Subject benchmark statement

Biomedical science

Draft for consultation June 2007

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Preface

Subject benchmark statements provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject or subject area. They also represent general expectations about standards for the award of qualifications at a given level in terms of the attributes and capabilities that those possessing qualifications should have demonstrated.

This subject benchmark statement, together with others published concurrently, refers to the **bachelor's degree with honours**[1]. In addition, some subject benchmark statements provide guidance on integrated master's awards.

Subject benchmark statements are used for a variety of purposes. Primarily, they are an important external source of reference for higher education institutions (HEIs) when new programmes are being designed and developed in a subject area. They provide general guidance for articulating the learning outcomes associated with the programme but are not a specification of a detailed curriculum in the subject.

Subject benchmark statements also provide support to HEIs in pursuit of internal quality assurance. They enable the learning outcomes specified for a particular programme to be reviewed and evaluated against agreed general expectations about standards. Subject benchmark statements allow for flexibility and innovation in programme design and can stimulate academic discussion and debate upon the content of new and existing programmes within an agreed overall framework. Their use in supporting programme design, delivery and review within HEIs is supportive of moves towards an emphasis on institutional responsibility for standards and quality.

Subject benchmark statements may also be of interest to prospective students and employers, seeking information about the nature and standards of awards in a given subject or subject area.

The relationship between the standards set out in this document and those produced by professional, statutory or regulatory bodies for individual disciplines will be a matter for individual HEIs to consider in detail.

This subject benchmark statement represents a revised version of the original published in 2002. The review process was overseen by the Quality Assurance Agency for Higher Education (QAA) as part of a periodic review of all subject benchmark statements published in this year. The review and subsequent revision of the subject benchmark statement was undertaken by a group of subject specialists drawn from and acting on behalf of the subject community. The revised subject benchmark statement went through a full consultation with the wider academic community and stakeholder groups.

QAA publishes and distributes this subject benchmark statement and other subject benchmark statements developed by similar subject-specific groups.

[1] This is equivalent to the honours degree in the Scottish Credit and Qualifications Framework (level 10) and in the Credit and Qualifications Framework for Wales (level 6).

The Disability Equality Duty (DED) came into force on 4 December 2006[2]. The DED requires public authorities, including HEIs, to act proactively on disability equality issues. The Duty complements the individual rights focus of the *Disability Discrimination Act* (DDA) and is aimed at improving public services and outcomes for disabled people as a whole. Responsibility for making sure that such duty is met lies with HEIs.

The Disability Rights Commission (DRC) has published guidance[3] to help HEIs prepare for the implementation of the Duty and provided illustrative examples on how to take the duty forward. HEIs are encouraged to read this guidance when considering their approach to engaging with components of the Academic Infrastructure[4], of which subject benchmark statements are a part.

Additional information that may assist HEIs when engaging with subject benchmark statements can be found in the DRC revised *Code of Practice: Post-16 Education*[5], and also through the Equality Challenge Unit[6] which is established to promote equality and diversity in higher education.

[2] In England, Scotland and Wales
[3] Copies of the guidance *Further and higher education institutions and the Disability Equality Duty*, guidance for principals, vice-chancellors, governing boards and senior managers working in further education colleges and HEIs in England, Scotland and Wales, may be obtained from the DRC at www.drc-gb.org/library/publications/disabilty_equality_duty/further_and_higher_education.aspx
[4] An explanation of the Academic Infrastructure, and the roles of subject benchmark statements within it, is available at www.qaa.ac.uk/academicinfrastructure
[5] Copies of the DRC revised *Code of Practice: Post-16 Education* may be obtained from the DRC at www.drc-gb.org/employers_and_service_provider/education/higher_education.aspx
[6] Equality Challenge Unit, www.ecu.ac.uk

Foreword

The core of this revised subject benchmark statement remains similar to that of the statement published in 2002, although, where appropriate, it has been updated to reflect recent developments. The introduction has been modified to make explicit what degrees this statement refers to while the section on benchmark standards has been expanded considerably to articulate threshold and typical levels of achievement expected of an honours graduate in biomedical science.

