QAA

Subject Benchmark Statement

Biomedical Sciences

November 2015

UK Quality Code for Higher Education
Part A: Setting and maintaining academic standards

Contents

How can I use this document?

This document is a Subject Benchmark Statement for biomedical sciences that defines what can be expected of a graduate in the subject, in terms of what they might know, do and understand at the end of their studies.

You may want to read this document if you are:

- involved in the design, delivery and review of programmes of study in biomedical sciences or related subjects
- a prospective student thinking about studying biomedical sciences, or a current student of the subject, to find out what may be involved
- an employer, to find out about the knowledge and skills generally expected of a graduate in biomedical sciences.

Explanations of unfamiliar terms used in this Subject Benchmark Statement can be found in the Quality Assurance Agency for Higher Education's glossary.[1]

[1] The QAA glossary is available at: www.qaa.ac.uk/about-us/glossary.

About Subject Benchmark Statements

Subject Benchmark Statements form part of the UK Quality Code for Higher Education (Quality Code) which sets out the Expectations that all providers of UK higher education reviewed by QAA are required to meet.[2] They are a component of Part A: Setting and Maintaining Academic Standards, which includes the Expectation that higher education providers 'consider and take account of relevant Subject Benchmark Statements' in order to secure threshold academic standards.[3]

Subject Benchmark Statements describe the nature of study and the academic standards expected of graduates in specific subject areas, and in respect of particular qualifications. They provide a picture of what graduates in a particular subject might reasonably be expected to know, do and understand at the end of their programme of study.

Subject Benchmark Statements are used as reference points in the design, delivery and review of academic programmes. They provide general guidance for articulating the learning outcomes associated with the programme but are not intended to represent a national curriculum in a subject or to prescribe set approaches to teaching, learning or assessment. Instead, they allow for flexibility and innovation in programme design within a framework agreed by the subject community. Further guidance about programme design, development and approval, learning and teaching, assessment of students, and programme monitoring and review is available in Part B: Assuring and Enhancing Academic Quality of the Quality Code in the following Chapters:[4]

- *Chapter B1: Programme Design, Development and Approval*
- *Chapter B3: Learning and Teaching*
- *Chapter B6: Assessment of Students and the Recognition of Prior Learning*
- *Chapter B8: Programme Monitoring and Review*.

For some subject areas, higher education providers may need to consider other reference points in addition to the Subject Benchmark Statement in designing, delivering and reviewing programmes. These may include requirements set out by professional, statutory and regulatory bodies, national occupational standards and industry or employer expectations. In such cases, the Subject Benchmark Statement may provide additional guidance around academic standards not covered by these requirements.[5] The relationship between academic and professional or regulatory requirements is made clear within individual statements, but it is the responsibility of individual higher education providers to decide how they use this information. The responsibility for academic standards remains with the higher education provider who awards the degree.

Subject Benchmark Statements are written and maintained by subject specialists drawn from and acting on behalf of the subject community. The process is facilitated by QAA. In order to ensure the continuing currency of Subject Benchmark Statements, QAA initiates regular reviews of their content, five years after first publication, and every seven years subsequently.

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[2] The Quality Code, available at www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code, aligns with the *Standards and Guidelines for Quality Assurance in the European Higher Education Area*, available at: www.enqa.eu/wp-content/uploads/2015/05/ESG_endorsed-with-changed-foreword.pdf

[3] Part A: Setting and Maintaining Academic Standards, available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/quality-code-part-a.

[4] Individual Chapters are available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/quality-code-part-b.

[5] See further Part A: Setting and Maintaining Academic Standards, available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/quality-code-part-a.

Relationship to legislation

Higher education providers are responsible for meeting the requirements of legislation and any other regulatory requirements placed upon them, for example, by funding bodies. The Quality Code does not interpret legislation nor does it incorporate statutory or regulatory requirements. Sources of information about other requirements and examples of guidance and good practice are signposted within the Subject Benchmark Statement where appropriate. Higher education providers are responsible for how they use these resources.[6]

Equality and diversity

The Quality Code embeds consideration of equality and diversity matters throughout. Promoting equality involves treating everyone with equal dignity and worth, while also raising aspirations and supporting achievement for people with diverse requirements, entitlements and backgrounds. An inclusive environment for learning anticipates the varied requirements of learners, and aims to ensure that all students have equal access to educational opportunities. Higher education providers, staff and students all have a role in, and responsibility for, promoting equality.

Equality of opportunity involves enabling access for people who have differing individual requirements as well as eliminating arbitrary and unnecessary barriers to learning. In addition, disabled students and non-disabled students are offered learning opportunities that are equally accessible to them, by means of inclusive design wherever possible and by means of reasonable individual adjustments wherever necessary.

[6] See further the *UK Quality Code for Higher Education: General Introduction*, available at: www.qaa.ac.uk/publications/information-and-guidance/publication/?PubID=181.

About this Subject Benchmark Statement

This Subject Benchmark Statement refers to bachelor's degrees with honours in biomedical sciences.[7]

This version of the Statement forms its third edition, following initial publication in 2002 and review and revision in 2007.[8]

Note on alignment with higher education sector coding systems

Programmes of study which use this Subject Benchmark Statement as a reference point are generally classified under codes within group B: Subjects Allied to Medicine in the Joint Academic Coding System (JACS).[9] This includes the following sub-codes:

B100 Anatomy, physiology and pathology
B200 Pharmacology, toxicology and pharmacy
B400 Nutrition

Programmes may also be classified under codes in group C: Biological Sciences.

Summary of changes from the previous Subject Benchmark Statement (2007)

This Subject Benchmark Statement for Biomedical Sciences has been revised substantially from the Biomedical Sciences Statement published in 2007. The latter related solely to the study of biomedical science, focusing on the pathobiology of disease. The updated Statement covers all of the biomedical sciences relating to human health and disease including generic biomedical sciences programmes and specialist and vocational programmes such as biomedical science, pharmacology, human nutrition and human physiology.

