



Subject Benchmark Statement

Biosciences

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How can I use this document?

This document is a Subject Benchmark Statement for biosciences 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 biosciences or related subjects
- a prospective student thinking about studying biosciences, 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 biosciences.

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.

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 biosciences.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 C: Biological Sciences in the Joint Academic Coding System (JACS).⁹ This includes the following sub-codes:

- C100 Biology
- C200 Botany
- C300 Zoology
- C400 Genetics
- C500 Microbiology
- C600 Sport and exercise science
- C700 Molecular biology, biophysics and biochemistry

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.gaa.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.gaa.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/.

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

This Subject Benchmark Statement for Biosciences has been revised substantially from the statement published in 2007. While that Statement aimed to strengthen the recognition of the importance of work in the laboratory and field, and the associated skills, it was focused strongly on the more general biosciences rather than those associated with the scientific study of human health and disease. This 2015 edition of the Subject Benchmark Statement remains the general statement about bioscience programmes based on the organismal biosciences and the molecular biosciences, but has been developed in close collaboration with the extensive review of the Biomedical Sciences Subject Benchmark Statement, such that the two statements should together be of value to the full range of programmes available in the UK.

1 Introduction

1.1 This Subject Benchmark Statement defines the biosciences 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. The Biosciences are key subject areas encompassing all areas of biology. This highly topical, dynamic area is continually advancing, contributing important benefits not only to the wider health and well-being of individuals and the nation, but also to the economic activity of the UK. A deeper understanding of biology and biological processes is essential to appreciate the complexity of life and our impact on the planet; to be able to feed ourselves, while working to maintain biodiversity and a stable and sustainable environment. The subject area includes those science programmes whose primary focus is the biology of plants, animals, including humans, fungi and microorganisms and ranges from generic programmes in plant sciences and zoology to more specialised programmes in for example genetics, biochemistry, and ecology. This Subject Benchmark Statement identifies the core areas which form the basis of all programmes in the biosciences, as well as those relating to specialist programmes in this subject area. As such it has significant and necessary overlap with the Biomedical Sciences 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, or the titles of subjects which comprise the biosciences. 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. Creativity and diversity are encouraged. The Statement provides a description of the skills and attributes acquired by biosciences graduates that equips them for a career in biosciences or elsewhere, and an inventory of delivery and assessment methods, as well as benchmark standards, thus enabling identification of vital components of biosciences 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 biosciences is designed to provide graduates with a broad understanding of the scientific basis of the study of living systems and practical experience of working in a laboratory and/or field situation. 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 biosciences are underpinned by a number of related sciences including chemistry, mathematics, data analytics, information technology and physics. Core biosciences subjects include: anatomy, biochemistry, bioinformatics, cell and molecular biology, ecology, genetics, immunology, microbiology, physiology, plant sciences, population biology, and zoology.

2.3 The biosciences play a pivotal and essential role in understanding life on earth from the molecular level to whole populations and ecosystems. The component subjects are at the forefront of modern science and involve leading-edge research activity. The biosciences are rapidly evolving subjects essential to the investigation and understanding of many of the current controversies, concerns and dilemmas of modern life. The study of the biosciences is critical to the understanding of major biological processes and the resolution of problems of international importance such as food security, climate change, impacts on biodiversity, as well as the molecular and biochemical processes which underpin life on earth, and whose understanding contributes directly to our health and well-being. The application of agricultural, industrial and medical biotechnologies, including the development of low-carbon technologies and the use of bio-based materials, developments in yield, and stress and disease resistance in crops and animals, are all critically dependent upon bioscience knowledge and application.

