is required.	
ii Bioremediation.	Use of organisms to degrade, detoxify or accumulate contaminating chemicals as exemplified by contamination of soil and treatment of oil spillages.	

National Course Specification: course details (cont)

COURSE Biotechnology (Higher)

ASSESSMENT

To gain the award of the course, the candidate must pass all unit assessments as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When units are taken as component parts of a course, candidates will have the opportunity to achieve at levels beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates and to provide evidence for appeals. Further information on the key principles of assessment are provided in the paper *Assessment* (HSDU, 1996) and in *Managing Assessment* (HSDU, 1998)

DETAILS OF THE INSTRUMENTS FOR EXTERNAL ASSESSMENT

The external course examination will sample across all the learning outcomes, and achievement will be graded on the basis of cut-off scores.

The assessment of knowledge and understanding, problem solving and practical abilities will be based upon the course content described for the three units:

- Microbiology (H)
- Microbiological Techniques (H)
- Biotechnology (H).

The content contexts of these units will be sampled using a weighting of 2:1:2 in the course examination which will include familiar contexts as well as contexts which are less familiar and more complex than in the unit assessments. While there are no compulsory practicals for the purposes of external assessment, there will be questions set in the examination on practical work in contexts less familiar to candidates.

The examination will consist of one paper of 2 hours 30 minutes with a total of 130 marks. The paper will consist of three sections:

Section A

This section will contain 30 multiple-choice questions. Of these, between 9 and 11 questions will test problem solving and/or practical abilities, the remainder will test knowledge and understanding. Section A will have an allocation of 30 marks. Candidates will be expected to answer all the questions.

Section B

This section will contain structured questions and data handling questions with an allocation of 80 marks. Between 25 and 30 marks will test problem solving and/or practical abilities, the remainder will test knowledge and understanding. Candidates will be expected to answer all the questions.

Section C

This section will consist of four extended response questions to test the candidates' ability to select, organise and present relevant knowledge. Candidates will be expected to answer two of the four questions. Section C will have an allocation of 20 marks and will include:

National Course Specification: course details (cont)

COURSE Biotechnology (Higher)

- Two structured extended response questions each with an allocation of ten marks. Candidates will be expected to answer one of these questions. Marking schemes for these questions will be similar to current practice for essay questions.
- Two open extended response questions for 10 marks (1 mark for relevance, 1 mark for coherence and 8 marks for knowledge and understanding). Candidates will be expected to answer one of these questions.

GRADE DESCRIPTIONS

Grade description for C

Candidates at Grade C will have demonstrated success in achieving the component units of the course. In the course assessment, candidates will generally have demonstrated the ability to:

- retain knowledge and skills over a longer period of time
- integrate knowledge and understanding, problem solving and practical abilities acquired across component units
- apply knowledge and understanding, problem solving and practical abilities in contexts similar to those in the unit outcomes.

Grade description for A

In addition candidates at Grade A will generally have demonstrated the ability to:

- retain an extensive range of knowledge and skills over an extended period of time
- integrate an extensive range of knowledge and understanding, problem solving and practical abilities acquired across component units
- apply knowledge and understanding, problem solving and practical abilities in contexts less familiar and more complex than in the unit outcomes.

Testing for the course outcomes

The following gives advice on how these outcomes will be assessed in the course assessment.

Knowledge and understanding

Candidates should be tested on their ability to recall learning and understand facts and principles detailed in the content statements and supplementary notes in the content tables in the course specification.

Problem solving and practical abilities

Questions relating to each of the following points will be included in the course examination in order to test the candidate's ability to:

- 1 Select relevant information from texts, tables, charts, keys, graphs and/or diagrams.
- 2 Present information appropriately in a variety of forms, including written summaries, extended writing, tables and/or graphs.

