Life study

Biology A level in the 21st century

Recommendations and summary of research findings

March 2004

The Wellcome Trust

The Wellcome Trust has commissioned the education research on which this summary report is based with the aim of stimulating discussion about the future role of biology A level in schools and its relationship to progression in life sciences through Higher Education and beyond.

Developments in bioscience research will affect our society's future prosperity and health, and pose major questions for us all. The Wellcome Trust is committed to sustaining the future of biomedical research through its core objectives of supporting the development of the knowledge base, supporting scientific careers and through engaging the public in discussion about the impact of science on society. We see school science education as foundational in fulfilling these objectives.

Full report available at
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You can e-mail your views and comments on this report to lifestudy@wellcome.ac.uk

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Contents

Executive summary

In the 21st century, biology will have a vital role in shaping the future. This presents an important challenge to bioscience education in general, and to advanced level biology in particular, as the gateway to higher level work and research in the subject. This report sets out to understand current views and attitudes towards GCE biology A level from a range of stakeholders and interested parties, in order to establish an informed basis for planning future biology courses, with proper regard to research priorities in the subject.

The research was carried out for the Wellcome Trust by a team from the University of Warwick, comprising education researchers, with biology backgrounds, from the Centre for Education and Industry, and specialist biologists from science education in the Warwick University Institute of Education. The field research was carried out between July 2002 and March 2003. The purpose of the research was to investigate:

- the response of students and teachers to current biology A-level courses;
- factors which make biology a popular option at AS and A level;
- the effectiveness of current biology A-level courses in preparing students for progression in the biosciences;
- the extent to which biology A-level courses reflect changing research priorities in biosciences.

The research showed clearly that biology was widely regarded as interesting and enjoyable. It was also widely regarded as an A level which offered good progression prospects to higher education and employment, giving access to a range of popular career routes, including medical and related professions. These factors emerged as the main motivators for students choosing to study biology at A level. There was a widespread belief that biology A level should provide a broad foundation of knowledge and skills across the subject. However, the research also showed that students' and teachers' interest and enjoyment were not evenly spread across the subject. Some topics, including human and medical biology, were very popular, but other topics were much less popular, notably plant biology, food production and agriculture. There were also differences in the assessment of importance of different biology topics. A relative lack of interest in a topic did not necessarily prevent recognition of the topic's importance, but did tend to result in lower perception of importance than for very popular topics. There was a marked similarity in the responses of A-level students and teachers.

While there was strong support for the proposition that biology A level should provide a broad foundation across the subject, there was also backing for more choice and opportunity to follow specialist options. This was seen as a possible response to rapidly expanding and advancing knowledge in the subject. In reality the 'choice' was made by the school or college, based on their available resources and expertise.

Current A-level courses seemed to be successful in maintaining students' interest in the subject, and encouraging a significant proportion to progress to higher education in bioscience. However, students seemed less well equipped to choose 'the right course' after A level. A majority of current biology A level students (55 per cent), and former students (now bioscience undergraduates [73.6 per cent] and postgraduates [74.5 per cent]) felt that biology A level is successful in maintaining interest in the subject, and encouraging progression to higher

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level study in the subject. However, results for all three groups of students showed less than half who felt that biology A level made them more sure which branch of bioscience to pursue. The evidence suggests that students have insufficient knowledge and experience to enable them to make truly informed choices from the full range of bioscience degrees available in higher education.

Students seemed to be broadly content with current biology A-level courses. All stakeholders, including the students, acknowledged the heavy factual content of the subject. However, many respondents did not regard this as a serious problem. Indeed, a significant proportion of students seemed to enjoy the descriptive, fact-based aspects of the course. There were some concerns, however, that assessment relied too heavily on factual recall. The factual content of biology A level does not prevent it from being one of the most popular subjects at A level, and the most popular science. It may be that some students who dislike dealing with a lot of factual information could be put off the subject, and this may include some students with high ability in maths and physics.

Higher education tutors and A-level teachers often expressed concerns about some other areas of knowledge and skills in biology A-level students. In particular, deficiencies in numeracy, mathematics and chemistry can be a problem. Some were also concerned about many students' lack of ability to produce extended pieces of writing. This is not required at A level, but is regarded as important for degree level studies and research. Research skills of current A-level students were good in parts, e.g. they seemed confident in using the Internet (although not always discerning about the quality of information), but less skilled in using other library or documentary sources. Current A-level students display greater confidence in oral work, and group discussions than their predecessors.

There was considerable variation in the amount of practical work experienced by students at A level. Experienced A-level teachers reported that they were doing less practical work now than in the past. Bioscience tutors in higher education reported that students with biology A level often have weak practical skills. The tutors did not necessarily see this as a serious problem, though, as these skills can be taught.

The research highlighted concerns about assessment and coursework in some representatives of all stakeholder groups, notably that there is now too much assessment and that this may have reached the point where it is taking up too much valuable teaching and learning time. Also the nature of assessment came in for criticism. While a variety of views was expressed, 51 per cent of teachers disagreed (24 per cent strongly) with the proposition that recent changes in assessment have had a positive effect. Coursework investigations were also criticized for being time consuming, but rather artificial exercises which do not reflect the true nature of science as a process of enquiry.

It was widely agreed that biology A level should seek to keep up with current research priorities in the biosciences, and should address important social and ethical questions. However, many teachers and university tutors advised caution in order to avoid some potential risks. These included:

- potential pressure on the essential 'core' of the subject;
- risk that 'trendy' topics are given undue weighting;

Biology A level should seek to keep up with current research priorities.

- practical difficulties and time required in implementing changes to the specifications;
- the need for a reasonable degree of stability in the A-level course;
- the capacity to support biology A-level teachers with adequate professional development;
- quality of debate involving students whose knowledge of the scientific background to current issues is limited.

Links between teachers of biology A-level and university bioscience tutors were not strong, and direct communication and understanding seemed limited. This may in turn explain why many life science students initially choose the 'wrong' course at undergraduate level.

Bioscience has become a highly complex field, with increasing overlaps with physical sciences, mathematics and engineering. Dialogue between the bioscience research community and those responsible for biology education is important for planning future development. This presents a major challenge, since the bioscience community is represented by a wide range of different groups, making it difficult to convey clear or consistent messages about priorities which are relevant to biology A level. Decisions about biology A-level development could become over-dependent on subjective judgement and opinion.

Recommendations

1. The development of the biology A level curriculum should remain responsive to the changing nature and the range of voices within contemporary biological science. If it does not, biology A level will lose credibility with some biologists and communication and progression between secondary, tertiary and higher phases will suffer.

2. There should be a review of what is genuinely foundational in biology A level – and what is not. This may help to clarify and define the essential core, which every biology A-level student should study, and at the same time map out the space that remains for free or restricted option choices that might satisfy the appetite for flexibility. Such a review should consider to what extent this 'foundation' consists of factual or conceptual knowledge and to what extent it is defined by a distinctive type of questioning and researching. Furthermore this review needs to take account of actual and possible changes in other courses that post-16 students are likely to be following.

3. Wherever possible, contemporary science issues and examples should be integrated into the subject core, rather than added on as option choices.

4. Providers of bioscience courses in higher education should be closely involved in discussions about the essential core and options structure of biology A level. The outcome of these discussions should inform decisions on the extent to which all bioscience degree courses should include a first-year foundation programme.

5. There should be a review of the coursework component of biology A level. This should aim to encourage a broader range of practical investigations, designed to support understanding through the development of investigative and practical skills. The review could examine the usefulness and practicability of producing a set of cost-effective, practical investigations which could be delivered by any school or college, subject to compatibility with particular assessment requirements, and which could be disseminated to teachers through professional development.

6. There should be investment in continuing professional development to support the teaching of existing topics and newer topics, such as biotechnology, so that teachers and students from all centres are able to tackle learning in these areas with confidence, enthusiasm and enjoyment. In the same way there need to be good learning resources and CPD to support teaching and learning in the area of ethical and social issues in biology. There is a particular need to produce innovative and motivating materials and activities to support plant biology, which might be linked with teacher professional development to rebuild confidence and generate enthusiasm for this part of biology.

7. There should be better understanding and more collaboration between students and staff in secondary and higher education with a view to improving progression. One strategy to achieve this might be the dissemination of good practice in links between biologists in schools and higher education.

There should be investment in continuing professional development to support the teaching of existing topics and newer topics.

