Biosciences

Subject benchmark statements

Subject benchmark statements provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject. They also represent general expectations about the standards for the award of qualifications at a given level and articulate the attributes and capabilities that those possessing such qualifications should be able to demonstrate.

This *Subject benchmark statement*, together with the others published concurrently, refers to the bachelors degree with honours.

Subject benchmark statements are used for a variety of purposes. Primarily, they are an important external source of reference for higher education institutions 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. Benchmark statements provide for variety and flexibility in the design of programmes and encourage innovation within an agreed overall framework.

Subject benchmark statements also provide support to institutions 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.

Finally, *Subject benchmark statements* may be one of a number of external reference points that are drawn upon for the purposes of external review. Reviewers do not use *Subject benchmark statements* as a crude checklist for these purposes however. Rather, they are used in conjunction with the relevant programme specifications, the institution's own internal evaluation documentation, in order to enable reviewers to come to a rounded judgement based on a broad range of evidence.

The benchmarking of academic standards for this subject area has been undertaken by a group of subject specialists drawn from and acting on behalf of the subject community. The group's work was facilitated by the Quality Assurance Agency for Higher Education, which publishes and distributes this *statement* and other *statements* developed by similar subject-specific groups.

In due course, but not before July 2005, the *statement* will be revised to reflect developments in the subject and the experiences of institutions and others who are working with it. The Agency will initiate revision and, in collaboration with the subject community, will make arrangements for any necessary modifications to the *statement*.

ISBN 1 85824 629 6

AR 039 3/2002

Published by
Quality Assurance Agency for Higher Education
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Southgate Street
Gloucester GL1 1UB

Tel 01452 557000
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Web www.qaa.ac.uk

Text printed by
Linney Direct Digital

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Academic standards - Biosciences

1 Introduction

1.1 Biologists responded early to the call for benchmarking, chiefly because of their strong desire that the benchmarks would be written to the community's own agenda. Representatives of many relevant learned and professional societies, including the UK Life Sciences Committee, 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. Thus a complete benchmarking group was essentially ready before the Quality Assurance Agency for Higher Education (QAA) started its own selection process. The way in which the group had been chosen was wholly acceptable to the QAA.

1.2 The group's members have a wide variety of specialist interests. They cannot, however, include experts in every field of the biosciences - that would be impossible without a much larger group. Nevertheless we have tried to ensure that there is at least one member who has some familiarity with all the sub-disciplines, so that most areas are represented. The group was not initially united in a positive view of the value of benchmarking; some scepticism about this was present at the outset and never completely disappeared from everyone's mind. But it was united in trying to produce benchmarks that would be useful without being a barrier to unconventional or novel ideas, or to multi- or inter-disciplinary approaches.

1.3 The word 'bioscience' has become common only in the last few years, and is still found in rather few titles of programmes, degrees, or departments. Nevertheless, the group decided to keep it for the title of this *Subject benchmark statement* (*statement*), because no other word embraces the whole range of what has only recently been regarded as a single subject.

1.4 Biology has become 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 appear in the media regularly. 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 that most biologists view as progress may alarm other people and the influence of the human species on the natural world has not been without costs. In recent times human activity has disturbed the environment to an unprecedented extent. We have reached a point in the earth's history where a knowledge 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.

1.5 The biosciences are studied under many different titles and in many different sorts of departments, schools, faculties, and institutions. Some biologists are ecologists and will do much of their work in the field. Many 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.

1.6 All subject communities believe that their subject is uniquely wide and diverse. The bioscientists are no exception. Until recently, there was little dialogue between different specialists: most biochemists knew little of the environment; many natural historians were uninterested in molecular processes. All this has changed; everyone now recognises the need to put their own work into a wider context. Nevertheless, the group still found it hard to identify much factual information (other than the obvious, the trivial or the banal) that should be expected of every student working in the biosciences. We have found that much of our work has concentrated on generic skills, and we have illustrated them by examples chosen from different areas of the biosciences, not intended to be prescriptive.

1.7 Our object in this *statement* is therefore not so much to describe the factual knowledge that a graduate in biosciences must have; 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 him or her for a career in biosciences or elsewhere, and make them valued by employers.

1.8 The *statement* is therefore addressed at programmes of teaching and learning whose titles show that they are in biosciences rather than those delivered in any particular department. The scope and range of biosciences, and the degree titles likely to be included are discussed below (paragraph 2.4).