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

2.5 The employment market for graduates in the biosciences is buoyant. Major employment areas include:

- animal industry and management
- bioscience, biotechnology and healthcare industries
- commerce (sales and marketing) related to healthcare, agricultural and diagnostic products
- diagnostic laboratories
- education: university, college and school teaching
- environmental and conservation projects
- food industry and food safety
- forensic laboratories
- government departments and the civil service
- government or charity-funded research laboratories and institutes
- international organisations
- patent offices
- regulatory matters in healthcare, including clinical trials.
- research and development for agri-environment industries
- research laboratories in universities

- science communication and public engagement
- science policy
- veterinary and agricultural laboratories

Science graduates are also well equipped to enter the general graduate-entry pool; they have well developed transferable skills, evidence-based analytical ability, and a knowledge of diversity and statistics and their implications.

3 Nature and extent of biosciences

3.1 The biosciences involves the study of life at all levels of complexity. While life forms are built from relatively few different types of atoms, these are assembled into ever more complex levels of organisation in molecules, cells, tissues and organs, organisms, communities and ecosystems. The development of our understanding of the importance of natural selection and evolutionary processes has been a major philosophical and scientific step forward, and continues to be fundamental to the biosciences. We now understand that life depends upon the intricate balance of interactions between the extraordinary variety of life forms and finite inanimate resources.

3.2 Study of the biosciences involves a multidisciplinary approach to the understanding of life processes. Complexity and the relationship between form and function are intrinsic to the biosciences. Although some biologists strive to reduce complex systems to their simplest components, all acknowledge that they are ultimately working with organisms whose complexity is fundamental to their life, difficult to understand and greatly influenced by their environment.

3.3 The complex and rapidly evolving nature of the biosciences requires a rigorous, research informed, scientific education. Depending upon the focus of their degree programme, students need to integrate the knowledge base of various key subjects to further their understanding. By the end of their programme students are equipped with the skills necessary to enable them to plan and perform a research project. They are aware of the need for good practice in the laboratory and in the field, including health and safety, and legal and ethical aspects of research design and analysis.

3.4 The Biosciences Subject Benchmark Statement covers a range of programmes and subjects grouped around the investigation of life processes and the interrelationships of living organisms. This involves study and understanding of the interrelationships of a variety of levels from molecules to populations.

3.5 The biosciences exist in an environment of current hypotheses rather than certainty, where natural variation occurs and can confuse empirical data. Knowledge of research design and the appropriate use of statistical analysis to enable a valid interpretation of experimental results is required. The biosciences are essentially practical and experimental subjects. Students are required to undertake appropriate practical education throughout their programme, which is progressive in nature and designed to supplement other academic learning.

3.6 The biosciences include areas in which rapid change and development are evident and where new knowledge and technologies are swiftly spreading through the subject. This means that there is an increasing need for graduates to develop independent learning skills and to prepare graduates for further study, through master's or doctoral programmes, or continuing professional development in the work place.

3.7 Undergraduate degree programmes in the biosciences 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 master's level study. Some programmes may include a sandwich year or work placements, and some may be accredited by the Royal Society of Biology.¹⁰ Degrees accredited by the Royal Society of Biology fall into two groups.

¹⁰ Further information available at: www.rsb.org.uk.

- Degree accreditation follows an independent and rigorous assessment of degree programmes which contain a solid academic foundation in biological knowledge and key skills, and prepare graduates to address the needs of employers. The accreditation criteria require evidence that graduates from accredited programmes meet defined sets of learning outcomes, including subject knowledge, technical ability and transferable skills.
- Advanced accreditation recognises academic excellence in the biosciences, and highlights degrees that educate the research and development leaders and innovators of the future. The Advanced Accreditation criteria require evidence that graduates meet defined sets of learning outcomes, including gaining substantial research experience. Degrees with Advanced Accreditation will include a period of practice, either as a sandwich year, or as an integrated master's programme.