This Subject Benchmark Statement has been developed in close collaboration with the 2015 review of the Biosciences Subject Benchmark Statement. The Biosciences Statement has also been revised substantially from the statement published in 2007, and is based on the organismal biosciences and the molecular biosciences. As such the Biomedical Sciences and the Biosciences Subject Benchmark Statements should together be of value to inform the full range of programmes available in the UK.

[7] Bachelor's degrees are at level 6 in *The Framework for Higher Education Qualifications in England, Wales and Northern Ireland* and level 10 in *The Framework for Qualifications of Higher Education Institutions in Scotland*, as published in *The Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies*, available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/qualifications.
[8] Further information is available in the *Recognition Scheme for Subject Benchmark Statements*, available at: www.qaa.ac.uk/publications/information-and-guidance/publication?PubID=190.
9 Further information about JACS is available at: www.hesa.ac.uk/content/view/1776/649/.

1 Introduction

1.1 This Subject Benchmark Statement defines the biomedical sciences subject area and relates to bachelor's degree programmes with honours, and the undergraduate elements of integrated master's degree programmes offered by degree-awarding bodies in the UK. Biomedical Sciences is a key subject area encompassing all areas of biology related to human health and disease. This highly topical, dynamic area is continually advancing, contributing important benefits not only to the health of individuals and the nation, but also to the economic activity of the UK. The subject area includes those science programmes whose primary focus is the biology of human health and disease and ranges from generic programmes in biomedical sciences and human biology to more specialised or vocational programmes in areas such as biomedical science, pharmacology, human physiology and human nutrition. This Subject Benchmark Statement identifies the core areas which form the basis of all programmes in the biomedical sciences, as well as those relating to specialist and vocational programmes in this subject area. As such it has significant and necessary overlap with the Biosciences Subject Benchmark Statement, particularly with regard to common areas which provide the basis for degree programmes in both subject areas.

1.2 The Subject Benchmark Statement is not a syllabus and no form of prescription is intended in the amount of time devoted to each component, the order in which the material is presented, nor the titles of subjects which comprise the biomedical sciences. It is expected, therefore, that providers of bachelor's degree with honours programmes and/or integrated master's degree programmes combine, teach and assess the subject matter in different ways and support the development of a wide range of practical skills. Creativity and diversity are encouraged. The statement provides, however, an inventory of content, delivery and assessment methods, as well as benchmark standards, thus enabling identification of vital components of biomedical sciences honours degrees in whichever form they are offered by higher education providers in the UK.

1.3 This Statement is intended to be valuable to potential students, their supporters and sponsors, employers, professional and regulatory bodies, universities, colleges and schools.

2 Defining principles

2.1 An honours degree programme in the biomedical sciences is designed to provide graduates with a broad understanding of the scientific basis of human health and disease. Graduates from these programmes 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.

2.2 Degree programmes in the biomedical sciences are underpinned by a number of related sciences including biology, chemistry, mathematics, information technology and, to a lesser extent, physics. Core biomedical sciences subjects include: human anatomy, physiology, biochemistry, genetics, immunology, microbiology, pharmacology, cell and molecular biology and Bioinformatics.

2.3 The biomedical sciences play a pivotal and essential role in health and healthcare. Most of the component subjects are at the forefront of modern science and therefore involve leading edge research activity. The biomedical sciences are rapidly evolving subjects and essential to the investigation and understanding of many of the current controversies, concerns and dilemmas of modern life such as diet and health, food safety, new microbiological threats, the potential impact of various biotechnologies such as genomics, proteomics, stem cell technology and reproductive technologies on health and well-being, and associated ethical concerns. They are critical to the understanding of major biological processes, such as ageing, and health problems of international importance such as infectious diseases, cardiovascular disease, diabetes, obesity, cancer and dementia.

2.4 Graduates in the biomedical sciences enter a rapidly changing employment environment in which lifelong learning plays an essential role. Many graduates of degree programmes in the biomedical sciences attain additional qualifications before or after taking up employment including master's degrees (MSc), doctoral degrees (PhD/DPhil and professional doctorates), postgraduate medical qualifications and teaching qualifications.

2.5 The employment market for graduates in the biomedical sciences is buoyant. A biomedical sciences degree is considered as an excellent basis for a wide variety of future graduate-entry career paths, some of which have a significant practical component. Major employment areas include:

- clinical and community healthcare
- clinical genetics laboratories
- clinical trials and regulatory sector
- commerce (sales and marketing) related to healthcare and diagnostic products
- diagnostic pathology and clinical laboratories
- education: university, college and school teaching
- food industry and food safety
- forensic laboratories
- government or charity-funded research laboratories and institutes
- lifescience industry
- Public Health England
- National Health Service
- National Health Service - Blood and Transplant
- research and development for the pharmaceutical, diagnostics, medical devices and laboratory instrumentation industries
- research laboratories in universities
- veterinary and agricultural laboratories.

3 Nature and extent of the biomedical sciences

3.1 Study of the biomedical sciences involves a multidisciplinary approach to the understanding of human health and disease. Graduates have knowledge of why and how health is maintained, how diseases, disorders and the ageing process develop, and how they affect the normal structure and functions of the human body.

3.2 The complex and rapidly evolving nature of the biomedical sciences requires a sound, research-informed, scientific education. Depending upon the focus of their degree programme, students of the biomedical sciences are expected to integrate the knowledge base of various key subjects to further their understanding of health maintenance, disease prevention, and the investigation, diagnosis, monitoring and therapy of human disease, as well as developments being made possible by biomedical research.

3.3 Advances in biomedical sciences impact significantly upon the health and well-being of society and the nation's economy. Graduates are expected to have an appreciation of the importance of research and knowledge of research design and the appropriate use of statistical analyses to enable a valid interpretation of experimental and survey results. Students undertake appropriate practical (sometimes clinical) education and/or fieldwork throughout their programmes; these aspects are progressive in nature and designed to supplement other academic learning. By the end of their programme students are equipped with the skills necessary to enable them to plan and perform a research project and are aware of the need for good laboratory practice and, if relevant, survey design and execution, health and safety, and legal and ethical aspects of research design and analysis.

