

Biosciences

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Preface

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

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

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

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

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

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

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

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

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

The Disability Equality Duty (DED) came into force on 4 December 2006². The DED requires public authorities, including HEIs, to act proactively on disability equality issues. The Duty complements the individual rights focus of the *Disability Discrimination Act* and is aimed at improving public services and outcomes for disabled people as a whole. Responsibility for making sure that such duty is met lies with HEIs.

The Equality and Human Rights Commission³ has published guidance⁴ to help HEIs prepare for the implementation of the Duty and provided illustrative examples on how to take the Duty forward. HEIs are encouraged to read this guidance when considering their approach to engaging with components of the Academic Infrastructure⁵, of which subject benchmark statements are a part.

Additional information that may assist HEIs when engaging with subject benchmark statements can be found in the *Code of Practice (revised) for providers of post-16 education and related services*⁶, and also through the Equality Challenge Unit⁷ which is established to promote equality and diversity in higher education.

² In England, Scotland and Wales.

³ On 1 October 2007, the Equal Opportunities Commission, the Commission for Racial Equality and the Disability Rights Commission merged into the new Equality and Human Rights Commission.

⁴ Copies of the guidance *Further and higher education institutions and the Disability Equality Duty, Guidance for Principals, Vice-Chancellors, governing boards and senior managers working in further education colleges and HEIs in England, Scotland and Wales*, may be obtained from www.equalityhumanrights.com/en/forbusinessesandorganisation/publicauthorities/disabilityequalityd/pages/disabilitye.aspx

⁵ An explanation of the Academic Infrastructure, and the roles of subject benchmark statements within it, is available at www.qaa.ac.uk/academicinfrastructure

⁶ Copies of the *Code of Practice (revised) for providers of post-16 education and related service*, published by the Disability Rights Commission, may be obtained from www.equalityhumanrights.com/en/publicationsandresources/Disability/pages/education.aspx/

⁷ Equality Challenge Unit, www.ecu.ac.uk

Foreword

This review of the subject benchmark statement for biosciences was carried out following a broad consultation and discussion led by the Heads of University Biological Sciences, with further feedback from, among others, the Institute of Biology, the Biosciences Federation and the Higher Education Academy Centre for Bioscience. They all recommended a minimal revision. This is a reflection of the excellent and thorough work of the original benchmarking group, whose arguments, debates and ethos have continued to inform this revision. The group was united in trying to produce standards that would be useful without being a barrier to innovative or new ideas, or to multidisciplinary or interdisciplinary approaches.

Notwithstanding the advice for only minimal revision, there is seen to be a need to re-emphasise the practical nature of the biosciences, through laboratory and fieldwork; and the need for significant levels of numeracy for a subject that is both complex and analytical. This revision has sought to embed the essential nature of significant field and/or laboratory work into the requirements of the benchmark statement. There is no 'minimum' amount of practical work. Rather, there is an explicit understanding that the biosciences are practical subjects, and cannot be effectively delivered without significant and extensive learning, teaching and experience in a field and/or laboratory environment.

Bioscience overlaps with several other subjects. In particular, the review group have spoken to the review group for the subject benchmark statement for biomedical science to clarify the essential differences between a broad generic benchmark statement, such as that for biosciences, and the more focused, vocational benchmark statement required by professionally recognised disciplines. For those undertaking programmes in biomedical science(s), a further commentary on the relationship between the two benchmark statements may be found in the foreword to the revised statement for biomedical science; the latter is aimed at those studying for a professionally recognised qualification.

The revision was aided by a report *Enthusiasing the Next Generation* produced in 2005 by the Biosciences Federation after a survey of biosciences departments in many HEIs of different types.

May 2007

1 Introduction

1.1 Biologists responded enthusiastically to the original call for benchmarking, chiefly because of their strong desire that the benchmark statement for the subject area would be written to the community's own agenda. For the first benchmark statement, representatives of many relevant learned and professional societies met under the aegis of the Institute of Biology, invited nominations to the benchmarking group, and made the final selection from the nominees with due regard to subject knowledge, type of institution, gender, age, location and so on.