4 Graduate and key transferable skills

4.1 The biosciences are subjects that combine scientific rigour with an acceptance of diversity and variability, thus providing very good training for the complexities of the world of employment. Studies in the biosciences encourage an understanding of multi-disciplinarity, an enquiring attitude and an appreciation of complexity. The subject content of individual programmes of study in the biosciences 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 biosciences knowledge, understanding and skills (detailed in Section 5) and specialist, subject specific knowledge, understanding and skills. Whatever the subject, students should expect to be confronted by some of the scientific, moral and ethical questions raised by their study subject, to consider viewpoints other than their own, and to engage in critical assessment and intellectual argument. Biosciences graduates will be comfortable with dealing with uncertainty.

Intellectual skills

4.2 Biosciences graduates should be able to:

- i analyse, synthesise and summarise information critically from a variety of sources
- ii consider issues from a number of perspectives and values and arrive at a considered critical judgement stating assumptions and limitations
- iii construct grammatically correct documents in an appropriate academic style and format, using and referencing relevant ideas and evidence
- iv understand the importance of academic and research integrity.

Analytical and data interpretation skills

4.3 Biosciences graduates should be able to:

- i receive and respond to a variety of sources of information: textual, numerical, verbal, graphical
- ii understand and manipulate numerical data
- iii solve problems by a variety of methods
- iv determine the validity and rigour of statistical outcomes.

Communication, presentation and information technology skills

4.4 Biosciences graduates should be able to:

- i communicate about their subject appropriately to a variety of audiences, including the general public, using a range of formats and approaches and employing appropriate scientific language
- ii cite and reference work in an appropriate manner, ensuring academic integrity and the avoidance of plagiarism whether intentional or not
- iii use the internet and other electronic sources critically as a means of communication and a source of information.

Interpersonal and teamwork skills

- 4.5 Biosciences 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.

Personal and professional development skills

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

5 Core biosciences knowledge, understanding and skills

5.1 The range of subject areas covered by individual programmes of study within the biosciences depends on the specific degree title offered. No single degree programme can cover the entirety of the subject, and the rich diversity of curricula provides students with abundant choice.

5.2 Approaches to study and forms of subject knowledge likely to be common to all biosciences 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 of some aspects of the specialist subject area. Whatever the degree programme, there is a need for an interdisciplinary and multidisciplinary approach in advancing knowledge and understanding of the processes and mechanisms of life, from molecular to cellular, and from organism to ecosystem
- ii engagement with the essential facts, major concepts, principles and theories associated with the chosen subject area, including knowledge of the processes and mechanisms that have shaped the natural world in terms, for example, of the spread of time from the geological to the present and of complexity from the environmental to the sub-cellular, including consideration of interactions between living systems and human activities
- iii competence in the core experimental and/or survey skills appropriate to the subject under study
- iv understanding of information and data, and their setting within a theoretical framework, accompanied by critical analysis and assessment to enable understanding of the subject area as a coherent whole
- v familiarity with the terminology, nomenclature and classification systems, as appropriate
- vi practical and theoretical methods of acquiring, interpreting and analysing biological information with a critical understanding of the appropriate contexts for their 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 diversity of life and its evolution
- viii knowledge of a range of communication techniques and methodologies relevant to the particular subject, including data analysis and the use of statistics (where this is appropriate)
- ix engagement with some of the current developments in the biosciences and their applications, and the philosophical and ethical issues involved
- x awareness of the contribution of biosciences to policy and other debates and controversies
- xi understanding of how biosciences knowledge forms the basis for informed concern about the quality and sustainability of life
- xii awareness of the boundaries and limitations of their learning
- xiii awareness of intellectual property (IP) and how scientific advances may be secured and progressed by the application of Intellectual Property Rights (IPRs)
- xiv an appreciation of how their skills and learning contribute to the many careers to which graduates will be progressing.

5.3 Students need to recognise that much of what they are taught is contested and provisional, particularly in the light of continuing scientific advances. The graduate attributes developed by those studying biosciences include:

- i an appreciation of the complexity and diversity of life processes through the study of organisms, their molecular, cellular and physiological processes, their genetics and evolution, and the interrelationships between them and their environment
- ii the ability to read and use appropriate literature with a full and critical understanding, while addressing such questions as content, context, aims, objectives, quality of information, and its interpretation and application
- iii the capacity to give a clear and accurate account of a subject, marshal arguments in a sophisticated way and engage in debate and dialogue 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.