3.4 Undergraduate degree programmes in the biomedical sciences in the UK exist in a number of different forms. Most are offered at bachelor's level. Some are integrated master's programmes, which include an additional year of study at master's level. Some programmes may include a sandwich year or work placements. Some include professional and practical training in order to fulfil statutory and/or accreditation requirements of relevant regulatory or professional bodies.

3.5 The range of biomedical sciences programmes include:

- Generic degrees in biomedical sciences and closely related areas of human biology.
- Integrated degrees in biomedical science accredited by the Institute of Biomedical Science (IBMS) and/or approved by the Health and Care Professions Council (HCPC).[10] Integrated degrees may be either full or part-time where academic study is integrated with work-based learning in an approved pathology laboratory.
- Biomedical science degrees accredited by the IBMS (full-time degrees may have a sandwich year or optional placement(s) in a pathology research or industrial laboratory).

[10] IBMS is the UK professional body for biomedical science in the UK. Its aims are to promote and develop biomedical science and its practitioners, further information available at: www.ibms.org. The HCPC is the UK statutory and regulatory body that maintains a register of health and care professionals. It seeks to protect the health and well-being of people using the services of health professionals by ensuring an appropriate level of education and training. Only those individuals who meet the HCPC standards of proficiency for their professional skills are eligible to apply to become registered, further information available at: www.hcpc-uk.org.

- Healthcare Science (Life Science) degrees, which have specialist pathways. These are accredited by the National School of Healthcare Science,[11] and to enable graduates to be eligible to apply for registration as a biomedical scientist also accredited by the IBMS and/or approved by the HCPC.
- Human nutrition degree programmes meeting the competency requirements for accreditation by the Association for Nutrition.[12] Some of these programmes include dietetics training and are accredited by the British Dietetic Association and approved by the HCPC.
- Programmes with an emphasis on the core biomedical sciences with significant elements of, for example, pharmacology, human or medical physiology.

Some of the above programmes, may be accredited by other bodies, including the Royal Society of Biology.[13]

[11] The National School of Healthcare Science was established as part of the Modernising Scientific Careers (MSC) programme to support the implementation and delivery of the new healthcare science education and training programmes and to comply with the structures within 'Liberating the NHS: Developing Healthcare Workforce - Policy 16977 (January 2012)' acting on behalf of the Chief Scientific Officer (CSO) for England. It also provides some elements of support for the three other UK health departments, further information available at: www.nshcs.org.uk.

[12] The Association for Nutrition Association holds the UK Voluntary Register of Nutritionists (UKVRN) and their purpose is to protect and benefit the public by defining and advancing standards of evidence-based practice across the field of nutrition and setting standards of competence for the wider nutrition workforce, available at: www.associationfornutrition.org.

[13] Further information available at www.rsb.org.uk.

4 Graduate and key transferable skills

4.1 The subject content of individual programmes of study in the biomedical sciences depends on the specific degree being offered and the institutional context. However, it will include the opportunity to develop a range of more generic graduate and transferable skills (detailed in this section) along with core biomedical knowledge, understanding and skills (detailed in section 5) and specialist, subject-specific knowledge, understanding and skills (detailed in section 6). Whatever the subject, students should expect to be confronted by some of the scientific, moral and ethical questions raised by their subject of study, to consider viewpoints other than their own, and to engage in critical assessment and intellectual argument.

Intellectual skills

4.2 Biomedical sciences graduates should be able to:

i recognise and apply subject-specific theories, paradigms, concepts or principles (for example, the relationship between genes and proteins, or the nature of essential similarities and differences between prokaryote and eukaryote cells)
ii make evidence-based decisions
iii obtain and integrate several lines of subject-specific evidence to formulate and test hypotheses
iv apply subject knowledge and understanding to address familiar and unfamiliar problems
v recognise the moral and ethical issues of investigations and appreciate the need for ethical standards and professional codes of conduct.

Practical and professional skills

4.3 Biomedical sciences graduates should be able to:

i demonstrate competence in the basic experimental skills appropriate to the subject(s) studied
ii demonstrate an awareness and knowledge of quality assurance and quality control principles as part of an understanding of the need for quality management systems and a culture of continued quality improvements of relevance to the subject(s) of study
iii plan an experiment in terms of hypothesis, sample, test or observation, controls, observable outcomes and statistical analysis
iv conduct and report on investigations, which may involve primary or secondary data (for example from a survey database). These data may be obtained through individual or group projects in the appropriate subject
v obtain, record, collate and analyse data using appropriate practical techniques, working individually or in a group, as is most appropriate for the subject
vi undertake practical investigations in a responsible, safe and ethical manner, paying due attention to risk assessment, relevant health and safety regulations, ethical issues, procedures for obtaining ethical permission and informed consent and issues relating to animal welfare and showing sensitivity to the potential impact of any investigations on the study and on other stakeholders.

Analytical, data interpretation and problem solving skills

4.4 Biomedical sciences graduates should be able to:

i receive and respond to a variety of sources of information: textual, numerical, verbal, graphical
ii carry out sample selection; record and analyse data in the laboratory or elsewhere; ensure validity, accuracy, calibration, precision, replicability and highlight uncertainty during collection
iii prepare, process, interpret and present data, using appropriate qualitative and quantitative techniques, statistical programmes, spreadsheets and programmes for presenting data visually
iv demonstrate an understanding of statistical significance and statistical power
v solve problems by a variety of methods, including the use of appropriate software
vi evaluate published claims by interpreting methodology and experimental data, and make judgements about the strength of the evidence.

Communication, presentation and information technology skills

4.5 Biomedical sciences graduates should be able to:

i communicate about their subject appropriately to a variety of audiences using a range of formats and approaches and appropriate scientific language
ii cite and reference work in an appropriate manner, including the avoidance of plagiarism
iii use a range of media critically as a means of communication and a source of information.