1.2 Bioscience is a topical and important subject relevant to everyone: cloning; genetically-modified organisms; the human genome project; the influence of mankind on the environment; the potential risks of some foods and many other such topics regularly appear in the media. The biosciences have much to contribute to the health and wealth of the nation. Fundamental understanding of diseases, for example, the role of microorganisms, together with the development of new vaccines, drugs and antibiotics, has saved many lives. But, new developments, which most biologists view as progress, may alarm other people, and the influence of the human species on the natural world has not been without cost. In recent times, human activity has disturbed the environment to an unprecedented extent. We have reached a point in the Earth's history where an understanding of biology is essential for a viable human future. It is, therefore, important for leaders of society, whether in government, industry, business or education, to appreciate this and for an informed electorate to understand the scope and limitations of biological knowledge and techniques. Only then can we face the challenging social, ethical and legal problems posed by new developments, such as stem cell cloning, gene patenting and gene therapy, while working to maintain biodiversity and a stable and sustainable environment.

1.3 The biosciences are studied under many different titles and in many different sorts of departments, schools, faculties and institutions. Some bioscientists are ecologists and will do much of their work in the field. Many bioscientists work in laboratories: some in university departments, others in the biotechnology, pharmaceutical, health and food industries. Like all sciences and all disciplines, the boundaries of biology are hard to define.

1.4 As was the case for the previous subject benchmark statement, the review group's objective is not to describe the factual knowledge that a graduate in biosciences must have as the subject is too wide and diverse for that to be useful. Rather it is to describe the skills and attributes acquired by the biosciences graduate that would equip them for a career in biosciences or elsewhere, and make them valued by employers. Education in the biosciences trains students in analytical and other transferable skills of use to the economy and the individual. Much of the review group's work has continued the approach of the previous statement by concentrating on generic skills. These are illustrated by examples chosen from different areas of the biosciences, without intending to be prescriptive.

1.5 This benchmark statement is addressed at programmes of teaching and learning whose titles show that they are in biosciences rather than those delivered in any particular department. Appendix A gives a list of some of the subject areas in which degree programmes in the biosciences are currently offered and illustrates the scope and range of biosciences. In addition to wide-ranging degrees such as biology,

biological sciences and life sciences, there are subdisciplines within the area that focus on particular groups of organisms (eg entomology). Other degrees emphasise specific technologies, interactions or systems (eg biotechnology, animal behaviour, biochemistry) or the environments that living organisms inhabit (eg ecology, environmental biology, marine biology); some are subdisciplines directed towards particular applications (eg forensic, brewing and distilling). Developments in molecular and structural biology have provided recent (but as yet incompletely exploited) opportunities to unify the disparate areas by identifying commonality between systems.

1.6 The original benchmarking group had hoped to write a statement that would be useful to a wide variety of potential audiences, including students, prospective students and employers, as well as those in HEIs involved in programme validation and design. In practice, it proved impossible to prepare something for such a wide range of stakeholders. As was the case for the original benchmark statement, therefore, the revised version is primarily aimed at colleagues in higher education. However, it is hoped that the statement will have some use for the other audiences.

2 Nature and extent of biosciences

2.1 The biosciences are the study of life at all levels of complexity from molecules to populations. 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. Darwin's theory of natural selection is a major philosophical and scientific step forward for humankind. This theory, bolstered by the study of modern genetics and molecular biology, has brought us to a clearer understanding of life's basic processes. We now understand that life depends upon the intricate balance of interactions between an apparently infinite variety of life forms and finite inanimate resources.

2.2 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 (including the presence of other organisms). Bioscience is a subject where everything is related to observation or experiment and in which data can come in varied and often complex forms.

2.3 The biosciences are a family of methods and disciplines grouped around the investigation of life processes and the interrelationships of living organisms. This may involve studies at a variety of levels from molecules to populations. All students should have at least some appreciation of all of these levels. There is always significant interaction between the levels. In the last few decades, many people working in disciplines that might previously have been classified with the physical sciences, such as organic chemistry, engineering and software development, have begun to collaborate with biologists to form multidisciplinary teams tackling topics, such as the Human Genome Project, bioengineering and systems biology.

2.4 The biosciences exist in an environment of current hypotheses rather than certainty, where natural variation occurs and can confuse empirical data. This means that students should develop competence in comparing the merits of alternative hypotheses

and receive guidance in terms of how to construct experiments or to make observations to challenge them.