8. Assessment in biology A level should be monitored and re-evaluated. Evaluation should include the following questions:

- Does the assessment regime test a sufficient range of biological and scientific skills?
- Does the assessment add value to the learning of students in biological science?
- How well matched are the styles of learning emphasized in delivery and the demands of assessment – particularly the higher order demands of the synoptic papers?
- Is there too much biology A level assessment?

9. Teachers need to deploy teaching strategies to support and develop a wider range of learning styles over and beyond 'memorization'. This might be brought about through continuing professional development for teachers of biology A level. However, opportunities for teachers to build their subject knowledge and understanding are currently lacking or difficult to access. In some cases the development of teachers' subject understanding may provide a way of extending learning styles for students. The Science Learning Centres being established in a joint initiative by the Department for Education and Skills and the Wellcome Trust could make a major contribution in this area.

10. Further research could be undertaken to explore more thoroughly the extent to which evidence supports the provisional finding that research priorities in the biological sciences have permanently shifted, to explain these changes and to evaluate their significance for the biology A-level curriculum. As part of this research it would be valuable to analyse the several changes that the biology A-level curriculum has undergone over the same period in order to evaluate the extent to which this curriculum may have responded to messages from the research community.

Introduction

Biology has remained a popular option for students at AS and A level during the past decade. The number of candidates entered for A level in England and Wales has risen, while entrants for chemistry and especially, physics have fallen.[1] Biology has also proved attractive to students who choose a mixture of A levels, and do not intend to progress further in science. Among the sciences, biology is well received, especially by girls, but also is popular with boys, since its relevance to their own personal lives is easily recognized (Osborne and Collins 1999).[2]

While biology's continuing popularity may be gratifying for the bioscience community, it does raise questions about whether the A level is providing the right preparation for the bioscientists of the future who will have such an important role in society, given the growing impact of biosciences on our lives. Many may agree with the statement on the Salters-Nuffield Advanced Biology project website that "we have just entered a century which is likely to be dominated by biology, and yet A-level biology has seen few curriculum initiatives in recent years".[3]

Biology A level must build on the foundations of science laid in pre-16 education, which has itself been the subject of concern. The Roberts Report (2002) 'SET for Success': stated that:

"The (science) curriculum is overcrowded, and assessment is based too much on memorization and recall, which is unrepresentative of how science is used in life."[4]

Additionally, the Nuffield Foundation Report 'Beyond 2000' (Millar and Osborne 1998) asserted that the content of the pre-16 science curriculum at secondary level had remained largely unaltered, and was essentially a diluted form of the 1960s GCE curriculum.[5]

Since that comment was made, new science courses (e.g. Applied Science and the piloting of 21st-century Science), are seeking to strengthen the link between the science curriculum and its applications in the modern world. However, there remains a substantial foundation of science content which is regarded as essential, and this feeds through to A-level sciences, including biology.

Recent years have seen dramatic advances in biosciences, to the extent to which some, e.g. in genetics and cell biology, have been described as 'revolutionary' (National Academy of Science 2002 BIO2010).[6] Some of these advances are posing fundamental social and ethical challenges. Biology education and biology A level need to decide how to respond to these changes and challenges. The pressure to increase the content of the A level in these 'revolutionary' areas is strong. The consequences, however, may be to squeeze other 'traditional' areas within bioscience. For example, aspects of taxonomy, classification and biodiversity may be struggling to maintain their profile (House of Lords Select Committee on Science and Technology)[7], and yet some would argue they form part of the foundations of biological knowledge.

There are difficult choices to be made. The content of biology A level cannot continue to expand as knowledge expands. This generates debate about what constitutes the essential 'core' of biology A level. Other debates focus on the balance between learning 'facts' and understanding scientific principles. Debate on these issues take place in the context of changes across 14–19 education, which impact on the future of A level.

It could be easy to be complacent about biology A level, given its continuing popularity. However, rapid advances in bioscience should stimulate urgent debate about how biology education, including the A level, and any future equivalent, should develop so that students will come through with appropriate knowledge, skills and understanding, and that sufficient numbers will progress successfully into bioscience research and development.

1 Statistics prepared by SIM QCA – Source: Inter Examinations Board Statistics (August 2002).

2 Osborne J and Collins S (1999) *Pupils, Teachers and Parents Views on the School Science Curriculum.* Kings College, London.

3 www.advancedbiology.org/course/background.asp – Salters-Nuffield Advanced Biology website.

4 Roberts Sir Gareth (2002) 'SET for Success – The supply of people with science, technology, engineering and mathematical skills' *The Roberts Report.*

5 Millar R and Osborne J (1998) *Beyond 2000: Science Education for the Future.*

6 National Academy of Science (2002) BIO2010: *Transforming Undergraduate Education for Future Research Biologists.*

7 House of Lords, Select Committee on Science and Technology 4th Report (2002–03) 'What on Earth? The Threat to the Science Underpinning Conservation: The Government's response and the Committee's Commentary HL Paper 130'.

Research methods

The research methodology was designed to collect information from a wide range of stakeholders with interests in biology A level and its development. Both quantitative and qualitative methods were used. Information was collected from:

- schools and colleges which provide biology A level courses;
- higher education institutions, in relation to progression from biology A level;
- the 'bioscience community', through representatives of some learned societies;
- various documentary sources.

Quantitative research

The quantitative research was carried out through questionnaires. Four stakeholder groups were surveyed (current AS/A2 students, A-level teachers, undergraduate and postgraduate bioscience students who had taken biology A level). As far as possible, the questionnaires for all four groups contained identical or similar questions covering four main areas:

- motivations for choosing to study biology A level;
- preferences for topics within biology A level, and perceptions of the social/scientific importance of topics;
- views on the curriculum, teaching and learning in biology A level;
- views on progression and plans for the future.

In the survey of current AS and A2 students, in order to maximize response rates, preliminary letters were sent to a sample of schools, to ask if they would be prepared to involve their students in the research. In total, 108 schools in England were contacted, of which 38 agreed to take part. This provided a student sample which included comprehensive, selective, state, independent, mixed and single sex schools. In the sample, 1500 questionnaires were sent out to schools, and 729 completed questionnaires were returned from AS/A2 biology students. A breakdown of the AS and A2 student respondents was as follows:

- 39 per cent were male and 61 per cent female;
- 68 per cent were studying biology AS level and 32 per cent A2 biology;
- 28 per cent were taking two other sciences at A level;
- 26 per cent were taking one other science at A level;
- 37 per cent were taking no other sciences apart from biology.

The same set of schools was used for part of the survey of biology A-level teachers. An additional 39 schools were also contacted for additional teacher data. In total, 57 questionnaires were returned by biology A-level teachers from 34 different schools in England.

In higher education, questionnaire surveys were carried out with bioscience students in nine different universities. These included Russell group, 'new', and other universities, and surveyed both undergraduate and postgraduate students from a range of disciplines within the biosciences. In total, 194 questionnaires were returned from undergraduates and 51 from postgraduates.

Qualitative research

Qualitative data was collected from some stakeholder groups, through structured individual interviews, and through focus group interviews.

Focus group interviews were carried out with 12 groups of AS/A2 students, of which five

were at AS level, five at A2 level and two were a mixture of AS and A2. A total of 75 students took part in focus group interviews.

Individual interviews were carried out with 23 biology A level teachers. Of these teachers, 11 taught in mixed comprehensive schools, seven in colleges of further education, four in independent schools, and one in a sixth form college.

Focus group interviews were carried out with five groups of university students. Three of these were with undergraduates (14 students in total) and two with postgraduates (ten students) from three different universities.

Face-to-face interviews were carried out with 21 university tutors whose responsibilities included subject tutoring, research supervision and admissions. In addition, one recruitment manager was interviewed. These interviews took place in 11 different universities including Russell group, new and other categories.

Some information was collected from 'learned societies' concerning their perceptions of the current and future needs in biosciences. This information was brought together through inviting relevant professional bodies to return a structured response form. Responses were received from seven different organizations.

In order to explore a more objective approach towards the choice of content in biology A level, documentary and other research was carried out to investigate possible indicators of priorities in bioscience research. This included using some database searches (in the Science Citation Index) with assistance from the Centre for Information Behaviour and the Evaluation of Research, City University, London.

Research findings

The views of AS/A2 students

What motivates students to study biology A level?

Two main factors emerged as principal motivators for students choosing AS/A2 biology. The first could be classified as a combination of interest, enjoyment and aptitude. The students reported having enjoyed the biology component of science studied at GCSE, and express a high level of interest, especially in topics they feel are most relevant to them (e.g. human biology). A large majority (88 per cent) of students agreed with the statement "I always found biology generally interesting", of whom 40 per cent of the total agreed strongly.