National Course Specification: course details (cont)

COURSE Biotechnology (Higher)

- 3 Process information accurately using calculations where appropriate. Calculations to include percentages, averages and/or ratios. Significant figures and units should be used appropriately.
- 4 Plan and design experimental procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required.
- 5 Evaluate experimental procedures in situations that are unfamiliar, by commenting on the purpose of approach, the suitability and effectiveness of procedures, the control of variables, the limitations of equipment, possible sources of error and/or suggestions for improvements.
- 6 Draw valid conclusions and give explanations supported by evidence. Conclusions should include reference to the overall pattern to readings or observations, trends in results or comment on the connection between variables and controls.
- 7 Make predictions and generalisations based on available evidence.

Complexity of data

The following advice is intended as general guidelines in setting the complexity of data to be used in problem solving questions.

At Higher, typically two sources of data (text, tables, charts, keys, diagrams or graphs) should be provided from which the problem has to be solved. It is, however, recognised that extracting data from one source could be more demanding than extracting data from two sources for example, depending upon the nature of the data.

Where there are not two separate sources of data, the provided data should normally have two to three patterns, trends, conditions, variables or sets of results from which information has to be selected and presented, or which have to be used as sources of evidence for conclusions, explanations, predictions or generalisations. The analysis of data should involve comparisons between two or more of these sets of data.

The planning, designing and evaluation of experimental procedures should involve one to two of the following: one or two treatments, adequate controls, limitations of equipment, sources of error, and possible improvements as appropriate.

DETAILS OF THE INSTRUMENTS FOR INTERNAL ASSESSMENT

Unit Microbiology

Outcomes 1 and 2

Outcomes 1 and 2 are assessed by a single holistic closed-book test with questions covering all the performance criteria for knowledge and understanding and problem solving for the unit. The ratio of the marks allocated to Outcomes 1 and 2 is 3:2.

National Course Specification: course details (cont)

COURSE Biotechnology (Higher)

Outcome 3

A report of one problem solving activity related to Higher Biotechnology is required covering all the performance criteria set out in the unit specification.

Candidates are only required to produce one report on a problem solving activity for Higher Biotechnology. This report can be used as evidence for Outcome 3 in 'Microbiology' and for Outcome 2 in 'Biotechnology'.

Microbiological Techniques

Outcome 1

Outcome 1 is assessed by closed-book test which covers the performance criteria for this outcome.

Outcome 2

Outcome 2 is assessed by a checklist of microbiological techniques.

Biotechnology

Outcome 1

Outcome 1 is assessed by closed-book test which covers the performance criteria for this outcome.

Outcome 2

A report of one problem solving activity related to Higher Biotechnology is required, covering all the performance criteria set out in the unit specification.

Candidates are only required to produce one report on a problem solving activity for Higher Biotechnology. This report can be used as evidence for Outcome 3 in 'Microbiology' and for Outcome 2 in 'Biology'.

APPROACHES TO LEARNING AND TEACHING

Suggestions for appropriate learning activities are contained within the tables of course content. An investigative approach should be taken to the learning and teaching of Biotechnology. Such an approach not only draws heavily on experimental work, but should provide opportunities to develop individual and group research using a variety of resources alongside the more traditional approaches of whole class teaching.

Practical work should contain a balance of illustrative experimental work and investigative practical work. Practical work can provide one way of delivering theoretical knowledge related to knowledge and understanding performance criteria. Practical investigations should be used to develop both problem solving and practical skills and not just to provide reports for the purposes of internal assessment. For example, investigative work provides opportunities to develop the problem solving performance criteria of planning and designing an investigation and presents opportunities to make predictions and generalisations which can then be tested in practical contexts.

Laboratory work should include the use of instrumentation and equipment that reflects current scientific use. Opportunities should be taken to capture data through computer interfacing, data loggers or videos. Such data may then be analysed by information technology (IT) or used for control technology.