2.5 The biosciences include areas (eg the so-called -omics technologies, such as genomics, proteomics, etc) in which rapid change and development are evident and where new knowledge and technologies are swiftly spread through the subject. This means that there is an increasing requirement to prepare graduates carefully for continuing their self-education and development after graduation to maintain their knowledge and understanding of rapidly changing areas.

2.6 The biosciences are essentially practical and experimental subjects. Consequently, appropriate opportunities to participate in collecting data by undertaking experiments and practical investigations (eg fieldwork for field biologists and laboratory studies for most other groups, the use of computers to deal with the huge amounts of data now being generated) are integral to any scheme of study in this area (see section 4, and in particular paragraph 4.4). The appreciation of hypothesis formation and testing is also often developed by project work in the various sub-disciplines. Group work, problem-based learning exercises in practical situations and (in some programmes) placements have important generic training benefits.

2.7 The biosciences are subjects that combine scientific rigour with an acceptance of diversity and variability, thus providing a very good training for the complexities of the world of employment. Many of the degree programmes enable the development of general skills and competencies suitable for the world of work in which the focus is not biology. Studies in the biosciences encourage an understanding of multidisciplinary, an enquiring attitude and an appreciation of complexity. They require development of competence in team and individual working as well as in numeracy (often including information technology, statistics and bioinformatics). Programmes also develop proficiency in preparing reports in a written format for many different purposes and in delivering presentations.

2.8 The biosciences overlap with disciplines, such as biomedical science, medicine, veterinary medicine and agriculture. Institutions can select the most appropriate subject benchmark statement or statements for their particular degrees. It might be helpful to develop titles (eg 'applied biology for agriculture') that make the objectives and home of the degree obvious to students and potential employers.

For example, the biosciences as applied to the biology of disease share much with biomedical science (which has its own subject benchmark statement). There can be no clear-cut distinction between the two, but degrees in bioscience are perhaps more likely to be inclined towards theoretical and experimental studies than to technical aspects of medical laboratory sciences.

2.9 Many students in medicine, veterinary medicine and dentistry take an 'intercalated' honours course that they frequently share with students of biological sciences; this is to the benefit of both groups of students and should not be inhibited by the constraints of any benchmark statement.

3 Subject knowledge, understanding and skills

3.1 The range of courses covered by individual programmes of study will depend on the specific degree offered and the institutional context. No provider has the resources or time to cover everything that is encompassed by the biosciences and the rich diversity of curricula provides students with abundant choice. Whatever the subject discipline, students should expect to be confronted by some of the scientific, moral and ethical questions raised by their study discipline, to consider viewpoints other than their own, and to engage in critical assessment and intellectual argument.

Subject knowledge and understanding

3.2 Approaches to study and forms of subject knowledge likely to be common to all biosciences degree programmes will include:

- 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 (often career-related) of some aspects of the discipline or subject area. Whatever the degree programme, there is a need for an interdisciplinary and (where appropriate) a multidisciplinary approach in advancing knowledge and understanding of the processes and mechanisms of life, from molecular to cellular, and from organism to community
- engagement with the essential facts, major concepts, principles and theories associated with the chosen discipline. 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 cellular. The influence on living systems of human activities (and the converse) could also be considered
- competence in the basic experimental skills appropriate to the discipline under study
- 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
- familiarity with the terminology, nomenclature and classification systems, as appropriate
- 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
- awareness of the contribution of their subject to the development of knowledge about the diversity of life and its evolution
- knowledge of a range of communication techniques and methodologies relevant to the particular discipline, including data analysis and the use of statistics (where this is appropriate)
- engagement with some of the current developments in the biosciences and their applications, and the philosophical and ethical issues involved. Awareness of the contribution of biosciences to debate and controversies, and how this knowledge and understanding forms the basis for informed concern about the quality and sustainability of life
- understanding the applicability of the biosciences to the careers to which graduates will be progressing.

Subject-specific skills

3.3 Learners working to acquire the qualities of mind appropriate to the biosciences should recognise much of what they are taught is contested and provisional, particularly in the light of continuing scientific advances. The actual qualities include:

- 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
- 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
- the capacity to give a clear and accurate account of a subject, marshal arguments in a mature way and engage in debate and dialogue both with specialists and non-specialists, using appropriate scientific language
- critical and analytical skills: a recognition that statements should be tested and that evidence is subject to assessment and critical evaluation
- the ability to employ a variety of methods of study in investigating, recording and analysing material
- the ability to think independently, set tasks and solve problems.