The second set of factors could be classified as career aspirations. A substantial proportion of respondents (54 per cent) had chosen biology as a necessary subject for possible careers in medical and related professions (e.g. dentistry, pharmacology, pathology, physiotherapy). Biology was also seen as attractive as an accessible science qualification for those seeking a balance of subjects offering broad career potential.

Which topics are preferred by students and what is their perceived importance?

For the purposes of the survey, the content of biology A level was classified into 15 main topic areas. Students were asked to express their level of interest in each topic, and their perception of the importance of each topic as a field within bioscience.

The topics which students found most interesting were human and medical biology, brain and neuroscience, cell biology, and growth and reproduction. In all these topics, over 90 per cent of students said they found them 'very' or 'quite' interesting. There was also strong interest in genetics, with 87.7 per cent of students finding this topic 'very' or 'quite' interesting. There does seem to be a link between career aspirations and interest in biology topics.

The topics which students found least interesting were food production and agriculture (41.4 per cent 'very' or 'quite' interested), plant biology (55.9 per cent), and ecology (57.6 per cent).

When students were asked to express views on the importance of topics in bioscience, there was a close match with their level of interest in the most popular topics. For example, human biology, which was rated as 'very' or 'quite' interesting by 96.7 per cent of respondents, was also rated as 'very' or 'quite' important by 97.9 per cent of respondents. Similarly, medical biology, neuroscience, genetics, growth and reproduction were all rated as 'very' or 'quite' important by over 90 per cent of students, as well as inspiring a high level of interest.

Some of the topics in which students expressed less interest were recognized as being important, though not at such a high level as those already listed. For example, food production, rated as 'very' or 'quite' interesting by only 41.4 per cent, was identified as 'very' or 'quite' important by 75.3 per cent of respondents. For ecology, the results were 57.6 per cent 'very' or 'quite' interesting, and 72.4 per cent 'very' or 'quite' important. There was a wide recognition of the importance of environmental biology, with 90.8 per cent of students rating this as 'very' or 'quite' important. The level of interest in environmental biology, however, was lower, with 75.2 per cent of students rating it as 'very' or 'quite' interesting. The topic which was rated as least important was plant biology, with 65.7 per cent rating it as 'very' or 'quite' important. As previously stated, the level of interest in plant biology is also low, with 40.8 per cent of students rating it as 'not

Chart 1: Topic interest levels for A-level students

Higher mean score corresponds to higher level of interest on a scale of 1–3

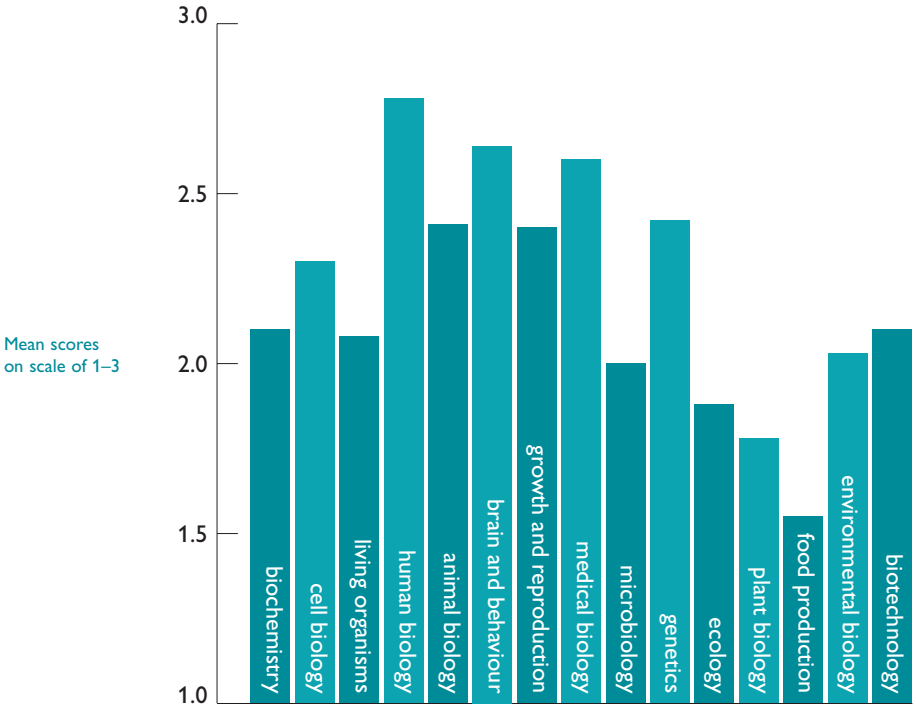
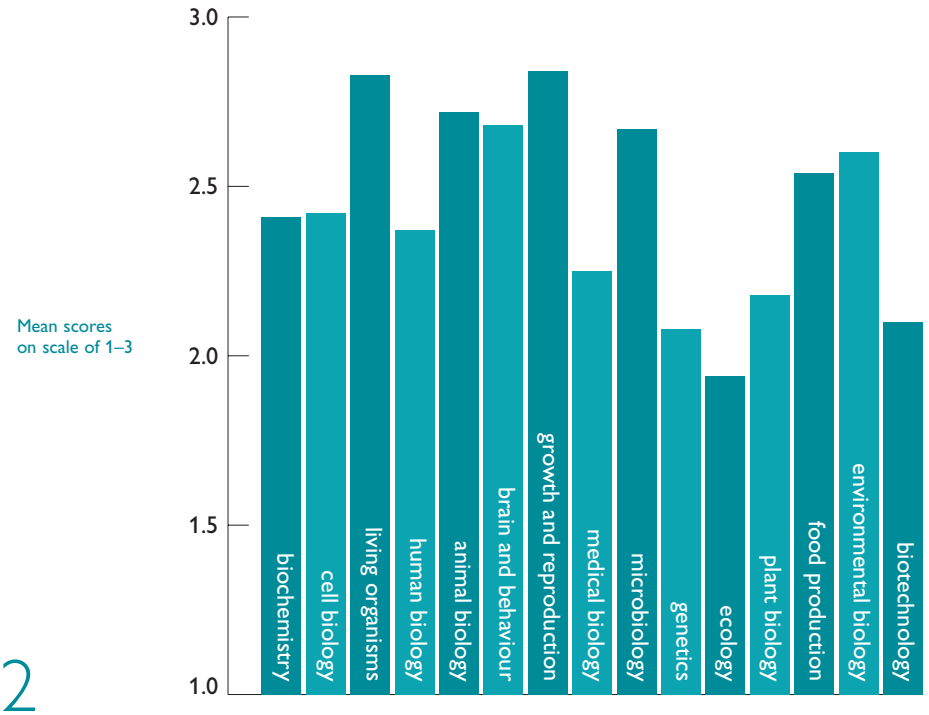


Chart 2: Perceptions of importance – A-level students

Higher mean score corresponds to higher perception of importance on a scale of 1–3



Biology A level provides a good foundation for degree-level studies.

very' or 'not at all' interesting. The results are shown in Charts 1 and 2.

It is not surprising that students showed a high level of interest in human and medical biology, given the direct relevance of these topics to every individual, a factor which was emphasized in focus group discussions. The high ratings for importance given to these and related topics, reflect a natural tendency to prioritize human wellbeing. Those topics in which students showed less interest (e.g. plant biology, food production) do seem to be at a disadvantage. More detailed discussion in focus group sessions confirmed these views. If it is accepted that these are part of an essential core in biology A level, there is a challenge in making them more attractive in terms of choice of content, teaching and learning styles, and supportive professional development for teachers. The lower level of importance which students attached to topics like food production, ecology and environmental biology may be due to a perception that these are not as closely associated with human wellbeing.

How do students view the curriculum, teaching and learning styles?

The research sought to identify students' views on the content of biology A level, exploring the concern that the current A level might be overloaded, and too reliant on memory recall. Responses indicated that they were not greatly concerned about this, and are broadly content with the volume of material and descriptive nature of the biology A-level curriculum. Just over half (51 per cent) of the students surveyed felt that the course contains about the right amount of material, and 58 per cent confirmed that the amount of factual material they were expected to learn was 'about right'. However, a substantial proportion of students (29 per cent) felt that the course contained too much material, although only 8 per cent agree 'strongly' with this.

A significant majority of students (62 per cent) believed that the A level covers the most important topics in the subject. Only 7 per cent disagreed with this view. Students were reluctant to propose removal of any topics from the course, in spite of their clear preferences, described earlier.