5.4 In addition to the generic graduate and key transferrable skills described in section 4, students also develop specific graduate skills during biosciences degree programmes.

Intellectual skills

5.5 Biosciences 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 nutrients in microbes, cells, plants and animals)
- ii analyse, synthesise and summarise information critically, including published research or reports
- 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 skills

5.6 Biosciences graduates should be able to:

- i demonstrate competence and progressive development in the basic and core experimental skills appropriate to the programme of study
- ii design, plan, conduct and report on investigations, which may involve primary or secondary data (for example from a survey database)
- iii obtain, record, collate and analyse data using appropriate techniques in the field and/or laboratory, working individually or in a group, as is most appropriate for the subject under study
- iv undertake field and/or laboratory investigations of living systems in a responsible, safe and ethical manner.

- v comply with health and safety policies, Good Laboratory Practice,¹¹ risk, and Control of Substances Hazardous to Health assessments recognise and explain the importance of quality control and quality assurance
- vi recognise and explain the need for procedures for obtaining informed consent and appreciate the underlying ethical issues, including respect for the rights of access, for example, in field work or in order to map the genes of a community, family or group of plants or animals, including humans
- vii demonstrate an understanding of the ethical and other issues relating to animal welfare.
- viii explain and justify the impact of investigations on the environment, on the organisms or subjects under investigation, and on other stakeholders.

Analytical and data interpretation skills

5.7 Biosciences graduates should be able to:

- i use and interpret a variety of sources of information: textual, numerical, verbal, graphical
- ii carry out sample selection; record and analyse data in the field and/or the laboratory; ensure validity, accuracy, calibration, precision, replicability and highlight uncertainty and possible bias 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 solve problems by the most appropriate method.

¹¹ Further information available at:
www.ec.europa.eu/growth/sectors/chemicals/good-laboratory-practice/index_en.htm.

6 Learning, teaching and assessment

6.1 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. The objective is to produce graduates who are competent in a range of knowledge, understanding, experience and skills appropriate to their chosen specialism. 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.

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

6.3 Learning and teaching strategies are not static but adapt to changes in philosophy and technology. Current strategies take account of graduate attributes and employability skills. They are student-centred and incorporate experiential, practical and formal academic practice. The learning environment, which includes virtual elements, provides opportunities for individual, small and large group activities.

6.4 Indicative activities include:

- self-directed study and research
- work-based and other placements
- interactions with science professionals
- 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 electronic multimedia, videos, recordings and broadcasts.

6.5 Students are likely to spend a significant proportion of their total study time on set assignments and self-directed study, individually and within groups. This entails information seeking and the use of learning resources available in electronic or other format, reading, report writing and problem-solving.

6.6 Laboratory classes, fieldwork and digital approaches to practical work (for example modelling and data mining) 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.

6.7 All honours degree students are expected to have some personal experience of the scientific approach, including the practice and evaluation of hypothesis driven 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, literature, field or laboratory work. Interpretation of the information is within the context of current knowledge. Consideration must always be given to safety and ethical aspects. It may 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 that it is a hypothesis-driven piece of work. It is important that students undertaking a project that is not based in the laboratory or field acquire the practical skills detailed in paragraph 5.6 elsewhere in the programme.

6.8 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 may also be useful for providing academic guidance and support and develop confidence and independence of thought.

6.9 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.

6.10 Assessment strategies are designed to determine achievement of learning outcomes and competencies. These are formative and summative and may include self and peer assessment. Assessment provides 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.