Graduate and transferable skills

3.4 Examples of the generic standards that are expected (at threshold and typical levels) are given in section 5 and supplemented by more specific standards in three named broad subject areas: molecular aspects of biology (including biochemistry); organism; and ecology and environmental biology. The specific graduate and transferable skills that should be developed in bioscience degree programmes are subdivided into the following headings and described in the following paragraphs:

- intellectual skills
- practical skills
- numeracy skills
- communication, presentation and information technology skills
- interpersonal and teamwork skills
- self-management and professional development skills.

Intellectual skills

3.5 Bioscience degree programme students should be able to:

- 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
- analyse, synthesise and summarise information critically, including published research or reports
- obtain and integrate several lines of subject-specific evidence to formulate and test hypotheses

- apply subject knowledge and understanding to address familiar and unfamiliar problems
- recognise the moral and ethical issues of investigations and appreciate the need for ethical standards and professional codes of conduct.

Practical skills

3.6 Bioscience degree programme students should be able to:

- undertake sufficient practical work to ensure competence in the basic experimental skills appropriate to the discipline under study
- design, plan, conduct and report on investigations, which may involve primary or secondary data (eg from a survey database). These data may be obtained through individual or group projects
- 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 discipline under study
- undertake field and/or laboratory investigations of living systems in a responsible, safe and ethical manner. For example, students must pay due attention to risk assessment, relevant health and safety regulations, issues relating to animal welfare and procedures for obtaining informed consent. In some biosciences, students will show that they respect 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. They should show sensitivity to the impact of investigations on the environment, on the organisms or subjects under investigation, and on other stakeholders.

Numeracy skills

3.7 Bioscience degree programme students should be able to:

- receive and respond to a variety of sources of information: textual, numerical, verbal, graphical
- carry out sample selection; record and analyse data in the field and/or the laboratory; ensure validity, accuracy, calibration, precision, replicability and highlight uncertainty during collection
- prepare, process, interpret and present data, using appropriate qualitative and quantitative techniques, statistical programmes, spreadsheets and programs for presenting data visually
- solve problems by a variety of methods, including the use of computers.

Communication, presentation and information technology skills

3.8 Bioscience degree programme students should be able to:

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

Interpersonal and teamwork skills

3.9 Bioscience degree programme students should be able to:

- 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
- recognise and respect the views and opinions of other team members; negotiating skills
- evaluate performance as an individual and a team member; evaluate the performance of others
- develop an appreciation of the interdisciplinary nature of science and of the validity of different points of view.

Self-management and professional development skills

3.10 Bioscience degree programme students should be able to:

- develop the skills necessary for self-managed and lifelong learning (eg working independently, time management, organisational, enterprise and knowledge transfer skills)
- identify and work towards targets for personal, academic and career development
- develop an adaptable, flexible and effective approach to study and work.

4 Teaching, learning and assessment

4.1 The objective of the programme of study is to produce graduates who are competent in a range of knowledge, understanding, experience and skills appropriate to their chosen specialism. The teaching and learning strategy should be 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 should be reinforced by a diversity of teaching and learning methods and should include assessment strategies that are matched to the expressed learning outcomes.

4.2 Teaching and learning strategies in the biosciences are not static but are adapted to changes in philosophy and technology; current strategies take place within a framework that may include:

- self-directed study and set assignments
- lectures and audiovisual presentations
- laboratory classes, computing/simulations, the use of bioinformatics tools and/or fieldwork
- seminars and workshops, including oral presentations and poster sessions
- tutorials
- projects
- placements
- distance-learning materials, including books, electronic multimedia, videos, recordings and broadcasts
- access to information, research papers, and data, including information on the internet
- problem-based learning.

4.3 Lectures can convey substantial elements of the subject content, provide core themes and explanations of difficult concepts, and set the scene for students' independent learning. Lectures should 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 will include reference to experimental evidence and arguments for and against specific hypotheses. The traditional format can be enhanced through the use of computer-based or other audio-visual aids and interactive student participation in groups or by communication networks.