Interpersonal and teamwork skills

4.6 Biomedical sciences graduates should be able to:

i identify individual and collective goals and responsibilities and perform in a manner appropriate to these roles, in particular those being developed through practical, laboratory and/or field studies
ii recognise and respect the views and opinions of other team members
iii use negotiating skills
iv evaluate their own performance as an individual and a team member;
v evaluate the performance of others
vi develop an appreciation of the interdisciplinary nature of science and of the validity of different points of view.

Self-management and professional development skills

4.7 Biomedical sciences graduates should be able to:

i develop the skills necessary for self-managed and lifelong learning (for example working independently, time management, organisational, enterprise and knowledge transfer skills)
ii build on knowledge and understanding of the role and impact of intellectual property (IP) within a research environment
iii identify and work towards targets for personal, academic, professional and career development
iv develop an adaptable, flexible and effective approach to study and work.

5 Core biomedical sciences knowledge, understanding and skills

5.1 Approaches to study and forms of subject knowledge likely to be common to all biomedical sciences degree programmes include:

i a broadly based core covering the major elements defined by the particular programme and providing the wider context required for the subject area, together with specialised in-depth study (which may be career related) of some aspects of the subject area. Whatever the degree programme, there is a need for an interdisciplinary and (where appropriate) multidisciplinary approach in advancing knowledge and understanding of the processes and mechanisms of life, from the molecular and cellular levels through to those of the whole body and the environment in which a person lives
ii engagement with the essential facts, major concepts, principles and theories associated with the chosen subject
iii competence in the basic experimental and/or survey skills appropriate to the subject under study
iv understanding of information and data within the context of biomedical sciences, accompanied by critical analysis and assessment to enable understanding of the subject area as a coherent whole
v familiarity with terminology, nomenclature and disease classification systems, as appropriate
vi methods of acquiring, interpreting and analysing biomedical sciences information with a critical understanding of the appropriate contexts for its use through the study of texts, original papers, reports and data sets
vii awareness of the contribution of their subject to the development of knowledge about the complexity of human health and disease
viii knowledge of a range of communication techniques and methodologies relevant to the particular subject, including data analysis, information technology and the use of statistics
ix engagement with current developments in the biomedical sciences and their applications, and the philosophical and ethical issues involved
x awareness of the contribution of biomedical sciences to debate and controversies, and how this knowledge and understanding forms the basis for informed concern about the quality and sustainability of health and well-being
xi awareness of intellectual property (IP) and how scientific advances can be secured and progressed by the application of intellectual property rights (IPRs)
xii understanding of the applicability of the biomedical sciences to the careers to which graduates will be progressing.

5.2 Students working to acquire graduate and professional attributes appropriate to the biomedical sciences need to recognise that much of what they are taught is likely to change in the future, particularly in the light of continuing scientific advances.

5.3 The attributes include:

i an appreciation of the complexity and diversity of life processes
ii the ability to read and use appropriate literature with a full and critical understanding, while addressing such questions as content, context, aims, objectives, experimental design, methodology, data interpretation and application
iii the capacity to give a clear and accurate account of a subject, the ability to mashal arguments, mediate and debate both with specialists and non-specialists, using appropriate scientific language

iv critical and analytical skills including a recognition that statements should be tested and that evidence is subject to assessment and critical evaluation
v the ability to employ a variety of methods of study in investigating, recording and analysing material
vi the ability to think independently, set tasks and solve problems
vii an understanding of how to identify, protect, and exploit intellectual property (IP) as part of the scientific innovation process.

5.4 Whatever the precise nature of their specific programme, graduates in the biomedical sciences are expected to have a broad basic understanding of how cells, organs and systems function in the human body in health and disease, the common causes and effects of disease, the body's defence mechanisms and approaches to treatment. These form the foundation for the more in-depth and advanced knowledge specific to their particular programme's focus or specialism within the biomedical sciences (see section 6).

5.5 Biomedical sciences programmes generally include:

i Human anatomy and physiology: the structure, function, neurological and hormonal control of the human body, its component parts and major systems (musculoskeletal, circulatory, respiratory, digestive, renal, urogenital, nervous, endocrine) and their relationship to each other
ii Cell biology: the structure and function of prokaryotic and eukaryotic cells; the cell as the fundamental unit of life; cell division, cell cycle, stem cells, cell specialisation and cooperation
iii Biochemistry: key chemical principles relevant to biological systems, the structure and function of biological molecules and the biochemistry of processes which support life including cellular metabolism and its control
iv Genetics, genomics and human variation: the structure and function of genes, the principles of their inheritance,genetic disorders with particular biomedical significance, evolution and population biology
v Molecular biology: the structure and function of biologically important molecules including DNA, RNA and proteins and the molecular events that govern cell function. Molecular biology overlaps with biochemistry, genetics and cell biology
vi The nature of disease and fundamentals of pathology to include the development of age-related diseases and the impact of lifestyle upon health and disease
vii Bioinformatics and systems biology: the computation of high volumes of biological data and the properties of a network of interacting components in a system, as well as the components themselves, including an appreciation of the algorithms to decipher biological relationships
viii Microbiology: the structure, physiology, biochemistry, identification, classification and control of micro-organisms, including the roles of normal flora
ix Immunology: acute and chronic inflammation, structure, function and mechanisms of action of the components of the immune system; innate and acquired immunity
x Pharmacology: the importance of drug actions in the living organism for prevention and treatment of disease; the principles of drug-receptor interactions and the relationship between dose and response, routes of administration, types of drugs, how drugs are metabolised and eliminated from the body, toxic effects; approaches for drug discovery; personalised medicine
xi Developmental biology, which may include topics such as human life cycles, ageing, stem cells and regenerative medicine
xii Physics and chemistry sufficient to support understanding of biochemical and biophysical processes and instrumentation.