National Course Specification: course details (cont)

COURSE Biotechnology (Higher)

Use of the additional 40 hours

This time should be distributed throughout the duration of the course. It should be used:

- to provide an introduction to the course and assessment methods
- to allow more practical work to be undertaken by the candidates
- for remediation of particular aspects of work in which candidates require to be re-assessed
- for consolidation and integration of learning
- to practise techniques in answering multiple-choice questions
- to develop extended response writing skills
- to practise applying knowledge and understanding, problem solving and practical abilities in contexts more complex than in the units
- to complete Outcome 3 report.

SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT	Microbiology (Higher)
NUMBER	DF5H 12
COURSE	Biotechnology (Higher)

SUMMARY

This unit seeks to develop knowledge and understanding, problem solving and practical abilities in the context of the structure of micro-organisms of biotechnological significance, microbial metabolism, genetic engineering and infection and immunity. This is a component unit of Higher Biotechnology.

OUTCOMES

- 1 Demonstrate knowledge and understanding related to microbiology.
- 2 Solve problems related to microbiology.
- 3 Solve problems related to Higher Biotechnology.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Intermediate 2 Biotechnology
- Standard Grade Biology at Credit level
- Intermediate 2 Biology.

Administrative Information

Superclass:	RH
Publication date:	March 2004
Source:	Scottish Qualifications Authority
Version:	01

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National Unit Specification: general information (cont)

UNIT Microbiology (Higher)

CREDIT VALUE

1 credit at Higher (6 SCQF credit points at SCQF 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Microbiology (Higher)

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 the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to microbiology.

Performance criteria

- (a) Micro-organisms are described correctly in relation to their structure and uses.
- (b) Microbial metabolism is described correctly in terms of energy release, patterns of growth and copying and translating genes.
- (c) Genetic engineering is described correctly in relation to the use of genes.
- (d) Immunity is described correctly in relation to infection.

Evidence requirements

Evidence of an appropriate level of achievement must be generated from a closed-book test with items covering all the above performance criteria.

OUTCOME 2

Solve problems related to microbiology.

Performance criteria

- (a) Relevant information is selected and presented in an appropriate format.
- (b) Information is accurately processed using calculations where appropriate.
- (c) Conclusions drawn are valid and explanations given are supported by evidence.
- (d) Experimental procedures are planned, designed and evaluated appropriately.
- (e) Predictions and generalisations made are based on available evidence.

Evidence requirements

Evidence of an appropriate level of achievement must be generated from a closed-book test with items covering all the above performance criteria, with problems in the context of the structure of micro-organisms, microbial metabolism, genetic engineering or infection and immunity.

National Unit Specification: statement of standards (cont)

UNIT Microbiology (Higher)

OUTCOME 3

Solve problems related to Higher Biotechnology.

Performance criteria

- (a) The problem to be solved is identified.
- (b) Resources required to solve the problem are identified and obtained.
- (c) Procedures appropriate to solving the problem are planned and designed.
- (d) The planned procedures are carried out.
- (e) The problem solving procedure is evaluated.

Evidence requirements

A report of one problem solving activity covering the above performance criteria in relation to the content and notes specified for Higher Biotechnology. The report must be the individual work of the candidate. Depending on the activity, the problem solving may be groupwork.

National Unit Specification: support notes

UNIT Microbiology (Higher)

This part of the unit specification is offered as guidance. The support notes 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 CONTENT AND CONTEXT FOR THIS UNIT

Outcome 1

a) Structure of micro-organisms

- i Prokaryotes and eukaryotes.
- ii Bacteria.
Structure and function.
Shape.
Gram positive and Gram negative bacteria.
Uses.
- ii Fungi.
Structure.
Reproduction.
Uses.
- iii Viruses.
The nature of viruses and their invasion of cells.
Alteration of cell instructions to produce more viruses.
Types.
Uses.

b) Microbial metabolism

- 1 Energy release
The role and production of adenosine triphosphate (ATP):
 - i ATP as a means of transferring chemical energy.
Regeneration of ATP from ADP and inorganic phosphate.
 - ii Glycolysis: the breakdown of glucose to pyruvic acid with a net production of ATP in the cytoplasm.
 - iii Krebs (citric acid, tricarboxylic acid) cycle and cytochrome system. The location of these reactions within the cristae and matrix of the mitochondrion in eukaryotes.
Relationship of folding of inner membrane to activity of mitochondrion.
The production of ATP, carbon dioxide, hydrogen and reduced co-enzyme.
 - iv The distinction between anaerobic and aerobic phases of respiration with reference to location, level of ATP produced and final metabolic products.
 - v Fermentation.
- 2 Patterns of growth
 - i Factors affecting growth.
 - ii The bacterial growth curve in liquid media.