6.11 Indicative assessment activities include:

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

7 Benchmark standards

7.1 The range of the biosciences is so wide and the scope of programmes offered by UK higher education providers so different that it is impossible to lay down detailed meaningful standards for all programmes that may be covered by this Subject Benchmark Statement. Three sets of examples of the kind of knowledge and skills that are expected of graduates in different fields of biology have been prepared.

7.2 We emphasise that these are examples, not intended to be prescriptive for any student or any programme. They do not cover everything, and many programmes have elements from more than one set and may additionally draw from aspects of the Biomedical Sciences Subject Benchmark Statement.

7.3 The standards required of students for this Subject Benchmark Statement have been divided into two groups.

7.4 The first set describes the transferable and core skills that are expected of all honours graduates in the biosciences. They are not specific for any particular subject.

7.5 The second group of standards is illustrative of specific topics, and involves factual and subject-specific knowledge.

7.6 In each case, the standards are divided into 'threshold' and 'typical'. The threshold level is the essence of the benchmark statement and is achieved by everyone obtaining an honours degree. The typical level is significantly higher and describes the standard that is expected to be achieved by a graduate who has performed well. Typical can be described as somewhere in the middle of the achievement range. Students achieving typical standards would, of course, also have achieved the threshold.

Generic standards, not specific to any particular area

Threshold standard

7.7 On graduating with an honours degree in biosciences, graduates will have the following core knowledge, understanding and skills:

- i experience and competence in a broad range of appropriate practical techniques and skills relevant to the biosciences 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
- ii the ability to explain biological phenomena at a variety of levels (from molecular to ecological systems) and how evolutionary theory is relevant to their area of study
- iii the ability to plan, execute and present 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 bioscience 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 how they underpin professional integrity and standards
- vi an appreciation of the impact on society of advances in the biosciences
- vii the ability to record data accurately, and to carry out basic manipulation of data (including qualitative data and statistical analysis, when appropriate)
- viii an understanding of the use of bioinformatics approaches in the analysis of large datasets

- ix strategies that enable them to update their knowledge of the biosciences
- x an awareness of professional standards, including Good Laboratory Practice¹² for data collection, recording and interpretation.

Typical standard

7.8 On graduating with an honours degree in biosciences, in addition to demonstrating the core knowledge, understanding and skills specified in the threshold standard, a graduate will be able to:

- i plan, execute and present an independent piece of work, in which qualities such as time management, problem solving and independence are evident, as well as interpretation and critical awareness of the quality of evidence
- ii construct reasoned arguments to support their position on the ethical and social impact of advances in the biosciences
- iii demonstrate a secure and accurate understanding of the explanation of biological phenomena at a variety of levels (from molecular to ecological systems) and explain the relationship of evolutionary theory to their area of study
- iv apply relevant advanced numerical skills to biological data
- v communicate science to peers and non-scientists
- vi demonstrate well developed strategies for updating, maintaining and enhancing their knowledge of the biosciences, including cross-disciplinary awareness
- vii access bioscience databases and use appropriate selection criteria to mine, manipulate and interpret data.

Subject-specific standards

7.9 This section describes subject-specific knowledge and skills that might be expected of graduates in the following broad areas of the biosciences: molecular aspects of biology (including biochemistry), organisms, and ecology and environmental biology. As is explained above, these are intended to be illustrative rather than definitive and details will depend on the learning outcomes of particular programmes.

Molecular aspects of biology (including biochemistry)

Threshold standard

7.10 On graduating with an honours degree in biosciences in which the study of molecular aspects of biology (including biochemistry) forms a significant proportion, graduates will be able to:

- i know and explain the structure and function of various types of cells in unicellular and multicellular organisms, the structure and function of cell membranes, cell differentiation
- ii express relevant biological reactions in chemical terms
- iii explain the chemistry and structure of the major biological macromolecules and how that determines their biological properties
- iv explain how the principles of genetics underlie much of the basis of molecular biology
- v explain the principles of gene expression and how it is controlled
- vi explain a range of appropriate and relevant experimental techniques and how they are used; and be able to perform some of them

¹² Further information available at:

www.ec.europa.eu/growth/sectors/chemicals/good-laboratory-practice/index_en.htm.