4.4 Laboratory classes, fieldwork and 'in-silico' approaches to practical work (eg modelling, data mining) support learning in the biosciences. They illustrate scientific approaches to discovery, provide opportunities for acquisition of subject-specific technical and transferable skills and reinforce the taught curriculum. Practical work should involve experiments carried out on material at a variety of levels of biological organisation. One objective of such work is to give students an appreciation of the variation inherent in biological systems, and 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 discipline.

4.5 Seminars, workshops and tutorials 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.

4.6 All honours degree students are expected to have some personal experience of the approach, practice and evaluation of scientific research (eg within a project or research-based assignment). This is likely to be in the students' final year and may draw on the experience gathered during the course as a whole. Such work is likely to include collection and analysis of information (eg from fieldwork, laboratory work, or questionnaires, as well as from the literature); interpretation of the information within the context of current knowledge; suggestions for further work; reference to safety and ethical considerations, where relevant; and a presentation or report on the findings. It may sometimes be appropriate for students to do this kind of work in areas not strictly related to research, for example, in education or in the public understanding of science. It is important that students undertaking a project that is not based in the laboratory or field have the opportunity elsewhere in the programme to acquire the practical skills detailed in paragraph 3.6. No matter how the research project is delivered, it is expected that it is a hypothesis-driven piece of work.

4.7 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.

4.8 Reports on fieldwork, placements or projects may be subject to oral examination in order to clarify the student's contribution and understanding. Somebody other than the student's immediate supervisor will normally be involved in the assessment of such work, and that assessment will always be subject to the approval of the external examiner.

4.9 Assessment strategies aim to test subject knowledge, independent thought and skills acquisition and to provide the sort of information about candidates that will be useful to employers. They will be balanced in accordance with the learning outcomes and will include some or all of the following modes:

- unseen examinations, seen or open-book examinations, computer-based assessments, self and peer assessment laboratory skills
- laboratory and/or fieldwork reports
- essays, summaries and assignments
- data interpretation exercises
- critical analysis of case-studies
- oral, poster, audiovisual, or electronic presentations
- a project or dissertation report
- a work experience report
- viva voce examinations.

5 Benchmark standards

5.1 The standards required of students for this subject benchmark statement have been divided into two groups.

5.2 The first set describes the transferable and core skills that would be expected of all honours graduates in the biosciences. They do not involve much factual knowledge and are not specific for any particular subject.

5.3 The second group of standards is illustrative of specific topics, and does involve factual and discipline-specific knowledge. The range of the biosciences is, however, so wide and the scope of courses offered by HEIs in the United Kingdom so different that it is impossible to lay down meaningful standards for all such areas.

5.4 Nevertheless, it was felt that it would be misleading to produce a subject benchmark statement that gave no examples of factual knowledge, and so three sets of examples of the kind of skills that we think should be expected of graduates in different fields of biology have been prepared. Individual programme providers can use these as guidelines and may sometimes find them directly helpful. We emphasise that they are examples, not intended to be prescriptive for any student or any programme. They do not cover everything: many graduates will have had courses with elements from more than one set; some programmes may have drawn on none of them.

5.5 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 anyone obtaining an honours degree, including those who just achieve an honour's degree. The typical level is significantly higher and describes the standard that would be expected to be achieved by a graduate who had performed well. Typical can be described as somewhere in the middle of the achievement range.

Generic standards, not specific to any particular area

5.6 All honours graduates in the biosciences would be expected to have achieved these standards at one of the two levels. Students achieving typical standards would, of course, also achieve the threshold.

Threshold standard

5.7 On graduating with an honours degree in biosciences, students should:

- be able to access bioscience information from a variety of sources and to communicate the principles in a manner appropriate to the programme of study
- have ability in a range of practical bioscience techniques, including data collection, analysis and interpretation of those data, and testing of hypotheses
- have an understanding of the explanation of biological phenomena at a variety of levels (from molecular to ecological systems) and be able to explain how evolutionary theory is relevant to their area of study
- be able to plan, execute and present an independent piece of hypothesis-driven work (eg a project) within a supported framework in which qualities such as time management, problem solving, and independence are evident

- have some understanding of ethical issues and the impact on society of advances in the biosciences
- be able to record data accurately, and to carry out basic manipulation of data (including qualitative data and some statistical analysis, when appropriate)
- have developed basic strategies to enable them to update their knowledge of the biosciences.