National Unit Specification: support notes (cont)

UNIT Microbiology (Higher)

- 3 Copying and translating genes
 - i DNA structure.
 - ii Single circular chromosome in prokaryotes.
 - iii Plasmids.
 - iv The structure of protein.
 - v RNA structure and function in protein synthesis.
The role of cellular organelles in protein synthesis.
 - vi An introduction to the Jacob-Monod hypothesis of gene action in bacteria.

c) Genetic engineering

- i Extraction and preparation of DNA sequences.
Purification of DNA.
Use of restriction endonucleases in gene sequences.
Separation of DNA fragments by gel electrophoresis and use of probes.
cDNA production.
- ii Transformation and cloning.
Advantages and disadvantages of using the bacterium *E. coli* and the yeast *S. cerevisiae* as recipients for foreign DNA.
Cloning vectors.
Transformation.
Cloning.

d) Infection and immunity

- i Micro-organisms as pathogens.
- ii Production of antibodies and the role of blood cells.
Cell-mediated response by T-lymphocytes.
Production of humoral antibodies by B-lymphocytes.
- iii The function of macrophages.
Phagocytosis and the function of lysosomes.
- iv Immunity.
Innate immunity.
Acquired immunity: natural and artificial.
Active and passive immunity.

Further detail is given in the supplementary notes in the course content section of the course specification.

National Unit Specification: support notes (cont)

UNIT Microbiology (Higher)

Outcome 2

Examples of learning activities which provide suitable contexts for the development of problem solving skills include:

- identify micro-organisms using keys
- identify a range of bacteria from prepared slides and flowcharts of identifying characteristics
- analyse data on different fermentation processes
- analyse data on bacterial population count
- obtain information from a variety of sources on the nature of DNA and RNA and their roles in protein synthesis
- analyse data on the restriction and electrophoresis of DNA
- produce a flow diagram to show the production process using *E. coli* and *S. cerevisiae*
- obtain and present information on the way the HIV 1 (Human Immunodeficiency Virus) disrupts the mechanisms of the immune system
- analyse data on the success of vaccination programmes in the global eradication of specified diseases.

Outcome 3

Suitable experiments in the context of this unit include:

- identify a range of bacteria using reaction to Gram stain and morphology
- design and carry out an investigation to show the activity of dehydrogenase enzymes in yeast
- demonstrate fermentation and/or lactic acid production in souring milk
- temperature/pH/glucose concentration on the growth of a named micro-organism
- carry out an investigation into the effects of β -galactosidase enzyme on lactose in milk
- carry out an investigation into antibody/antigen reaction using animal sera and antisera.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Details of suitable approaches are provided in the course specification.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

It is recommended that a holistic approach is taken to assessment, eg Outcomes 1 and 2 could be assessed by an integrated end of unit test with questions covering all the performance criteria for knowledge and understanding and problem solving. The National Assessment Bank will provide advice on suitable approaches.