May 2007

1 Introduction

1.1 This subject benchmark statement defines the subject area of biomedical science relating to bachelor's degrees with honours, incorporating this title, offered by universities in the United Kingdom (UK). There are three types of biomedical science degrees:

i integrated degrees accredited by the Institute of Biomedical Science [7] (IBMS) and/or approved by the Health Professions Council[8] (HPC). Integrated degrees may be either full-time or part-time where academic study is integrated with work-based learning in an approved NHS laboratory
ii degrees accredited by the IBMS (full-time degrees may have a sandwich year or optional placement(s) in an NHS, research or industrial laboratory)
iii degrees which are not accredited by the IBMS (these degree programmes may also offer a sandwich year or optional placements).

1.2 This subject benchmark statement applies to those biomedical science degrees that are IBMS-accredited and/or HPC-approved. Those interested in non-accredited or non-approved programmes may wish to refer to the subject benchmark statement for bioscience, in addition to this document. This statement is intended to be valuable to potential students, their parents and guardians, employers, professional and regulatory bodies, universities, colleges and schools.

1.3 The statement is not a syllabus and no form of prescription is intended in the amount of time devoted to each component or the order in which the material is presented, or the titles of subject areas which comprise biomedical science. It is expected, therefore, that providers of bachelor's degree with honours programmes will combine, teach and assess the subject matter in different ways. Creativity and diversity are encouraged. The statement will provide, however, an inventory of content, delivery method and assessment of programmes, thus enabling identification of vital components of biomedical science honours degrees in whichever form they are presented by HEIs in the UK.

1.4 Honours graduates in biomedical science are readily employable in a wide range of areas in the public and private sectors due to their education at the interface between biological science in its broadest sense and medical science.

2 Defining principles

2.1 An honours degree programme in biomedical science is designed to give graduates a broad understanding of the scientific investigation of human health and disease. An honours graduate will have the qualities needed for employment in situations which require the exercise of professionalism, independent thought, personal responsibility and decision making in complex and unpredictable circumstances.

[7] IBMS is the professional body for biomedical scientists in the UK. It aims to promote and develop biomedical science and its practitioners.

[8] The HPC is the UK statutory and regulatory body that maintains a register of health professionals, including biomedical scientists. It works to protect the health and well-being of people using the services of health professionals. Only those individuals who meet the HPC standards of proficiency for their professional skills are eligible to become registered.

2.2 Biomedical science is concerned with the integration of a wide range of subjects, ie biology, chemistry and, to a lesser extent, physics and mathematics, to understand the pathobiology of human disease. Pathobiology, in this sense, means predominantly human anatomy, physiology, biochemistry, genetics, immunology, microbiology, and cell and molecular biology. More specific knowledge of disease processes comes from the study of clinical laboratory specialities, such as cellular pathology, clinical biochemistry, clinical immunology, haematology, transfusion science, clinical genetics and medical microbiology. This enables a biomedical scientist to understand the science of the causes, consequences, diagnosis and treatment of disease.

2.3 Biomedical science plays a pivotal and essential role in healthcare. Most of the component subjects are at the forefront of modern science and therefore attract leading-edge research activity. This means that biomedical science is a rapidly evolving subject and highly relevant to investigating and understanding current controversies, concerns and dilemmas of modern life such as food safety, the use of stem cells, assisted reproductive technologies, pre-implantation embryo diagnosis and genetic manipulation (cloning and gene therapy). It is also critical to the understanding of major health problems of international importance such as malaria, human immunodeficiency virus (HIV) infection, methicillin-resistant *Staphylococcus aureus* (MRSA) infection, cardiovascular disease, diabetes, obesity, cancer and dementia.

2.4 Graduates in biomedical science enter a very buoyant employment market and are sought by a wide range of employers. Major employment areas include:

- NHS clinical laboratories
- National Blood Service laboratories
- private pathology laboratories
- Health Protection Agency
- veterinary and agricultural laboratories
- clinical genetics laboratories
- forensic laboratories
- research laboratories in universities
- government or charity-funded research laboratories
- research and development for the pharmaceutical, diagnostics, medical devices and laboratory instrumentation industries
- clinical trials, regulatory affairs (drug registration and patents)
- commerce (sales and marketing) related to healthcare and diagnostic products
- education: university, college and school teaching
- food industry and food safety
- biotechnology industry.