Typical standard

5.8 On graduating with an honours degree in biosciences, students should:

- be able to access and evaluate bioscience information from a variety of sources and to communicate the principles both orally and in writing (eg essays, laboratory reports) in a way that is well organised, topical and recognises the limits of current hypotheses
- have ability in a broad range of appropriate practical techniques and skills relevant to the biosciences. This will include the ability to place the work in context and to suggest lines of further investigation have a secure and accurate understanding of the explanation of biological phenomena at a variety of levels (from molecular to ecological systems) and be able to understand the relationship of evolutionary theory to their area of study
- be able to plan, execute and present an independent piece of work (eg a project), in which qualities such as time management, problem solving and independence are evident, as well interpretation and critical awareness of the quality of evidence
- be able to construct reasoned arguments to support their position on the ethical and social impact of advances in the biosciences be able to apply relevant advanced numerical skills (including statistical analysis, where appropriate) to biological data
- have well-developed strategies for updating, maintaining and enhancing their knowledge of the biosciences.

Subject-specific standards

5.9 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 in paragraphs 5.3 and 5.4, these are intended to be illustrative rather than definitive.

Molecular aspects of biology (including biochemistry)

5.10 For a degree programme in which the study of molecular aspects of biology (including biochemistry) forms a significant proportion, criteria for achievement might include the following, although details would depend on the learning outcomes of particular programmes.

Threshold standard

5.11 On graduating with an honours degree in biosciences in which the study of molecular aspects of biology (including biochemistry) forms a significant proportion, students should:

- be able to express relevant biological reactions in chemical terms
- understand how the chemistry and structure of the major biological macromolecules, including proteins and nucleic acids, determines their biological properties
- understand how the principles of genetics underlie much of the basis of modern molecular biology
- understand the main principles of gene expression
- know and understand the structure and function of various types of cells in unicellular and multicellular organisms, the structure and function of cell membranes, cell differentiation
- understand a range of appropriate and relevant experimental techniques and how they are used; and be able to perform some of them
- have a knowledge of cell metabolism, including the main anabolic and catabolic pathways
- have knowledge of enzyme structure and function and of some of the most important mechanisms controlling the action of enzymes and other proteins.

Typical standard

5.12 On graduating with an honours degree in biosciences in which the study of molecular aspects of biology (including biochemistry) forms a significant proportion, students should:

- be able to understand and explain the chemistry that underlies biochemical reactions and the techniques used to investigate them
- understand the principles that determine the three-dimensional structure of biological macromolecules and be able to explain detailed examples of how structure enables function
- acquire a critical understanding of the molecular basis of genetics and be able to explain some detailed examples
- have 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
- be familiar with a wide range of cells (both prokaryotic and eukaryotic) and be able to explain critically how their properties suit them for their biological function, and how they could be investigated experimentally
- be able to devise and evaluate suitable experimental methods for the investigation of relevant areas of biochemistry and molecular biology

- have a critical understanding of essential features of cell metabolism and its control, including topics such as energy and signal transduction, respiration and photosynthesis. This should include knowledge and experience of some experimental techniques
- understand 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.

Organisms

5.13 For a degree programme in which the study of organisms forms a significant proportion, criteria for achievement might include the following, although details would depend on the learning outcomes of particular programmes.

Threshold standard

5.14 On graduating with an honours degree in biosciences in which the study of organisms forms a significant proportion, students should be able to:

- describe the structure, diversity and reproduction of the organisms studied
- describe basic organism structure and diversity
- describe mechanisms for the life processes and appreciate how the physiology of an organism fits it for its environment
- show an appreciation of the integration of metabolism
- show knowledge of the basic genetic principles relating to, and evolution of, the organisms studied
- describe how organisms are classified and identified
- appreciate the interactions of organisms with each other and the environment
- describe the place of the organisms studied in the living world
- appreciate the importance of the 'behaviour' of the organisms studied.

Typical standard

5.15 On graduating with an honours degree in biosciences in which the study of organisms forms a significant proportion, students should be able to:

- critically analyse the impact of external influences on growth and reproduction, and explain reproductive strategies
- critically recount the interactions of structure and metabolic function at cellular and organism level
- describe and critically evaluate the evidence for the mechanisms of life processes
- interpret the significance of internal and external influences on the integration of metabolism for survival and health
- describe and analyse patterns of inheritance and complex genetic interactions relating to the lives and evolution of the organisms studied

- enumerate the methods and principles underlying taxonomy and classification
- critically describe the principles and processes governing interactions of organisms and their environment
- critically analyse the contribution of the organisms to the biosphere
- critically assess the contribution of 'behavioural patterns' to survival and success.