National Unit Specification: support notes (cont)

UNIT Microbiology (Higher)

Outcome 2

Test items should be constructed to allow candidates to generate evidence relating to the performance criteria as follows:

- a) Selecting and presenting information:
 - sources of information to include: texts, tables, charts, graphs and diagrams
 - formats of presentation to include: written summaries, extended writing, tables and graphs.
- b) Calculations to include: percentages, averages, ratios. Significant figures and units should be used appropriately.
- c) Conclusions drawn should include some justification.
- d) Candidates could plan and design procedures to test given hypotheses or to illustrate particular effects. This could include identification of variables, controls and measurements or observations required. The evaluation of given experimental procedures may include situations which are unfamiliar to candidates and could test the candidates' ability to comment on the purpose of approach or the suitability of given experimental procedures. Candidates could comment on the limitations of the set-up, apparatus, suggested measurements or observations, limitations of equipment, appropriateness of controls, sources of error and possible improvements.
- e) Candidates could make predictions and generalisations from given experimental results or, given situations, predict what the results might be.

Outcome 3

This involves the submission of one report of a problem solving activity related to Higher Biotechnology.

Candidates are only required to produce one report on a problem solving activity for Higher Biotechnology. This report can be used as evidence for Outcome 3 in 'Microbiology' and for Outcome 2 in 'Biotechnology'.

The 'Outcome 2: Teacher/lecturer guide' is provided to indicate what might be addressed to achieve a specific performance criterion. The relevance of the items will vary according to the problem solving activity being undertaken eg bullet points which refer to variables would not apply in a case study type problem solving activity. The professional judgement of the teacher/lecturer will be important in deciding if a performance criterion has been met for a particular activity.

National Unit Specification: support notes (cont)

UNIT Microbiology (Higher)

Outcome 2: Teacher/Lecturer guide

All the performance criteria given in the left-hand column must be achieved in order to attain the outcome. The right-hand column gives suggestions which might aid the professional judgement of the assessor.

Performance criteria	Suggestions to aid professional judgement
(a) The problem to be solved is identified.	Main features of the problem are identified.
(b) Resources required to solve the problem are identified and obtained.	Resources might include: <ul style="list-style-type: none"> • sources of information • set procedures • people • equipment/physical resources • materials.
(c) Procedures appropriate to solving the problem are planned and designed.	The plan might include: <ul style="list-style-type: none"> • what is to be measured/collected • variable altered • variable kept constant • how many readings/measurements/observations/subjects • equipment/resources required • how data will be recorded, analysed and presented.
(d) The planned procedures are carried out.	This would include a record of the data collected, analysis and presentation of data. Data should be analysed and presented in tabular, graphical format or as a scatter diagram or equivalent as appropriate: <ul style="list-style-type: none"> • for tabular presentation this must include: suitable headings and units showing averages or other appropriate computations • for graphical presentation this must include: data presented as a histogram, bar chart, connected points, line of best fit as appropriate, with suitable skills and axes labelled with quantities and units and with data correctly plotted.
(e) The problem solving procedure is evaluated.	The evaluation might include: <ul style="list-style-type: none"> • an assessment of the effectiveness of the procedure including: planning and organising and the outcome of the activity • drawing valid conclusions, which make use of the presented evidence • suggestions for alternative or modified strategies, further work, predictions or generalisations • an assessment/explanation of the relevance of the results.

National Unit Specification: support notes (cont)

UNIT Microbiology (Higher)

The bullet points under each performance criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the experiment. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to moderation) against the performance criteria. It is appropriate to support candidates in producing a report to meet the performance criteria. Re-drafting of a report after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting and resubmission is only required if the entire report does not need to be rewritten.

Conditions required to complete the report

Teachers and lecturers may wish candidates to write up reports under their direct supervision so that they can provide appropriate advice and support. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidates' response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Use of IT

Candidates may, if they wish, present their reports in a word-processed format. Candidates may use Excel (or any other suitable data analysis software) when tackling Outcome 3. However, candidates must not be given a spreadsheet with pre-prepared column headings nor formulae, as they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. The use of clip art or images captured by digital camera may also be used in recording details of experimental methods.

Transfer of evidence

Candidates may transfer evidence for Outcome 3 from one level to the one below provided the experiments are in the context of the course concerned.