2.5 In order to gain employment as a biomedical scientist in the NHS in the UK, it is a legal requirement to be registered with the HPC. In order to be eligible for registration with the HPC, graduates need to hold an integrated degree approved by the HPC and/or accredited by the IBMS, or an IBMS-accredited degree that is supported by a period of approved postgraduate clinical training.

2.6 Not all HEIs providing biomedical science degrees seek such approval or accreditation. Graduates from non-approved or non-accredited degrees who wish to seek HPC registration usually require supplementary education from an accredited programme.

2.7 Biomedical science graduates enter a rapidly changing environment in which lifelong learning plays an essential role. Many biomedical science graduates achieve additional qualifications before or after taking up employment including MSc, PhD, professional doctorates and postgraduate medicine. Professional doctorates are recently developed qualifications which assist biomedical scientists to function at the highest levels within the profession.

3 Nature and extent of biomedical science

3.1 Biomedical science involves a multidisciplinary approach to the study of human disease. Graduates must have knowledge of why and how diseases develop, and how disease affects the normal structure and functions of the human body. They will have an awareness of the current methods used for the laboratory investigation, diagnosis and monitoring of disease and for biomedical research. This will include an appreciation of the development and evaluation of new methods. Graduates will also be familiar with current and developing therapeutic intervention strategies.

3.2 The complex multidisciplinary nature of biomedical science requires a sound, research-informed, scientific education. Graduates need to have knowledge of several key subject areas. Biomedical science students are encouraged to integrate the knowledge base of various key disciplines to further their understanding of the laboratory investigation, diagnosis, monitoring and therapy of human disease as well as the contributions made by biomedical research. This can be achieved by the incorporation of a pathobiology component within the programme.

3.3 Advances in biomedical science as a result of research and development impact upon the health and well-being of society. Knowledge of research design and the appropriate use of statistical analysis to enable a valid interpretation of experimental results is required. Students are required to undertake appropriate practical education throughout their programme, which is progressive in nature and designed to supplement other academic learning. Final-year students will be equipped with the skills necessary to enable them to plan and perform a research project and be aware of the need for good laboratory practice, health and safety, and legal and ethical considerations.

4 Subject knowledge and understanding

4.1 Biomedical science graduates acquire knowledge in the subject areas indicated below. The sub-headings are not intended to imply module titles and the subject matter is not intended to constrain module content.

Basic knowledge

i **Human anatomy and physiology** refers to the structure, function and control of the human body, its component parts and major systems.

ii **Cell biology** is the study of the structure and function of cells (and the organelles they contain) and includes their life cycle, division, self-replication and eventual death.

iii **Biochemistry** is the study of chemical processes which support life. It requires knowledge of key chemical principles which are relevant to biological systems and includes the structure and function of biological molecules and cellular metabolism and its control.

iv **Genetics** is the study of the structure and function of genes (including their role in human disease) and inheritance.

v **Molecular biology** is that branch of biology that deals with the manipulation of nucleic acids (deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)) so that genes can be isolated, sequenced or mutated. It covers methods which allow the insertion of new genes into the genome or the deletion of genes from the genome of an organism. It allows the functions of genes and the effects of gene mutations to be investigated.

vi **Immunology** is the study of components of the immune system, their structure, function and mechanisms of action. It includes innate and acquired immunity.

vii **Microbiology** is the study of the structure, physiology, biochemistry, classification and control of micro-organisms, including the role of normal flora.

Clinical laboratory specialities

4.2 These subjects[9] specifically address the knowledge and understanding of disease processes in the context of laboratory investigation and include the following.

i **Cellular pathology** is the microscopic examination of normal and abnormal cells (cytopathology), and tissues (histopathology) for indicators of disease. A biomedical science graduate will have a knowledge of:

- the preparation of cells and tissues for microscopic examination
- microscopy and its applications
- the gross structure and ultrastructure of normal cells and tissues and the structural changes which may occur during disease
- the principles and applications of visualisation and imaging techniques.

ii **Clinical biochemistry** is the evaluation of analytes to aid the screening, diagnosis and monitoring of disease. A biomedical science graduate will have knowledge of:

- the principles and applications of routine methods used in clinical biochemistry
- the investigation of the function and dysfunction of organs and systems and of the biochemical changes in disease
- the principles of the biochemical investigations used in the diagnosis, treatment and monitoring of disease
- therapeutic drug monitoring and investigation of substance abuse.