6 Subject-specific knowledge, understanding and skills

6.1 In this section of the Subject Benchmark Statement a number of named degrees are included by way of exemplification. For each of these the additional subject-specific knowledge, understanding and skills expected of students have been outlined. These additional elements are normally included as part of the curriculum for such named degrees in addition to those core elements of biomedical sciences knowledge, understanding and skills described in section 5. These exemplars do not encompass all the variety of specifically named biomedical sciences degrees, but represent the majority of such named programmes currently on offer within UK higher education. Over time additional exemplars of further specifically named biomedical sciences degrees may be added to this section.

Biomedical Science

6.2 Within the broader biomedical sciences are clinical laboratory subjects that specifically address the knowledge and understanding of disease processes in the context of the study and investigation of those processes. This knowledge and understanding may then be applied from a professional, evidence-based approach to research into the pathogenesis and origins of disease processes and the diagnosis and monitoring of disease. While these are important attributes for a research scientist they are also the basis for statutory regulation as a Biomedical Scientist. These degrees may carry a variety of titles but must be accredited by IBMS in order for graduates to meet the academic requirements for registration with HCPC as Biomedical Scientists. Graduates must also satisfy additional HCPC requirements for registration.[14]

6.3 Biomedical science students are encouraged to use and integrate the knowledge of various key subjects to further their understanding of the study, investigation, diagnosis and monitoring of human health and disease and the therapeutic strategies applicable to disease states. Programmes therefore reflect a system-led approach that integrates the clinical specialities through underpinning knowledge of biomedical science processes, investigation and treatment used for specific diseases. Biomedical science graduates are aware of the current laboratory methods available for the study, investigation, diagnosis and monitoring of human health and disease in clinical and research environments. This includes an appreciation of the development and evaluation of new and current methods and therapeutic intervention strategies.

6.4 In addition to those areas outlined in sections 4 and 5, a biomedical science graduate will have the following core knowledge, understanding and skills.

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 gross structure and ultrastructure of normal cells and tissues and the structural changes which may occur during disease
- reproductive science, including infertility and embryology
- the preparation of cells and tissues for microscopic examination
- the principles and applications of visualisation and imaging techniques, including microscopy, to aid diagnosis and treatment selection.

ii Clinical biochemistry is the investigation of the function and dysfunction of systems, organs and tissues by the measurement of biochemical markers. A biomedical science graduate will have knowledge of:

[14] Further information on the requirements for HCPC Standards of Proficiency is available at: www.hcpc-uk.org.

- the range, and methods used for the collection of, clinical samples that may be subjected to biochemical analysis
- the principles and applications of biochemical investigations used for screening, diagnosis, treatment and monitoring of disease
- therapeutic drug monitoring and investigation of substance abuse.

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

- the principles of the function and measurement of effectors of the immune response
- the causes and consequences of abnormal immune function, neoplastic diseases and transplantation reactions together with their detection, diagnosis, treatment and monitoring
- immunological techniques used in clinical and research laboratories
- 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:

- the structure, function and production of blood cells
- the regulation of normal haemostasis
- nature and diagnosis of anaemias, haematological malignancies, haemorrhagic and thrombotic diseases
- techniques for their investigation.

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
- immune mediated destruction of blood cells
- the preparation, storage and use of blood components
- the selection of appropriate blood components for transfusion and possible adverse effects.

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:

- genomic, transcriptomic, proteomic methods used to analyse and study human chromosomes and DNA
- the application of molecular biology and Bioinformatics in medicine
- pharmacogenetics and personalised medicine
- genetic testing and associated ethical issues.

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
- public health microbiology
- the laboratory investigation of a range of infectious diseases, including isolation and identification of microorganisms
- anti-microbial and anti-viral therapy (including drug resistance)
- infection control.

Pharmacology

6.5 Pharmacology is the science of drugs, their chemical and physical properties, their actions on living tissues and systems, and their effects on health and disease. Pharmacologists have played a crucial role in the discovery of hundreds of chemicals used in the treatment of disease and the relief of human and animal suffering. The scientific foundations that underpin modern pharmacology include the areas outlined in sections 4 and 5. In addition, pharmacologists have extended understanding of mechanisms of drug action, drug discovery, safety and efficacy. In designing degree programmes staff are encouraged to seek an integrated approach to pharmacology teaching and assessment that embeds practical and transferable skills into the investigation of pharmacological principles.

6.6 In addition to those areas outlined in sections 4 and 5, a pharmacology graduate will have the following core knowledge, understanding and skills:

i Pharmacodynamics (what drugs do to the body) in health and disease, including:
- molecular targets of drug action: receptors, enzymes, ion channels, transporters and others
- drug-receptor relationships, including agonism (full, partial, biased and inverse), antagonism (competitive and non-competitive), and an understanding of how these properties relate to drug specificity, selectivity and potency
- the main molecular targets for drugs, knowledge of their structure and function, and the ways in which drugs alter this function at the molecular level
- changes in receptor signalling caused by drug action, including mechanisms of desensitisation and tolerance
- how drug action affects the major organ systems of the body as well as drug effects on cell function, cell proliferation and cell death
- emerging technologies in personalised medicine (for example small molecular inhibitors, antisense therapy, biopharmaceuticals, novel drug delivery systems).

ii Pharmacokinetics (what the body does to drugs), including absorption, distribution, biotransformation and excretion

iii Individual variation in drug action and toxicity for example: the effects of ethnicity, gender, age, pregnancy, genetic factors, disease and drug-drug interactions, in addition to the potential for allergy and drug addiction

iv Pharmacological methods, including knowledge and/or practical experience of:
- drug concentration/dose-response relationships
- experimental methods and techniques applied to pharmacology (for example bioassays, receptor binding, receptor cloning, recombinant proteins for therapy, animal models of disease, genetic manipulation of cells and animals and their uses)
- ethical and legal issues pertaining to the use of animals in research, as outlined in the Animal (Scientific Procedures) Act 1986, with knowledge of approaches to replace, refine and reduce their use
- drug discovery and development, including toxicology, with knowledge of the regulatory processes that monitor drug quality, safety, and effectiveness
- principles of clinical trials, for example: the avoidance of bias, the effect of sample size, the placebo effect, the concept of therapeutic index which relies upon the integration of pharmacodynamics, pharmacokinetics, toxicology and other safety information to contribute to an understanding of the risk associated with a drug, as well as the ethical issues surrounding the use of human study participants and human tissues.