Ecology and environmental biology

5.16 For a degree programme in which the study of ecology and environmental biology forms a significant proportion, criteria for achievement might include the following, although details would depend on the learning outcomes of particular programmes.

Threshold standard

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

- demonstrate knowledge of biogeochemical cycles and pathways
- describe and exemplify nutrient and energy flow through individuals, populations and communities
- describe the structure, biogeography and diversity of ecosystems in relation to climate, geology, soils, palaeo-historical and evolutionary factors
- describe and exemplify patterns of distribution of organisms in relation to biotic and abiotic factors
- demonstrate knowledge of population processes, dynamics and interactions, and associated theoretical models
- demonstrate knowledge of community structure, development, biodiversity, and associated theoretical models
- demonstrate awareness of human interactions with natural populations and ecosystems, including habitat modification, pollution, exploitation and conservation
- demonstrate awareness of the applied significance of species as resources and as damage-causing organisms
- carry out routine investigations as instructed, using ecological methodologies and data analyses.

Typical standard

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

- demonstrate comprehension and intelligent engagement with biogeochemical cycles and pathways
- discuss and demonstrate comprehension of nutrient and energy flow through individuals, populations and communities

- demonstrate comprehension of the structure, biogeography and diversity of ecosystems in relation to climate, geology, soils, palaeo-historical and evolutionary factors
- discuss and critically analyse patterns of distribution of organisms in relation to biotic and abiotic factors
- demonstrate comprehension and critical analysis of population processes, dynamics and interactions, and associated models
- demonstrate comprehension and critical analysis of community structure, development, biodiversity, and associated models
- evaluate and critically analyse the effects of such human interactions on natural populations and ecosystems
- be capable of evaluating the impacts of harvesting resources, controlling pest/pathogens and different approaches to species management
- apply critical understanding of ecological methodologies and data analyses.

Appendix A: Some degree titles in the biosciences as given by the Universities and Colleges Admissions Service

This list is not exhaustive and is most unlikely to have a long life. Developments (especially in the molecular aspects of the subject) are likely to result in many new degree titles within the biosciences.

Agricultural biology	Developmental biology
Animal biology	Environmental biology
Applied biology	Evolutionary biology
Applied biology science	Fishery biology
Applied cell science	Food biology
Applied marine biology	Human biology
Applied molecular biology	Human biology science
Applied plant biology Aquatic	Infection biology
Aquatic biology	Life science
Behavioural biology	Marine biology
Biological science	Mathematical biology
Biology applied	Medical biology
Biology cybernetics	Medical molecular biology
Biology of cell	Medical science
Biology of organisms	Molecular biology
Biology of plant	Molecular cell biology
Biology process engineering	Neurobiology
Biomedical sciences ⁸	Plant biology
Cell biology	Social biology
Coastal marine biology	Water biology
Computing biology	Wildlife biology
Conservation biology	

⁸ Biomedical sciences is a collection of medically related biosciences such as anatomy, physiology, pharmacology, immunology, biochemistry etc. Biomedical science is that branch of medical science specifically concerned with laboratory diagnosis and monitoring of human disease; this is covered by its own subject benchmark statement and only honours graduates in biomedical science programmes that are accredited and/or approved by the Institute of Biomedical Science and the Health Professions Council are eligible to register as biomedical scientists without undertaking further education.

Appendix B: Membership of the review group for the 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

Appendix C: Membership of the original benchmarking group for biosciences

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

Professor Jeffrey Bale	University of Birmingham
Professor Paul Brain	University of Wales, Swansea
Dr Darrell Brooks	University of Central Lancashire
Dr Sara Churchfield	King's College London
Dr Simon van Heyningen (chair)	University of Edinburgh
Dr Kathleen Kane	University of Strathclyde
Dr Jackie Landman	The Nutrition Society
Professor Caroline MacDonald	University of Paisley
Professor David Male	Open University
Professor Roger Marchant	University of Ulster
Dr Helen O'Sullivan	Liverpool Hope
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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