[9] The traditional disciplines of cellular pathology, clinical biochemistry, clinical immunology, haematology, transfusion science, clinical genetics and medical microbiology are increasingly being reconfigured into blood science, cellular science and infections in major pathology service units in the NHS. This subject benchmark statement presents the essential topics in traditional style.

iii **Clinical immunology** is the study of immunopathological conditions and abnormal immune function. A biomedical science graduate will have knowledge of:

- the causes and consequences of diseases associated with abnormal immune function, neoplastic diseases of the immune system and transplantation reactions together with their diagnosis, treatment and monitoring
- immunological techniques used in clinical and research laboratories
- the principles of the function and measurement of effectors of the immune response
- the principles of organ transplantation
- the detection and monitoring of treatment of neoplasia
- hypersensitivity, immunodeficiency, autoimmunity
- prophylaxis and immunotherapy.

iv **Haematology** is the study and investigation of the different elements that constitute blood in normal and diseased states. A biomedical science graduate will have knowledge of:

- blood cell production (haematopoiesis)
- the structure and function of blood cells
- the nature and diagnosis of anaemias
- haemoglobinopathies and thalassaemias
- haematological malignancy
- haemostasis and thrombosis.

v **Transfusion science** is the identification of blood group antigens and antibodies which ensures a safe supply of blood and blood components. A biomedical science graduate will have knowledge of:

- the genetics, inheritance, structure and role of red cell antigens
- the preparation, storage and use of blood components
- the selection of appropriate blood components for transfusion and possible adverse effects
- immune mediated destruction of blood cells
- the role of histocompatibility antigens in transplantation.

vi **Clinical genetics** is the identification of genetic mutations and polymorphisms and their influence on disease processes. A biomedical science graduate will have knowledge of:

- the principles of the methods used to study human chromosomes and DNA
- epigenetics
- the identification of genes for Mendelian diseases
- testing and screening for genetic susceptibility.

vii **Medical microbiology** is the study and investigation of pathogenic microorganisms. A biomedical science graduate will have knowledge of:

- the pathogenic mechanisms of a range of microorganisms
- the laboratory investigation and the epidemiology of infectious diseases
- food, water and environmental microbiology
- anti-microbial and anti-viral therapy (including drug resistance)
- infection control.

Integrated studies

4.3 Programmes should contain a reflective, integrated component in which these clinical laboratory specialities are represented in a system-led approach to the study of disease and its treatment.

5 Subject-specific skills and other skills

5.1 A biomedical science graduate will be aware of the need for compliance with health and safety policies, good laboratory practice, risk and control of substances hazardous to health assessments, the *Human Tissue Act 2004,* and the importance of quality control and quality assurance. Students who graduate from integrated programmes have the opportunity to demonstrate competence in these and other skills in a clinical laboratory environment.

5.2 There are a range of skills which a biomedical science graduate will have the opportunity to acquire during the programme of study:

- discipline and subject-specific skills associated with biomedical laboratory practice including use of relevant instrumentation, liquid handling, aseptic techniques, sample preparation and safe handling of specimens
- research skills, including ethics, governance, audit, experimental design, statistical analysis, literature searching, critical appraisal of literature, scientific communication
- key transferable skills (communication, information technology, numeracy, data analysis).

6 Teaching, learning and assessment

6.1 The primary aim of teaching, learning and assessment strategies is to equip students with the necessary subject knowledge skills to make a contribution within biomedical science following graduation. Cross-referencing of topics from one section to another is essential to ensure effective teaching and integrated learning. These strategies are designed to be enriching, stimulating, challenging, effective and enjoyable.

6.2 Teaching, learning and assessment are progressive throughout programmes to encourage the transition from dependent to independent learning, so that students become increasingly responsible for their own learning as the programme advances and throughout the rest of their professional careers.

6.3 This is supported by clear, detailed and accurate documentation, which is available to students and must specify the overall rationale of the programme and individual modules. Syllabus details, learning outcomes, assessment regulations and scheduling are also included.

6.4 Teaching is conducted by appropriately qualified professionals who undertake pertinent and ongoing staff development relevant to the educational aspects of subject discipline(s) for which they are responsible. All student learning is appropriately underpinned by research, scholarship and professional practice of teaching staff. HEIs are encouraged to establish formal links with local employers to maintain the currency of their programme.