Of the students, 45 per cent felt that there was an over-reliance on memory recall. Set alongside other responses, as described above, this seems to be a comment on teaching, learning and assessment than the factual content itself. The results suggest that many students enjoy the factual and descriptive nature of biology A level, and that this is a feature which makes it accessible to a wide range of students. It also may contribute to its perception by some as being 'easier' than other sciences. For example, chemistry was seen as being more 'analytical' and involved more scientific thinking.

"I think biology is a lot about memory, more so than chemistry. People who do well are the people who are going to work hard. Revision is a valuable skill. You learn how to do it and go over things. You can build up the connections."

A2 biology student

A majority of students believe that biology A level should continue to provide a broad foundation in the subject, and that specialization should come later. At the same time, there was support for the availability of options to allow more detailed investigations of certain topics. However, some students doubted the capacity of schools or colleges to provide specialist

...more attention should be given to social and ethical issues...

options, and the point was made that it is the school or college which chooses the option, rather than the students.

Assessment, both internal and external, features prominently throughout the A-level course. Most students had either just been assessed or were preparing for assessment. Students were often critical of assessment practices. In particular, some expressed difficulty in relating the questions to the learning they had done. It is, of course, possible that this is sometimes due to the students not appreciating that they are being asked to apply their learning in an unfamiliar context. On the other hand, some students expressed concern about a perceived high proportion of marks awarded for pure factual recall.

"You need to learn lots of names. It is unfair to recall the exact word. This does not show that you understand."

A2 biology student

Assessed coursework aroused some strong feelings in focus group sessions, presumably based on personal experiences. There was concern expressed about the amount of time coursework takes up. Positive views tend to relate to the opportunity provided for students to demonstrate capability in a different context as exemplified by one student:

"Coursework is an opportunity for those not good at exams to show their capabilities."

Among those students who were critical, one had no doubt that coursework did not add any value to the A-level course, saying:

"Coursework should go!"

Students were asked to identify the topics they felt were current priorities for bioscience research. The most frequent references included genetics, gene technology, human health. GM foods and environmental issues were also prominent. A majority of students took the view that biology A level did not give much opportunity to find out about current research, and would welcome more of this. Some students favoured a move towards an A level in which investigations were developed in greater depth to give more experience of a research approach. However, others prefer a 'safer' approach based on factual information and established knowledge.

Students did show strong interest in controversial issues in bioscience. Almost half of all students (48 per cent) believed that more attention should be given to social and ethical issues in bioscience.

The research identified considerable differences in the amount of practical work undertaken by students. A substantial majority enjoyed practical work, and were positive about its value as a learning approach. Of students, 44 per cent agreed that there was sufficient opportunity for laboratory practical work overall. However, this masks the finding that while AS students are quite satisfied with the amount of practical, the A2 students were not, as practical work seems to reduce in the A2 year. Students were divided about whether there should be more assessment of practical work. Some feel this is a good way to develop and display critical thinking, but others felt this was not a reliable method of assessment, because "things can go wrong".

While some students had significant opportunities for fieldwork, many did not. Of students, 57 per cent disagreed with the statement "there is enough opportunity for

biological study outside the classroom, e.g. visits and field work". Those that did carry out field work reported different experiences. Some were inspired and excited, but others criticized the actual tasks they had carried out as being dull or tedious. Further research would be needed to identify the factors influencing these perceptions. Some evidence from focus groups suggested that students from the independent sector may have more opportunities for field work than those from the maintained sector.

Views on progression

A substantial (and unrealistic) proportion (24 per cent) of all students studying AS or A2 biology express the hope to study medicine at university. A relatively low proportion of biology students (14 per cent) plan to study other sciences at university.

Of students who planned to study biosciences at university, 55 per cent felt that biology A level had strengthened their commitment to the subject in general. (Less than 10 per cent disagreed with this proposition.) However, while biology A level seems successful in strengthening or maintaining general interest, fewer students (42 per cent) who plan to take bioscience degrees reported that their experience of AS/A2 level has helped them make up their mind about which kind of biological science they want to take further. This confirms the view that the A-level courses are not wholly effective in helping students to choose between higher biology courses.

The views of A-level teachers

What motivates students to choose biology A level?

As reported by the students themselves, teachers identified interest in the subject (93 per cent) and aptitude (83 per cent) as key motivators. They also identify potential progression and employment prospects as an important factor (73 per cent).
Of teachers, 64.4 per cent agreed with the statement that "some students find biology easier than other subjects".

Teachers recognized biology as a popular choice at A level, with a high conversion and retention rate from AS to A2.

What are teachers' topic preferences and perceptions of importance?

The topics identified by teachers as the most interesting parts of the A-level course were very similar to those identified by A-level students, and reinforce a leaning towards human, medical and related fields, and away from plant biology. The highest levels of interest, as percentage responses from teachers, for 'very' or 'quite' interesting topics were for human biology (98.3 per cent), brain and neuroscience (98.3 per cent), growth and reproduction (96.6 per cent), animal biology (96.6 per cent), medical biology (94.9 per cent) and genetics (94.9 per cent). The lowest levels of interest, (percentage responses for 'very' or 'quite' interesting) were in plant biology (50.8 per cent), food production and agriculture (52.5 per cent), classification (55.9 per cent) and ecology (71.2 per cent).

Teachers also showed very similar responses to A-level students when asked to rate the importance of biology topics for society, although they were more ready to attach high importance to topics which they may not rate very highly in terms of interest. Human biology, medical biology, and genetics were all rated as important by 100 per cent of teachers. Most other topics were regarded as 'very' or 'quite' important by more than 90 per cent of teachers. Some topics regarded as less interesting were acknowledged as important, e.g. food production and agriculture is rated 'very' or 'quite' important by 86.4 per cent of teachers, but 'interesting' by only 50.8 per cent of teachers.

The topic rated least important by teachers was classification and the variety of living things. Only 72.9 per cent of teachers rated this as 'very' and 'quite' important. Almost a third of teachers (27.1 per cent) rate classification as 'not very', or 'not at all' important. These results are displayed in Charts 3 and 4 (opposite).

Teachers seemed to show a greater appreciation of the importance of topics which they may not find very interesting than is the case with A-level students. However, teacher preferences for certain topics may be communicated to students, even if unintentionally. It is difficult to generate the same enthusiasm and excitement for topics in which the teacher has less interest. In addition, relatively few biology teachers seemed to have a strong background in plant biology. These factors may tend to reinforce the preferences already displayed by students, and maintain this situation over time.

What are teachers' views on the curriculum content, teaching and learning?

The research identified a range of views among teachers of biology A level, which it suggests could be divided into:

- **'traditionalists'** – who tend to disagree with the proposition that the A level is overloaded with content, are reluctant to support the