1.9 The group was aided by a report *The Core Attributes of Biological Science Graduates* produced in 1997 by the Biochemical Society and the Institute of Biology after a survey of biosciences departments in many HEIs of different types.

The survey showed that there was surprisingly good agreement on the attributes that would be expected of an Honours graduate (both in generic and subject-specific skills) and in the attributes that are assessed. But some of the most expected attributes are least likely to be assessed (eg investigative skills and communication).

1.10 We discuss below (for example in paragraph 2.9) how the biosciences overlap with other subjects. In particular we have spoken to the benchmarking groups in biomedical subjects and in agriculture, biomedical sciences, medicine, and veterinary medicine, and we hope to have clarified where overlaps exist, and where they are inevitable.

1.11 The 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 higher education institutions (HEIs) that are involved in course validation and design. In practice, it proved impossible to prepare something for such a wide range of stakeholders, and the final document is primarily aimed at those in higher education. We hope it will have some use for the others.

2 The nature and extent of the biosciences

2.1 The biosciences are the study of life at all levels of complexity from molecules to populations. Whilst 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. Biology 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 inter-relationships 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 them. 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 and bioengineering.

2.4 The biosciences are thus divided into many specialisms. In addition to wide-ranging degrees such as biology, biological sciences and life sciences, there are sub-disciplines within this area that focus on particular groups of organisms (eg entomology). Other degrees emphasise specific technologies, interactions or systems (eg animal behaviour, biochemistry, biotechnology), or the environments that living organisms inhabit (eg ecology, environmental biology, marine biology); some are sub-disciplines directed towards particular applications (eg forensic, brewing and distilling). Appendix 1 gives a list of some of the subject areas in which degree courses in the biosciences are currently offered. Developments in molecular and structural biology have provided recent (but still incompletely used) opportunities to unify the disparate areas by identifying commonality between systems using a largely reductionist approach.

2.5 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.

2.6 The biosciences include areas (eg genetics and molecular biology) 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.

2.7 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) 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.

2.8 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 life. Many of the degree schemes 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 multidisciplinarity, an enquiring attitude and an appreciation of complexity. They require development of competence in team and individual working and in numeracy (often including IT and statistics and, increasingly the new subject of bioinformatics), as well as proficiency in preparing reports in a written format for many different purposes, and in delivering presentations.

2.9 The biosciences overlap with disciplines such as biomedical sciences, medicine, veterinary medicine, and agriculture. There will be some degree schemes in these different benchmarking areas having identical or very similar titles (see paragraph 1.10). Institutions can select the most appropriate *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.

2.10 For example, the biosciences as applied to the biology of disease share much with the biomedical sciences (which have their own *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.

2.11 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.

3 Knowledge, understanding and skills in the biosciences

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.

3.2 Subject knowledge

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

- 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;
- 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 practical and presentational 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;
- the applicability of the biosciences to the careers to which graduates will be progressing.

3.3 Generic skills

The qualities of mind that a student should acquire by studying biosciences are as follows. Learners working to acquire them should recognise that much of what they are taught is contested and provisional, particularly in the light of continuing scientific advances:

- 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;
- 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.

3.4 Graduate and key skills

The specific graduate and key skills that should be developed in bioscience degree courses are subdivided into the following headings, and described in the paragraphs below. Examples of the generic standards that are expected (at threshold and good levels) are given in section 5, and supplemented by more specific standards in three named broad subject areas:

- intellectual skills;
- practical skills;
- communication skills;
- numeracy, communications and information technology (C & IT) skills;
- interpersonal and teamwork skills;
- self-management and professional development skills.

3.5 Intellectual skills

- recognising and applying 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;
- analysing, synthesising and summarising information critically, including published research or reports;
- obtaining and integrating several lines of subject-specific evidence to formulate and test hypotheses;
- applying subject knowledge and understanding to address familiar and unfamiliar problems;
- recognising the moral and ethical issues of investigations and appreciating the need for ethical standards and professional codes of conduct.

3.6 Practical skills

- designing, planning, conducting and reporting on investigations, which may involve primary or secondary data (eg from a survey database). These data may be obtained through individual or group projects;
- obtaining, recording, collating and analysing data using appropriate techniques in the field and/or laboratory, working by themselves or in a group, as is most appropriate for the subject under study;
- undertaking 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, and procedures for obtaining informed consent. In some biosciences, graduates 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.