6.5 Motivation and challenge of the student requires a skilled and balanced selection of teaching and learning techniques. Blended learning is encouraged and developed through a combination of the following methodologies (which are not intended to be prescriptive or exhaustive):

- lectures (traditional, interactive, and virtual learning environment)
- tutorials
- seminars and workshops
- laboratory sessions
- self-directed study
- computer-aided learning
- case studies and problem-based learning
- demonstrations
- active learning sets
- work-based learning and/or placements
- reflective practice (including personal development plans)
- project work.

6.6 Assessment strategies are integral to teaching and learning. The instruments of assessment must accord with the stated learning outcomes and be appropriate to the level of study.

6.7 A large number of assessment methods have been developed to measure the knowledge, competence, understanding and ability of students within specified criteria. Assessment methods may include the following (which are not intended to be prescriptive or exhaustive):

- unseen examinations
- open book examinations
- essays
- laboratory reports
- project reports
- analytical and data interpretation exercises
- poster presentations
- oral presentations
- learning logs, portfolios, diaries and personal development plans

- peer review
- oral examinations
- abstract writing and journal article reviews.

7 Benchmark standards

7.1 It is recognised that biomedical science programme designers will achieve the goals set for standards in various ways and this will be demonstrated in individual programme specifications.

7.2 The achievement of the knowledge and skills described in this subject benchmark statement is monitored by such measures as anonymous and double marking of assessment. Central to this process is the involvement of external examiners with responsibility for ensuring that standards in any particular institution are comparable with others.

7.3 The benchmark standards have been divided into three groups: those that are subject-specific and apply more specifically to either the basic knowledge or the clinical laboratory specialities described in section 4, and those that are generic and pertain to all areas of biomedical science. The statement recognises that it would be prescriptive to set out standards for all the areas of knowledge and skills listed in sections 4 and 5 and has therefore articulated standards for a selection to exemplify the standards expected of a graduate in biomedical science.

7.4 Each standard is divided into ‘threshold’ and ‘typical’ levels of achievement. The threshold level is intended as the minimal acceptable achievement of an honours graduate towards the bottom of the Third class category. The typical level represents a higher level of achievement commensurate with that of an honours graduate towards the bottom of the Upper Second class category.

Basic knowledge

Threshold standards	Typical standards
On graduating with a bachelor's degree with honours in biomedical science, students should be able to:	
• demonstrate a sufficient knowledge of the structure and function of the cardiovascular, endocrine, gastrointestinal, nervous, renal, reproduction, neurological, respiratory and skeletal systems of the human body	• demonstrate sound knowledge of the structure and function of the cardiovascular, endocrine, gastrointestinal, nervous, renal, reproduction, neurological respiratory and skeletal systems of the human body with some evidence of reference to pertinent literature
• describe clearly the control of the functioning of the component parts of the above systems	• demonstrate a clear knowledge and understanding of the integrated control of the component parts of the major systems of the human body
• have a knowledge of basic human anatomy and physiology sufficient to underpin studies in the clinical laboratory specialities	• have the depth of knowledge and understanding of human anatomy and physiology to thoroughly support detailed studies in the clinical laboratory specialities
• have a knowledge and understanding of prokaryote and eukaryote cell structure and function (including organelles) and how cells respond to stress and injury	• have a detailed knowledge and understanding of how cell structure is adapted for function in a wide variety of cells (and organelles) and of the mechanisms by which stress and injury affect cell structure and function
• have some knowledge and understanding of cell structure and function at the molecular level, and have some appreciation of the interplay of complex molecular events that help to maintain cell homeostasis	• have a detailed knowledge and understanding of cell structure and function at the molecular level and be able to illustrate the molecular mechanisms involved in regulating homeostasis, eg cell communication, vesicle trafficking, protein synthesis, processing and targeting, cell cycle, and cell death
• relate the structure and function of carbohydrates, lipids, nucleic acids and proteins to the chemical properties of their building materials	• have a sound knowledge and understanding of key structural features of macromolecules which determine their functional capabilities
• describe metabolic pathways as interconnected sequences of coupled enzyme-catalysed reactions and interrelate catabolism and anabolism	• demonstrate the requisite knowledge and understanding of the salient features of metabolic pathways
• explain the synthesis of storage forms of fuel molecules and their degradation to provide usable energy through metabolic processes	• demonstrate a sound knowledge and understanding of adenosine triphosphate generation in human cells, including oxidative phosphorylation