Chart 3: Topic interest levels for A-level teachers

Higher mean score corresponds to higher level of interest on a scale of 1–3

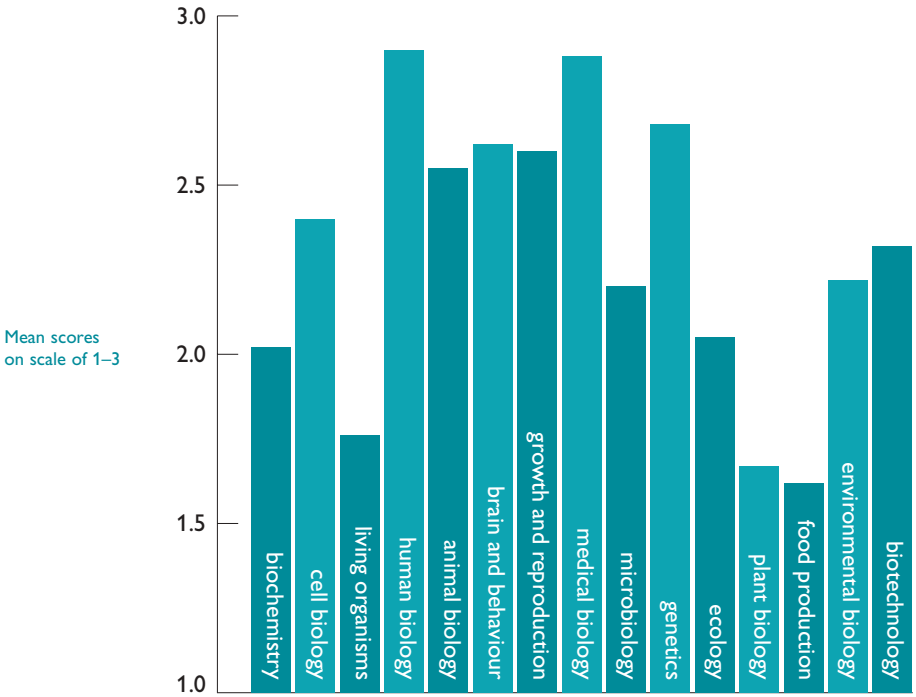
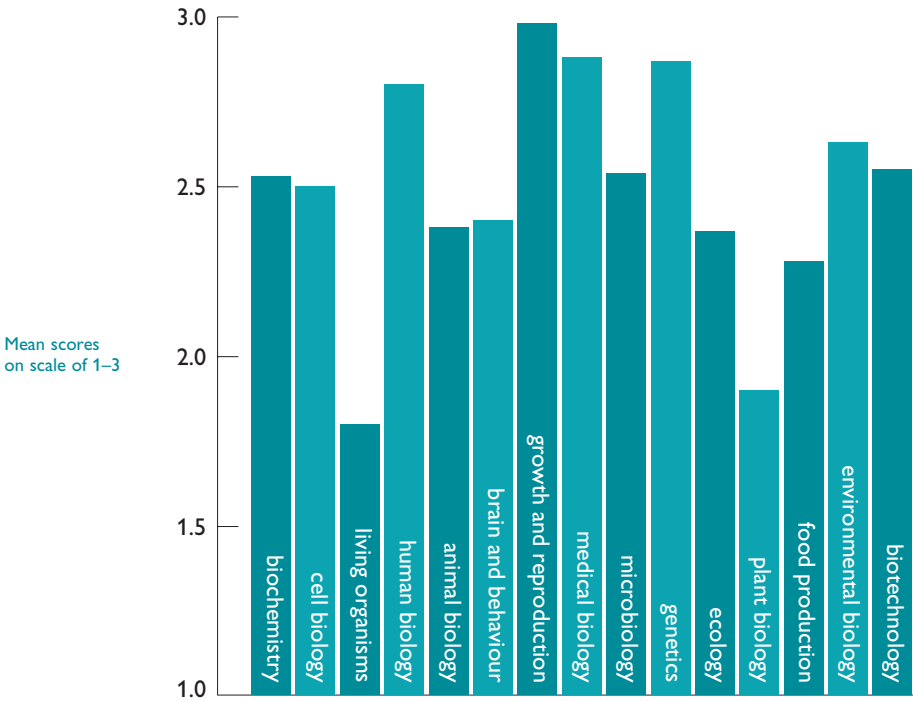


Chart 4: Perceptions of importance – A-level teachers

Higher mean score corresponds to higher perception of importance on a scale of 1–3



...should provide a broad foundation in the subject

removal of traditional topics, and regret the loss of essay-style assessment;

- **'moderates'** – who tend to be concerned about volume of content, and to favour more investigative work. However, they also tend to be cautious about disruption caused by change, and are reluctant to name topics which could removed to make more space for investigation;

- **'radicals'** – who tend to feel strongly that the A level is overloaded with factual knowledge and support radical change, removing topics (or making them options) to make space for more investigative work, and current issues.

These descriptions summarize the range of views expressed by teachers, but further research would be needed to test the validity of this type of classification. Some of the relevant research findings are described below.

Teachers were divided about whether the biology A-level curriculum was overloaded with content. At AS level, 39.7 per cent of teachers agree that there is too much content, but 32.7 per cent disagree. The results are similar for A2, with slightly more teachers (44.8 per cent) believing there is too much content, but still more than 30 per cent disagreeing.

A majority of teachers (60.2 per cent) felt that the A level should provide a broad foundation in the subject, while only 12 per cent disagreed. Just under a third (30 per cent) of teachers believed that there were topics which could be dropped, but there was little consensus about which topics these might be, although 9 per cent suggested a reduction in plant biology. On the other hand 50 per cent of teachers believed that there were topics which should be added or developed further. However, there was no clear consensus about which these might be. The 26 teachers who made specific suggestions named 16 different topics.

There is a wide range of opinion among teachers of biology A level. Views are split on the need for change and the content of the curriculum, while strong support exists for the 'broad foundation'. This suggests the value of involving stakeholders in a curriculum analysis leading to a definition of a broad foundation which is fully up to date. It could then be argued that the range of additional topics could be covered through further development of options. A majority of teachers (59 per cent) favoured "a further development of the core plus option structures for biology A level in order to allow greater choice and specialization in specific topics". This would, however, raise other issues. The degree of choice offered by the options may be largely illusory, in that they tend to be chosen by the school, according to available resource (equipment costs etc.) and staff expertise. Another factor influencing choice of options is the degree of popularity with the students. Schools will not select an option unless the majority of students find it interesting. This could tend to reinforce the bias towards human and medical biology at the expense of plant biology.

Given the fact that a substantial proportion of present and former A-level students, and A-level teachers express broad satisfaction with the content of the current A level (e.g. about a third of teachers see no need for change), any proposals for change will need to be supported by a strong rationale.

Of the teachers surveyed, (56 per cent) agreed that 'learning facts seems more important than developing understanding or critical skills', while 29 per cent disagreed with this statement.

...any proposals for change will need to be supported by a strong rationale

In response to the statement "the course relies too much on memory", 46 per cent of teachers agreed, while 29 per cent disagreed. This diversity of views encompasses strong feelings on either side. In one teacher's view:

"There is an awful lot of memory involved. The AS biology could be passed by anyone with a decent short-term memory."

Other teachers believe that memorization is important:

"Lots of university work does depend on memorization. I did so myself in my recent MSc."

A majority of teachers (67.2 per cent) expressed the view that future development of biology A level should place greater emphasis on scientific skills and understanding. Many felt that the current A level offers insufficient scope for these skills.

"…not well developed in our students, and there should be more opportunity to raise their understanding."

Teachers were divided on the extent to which biology A level can or should cover current research priorities. Some teachers believed that more should be done to include current research. Others adopt a more cautious position, wanting to protect the broad foundation. One teacher argued that:

"There is a tension. It is important that people in A level are aware. But there is not time to get to grips – to fully understand those issues – not in place of doing foundations. Demands of research can call the need for more (not less) foundational knowledge. Genetics must be set in a broader biological understanding. It is difficult to fully teach something like the Human Genome Project within the course."

Almost all teachers valued practical work and felt that it added greatly to students' understanding. However, most teachers believed they have less time for practical work than they would like. Experienced teachers confirmed that they were doing less practical than they have done in the past. Of the teachers surveyed, 52.5 per cent disagreed with the statement "there is sufficient opportunity for laboratory practical work". The situation for fieldwork is even more marked, with 64.7 per cent disagreeing with the statement that there is "sufficient opportunity for fieldwork".

Teachers expressed concern and reservations about current coursework, with doubts about whether it was adding value to the course. Over half of teachers (50.8 per cent) felt that recent changes in assessment of coursework had not been beneficial. In one teacher's view:

"Jumping through hoops does not develop investigative thinking."

Most teachers felt that there was too much assessment in the course overall.

"There should be less assessment. They should not sit so many exams and do so much coursework. We have to teach and assess every unit. There is no freedom to learn in a more investigative manner."

What experience do teachers have of continuing professional development related to teaching biology A level?

Rapid advances in the biosciences present a major challenge for biology teachers in keeping their own scientific knowledge up to date.

Rapid advances in the biosciences present a major challenge for biology teachers.

Continuing professional development must play a vital role in supporting teachers, giving them confidence, and ensuring that their teaching reflects modern biology. However, teachers clearly did not feel that current provision for professional development is adequate. Only 29.8 per cent of teachers agreed with the proposition that they had sufficient opportunity for professional development, while 57.9 per cent disagreed. Furthermore, a substantial majority reported that the professional development they received was focused on specific course delivery and assessment issues. Professional development which focuses on expanding the biological skills and knowledge of teachers was rare.

Most teachers (62.1 per cent) felt that they were aware of current research priorities in bioscience, although 62.7 per cent of teachers agreed with the proposition that it was difficult to keep up with current research in their subject.