3.7 Numeracy, communication and information technology skills

- receiving and responding to a variety of sources of information: textual, numerical, verbal, graphical;
- communicating about their subject appropriately to a variety of audiences using a range of formats and approaches;
- citing and referencing work in an appropriate manner;
- sample selection; recording and analysing data in the field and/or the laboratory; validity, accuracy, calibration, precision, replicability and uncertainty during collection;
- preparing, processing, interpreting and presenting data, using appropriate qualitative and quantitative techniques, statistical programmes, spreadsheets and programs for presenting data visually;
- solving problems by a variety of methods including the use of computers;
- using the internet and other electronic sources critically as a means of communication and a source of information.

3.8 Interpersonal and teamwork skills

- identifying individual and collective goals and responsibilities and performing in a manner appropriate to these roles;
- recognising and respecting the views and opinions of other team members; negotiating skills;
- evaluating performance as an individual and a team member; evaluating the performance of others;
- developing an appreciation of the interdisciplinary nature of science and of the validity of different points of view.

3.9 Self-management and professional development skills

- developing the skills necessary for self-managed and lifelong learning (eg working independently, time management and organisation skills);
- identifying and working towards targets for personal, academic and career development;
- developing an adaptable, flexible, and effective approach to study and work.

4 Teaching, learning, and assessment

4.1 The objective 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 audio-visual presentations;
- laboratory classes, computing/bioinformatics sessions 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 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 computer sessions support learning in scientific approaches to discovery, practical experience, opportunities for acquisition of subject-specific and transferable skills, and reinforcement of the taught curriculum. Practical work may involve experiments carried out on material at a variety of levels from molecules to whole organisms. 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 is to help students to consolidate, deepen and extend the knowledge and understanding that they have previously acquired.

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.

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 assignments). This is likely to be in the student's 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.

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 project 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, audio-visual, or electronic presentations;
- a project or dissertation report;
- a work experience report;
- viva voce examinations.

5 Subject standards

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

5.2 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 UK so different that it is impossible to lay down meaningful standards for all such areas. Nevertheless, we felt that it would be misleading to produce a *statement* that gave no examples of factual knowledge, and so we have prepared three sets of examples of the kind of skills that we think should be expected of graduates in different fields of biology. Individual course 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 course. 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.

5.3 In each case, the standards are divided into 'threshold' and 'good'. The 'threshold' level is the essence of the benchmark, and achieved by anyone obtaining an honours degree, including those who are placed towards the bottom of the third class. The 'good' level is significantly higher, and describes what we hope would be achieved by a graduate who had performed well. It is difficult to describe this in terms of a particular honours classification, but 'good' is perhaps somewhere in the middle of an upper second class Honours degree.

Generic standards, not specific to any particular area

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

Threshold

- 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 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.

Good

- 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;
- demonstrated ability in a range of appropriate practical techniques and skills relevant to research in 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
(See paragraph 5.2.)

Molecular aspects of biology (including biochemistry)

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	Good
• be able to express relevant biological reactions in chemical terms;	• understand and explain the chemistry that underlies biochemical reactions and the techniques used to investigate them;
• understand how the chemistry and structure of the major biological macromolecules, including proteins and nucleic acids, determines their biological properties;	• understand the principles that determine the three-dimensional structure of biological macromolecules and be able to explain detailed examples of how structure enables function;
• understand how the principles of genetics underlie much of the basis of modern molecular biology;	• have a critical understanding of the molecular basis of genetics, and be able to explain some detailed examples;
• understand the main principles of gene expression;	• have critical knowledge and understanding of gene expression, with a detailed knowledge of specific examples; the structure, arrangement, expression, and regulation of genes; relevant experimental methods;
• 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;	• 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;
• understand a range of appropriate and relevant experimental techniques and how they are used; be able to perform some of them;	• be able to devise and evaluate suitable experimental methods for the investigation of relevant areas of biochemistry and molecular biology;
• have a knowledge of cell metabolism, including the main anabolic and catabolic pathways;	• 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;
• have knowledge of enzyme structure and function and of some of the most important mechanisms controlling the action of enzymes and other proteins.	• 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