• describe intracellular and extracellular strategies to regulate cellular metabolism	• demonstrate a clear understanding of the factors, internal and external, which effect the regulation of cellular metabolism in health and disease
• understand how the principles of genetics underlie modern molecular biology	• have a critical understanding of the molecular basis of genetics, and be able to explain some detailed examples
• understand the main principles of gene expression	• have a critical knowledge and understanding of the structure, arrangement, expression and regulation of genes, and of relevant experimental methods
• have a knowledge and understanding of innate and acquired immunity	• have a detailed knowledge and understanding of innate and acquired immunity and of the regulation of immune responses, and be able to discuss specific examples
• have a knowledge of important morphological features of the major classes of microorganisms and be able to handle, culture and observe microorganisms in a safe and asceptic manner.	• understand the physical and chemical requirements for microbial growth, appreciate how morphological features affect microbial physiology and be able to identify selected microorganisms.

Clinical laboratory specialities

Threshold standards	**Typical standards**
On graduating with a bachelor's degree with honours in biomedical science, students should be able to:	
• describe the microscopic appearance of normal and abnormal cells and tissues	• discuss the microscopic appearance of cells and tissues and relate these to underlying disease processes
• describe the changes cells and tissues undergo when removed from the body, the principles of fixation, methods for the preparation of cells and tissues (including cytological and frozen material), decalcification and embedding techniques	• understand the principles of fixation and application of fixatives for optimal demonstration cells and tissues and discuss methods for the preparation of cells and tissues and know when and when not to use them
• describe the principles and practice of microtomy, and of section mounting	• discuss the principles and practice of microtomy, and be aware of a range of microtomes, and be able to discuss the principles and practice of section mounting and understand the requirement for good quality sections
• describe the principles of simple routine staining procedures and demonstrate practical ability in their application	• discuss the principles of a wide range of routine staining procedures (including immunocytochemistry and immunofluorescence) and have a knowledge of their application for disease diagnosis

• describe the principles and practice of light, fluorescent and electron microscopy and understand their role in the diagnosis of disease	• discuss the application of different specialised forms of microscopy such as phase contrast, polarised light and scanning electron microscopy
• have a knowledge and understanding of the biochemical responses that may occur in a range diseases states	• have a detailed knowledge and understanding of the biochemical responses which may occur in a wide range diseases states and explain in detail the molecular mechanisms involved in such responses
• have an appreciation of how biochemical changes associated with disease are assessed in the clinical laboratory and how information about such changes is applied to the diagnosis and monitoring of disease	• have a detailed and critical appreciation of how biochemical changes associated with disease are assessed in the clinical laboratory, be confident with the application of appropriate quality control measures and be able to critically evaluate how information about biochemical changes can be used in the diagnosis and monitoring of disease
• have a knowledge and understanding of the causes and consequences of diseases associated with abnormal immune function, neoplastic diseases of the immune system and transplantation reactions	• have a detailed critical knowledge and understanding of the causes and discuss in detail the pathophysiology of a range of diseases associated with abnormal immune function, neoplastic diseases of the immune system and transplantation reactions
• have an appreciation of how diseases associated with abnormal immune function, neoplastic diseases of the immune system and transplantation reactions are diagnosed, treated and monitored	• have a detailed knowledge and understanding and be able to critically evaluate how a range of diseases associated with abnormal immune function, neoplastic diseases of the immune system and transplantation reactions are diagnosed, treated and monitored
• have a knowledge and understanding of diseases of haematopoiesis and haemostasis, and of the anaemias and leukaemias	• have a detailed knowledge and understanding of diseases of haematopoiesis and haemostasis, and of the anaemias and leukaemias, and be able to interpret critically the results of laboratory tests to diagnose these and other diseases
• explain the biochemical basis of the human ABO blood group system	• explain the biochemical basis and calculate the mode of inheritance of various blood group systems
• appreciate the selection, preparation, storage and safe provision of appropriate blood components	• demonstrate an awareness of how blood component therapy can be used effectively and efficiently in order to optimise patient benefit
• be aware of the possible adverse effects associated with the use of blood and blood products	• identify the causes, signs and symptoms of haemolytic transfusion reactions and other adverse reactions and to have an awareness of the significance of serious hazards of transfusion reports