Teachers were divided in their views about emphasis on social and ethical issues. They acknowledged the importance of these issues and the strong interest shown by students, but some teachers felt there is already adequate opportunity in the current A level to deal with this. Others felt more should be done. A number of factors may have influenced teachers' response to this question. There may be concerns that discussion of these issues could become too time-consuming in a crowded course, and that a lack of depth of knowledge of the relevant science could lead to rather uninformed debate, which contributes little to scientific learning. On the other hand, it could be argued that it is also important to consider how science is influenced by 'lay' opinions. Another factor likely to influence teachers' views, is the extent to which they feel comfortable engaging in debate on controversial issues, rather than dealing with scientific facts. A detailed investigation into how schools deal with controversial scientific issues was carried out in previous research commissioned by the Wellcome Trust ('Valuable Lessons').[8]

Views on progression

A substantial majority of teachers (82.8 per cent) believed that biology A level provides a good foundation for degree-level studies in bioscience. In general, the A level was seen as good 'currency' for progression into higher education; 69 per cent felt it was good preparation for medical degrees and 60 per cent felt it was good preparation for any degree course.

While a majority of teachers (76.3 per cent) claimed to have a good understanding of the expectations of bioscience degree courses in general, many teachers felt that they lacked up-to-date knowledge of the options for bioscience study in higher education. Interviews with teachers and with higher education bioscience tutors suggested that contact and communication between teaching staff in schools and HE is limited.

8 The Wellcome Trust (2001) 'Valuable Lessons: Engaging with the social context of science in schools'.

Views of undergraduate and postgraduate bioscience students

Why did undergraduate and postgraduate students study biology A level?

Undergraduate and postgraduate students reported the same key motivating factors as those identified by current A-level students. For over 90 per cent of students, intrinsic interest in the subject was a key motivator. Aptitude was important for over 80 per cent of students and career or progression prospects were also rated as important motivators, especially for the postgraduate students (72.5 per cent compared to 59.3 per cent for undergraduates).

In the focus group discussions, the capacity of some biology A-level teachers to inspire and motivate students was also emphasized.

A number of students had previously aspired to careers in medical or related occupations, but had subsequently followed a different area of interest within the biosciences.

Topic preferences and perceptions of importance

While the sample was not fully representative across the full range of biosciences, students from a range of different areas were asked to reflect on their preferences as former A-level students. The preferences expressed by undergraduate and postgraduate students were very similar to those expressed by current A-level students and teachers. Human biology and medical biology were regarded as 'very' or 'quite' interesting by about 90 per cent of undergraduates and postgraduates. Cell biology was also highly rated for interest (about 86–90 per cent), and genetics was scored at a similar level. As with current A-level students, the topics which were reported as least interesting were food production and agriculture ('very' or 'quite' interesting for 45.3 per cent of undergraduates, and 34.7 per cent of postgraduates) and plant biology ('very' or 'quite' interesting for 49 per cent of undergraduates and 45.8 per cent of postgraduates).

Undergraduate and postgraduate students attached a high level of importance to topics almost across the breadth of the subject. Most topics were rated as important by more than 85 per cent of the students. The lowest levels of importance were assigned to classification and the variety of living organisms, by both the undergraduates and postgraduates, with only about 70 per cent regarding this as important. Food production, agriculture and plant biology were rated as important by about 75 per cent of undergraduates. Although this is relatively low compared to other topics, this came from students who expressed low levels of interest in these topics. Postgraduate students, who also expressed low levels of interest in food production, agriculture and plant biology, rate these topics higher for importance (80 per cent for undergraduates, 92 per cent for food production and agriculture). These results are displayed in Charts 5, 6, 7, and 8 (on the next page).

Chart 5: Topic interest levels for undergraduates

Higher mean score corresponds to higher level of interest on a scale of 1–3

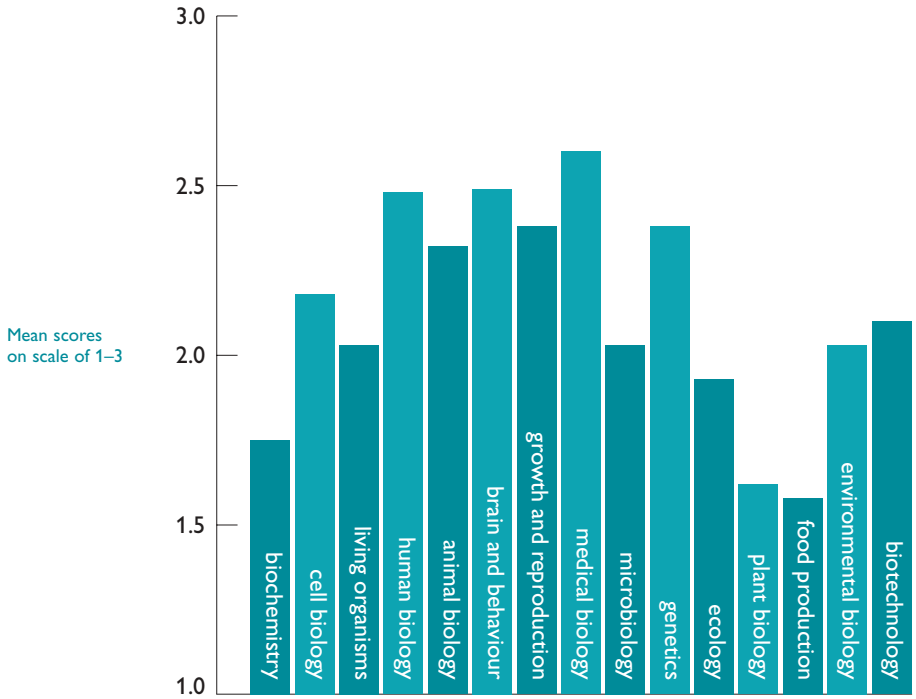


Chart 6: Topic interest levels for postgraduates

Higher mean score corresponds to higher level of interest on a scale of 1–3

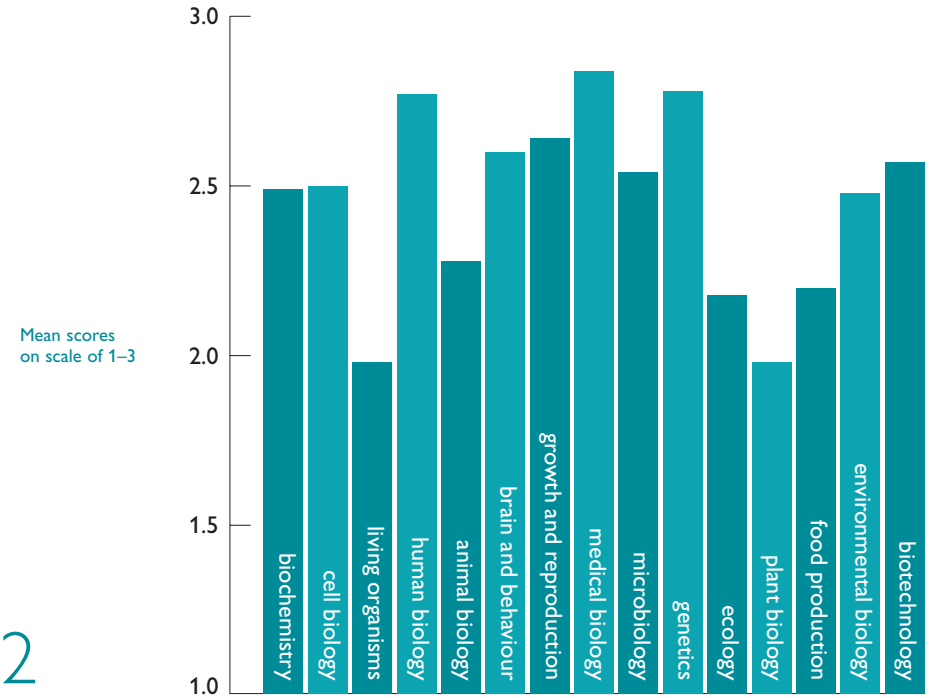


Chart 7: Perceptions of importance – Undergraduates

Higher mean score corresponds to higher perception of importance on a scale of 1–3