Candidates, who are repeating a course, may carry forward evidence of an appropriate standard, generated in a previous year.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT	Microbiological Techniques (Higher)
NUMBER	D042 12
COURSE	Biotechnology (Higher)

SUMMARY

This unit seeks to develop knowledge, understanding and practical skills in growth limitation and sterilisation, culturing and identifying micro-organisms. This is a component unit of Higher Biotechnology.

OUTCOMES

- 1 Demonstrate knowledge and understanding related to microbiological techniques.
- 2 Carry out techniques related to microbiology.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Intermediate 2 Biotechnology
- Standard Grade Biology at Credit level
- Intermediate 2 Biology.

Administrative Information

Superclass:	RH
Publication date:	June 2002
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Version:	04

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National Unit Specification: general information (cont)

UNIT Microbiological Techniques (Higher)

CREDIT VALUE

1 credit at Higher (6 SCQF credit points at SCQF 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

There is no automatic certification of core skills or core skills components in this unit.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Microbiological Techniques (Higher)

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 the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to microbiological techniques.

Performance criteria

- (a) Microbiological techniques are described correctly in relation to growth limitation and sterilisation, and culturing.
- (b) The identification of micro-organisms is described correctly in terms of the Gram stain and biochemical tests.

Evidence requirements

Evidence of an appropriate level of achievement must be generated from a closed-book test with items covering both the above performance criteria.

OUTCOME 2

Carry out techniques related to microbiology.

Performance criteria

- (a) The preparation for work is in accordance with given specifications.
- (b) Techniques are carried out in accordance with safe practice and given specifications.
- (c) The record of work is clear and accurate.
- (d) Results and relevant observations are reported clearly.

Note on the range for the outcome

Techniques: growth limitation and sterilisation; culturing micro-organisms; identifying micro-organisms.

Evidence requirements

A checklist of the individual work of the candidate covering all of the above performance criteria for all of the range.

National Unit Specification: support notes

UNIT Microbiological Techniques (Higher)

This part of the unit specification is offered as guidance. The support notes 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 CONTENT AND CONTEXT FOR THIS UNIT

Outcome 1

a) Microbiological techniques

- 1 Growth limitation and sterilisation techniques
 - i Sterilisation and disinfection.
Comparison of autoclaving, use of dry heat and gamma irradiation.
Chemical disinfectants.
Filtration methods.
 - ii Risk assessment and coping with spillages.
The difference between hazard and risk.
Different types of risk assessment.
The principles of control measures.
Procedures for dealing with small-scale spillages of broths and containment of large scale spillages from fermenters.
- 2 Culturing techniques
 - i Media preparation and sterilisation.
Preparation of plates, slopes and broths for inoculation.
Sterilisation and pouring of media.
Suitability of media for inoculation.
Types of media.
 - ii Isolating and culturing micro-organisms.
Loop and pipette transfer of micro-organisms.
Use of selective and differential media and discrete growth characteristics to separate mixed cultures into component organisms and obtain pure cultures.
Growth conditions of a range of micro-organism.
 - iii Enumerating micro-organisms.
Total count.
Serial dilutions.
Viable count.
Plaque assay.
 - iv Preparing a bacterial lawn.
 - v Tissue culture.
Callus culture: apical meristem culture.

b) Identification of micro-organisms

- 1 Microscopy.
 - i Gram stain.
 - ii Morphology.

National Unit Specification: support notes (cont)

UNIT Microbiological Techniques (Higher)

- 2 Biochemical tests.
 Presence of specific micro-organisms identified using appropriate diagnostic tests.
 - i Extra cellular degradation.
 - ii Fermentation of carbohydrate.
 - iii Tests measuring other biochemical reactions.

Outcome 2

Techniques related to growth limitation and sterilisation:

- sterilise instruments, equipment and media by autoclaving
- use Browne's tubes to check sterilisation
- prepare and use disinfectants for bench swabbing, surface sterilisation and disposal
- clear up simulated spillages in accordance with an appropriate code of practice.