Human Nutrition

6.7 Degree programmes in Human Nutrition include a comprehensive education in nutritional science and its application to the maintenance of human health and the prevention of disease, echoing the 'science' competencies outlined in the Association for Nutrition (AfN) competency requirements for programme accreditation. AfN accreditation supports development of nutritionists' skills by recognising higher education programmes which deliver evidence-based nutrition education to a professional level. Some programmes may allow students to specialise and subsequently work in areas such as clinical nutrition, diet therapy, sports and exercise nutrition or health promotion/nutritional education.

6.8 Many graduates of Human Nutrition programmes who progress to work as nutritionists undertake voluntary professional registration with AfN. Human Nutrition graduates are employed in a wide range of areas, such as: health promotion, the food industry, sports nutrition, teaching, and nutritional research. Some Human Nutrition graduates progress to undertake postgraduate training in Dietetics and work as dietitians. Similar to biomedical scientists, those working as dietitians in the health service in the UK must undertake statutory registration with HCPC.

6.9 In addition to those areas outlined in sections 4 and 5, a human nutrition graduate will have the following core knowledge, understanding and skills:

i An integrated knowledge of:
- the chemistry of living processes; the role of nutrients in the major metabolic pathways and the cellular and molecular basis of disease including the processes of gene expression
- the clinical biochemistry of human disease and its management, with a focus on the nutritional factors involved
- the assessment of nutritional status and the key nutritional issues associated with different stages of the human life cycle as well as the relationship between socio-demographic, economic and environmental factors on dietary behaviour and patterns
- the concepts and processes associated with food science, food safety, food storage, food processing and food microbiology
- clinical nutrition, diet therapy and health promotion/nutritional education
- nutritional issues associated with sports and exercise to maximise performance.

ii The nutritional impact on the nature of disease: the ability to describe and discuss key scientific principles underpinning the nutritional biosciences and knowledge and core theoretical understanding of the multidisciplinary nature of human disease and its management.

iii Nutrient status and disease: the ability to discuss in detail the impact of nutrients and their status, gene nutrient interactions and their potential role in the prevention of diet-related diseases.

iv Diet and nutritional research: the ability to describe the wide variety of research methods that can be used to collect, interpret, manipulate and analyse and present diet and nutritional status and to select the most appropriate for addressing a specific nutritional problem.

v Ethical standards and professional codes of conduct: the ability to identify the moral and ethical issues associated with nutritional investigations and familiarity with the need for ethical standards and professional codes of conduct necessary within nutritional investigations.

Human/Medical Physiology

6.10 Physiology is an integrative science focused on knowledge and understanding of how the body functions throughout the levels of organisation from chemical/molecular, through cellular to systems and organismal level. Clear understanding of normal anatomy and physiology including nervous, hormonal, and other homeostatic control mechanisms, provides the basis on which to build knowledge and understanding of the impact of disease and inherent pathophysiological changes and processes on cells, tissues, and body systems. The scientific foundations that underpin modern physiology include the core knowledge outlined in sections 4 and 5 of this Subject Benchmark Statement. Degree programmes are encouraged to contextualise the teaching of human physiology with particular reference to dysregulation and the pathophysiological processes that underpin disease and the biomedical sciences.

6.11 In addition to those areas outlined in sections 4 and 5, a physiology graduate will have the following core knowledge, understanding, and skills:

i Integrated human physiological systems and processes:

- chemical, cellular, tissue, organ, organ-system and organism levels, and the internal and external factors that regulate physiological systems;
- structure-function relationships and fundamental functions of each body system and inter-relationships with other systems;
- life processes including metabolism, responsiveness, movement, growth, differentiation, and reproduction;
- systems of cell-cell communication.

ii Internal and external regulation:

- homeostasis (autoregulation and extrinsic regulation), the function of homeostatic regulation, role of negative feedback in maintenance of homeostasis and components of feedback systems (loops);
- neural tissue, spinal cord, spinal nerves and spinal reflexes, brain and cranial nerves and neural integration;
- fluid, electrolyte, and acid-base balance including systems of control of body fluid and electrolyte balance including pH control and maintenance and disturbances and impact on health.
- endocrine system including hormone secretion, distribution, and mechanisms of hormone action and control of endocrine activity;
- response to internal and external stressors including adaptations and pathophysiological aspects;
- coordination, communication, and integration of activity of body systems through neuronal, hormonal, and chemical mechanisms, and relationship with pathophysiology;
- goal of physiological regulation, response to external changes to the environment - the key to adaption and survival in a changing environment.

iii Cellular physiology:

- principle components of a human cell and the main transport processes (diffusion, filtration, carrier-mediated transport, vesicular transport) and maintenance of cellular integrity;
- cellular differentiation, life cycle, and diversity of cell types and the complex intracellular chemical events that sustain life and underpin cellular response to the internal/external environment.

iv Tissues, support, and movement:
- structural and functional attributes of epithelial tissues, connective tissues, and membranes, and core aspects of tissue injury and repair;
- fundamental appreciation of skin, bone structure, skeleton, and articulations;
- skeletal muscle and other types of muscular tissue;
- exercise physiology and impact of exercise and related nutritional aspects on adaptation and regulation/maintenance of physiological processes.

v Fluids and transport:
- cardiovascular system including nature of blood and haemostasis, heartbeat and cardiodynamics, cardiovascular physiology and cardiovascular regulation
- lymphatic system including organisation, defences and immunity.

vi Environmental exchange:
- respiratory system and respiratory physiology
- digestive and hepatobiliary systems including components/organs and processes of digestion and absorption, detoxification and elimination;
- metabolism and energetics;
- urinary system and the principles of renal physiology.

vii Continuity of life:
- reproductive system (male and female) and integration with other systems
- development and inheritance including fertilisation, pregnancy, prenatal development, foetal growth, aspects of and human inheritance, development, and ageing.

viii Comparative physiology:
- appreciation of fundamental similarities and differences in the complex structure and function of human body cells and systems with that of other organisms/species
- opportunities and limitations of comparative physiology.

ix Physiological experimentation, data management, and subject articulation:
- ethical and legal issues pertaining to use of humans or animals (or tissues) in research and other contexts
- core physiological techniques and practical skills, including experimental design, measurement, data handling, and statistical analysis.