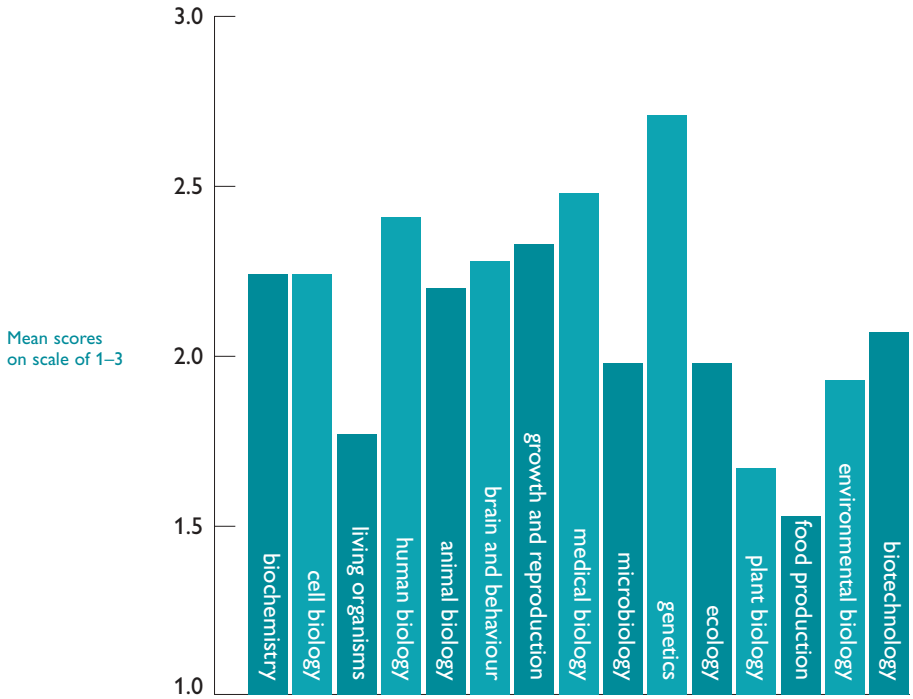
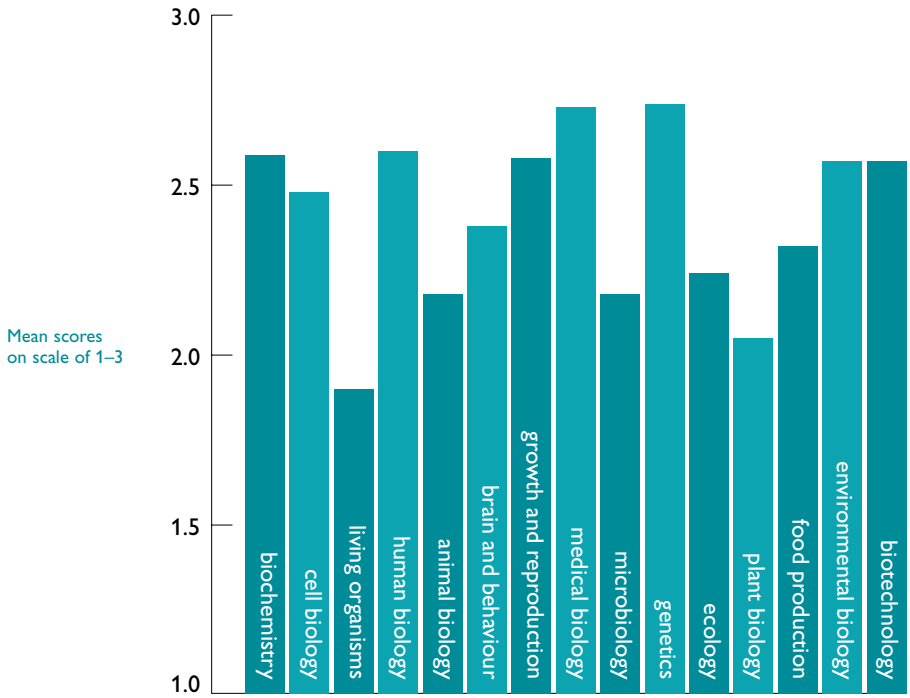


Chart 8: Perceptions of importance – Postgraduates

Higher mean score corresponds to higher perception of importance on a scale of 1–3



How well did biology A level prepare for progression to higher level study in biosciences?

Undergraduates and postgraduates strongly supported the role of biology A level in providing a broad foundation in the subject. Of respondents, 90 per cent agreed with this point. A substantial majority of undergraduates (70.2 per cent) felt that biology A level is successful in providing a good preparation for bioscience degree studies. About 50 per cent of postgraduates also agree that the A level was a good preparation for degree studies. About 30 per cent of postgraduates are more 'neutral' on this point. It may be that the time elapsed make it more difficult for them to judge.

Some students did report a degree of surprise about the demands and levels of difficulty encountered when they took up degree studies. Also some topic areas proved to be very different in their nature when A level was compared with undergraduate study. A frequently cited example was genetics where some students who had enjoyed the topic at A level found that it was very different (and not necessarily to their taste) at degree level.

Students reported very different experiences in practical work and fieldwork in their A-level courses. Some felt they had had sufficient opportunity, some had not, and others felt the amount of practical work was about right. The results for fieldwork, however, were weighted towards those who felt they had not had sufficient opportunity. In the focus group interviews, these differences came out strongly. Some students had had extensive opportunities for fieldwork, including residential courses, while others had none. The evidence (albeit from a small sample) suggested greater opportunity for fieldwork for students in the independent sector.

Students were asked for their views on the balance between learning and memorizing facts and developing analytical skills in biology A level. About half of the students felt that the A level relied too much on memorizing facts and that learning facts was more important to them than understanding biological principles. While some students did feel that A level contributes to the development of analytical and thinking skills, greater emphasis was needed on this.

"Critical thinking is the fundamental job of A level. Students need to understand why people might disagree… This is also about issues of uncertainty and risk, which are common to science."

The students were asked for their views on current research priorities in the biosciences. A range of priorities was identified, dominated by topics with immediate and direct connections to human wellbeing. There was support for attention to research priorities in A-level work, and for the inclusion of social and ethical issues. In the focus groups, this led to discussion about the extent to which discussion of social or ethical issues needs to be underpinned by sound biological and scientific understanding.

Some students commented on the need for sound mathematical skills for degree-level work. Also there was a need for ability to produce extended writing. Biology A level had not contributed much to the development of these skills.

Views of tutors in higher education

These findings were based on qualitative analysis of interviews conducted with 21 university tutors in a range of bioscience disciplines.

What do university tutors consider as the reasons for students choosing to study bioscience at A level?

Higher education tutors shared the view of other stakeholders that the main motivators for students choosing biology and bioscience are interest, aptitude and career aspirations.

They saw the popularity of biology as enhanced by its perception as a relatively 'soft' science compared to physical sciences. Students are often surprised by the 'harder' analytical and mathematical demands of degree-level biosciences.

How well prepared are students entering degree courses in biosciences?

Higher education tutors were almost unanimous in their support for the proposition that biology A level should provide a broad foundation in the subject. While the A level has traditionally provided this foundation, some concern was expressed about pressures leading to some fundamental aspects of biology becoming neglected in favour of concentration on popular areas of interest. In particular, over a third of tutors interviewed believed that plant biology was losing out to human biology, and that students come into higher education with very little interest in, or knowledge of, plants. The perceived lack of balance was described by one tutor as:

"...the single most irksome thing for teachers of biology generally. There is a perception from both students coming in, and from the staff who teach them, that A-level biology teaches you that all animals are fascinating, as long as they are human, all diseases are fascinating, as long as they are human diseases, physiology is fascinating as long as it is human physiology… Most of the things they learn are related to man."

University tutors were almost unanimous in believing that biology A level should provide a good foundation across the subject.

More than a third of tutors interviewed felt that A-level students did not seem to be developing a good understanding of 'whole organisms'. The subject focuses more at the cellular and biochemical level, and while this reflects some key developments in modern bioscience, the perceived result was that students' knowledge tends to be rather fragmented.

Many of the tutors interviewed (more than 75 per cent) commented on gaps or weaknesses they perceived in undergraduate entrants in supporting subjects, especially mathematics and chemistry. This hindered the progress of some students, and there is an increasing use of additional courses or modules in universities to address some of these gaps. The wider choice of A levels now available to students may well have exacerbated this problem, with significant numbers taking biology alongside non-science subjects, and without mathematics.

Tutors were asked for their views about the degree of development of a range of skills in students coming through A level. Laboratory practical skills were found to be very variable and, in many students, not well developed. Some students appeared to have limited experience of practical work. However, some tutors did not necessarily regard a lack of practical skills as

Biology A level should change or adapt to reflect current research priorities.

a significant problem, since these skills could be taught in higher education. There was recognition that schools could not be equipped to offer a level of practical activity which is comparable to that offered in universities.

In addition to weaknesses in numeracy and mathematics skills, a number of tutors identified a lack of ability in extended writing. This was held to be an important skill, which is needed in order to structure a scientific argument. The current biology A-level courses do not require extended writing.