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	Good
• describe the structure, diversity and reproduction of the organisms studied;	• critically analyse the impact of external influences on growth and reproduction, and explain reproductive strategies;
• describe basic organism structure and diversity;	• critically recount the interactions of structure and metabolic function at cellular and organismal levels;
• describe mechanisms for the life processes and appreciate how the physiology of an organism fits it for its environment;	• describe and critically evaluate the evidence for the mechanisms of life processes;
• show an appreciation of the integration of metabolism;	• interpret the significance of internal and external influences on the integration of metabolism for survival and health;
• show knowledge of the basic genetic principles relating to and evolution of the organisms studied;	• describe and analyse patterns of inheritance and complex genetic interactions;
• describe how organisms are classified and identified;	• enumerate the methods and principles underlying taxonomy and classification;
• appreciate the interactions of organisms with each other and the environment;	• critically describe the principles and processes governing interactions of organisms and their environment;
• describe the place of the organisms studied in the living world;	• critically analyse the contribution of the organisms to the biosphere;
• appreciate the importance of the 'behaviour' of the organisms studied.	• critically assess the contribution of 'behavioural patterns' to survival and success.

Ecology and environmental biology

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	Good
• demonstrate knowledge of biogeochemical cycles and pathways;	• demonstrate comprehension and intelligent engagement with biogeochemical cycles and pathways;
• describe and exemplify nutrient and energy flow through individuals, populations and communities;	• discuss and demonstrate comprehension of 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;	• demonstrate comprehension of 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;	• discuss and critically analyse 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 comprehension and critical analysis of population processes, dynamics and interactions, and associated models;
• demonstrate knowledge of community structure, development, biodiversity, and associated theoretical models;	• demonstrate comprehension and critical analysis of community structure, development, biodiversity, and associated models;
• demonstrate awareness of human interactions with natural populations and ecosystems, including habitat modification, pollution, exploitation and conservation;	• evaluate and critically analyse the effects of such human interactions on natural populations and ecosystems;
• demonstrate awareness of the applied significance of species as resources and as damage-causing organisms;	• evaluate the impacts of harvesting resources, controlling pest/pathogens and different approaches to species management;
• carry out routine investigations as instructed, using ecological methodologies and data analyses.	• apply critical understanding of ecological methodologies and data analyses.

Appendix 1

Some degree titles in the biosciences as given by UCAS

Degrees ranging across the entire area

Biological sciences
Biology
Biology and society
Biosciences
Life sciences

Focus on particular groups of organisms

Algology
Animal biology
Botany
Entomology
Human biology
Ichthyology
Lichenology
Microbiology
Mycology
Ornithology
Plant science
Virology
Zoology

Focus on particular systems, approaches or technologies

Anatomy
Animal behaviour
Animal nutrition
Biochemistry
Biomolecular analysis
Biophysics
Biosystematics
Cell biology
Developmental biology
Ethology (behaviour)
Genetics
Immunology
Infection biology
Molecular biology
Neuroscience
Nutrition
Nutritional biochemistry
Parasitology
Pharmacology
Pharmaceutical science
Physiology
Population biology
Psychobiology
Science (biomolecular studies)
Taxonomy

Focus on particular environments that organisms inhabit
Animal ecology
Aquatic biology (marine and freshwater)
Biodiversity conservation
Biogeography
Conservation management
Ecology
Environmental biology
Environmental biogeochemistry
Environmental pollution
Field biology and habitat management
Human ecology
Marine biology
Natural history
Natural science
Natural resource studies
Wildlife conservation
Wildlife management
Wildlife identification

Focus on particular applications of biology
Applied biology
Applied biochemistry and molecular biology
Applied biological sciences
Applied genetics
Applied microbiology
Applied physiology and pharmacology
Bioarchaeology
Biomedical sciences
Biomedical statistics
Biotechnology
Brewing and distilling
Exercise and movement
Food science
Forensic science
Health studies
Medical biochemistry
Medical biotechnology
Pathology
Palaeobiology
Palaeoecology
Sport biology
Sport science (biological)
Toxicology
Wine studies

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.

Appendix 2

Membership of the benchmark group

Professor Jeffrey Bale	University of Birmingham
Professor Paul Brain	University of Wales, Swansea
Dr Darrell Brooks	University of Central Lancashire
Dr Sara Churchfield	Kings 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