- vii describe cell metabolism, including the main anabolic and catabolic pathways
- viii describe protein structures and functions and their control mechanisms.

Typical standard

7.11 On graduating with an honours degree in biosciences in which the study of molecular aspects of biology (including biochemistry) forms a significant proportion, in addition to demonstrating the outcomes specified in the threshold standard, a graduate will be able to:

- i understand the chemistry that underlies biochemical reactions and the techniques used to investigate them
- ii explain the principles that determine the three-dimensional structure of biological macromolecules and give detailed examples of how structure enables function
- iii demonstrate a critical understanding of the molecular basis of genetics and explain some detailed examples
- iv demonstrate critical knowledge and understanding of gene expression, with a detailed knowledge of specific examples; the structure, arrangement, expression, and regulation of genes; and relevant experimental methods
- v demonstrate knowledge of a wide range of cells (both prokaryotic and eukaryotic) and explain critically how their properties suit them for their biological function, and how they could be investigated experimentally
- vi devise and evaluate suitable experimental methods for the investigation of relevant areas of biochemistry and molecular biology
- vii demonstrate a critical understanding of essential features of cell metabolism and its control, including topics such as energy and signal transduction, respiration and photosynthesis (including knowledge and experience of some experimental techniques)
- viii explain the chemical and thermodynamic principles underlying biological catalysis and the role of enzymes and other proteins in determining the function and fate of cells and organisms
- ix mine, manipulate and interpret data from small molecule and/or macromolecular databases.

Organisms

Threshold standard

7.12 On graduating with an honours degree in biosciences in which the study of organisms forms a significant proportion, graduates will be able to:

- i describe the structure and diversity of the organisms studied, including their modes of reproduction, development and life history of the organisms
- ii describe mechanisms for the life processes and appreciate how the physiology of an organism fits it for its environment
- iii demonstrate an appreciation of the integration of metabolism
- iv demonstrate knowledge of the basic genetic principles relating to, and evolution of, the organisms studied
- v describe how organisms are classified and identified
- vi explain the interactions of organisms with each other and the environment
- vii describe the place of the organisms studied in the living world
- viii demonstrate an appreciation of the importance of the 'behaviour' of the organisms studied.

Typical standard

7.13 On graduating with an honours degree in biosciences in which the study of organisms forms a significant proportion, in addition to demonstrating the outcomes specified in the threshold standard, a graduate will be able to:

- i describe and analyse the impact of external influences on growth and reproduction, and explain reproductive strategies
- ii demonstrate an understanding of the interactions of structure and metabolic function at cellular and organism level
- iii describe and critically evaluate the evidence for the mechanisms of life processes
- iv demonstrate an understanding of the significance of internal and external influences on the integration of metabolism for survival and health
- v describe and analyse patterns of inheritance and complex genetic interactions relating to the lives and evolution of the organisms studied
- vi explain the methods and principles underlying taxonomy and classification
- vii describe the principles and processes governing interactions of organisms and their environment
- viii critically analyse the contribution of the organisms to the biosphere
- ix critically assess the contribution of 'behavioural patterns' to survival and success.

Ecology and environmental biology

Threshold standard

7.14 On graduating with an honours degree in biosciences in which the study of ecology and environmental biology forms a significant proportion, graduates will be able to:

- i demonstrate knowledge of biogeochemical cycles and pathways
- ii describe and exemplify nutrient and energy flow through individuals, populations and communities
- iii describe the structure, biogeography and diversity of ecosystems in relation to climate, geology, soils, palaeo-historical, taxonomic and evolutionary factors
- iv describe and exemplify patterns of distribution of organisms in relation to biotic and abiotic factors
- v demonstrate knowledge of population genetics, dynamics and interactions, and associated theoretical models
- vi demonstrate knowledge of community structure, development, biodiversity, and associated theoretical models
- vii show awareness of human interactions with natural populations and ecosystems, including habitat modification, pollution, exploitation and conservation
- viii show awareness of the applied significance of species as resources and as damage-causing organisms
- ix carry out routine investigations as instructed, using appropriate ecological and/or molecular methodologies and data analyses
- x exhibit practical fieldwork skills including but not limited to ecological survey techniques, taxonomic identification of organisms and ecological impact assessments.