Techniques related to culturing micro-organisms:

- prepare media from a ready made formula and from a recipe and autoclave
- prepare plates, slopes and broths for inoculation
- isolate pure cultures given mixed cultures
- estimate viable bacterial numbers by serial dilution and plate count
- use a haemocytometer to measure total cell count of a yeast culture
- use colorimeter to measure turbidity of broth culture
- prepare a bacterial lawn.

Techniques related to identifying micro-organisms:

- identify a range of bacteria using reaction to Gram stain and morphology
- test for the presence of specific micro-organisms using a range of diagnostic tests.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Details of suitable approaches are detailed in the course specification.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Details of suitable approaches will be available from the National Assessment Bank.

Outcome 1

Outcome 1 for this unit is assessed by a test designed to provide evidence that the outcome and performance criteria have been achieved. The National Assessment Bank provides advice on suitable approaches.

National Unit Specification: support notes (cont)

UNIT Microbiological Techniques (Higher)

Outcome 2

Candidates are required to demonstrate competence in carrying out one technique from each of: growth limitation and sterilisation; culturing micro-organisms; identifying micro-organisms. The National Assessment Bank provides guidance on assessment of performance of these techniques in relation to the performance criteria.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT	Biotechnology (Higher)
NUMBER	DF5J 12
COURSE	Biotechnology (Higher)

SUMMARY

This unit seeks to develop knowledge and understanding, problem solving and practical abilities in the context of biotechnological processing, agriculture and horticulture applications, and clinical and forensic medicine applications. This is a component unit of Higher Biotechnology.

OUTCOMES

- 1 Demonstrate knowledge and understanding related to biotechnology.
- 2 Solve problems related to Higher Biotechnology.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Intermediate 2 Biotechnology
- Standard Grade Biology at Credit level
- Intermediate 2 Biology.

Administrative Information

Superclass:	RH
Publication date:	March 2004
Source:	Scottish Qualifications Authority
Version:	01

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National Unit Specification: general information (cont)

UNIT Biotechnology (Higher)

CREDIT VALUE

1 credit at Higher (6 SCQF credit points at SCQF 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Biotechnology (Higher)

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 the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to biotechnology.

Performance criteria

- (a) Biotechnological processing is described correctly in relation to production methods.
- (b) Biotechnology is described correctly in terms of its agricultural and horticultural applications, and clinical and forensic medicine applications.

Evidence requirements

Evidence of an appropriate level of achievement must be generated from a closed-book test with items covering both the above performance criteria.

OUTCOME 2

Solve problems related to Higher Biotechnology.

Performance criteria

- (a) The problem to be solved is identified.
- (b) Resources required to solve the problem are identified and obtained.
- (c) Procedures appropriate to solving the problem are planned and designed.
- (d) The planned procedures are carried out.
- (e) The problem solving procedure is evaluated.

Evidence requirements

A report of one problem solving activity covering the above performance criteria in relation to the content and notes specified for Higher Biotechnology.

The report must be the individual work of the candidate. Depending on the activity, the problem solving may be groupwork.

National Unit Specification: support notes

UNIT Biotechnology (Higher)

This part of the unit specification is offered as guidance. The support notes 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 CONTENT AND CONTEXT FOR THIS UNIT

Outcome 1

a) Biotechnological processing

- 1 Large scale cell and tissue culture production.
 - i Laboratory models.
 - ii Scaling up.
 - iii Industrial fermenters.

- 2 Downstream processing as the extraction and purification of the desired end product (cells, solvent or solute).
 - i Extracting cells from liquid culture.
 - ii Obtaining solvent and solute.

- 3 Comparison of batch and continuous flow processes.

- 4 Enzymes in production.
 - i Different processing techniques for production of intracellular and extracellular enzymes.
 - ii Immobilisation of enzymes.
 - iii Uses of enzymes.

- 5 Production of transgenic organisms.
 - i Transgenic animals.
 - ii Transgenic plants.