7 Learning, teaching and assessment

7.1 The objective of the programme of study is to produce graduates who are competent in a range of knowledge, understanding and experience and skills appropriate to their chosen Biomedical Sciences degree. The learning, teaching and assessment strategy is designed to encourage a progressive acquisition of subject knowledge and skills by moving from study methods that have a greater degree of support and assistance gradually towards more independence and self-direction. Such progression is reinforced by a diversity of learning and teaching methods and assessment strategies that support learning and are matched to the expressed learning outcomes. Cross-referencing of topics from one element to another is essential to ensure effective teaching and integrated learning. These strategies are designed to be enriching, stimulating, challenging, effective and enjoyable. As the programme advances students become increasingly responsible for their own learning in preparation for the rest of their professional careers.

7.2 Learning and teaching strategies in the biomedical sciences are not static but adapt to changes in philosophy and technology. In this context, there is an expectation that teaching staff should have access to professional development opportunities. Current strategies are student-centred and incorporate experiential, practical and formal academic practice, and may include:

- self-directed study and research
- work-based placements or other appropriate professional experience
- case studies and problem-based learning
- peer and collaborative learning, including the use of social media
- reflective practice and portfolio building
- laboratory classes, fieldwork, workshops, computer modelling/simulations
- research projects
- seminars, tutorials, lectures
- interactive sessions, including debates and oral/poster presentations
- use of a variety of appropriate materials, including books, electronic multimedia, videos, recordings and broadcasts.

7.3 Lectures may convey substantial elements of the subject content, provide core themes and explanations of difficult concepts, as well as set the scene for and inspire students' independent learning. Lectures encourage and enable students to develop skills in listening and selective note taking, to appreciate how information is structured and presented, and to understand the means by which scientific information is obtained. Where appropriate, lectures include reference to experimental evidence and arguments for and against specific hypotheses. The traditional format may be enhanced through the use of computer-based or other learning aids and interactive student participation in groups or by communication networks.

7.4 Laboratory classes, fieldwork and in silico approaches to practical work (for example modelling and data mining) support learning. They illustrate scientific approaches to discovery, provide opportunities for acquisition of subject-specific technical and transferable skills and reinforce the taught curriculum. One objective of practical work is to give students an appreciation of the variation inherent in biological systems. This may be associated with appropriate methods to deal with the variation, including data handling and statistics. Another objective is to help students to consolidate, deepen and extend the knowledge and understanding that they have previously acquired. Above all, such classes train students in the practical skills and competencies required of their chosen subject area.

7.5 All honours degree students are expected to have some personal experience of the approach to, practice and evaluation of scientific research, such as a project/research based assignment. This is likely to be in the students' final year and may draw on the experience gathered during the programme as a whole. Such work is likely to include data collection and analysis from, for example, laboratory, field or literature work. Interpretation of the information is within the context of current knowledge. Consideration must always be given to safety and ethical aspects. It may sometimes be appropriate for students to work outside the laboratory or field environment, for example, in education or in the public understanding of science. However the research project is delivered, it is expected to include an element of novelty satisfied by work that is hypothesis-driven or which leads to formation of an hypothesis.

7.6 Other forms of contact provide a context for interactive learning and allow students to explore aspects of the subject in some depth. They also provide opportunities for the development of interpersonal skills such as information retrieval, problem-solving, communication and team working. Particularly when the number of students in a group is very small, these meetings can also be useful for providing academic guidance and support and develop confidence and independence of thought.

7.7 Assessment strategies are designed to determine achievement of learning outcomes and competencies. These are both formative and summative and may include self and peer assessment. They provide evidence to employers of graduate attributes. Assessment is progressive in terms of level and content and leads to effective feedback to enable development of students' knowledge and skills, and may include:

- unseen, seen or open-book examinations, computer-based assessments
- laboratory and/or fieldwork reports
- project or dissertation report
- work experience assessment
- observed practice
- online activities, essays, summaries and assignments
- data interpretation exercises
- critical analysis of case-studies
- oral, poster, and other presentations such as journal articles.

8 Benchmark standards

8.1 It is recognised that Biomedical Sciences programmes are designed to enable students to achieve the benchmark standards in various ways, set out in information about individual programmes.

8.2 The following benchmark standards indicate threshold levels of achievement, the minimal acceptable achievement of an honours graduate.

8.3 As indicated in section 3.3, the range of Biomedical Sciences degree programmes offered by UK higher education providers is sufficiently broad that one set of detailed and restrictive standards for all programmes that may be covered by this benchmark statement would not be helpful. In order to provide meaningful benchmark standards for the various biomedical sciences subjects these are therefore based on the generic and subject-specific skills and knowledge described in sections 4, 5 and 6 of this document.

8.4 The standards required of students for this Subject Benchmark Statement may be divided into two groups.

8.5 The first group relates to the transferable skills and knowledge associated with the core subject areas described in sections 5.1-5.4, which are expected of all honours graduates in the biomedical sciences. All Biomedical Sciences honours graduates, regardless of their specialism, are expected to have attained understanding of, and competence in, these areas.