Some other skills were felt to have improved, notably oral skills, the ability to contribute to discussions and make presentations. Some aspects of information research skills had improved, especially in the use of the Internet. However, the ability to use some other more traditional sources (e.g. library) were considered less well developed.

Tutors were asked about the extent to which biology A level should change or adapt to reflect current research priorities. While it was agreed that the A level should keep in touch with key developments, caution was advised. It often takes time to confirm what constitutes a 'key development'. There was no strong feeling that the current A level is out of date. One tutor commented:

"For such a fast moving subject, I think the current specifications are remarkably up to date. It is impossible to keep pace… The emphasis of the specifications is on the areas which are growing fastest."

A number of tutors felt that the purpose of the A level was not completely clear. Some potential tension existed between biology A level as a popular versatile and accessible subject offering a broad range of progression opportunities, and an academic preparation for progression to higher level work in bioscience. Whilst these two aims are not mutually exclusive, they could present different priorities for future development and this was worthy of further consideration.

Most tutors felt that biology A level had little influence on whether students chose to progress to postgraduate research in bioscience. Most students seem to make this choice during their first degree course. It was felt that the A level had an important role in maintaining and developing interest in the subject.

Views from learned societies and professional bodies

The biosciences are served by a large number of learned societies and professional associations. It was beyond the scope of this research to undertake a detailed survey of their views. Some views were sampled, although these cannot be regarded as fully representative. Of 21 organizations contacted, seven provided responses.

Knowledge and content

Respondents expressed various concerns about the content on biology A level. It was felt that some topics receive insufficient attention, and that coverage was sometimes too superficial. The topics named varied, but included aspects of genetics, immunology, microbiology and bioprocessing. There was significant backing for an increase in coverage of neuroscience.

"As far as I am concerned, I should like to make a plea for more neuroscience in the biology curriculum. In my experience (from giving talks in schools and at A-level conferences), sixth formers are fascinated by the brain, and it is not difficult to teach neuroscience in an interesting and convincing way, without great technical detail."

(This view connects well with the views expressed by A-level students themselves.)

Several respondents expressed concern about excessive fragmentation of knowledge in A-level (and undergraduate) studies.

"Students seem to be used to small chunks of work, e.g. a unit in physiology, a unit in genetics and so on. Therefore, it is sometimes difficult for them to see the whole picture."

The importance of knowledge of other supporting subjects was emphasized by some respondents, especially with regard to mathematics and chemistry.

Views were divided on the extent to which biology A level reflects current research priorities. One respondent thought:

"Research priorities are properly reflected in the current A-level curriculum regarding genes and molecular biology, but perhaps not in the case of neuroscience…"

Another reported the view of colleagues that:

"Current research priorities were not properly represented in current A-level syllabuses, and A-level specifications were slow to catch up. It was thought that existing coverage is uninspiring and limited."

Skills

Some respondents expressed concerns about skills in laboratory practical work.

"Use of basic laboratory equipment such as balances, pH meters, and microscopes is poor, and the ability to make up basic molar solutions or dilutions is also lacking."

Other skills which were regarded by some respondents as insufficiently developed by A level included data handling, organizational skills, problem solving and independent learning. Concerns were expressed that many students did not develop the ability to structure a coherent argument based on facts, recognize the limitations of science, and critically analyse the strengths and weaknesses of an argument.

A number of representatives of the learned societies expressed concerns about assessment and testing. Some felt that there was too much testing and that formal assessment could restrict and devalue other kinds of learning. It was suggested that assessment had become too dominant.

"...students were only learning what was needed to pass exams..."

"Due to time pressures, etc. It was also thought that students were only learning what was needed to pass exams, and that the ability to think had been seriously eroded."

There was also some concern about the nature of assessment with recommendations that some more extended, essay style questions should be brought back. Another suggestion was to improve practical assessment, so that students are clearly required to apply scientific knowledge and make decisions independently.

The current approach in which courses and assessment are becoming more modular was felt to contribute to the tendency for learning to become fragmented:

"A modular system inevitably tends towards packaged learning. There needs to be more credit given for ability to think across modules. Emphasis on understanding rather than rote learning would prepare pupils better for higher education."

Research conclusions

1. Most stakeholders agreed that biology A level should provide a broad foundation for progression to higher level studies and careers in the biological sciences. However, some university tutors identified significant imbalance (e.g. deficiency in plant biology and in understanding of whole organisms) and some learned societies identified other areas of neglect, e.g. neuroscience.

2. Stakeholders were divided in their views of the structure of AS and A2 biology. Most valued the extensive descriptive and traditional content while a minority of respondents were critical of the burden of knowledge and the way this impacts upon learning and assessment. The descriptive nature of the subject was seen as a factor in the subject's 'general', rather than its 'scientific' appeal. However, a number of university tutors expressed the view that some students achieving a good grade in biology A level can struggle with the 'harder' scientific content at degree level.

3. A majority of stakeholders supported the principle that biology A level should provide a broad foundation in the subject, and support the notion of greater choice through, for example, the inclusion of specialist options, an increase in topical scientific issues and more attention to social and ethical issues.

4. Biology A level is effective in maintaining and developing the interest of students intending to continue their studies in biological sciences and also attracts significant numbers of students who do not intend to continue studies in the subject. However, a variety of stakeholders voiced concerns about how well existing courses inform choices about progression into the full range of bioscience courses.

5. Most stakeholders were broadly content with skills developed in biology A level courses. However, a majority of university tutors and some teachers and learned societies perceived that current biology A-level courses appear to be less effective in developing practical skills, numerical skills and the ability to produce extended writing than in the past. However, stakeholders reported that students tend to be increasingly confident in group work, the use of ICT and discussion work.

6. Coursework investigations were considered by many teachers, and some sixth formers, as mechanical, time consuming and unreliable as an assessment of investigative skills. Some university tutors believed that students have not gained sufficient understanding of the true nature of scientific enquiry.

7. The current assessment regime has imposed time pressures which limit the scope for scientific reflection and investigation. Representatives of all stakeholders expressed concern about the volume, timing and impact of assessment. Just over half of teachers expressed dissatisfaction with recent changes in the assessment of coursework.

8. There was a close correlation in the relative interest shown by A-level teachers, students, undergraduates and postgraduates in different topics in biological sciences. This correlation suggests that preferences for human and medical biology, and some other topics such as genetics, are likely to be reinforced. Plant biology and, to a lesser degree, ecology are relatively less popular.

9. Teachers felt that their opportunities for professional development are limited and

inadequate. Professional development is focused on specific course delivery and assessment issues, with little opportunity for the development of new subject knowledge, including recent advances in bioscience.

10. All groups generally agreed that biology A level should reflect current research priorities, while maintaining reasonable balance with the provision of a broad foundation in the subject. Most A-level teachers and university tutors felt that biology A level has responded to recent developments in the subject. Most students welcomed opportunities to find out more about current research and to learn about controversial issues in the biological sciences. The challenge is to find a balance which takes account of the diverse 'claims' of priority in rapidly advancing biosciences, and the widely held support for a 'broad foundation' in biology A level.

11. The changing nature of bioscience research is also significant, with an increase in interdisciplinary approaches, which require physical sciences, information technology and mathematics in addition to traditional biology. The evidence suggested that biology A level has made progress in responding to some of the major development areas in research (e.g. cell biology, biochemistry, genetics) in terms of basic content. However, current A-level courses are still provided as separate sciences, in a way which does not lend itself easily to an inter-disciplinary approach. Also a significant number of students choosing biology AS or A level could find the subject more difficult, and less attractive if there was an increase in the physical science and mathematics content.

12. The introduction of option choices and modular structures in biology A level has led to variations in the topics covered by students. This has meant that universities cannot assume all students have covered the same work and has contributed to the introduction of foundation work in the first year of degrees. This may lead to repetition or issues about 'pace' for some students.

13. Contact and communication between biology A-level teachers and university tutors (who are not admissions tutors) was limited. This is likely to make preparation of students for degree courses less effective, and also may reduce the quality of advice about bioscience specialisms.

14. Detailed consideration should be given to teaching and learning styles in biology A level. Many stakeholders were concerned about excessive reliance on factual recall and insufficient emphasis on developing scientific understanding. Many felt that practical work is inadequate. It is important to acknowledge that the evidence showed a wide diversity of views. The evaluation of different A-level courses offering a choice of styles and approaches could make a valuable contribution to the debate about these issues.

Notes

Notes

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