- 6 New breeding techniques.
 - i Embryo manipulation.
 - ii Embryo cloning.
 - iii Somatic cell cloning.

b) Biotechnology applications

- 1 Agriculture and horticulture applications
 - i Crop protection.
Microbial pesticides.
Transfer of gene for bacterial toxin into plants.
Herbicide resistance.
 - ii Plant production.

- 2 Clinical and forensic medicine applications
 - i Producing vaccines by genetic engineering.
Advantages over conventional production methods.
Production of Hepatitis vaccine.

National Unit Specification: support notes (cont)

UNIT Biotechnology (Higher)

- ii Monoclonal antibodies.
Production.
Uses.
 - iii Transgenic animals.
Production of medical products by transgenic animals.
Advantages and disadvantages over the use of micro-organisms.
 - iv Stem cell culture.
 - v DNA profiling.
- 3 Environmental application
- i Biosensors as pollution detectors.
 - ii Bioremediation.

Outcome 2

Examples of suitable learning activities for this outcome include:

- set up a small scale laboratory fermenter and monitor and control various conditions such as pH and temperature
- autolyse yeast and test viability at different stages in a downstream process
- investigate the effect of pectinase, amylase, cellulase and RGase on the production and clarity of fruit juice
- investigate the action of cellulase on cellulose
- investigate methods of removing immobilised enzyme beads from the substrate
- analyse data on DNA profiling.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Details of suitable approaches are provided in the course specification.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcome 1

Outcome 1 for this unit is assessed by a test designed to provide evidence that the outcome and performance criteria have been achieved.

The National Assessment Bank will provide advice on suitable approaches.

Outcome 2

This involves the submission of one report of a problem solving activity related to Higher Biotechnology.

Candidates are only required to produce one report on a problem solving activity for Higher Biotechnology. This report can be used as evidence for Outcome 3 in 'Microbiology' and for Outcome 2 in 'Biology'.

National Unit Specification: support notes (cont)

UNIT Biotechnology (Higher)

The 'Outcome 2: Teacher/Lecturer guide' is provided to indicate what might be addressed to achieve a specific performance criterion. The relevance of the items will vary according to the problem solving activity being undertaken eg bullet points which refer to variables would not apply in a case study type problem solving activity. The professional judgement of the teacher/lecturer will be important in deciding if a performance criterion has been met for a particular activity.

National Unit Specification: support notes (cont)

UNIT Biotechnology (Higher)

Outcome 2: Teacher/Lecturer guide

All the performance criteria given in the left-hand column must be achieved in order to attain the outcome. The right-hand column gives suggestions which might aid the professional judgement of the assessor.

Performance criteria	Suggestions to aid professional judgement
(a) The problem to be solved is identified.	Main features of the problem are identified.
(b) Resources required to solve the problem are identified and obtained.	Resources might include: <ul style="list-style-type: none"> • sources of information • set procedures • people • equipment/physical resources • materials.
(c) Procedures appropriate to solving the problem are planned and designed.	The plan might include: <ul style="list-style-type: none"> • what is to be measured/collected • variable altered • variable kept constant • how many readings/measurements/observations/subjects • equipment/resources required • how data will be recorded, analysed and presented.
(d) The planned procedures are carried out.	This would include a record of the data collected, analysis and presentation of data. Data should be analysed and presented in tabular, graphical format or as a scatter diagram or equivalent as appropriate: <ul style="list-style-type: none"> • for tabular presentation this must include suitable headings and units showing averages or other appropriate computations • for graphical presentation this must include data presented as a histogram, bar chart, connected points, line of best fit as appropriate, with suitable scales and axes labelled with quantities and units and with data correctly plotted.
(e) The problem solving procedure is evaluated.	The evaluation might include: <ul style="list-style-type: none"> • as assessment of the effectiveness of the procedure including planning and organising and the outcome of the activity • drawing valid conclusions, which make use of the presented evidence • suggestions for alternative or modified strategies, further work, predictions or generalisations • an assessment/explanation of the relevance of the results.

National Unit Specification: support notes (cont)

UNIT Biotechnology (Higher)

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).