Threshold standard for all Biomedical Sciences

8.6 On graduating with an honours degree in biomedical sciences, the graduate will have the following core knowledge, understanding and skills:

i the ability to explain biomedical sciences phenomena at a variety of levels (from molecule to cell to organ and system function) in the human body in health and disease, the common causes and effects of disease, the body's defence mechanisms and approaches to treatment

ii experience and competence in a broad range of appropriate practical techniques and skills relevant to the biomedical sciences including data collection, analysis and interpretation of those data, and testing of hypotheses and the ability to place the work in context and to suggest lines of further investigation

iii experience in planning, execution and presentation of a piece of hypothesis-driven work within a supported framework in which qualities such as time management, problem solving, and independence are evident

iv the ability to access and evaluate biomedical sciences information from a variety of sources and to communicate the principles both orally and in writing in a way that is organised and topical, and recognises the limits of current hypotheses;

v an appreciation of ethical issues and professional integrity and standards and the impact on society of advances in the biomedical sciences

vi the ability to record data accurately, and to carry out basic manipulation of data (including qualitative data and statistical analysis, when appropriate);

vii the ability to assess the evidence base for scientific claims, by reading primary literature and commenting on the adequacy of the methods, data and interpretation

viii an awareness and understanding of intellectual property issues (IP) issues and how they relate to the innovation process

ix strategies which enable them to update their knowledge of the biomedical sciences.

8.7 The second group of standards relates to the transferable skills and knowledge associated with the individual specialist and vocational areas within the biomedical sciences, as described in sections 6.1-6.4. All honours graduates from named specialist or vocational programmes are expected to have also attained understanding of, and competence in, the areas documented in the relevant benchmark section below, which is illustrative, rather than definitive.

Subject-specfic threshold standard - Biomedical Science

8.8 On graduating with an honours degree in biomedical science, the graduate will have the following specialist knowledge, understanding and skills:

i the ability to integrate the knowledge of various key subjects to further the understanding of the study, investigation, diagnosis and monitoring of human health and disease
ii knowledge and understanding of various therapeutic strategies applicable to disease states
iii awareness of the current laboratory methods available for the study, investigation, diagnosis and monitoring of human health and disease in clinical and research environments
iv an appreciation of the development and evaluation of new and current methods and therapeutic intervention strategies.

Subject-specific threshold standard - Pharmacology

8.9 On graduating with an honours degree in pharmacology, the graduate will have the following specialist knowledge, understanding and skills:

i knowledge and understanding of the science of drugs, their chemical and physical properties
ii an understanding of the actions of drugs on living tissues and systems, and their effects on health and disease
iii an understanding of drug absorption, distribution, metabolism and elimination
iv an extended understanding of the relationship between drug concentration and response, the principle mechanisms of drug action, the drug discovery process, factors affecting drug safety and efficacy
v experience in a range of practical skills of relevance to the investigation of drug action.

Subject-specfic threshold standard - Human Nutrition

8.10 On graduating with an honours degree in human nutrition, the graduate will have the following specialist knowledge, understanding and skills:

i the ability to describe and discuss key scientific principles underpinning the nutritional biosciences
ii knowledge of socio-demographic, economic and environmental factors on dietary behaviour and patterns
iii an understanding of the clinical biochemistry of human disease and its management, with a focus on the nutritional factors involved
iv the ability to discuss in detail the impact of nutrients and their potential role in the prevention of diet-related diseases
v the ability to describe and apply a wide variety of research methods that can be used to collect, interpret, manipulate and analyse and present diet and nutritional status.

Subject-specfic threshold standard - Human/Medical Physiology

8.11 On graduating with an honours degree in human/medical physiology, the graduate will have the following specialist knowledge, understanding and skills:

i an understanding of how the body functions throughout the levels of organisation from chemical/molecular, through cellular to systems and organismal level
ii knowledge and understanding of normal anatomy and physiology including nervous, hormonal, and other homeostatic control mechanisms
iii knowledge and understanding of the impact of disease and inherent pathophysiological changes and processes on cells, tissues, and body systems
iv the ability to discuss the pathophysiological processes that underpin disease and the biomedical sciences
v the ability to describe and apply a wide variety of scientific methodologies to investigate human physiological processes.

Appendix: Membership of the benchmarking and review groups for the Subject Benchmark Statement for biomedical sciences

Membership of the review group for the Subject Benchmark Statement for biomedical sciences (2015)

Professor Yvonne Barnett (Chair)	Nottingham Trent University, President of Heads of University Centres of Biomedical Sciences (HUCBMS)
Dr Craig Donaldson	Plymouth University
Dr Sally Hicks	Cardiff Metropolitan University
Dr Ian Locke	University of Westminster
Dr Ian McFadzean	King's College London
Professor Jacqueline McCormack	University of Ulster
Professor P Gerry McKenna	Heads of University Centres of Biomedical Sciences (HUCBMS) and formerly University of Ulster
Christine Murphy	Institute of Biomedical Science
Joyce Overfield	Institute of Biomedical Science
Professor Valerie Randall	University of Bradford
Alan Wainwright	Institute of Biomedical Science
Dr Melisa Wallace	Cardiff University
Dr Linda Walsh	Glasgow Caledonian University

The group also acknowledges the contributions of:

Dr Blair Grubb	University of Leicester
Professor Neville McClenaghan	University of Ulster
Dr Claire Robertson	University of Westminster

Employer representative(s)

Dr Glenn Crocker	BioCity Nottingham Limited
Jacqueline Wales	National Health Service

Student reader

Natalie Kempston	Imperial College London

QAA officers

Janet Bohrer	Quality Assurance Agency for Higher Education
Harriet Barnes	Quality Assurance Agency for Higher Education
Dan Murch	Quality Assurance Agency for Higher Education

Membership of the review group for the subject benchmark for biomedical science (2007)

Details provided below are as published in the 2007 Subject Benchmark Statement for biomedical science.

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

Membership of the original benchmarking group for biomedical science (2002)

Details provided below are as published in the original Subject Benchmark Statement for biomedical science (2002).

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

QAA1373 - Nov 2015

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Registered charity numbers 1062746 and SC037786