Typical standard

7.15 On graduating with an honours degree in biosciences in which the study of ecology and environmental biology forms a significant proportion, in addition to demonstrating the outcomes specified in the threshold standard, a graduate will be able to:

- i demonstrate comprehension and intelligent engagement with biogeochemical cycles and pathways
- ii discuss and demonstrate comprehension of nutrient and energy flow through individuals, populations and communities
- iii understand the structure, biogeography and diversity of ecosystems in relation to climate, geology, soils, palaeo-historical, taxonomic and evolutionary factors
- iv discuss and critically analyse patterns of distribution of organisms in relation to biotic and abiotic factors
- v demonstrate comprehension and critical analysis of population processes, dynamics and interactions, and associated models
- vi demonstrate comprehension and critical analysis of community structure, development, biodiversity, and associated models
- vii critically analyse and evaluate the effects of such human interactions on natural populations and ecosystems
- viii evaluate the impacts of harvesting resources, controlling pest/pathogens and different approaches to species management
- ix apply critical understanding of ecological methodologies and data analyses
- x demonstrate an appreciation of the multidisciplinary approach required to address ecological and environmental issues.

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

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

Professor David Coates (Chair)	University of Dundee
Professor Susan Dewar	Professor Heriot-Watt University
Dr Nicola Jackson	North Hertfordshire College
Professor Jane Lewis	University of Westminster
Dr Ian McFadzean	King's College London
Professor Gerry McKenna	Heads of University Centres of Biomedical Sciences and formerly University of Ulster
Dr Jacqueline Nairn	University of St Andrews
Professor Richard Reece	University of Manchester
Professor Jon Scott	University of Leicester
Professor Robert Slater	Formerly University of Hertfordshire
Dr Melisa Wallace	Cardiff University

The Royal Society of Biology contributed to the review process by coordinating and facilitating feedback from their members.

Feedback was also collected from the Royal Society of Biology Employer Advisory Group.

Student reader

Martynas Serys-Kubertavicius	University of Edinburgh
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QAA officers

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

Membership of the review group for the subject benchmark for biosciences (2007)

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

Dr Sue Assinder	Biosciences Federation and Bangor University
Professor Paul Brain	Swansea University
Professor John Bryant	Society for Experimental Biology and the University of Exeter
Professor David Coates (Chair)	Heads of University Biological Sciences, Institute of Biology and the University of Bradford
Professor Kevan Gartland	Biochemical Society and Glasgow Caledonian University
Professor Ed Wood	Higher Education Academy Subject Centre for Bioscience and the University of Leeds

Membership of the original benchmarking group for biosciences (2002)

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

Professor Jeffrey Bale	University of Birmingham
Professor Paul Brain	University of Wales
Dr Darrell Brooks	University of Central Lancashire
Dr Sara Churchfield	King's College London
Dr Simon van Heyningen (Chair)	The University of Edinburgh
Dr Kathleen Kane	University of Strathclyde
Dr Jackie Landman	The Nutrition Society
Professor Caroline MacDonald	University of Paisley
Professor David Male	The Open University
Professor Roger Marchant	University of Ulster
Dr Helen O'Sullivan	Liverpool Hope University
Professor Wendy Purcell	University of the West of England, Bristol
Dr James Rimmer	Aston University
Professor Robert Slater	University of Hertfordshire
Professor Janet Sprent	University of Dundee

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