• have a knowledge of the role of histocompatibility antigens in transplantation	• appreciate the significance of histocompatibility antigens and their role in rejection reactions involving allografts
• demonstrate knowledge of some diagnostic options where genetic disease is suspected	• demonstrate a wide knowledge of diagnostic options where genetic disease is suspected, showing a good understanding of the methods available for diagnostic and molecular analysis
• understand the rationale behind the human genome project	• discuss the rationale behind the human genome project and how this may alter both diagnosis and treatment of diseases
• explain how mutations in DNA can give rise to the pathological changes seen in some diseases and how these mutations may be inherited	• have a detailed knowledge of how mutation in DNA can give rise to the pathological changes seen in several diseases and be able to calculate modes of inheritance
• understand and carry out quantitative and qualitative methods to enumerate, identify and determine antibiotic sensitivity of microoorganisms of medical importance	• have a detailed knowledge of the principles and practices used in the isolation, identification and determination of antibiotic sensitivity of selected human pathogens
• describe selected serological and molecular methods used in the diagnosis of infectious diseases.	• have a detailed knowledge of several serological and molecular methods used in the diagnosis of infectious diseases, and how such methods will influence medical microbiology in the future.

Generic skills

Threshold standards	**Typical standards**
On graduating with a bachelor's degree with honours in biomedical science, students should be able to:	
• access biomedical science information from a variety of sources and to communicate the principles in an appropriate manner	• access and evaluate biomedical science information from a variety of sources and to communicate the principles both orally and in writing (eg essays, laboratory reports) in a way that is well-organised and topical
• have ability in a range of practical techniques relevant to biomedical science including data collection, analysis and interpretation of those data, and testing of hypotheses;	• demonstrate ability in a range of appropriate practical techniques and skills relevant to research in biomedical science, including the ability to place the work in context and to suggest lines of further investigation

• have an understanding of the explanation of biomedical concepts at all levels of biological organisation ranging from molecules to intact organisms	• have a secure and accurate understanding of the explanation of biomedical concepts at all levels of biological organisation ranging from molecules to intact organisms
• plan, execute and present an independent piece of work (eg a project) within a supported framework in which qualities such as time management, problem solving and independence are evident	• plan, execute and present an independent piece of work (eg a project), in which qualities such as time management, problem solving and independence are evident, as well interpretation and critical awareness of the quality of evidence
• have some understanding of ethical issues and their impact on advances in biomedical science	• construct reasoned arguments to support their position on ethical issues which impact on advances in biomedical science
• record data accurately, and to carry out basic manipulation of qualitative and quantitative data (and some statistical analysis when appropriate)	• apply relevant advanced numerical skills (including statistical analysis where appropriate) to data
• have developed basic strategies to enable them to update their knowledge of biomedical science.	• have well-developed strategies for updating, maintaining and enhancing their knowledge of biomedical science.

Appendix A - Membership of the review group for the subject benchmark statement for biomedical science

Prof David Billington (Chair)	Liverpool John Moores University
Dr Jim Blackstock	Glasgow Caledonian University
Prof Bill Gilmore	Manchester Metropolitan University
Dr Robert Munro	University of Wales Institute Cardiff
Dr Sue Parkin	University of Bradford
Mr Alan Wainwright	Institute of Biomedical Science

Appendix B - Membership of the original benchmarking group for biomedical science

Details below appear as published in the original subject benchmark statement for biomedical science (2002).

Ms Helen Allen	Altnagelvin Hospital, Londonderry
Dr Yvonne Barnett	University of Ulster
Dr Jim Blackstock	Glasgow Caledonian University
Dr Maureen Bowen	University of Wales Institute, Cardiff
Mr John Fulthorpe	Institute of Biomedical Science.
Mr Robin Knight	National Blood Service, London
Mrs Mary Popeck	University College London Hospital NHS Trust
Professor David Rogers (Chair)	University of Portsmouth
Mr Gordon Sutehall	Addenbrooke's Hospital, Cambridge
Mr Andrew Usher	North Bristol NHS Trust