The Uptake of Plant Sciences in the UK

A Research Project

For the
Gatsby Charitable Foundation

by
The Centre for Education and Industry
University of Warwick

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SECTION 1: SUMMARY

The Gatsby Charitable Foundation commissioned this research project from the Centre for Education and Industry (CEI) at the University of Warwick in order to investigate trends in the uptake of plant sciences in the UK. The purpose of the research was to investigate the extent to which there is a problem in attracting people into the study of plant sciences, and into plant science research. The research took place between March and December 2008, and set out to address the following questions.

- Does the available data support the view that there is a problem in attracting sufficient, well-qualified people into plant science in the UK?

- Does the data show any trends over the past ten years that are likely to affect the supply of plant scientists in the UK?

- Is there a real or likely shortage of plant scientists in the UK?

The aims of the project were to collect quantitative and qualitative data relevant to those questions. Data were collected through desk-based research, and a series of interviews with university-based academics working in the plant sciences. Additional data were collected through informal discussions with professionals working in biology education, and through attendance at the Gatsby Plant Science Network Annual meeting. The collected data relate to courses and qualifications from secondary school through to postgraduate study. The research reviewed curriculum programmes and assessment at Key Stages 3 and 4 and GCE AS and A level in England. There was also some reference to the Scottish system.

Key findings

1.1 Biology in schools and colleges – laying the foundation for plant science
These findings are based mainly on reviewing practice in the English education system.

1.1.1 For pupils in secondary schools, learning and assessment relating to plants is an integral part of a broader biology or science education.

1.1.2 Previous research (The ROSE report (UK summary 2006)[1] and Stagg P, Stanley J, Leisten R, 2004) has shown that plant biology tends to be one of the least popular topics for pupils, while human and medical biology are amongst the most popular.

1.1.3 Criteria for the biology curriculum are laid down at national level, and are intended to ensure appropriate coverage of all key aspects of the subject, including plant biology. A review of the national criteria and awarding body specifications[2] indicates that, technically, it can be argued that plant biology is covered appropriately in GCSE and GCE AS and A levels. Revised GCE AS and A level in biology were introduced in September 2008. Whilst the Qualifications and

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[1] Jenkins E W, Pell R G (2006) *The Relevance of Science Education Project (ROSE) in England: A Summary of Key Findings* Centre for Studies in Science and Mathematics Education, University of Leeds

[2] QCA criteria and sample awarding body specifications for both pre and post 2008 were reviewed

Curriculum Authority (QCA) has made new statements about the need for adequate balance between plant biology, animal biology and microbiology, it is too soon to tell how this will be put into practice.

1.1.4 Evidence from this and previous research[3] suggests that, in practice, the teaching and learning experience for pupils in relation to plant biology compares unfavourably with other aspects of the subject, notably human and medical biology. A majority of the respondents (plant scientists in universities) interviewed in this research reported that most UK students entering biological science courses at university show little interest in, or knowledge of plants.

1.1.5 The biology curriculum and specifications, especially at GCE AS and A level, do not themselves provide sufficient encouragement for the development of a coherent concept of plants as whole organisms, or assist appreciation of the fundamental importance of plants in relation to key environmental and global issues for the 21st century.

1.1.6 Some evidence supports the view that pupils' enjoyment of plant biology can be enhanced through special programmes and activities. For example, the Science and Plants for Schools programme (SAPS) received positive endorsement from university plant scientists (3) interviewed in this research, and from postgraduate students (2) at the Gatsby Plant Science Annual Network meeting who had experienced this at school.

1.1.7 There are strong indications from this research that young people do not have access to good sources of information advice and guidance about the potential of plant science for future careers. Several of the university plant scientists interviewed in this research believed that some students feared that specialisation in plant science could narrow their future career options.

1.2 Provision for plant science in universities

1.2.1 At undergraduate level, only a small number of universities offer separately identified degree programmes in plant science or botany for new applicants[4]. This research has found that the numbers of universities offering such programmes is continuing to decline, as student demand for these programmes is very low. However, a number of other universities offer the option for specialisation in plant science in the later years of a degree course for students who initially enrolled on other biological science degrees[5].

1.2.2 Re-organisation and re-structuring of provision in biological sciences in some universities has led to changes in the way plant science is provided in undergraduate degree programmes[6] and may tend to make the plant science less

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[3] Stagg P, Stanley J, Leisten R (2004) Life Study: Biology A level in the 21st Century. (Full report available at www.wellcome.ac.uk/education/lifestudy

[4] The UCAS Course Search facility lists 9 universities offering degrees in JACS code 200 (botany and plant science) http://www.ucas.ac.uk/students/coursesearch/

[5] Evidence includes interview data from plant scientists in the sample group of universities

[6] Evidence from changes in course provision in universities sampled in this research, and supported by interview data from plant scientists in those universities.

‘visible’[7]. However, this also helps to secure the position of plant science, creating and maintaining viable courses, and can form part of a strategic view of the development of a more integrated model for biological sciences.

1.2.3 Despite the decline in provision of separately identified degree programmes noted above, and fluctuations in individual institutions, this research has not detected any significant decline over the past ten years in undergraduate plant science provision overall (in terms of availability of opportunity for students to study plant science within degree programmes) in the universities included in the sample.

1.2.4 The evidence from this research does not suggest any detectable decline in postgraduate work in plant sciences in the past ten years, although the proportion of PhDs in plant science has remained relatively low compared to other branches of biological sciences. Also, most respondents in this research did not report difficulty in recruiting postgraduate students where studentships were available. However, some respondents did report difficulty in securing funding support for postgraduate work in plant sciences e.g. where plant science staff were in a minority within a department, school or faculty, they were in a weak competitive position in securing funding and studentships.

1.2.5 The evidence from this research did not suggest there was a current shortage of suitably qualified staff for teaching and researching plant science at undergraduate and postgraduate levels[8]. Also, with isolated exceptions, there did not currently appear to be significant difficulty in recruiting new staff.

1.2.6 A number of respondents expressed concern about future capacity to respond to any increased demand for plant scientists for teaching and research, based on the importance of plants in relation to global issues such as climate change and food shortages.

1.2.7 Evidence from some respondents suggested that it was possible to stimulate greater interest, and to attract undergraduate students towards plant biology, through high quality teaching and carefully selected course content e.g. by drawing on issues that help show the vital importance of plants in an environmental or global context.

1.2.8 Provision for learning and research in specialist centres (e.g. the John Innes Centre, HRI Warwick) has a major role in plant science. There is evidence which is indicative of decline in this area during the past ten years[9].

[7] Evidence includes interview data from plant scientists in the sample group of universities
[8] Qualitative and quantitative data from 10 universities sampled in this research
[9] Evidence from documentary/online sources and interview data from plant scientists in the sample group of universities

1.3 Uptake of undergraduate and postgraduate study – from quantitative data

1.3.1 At undergraduate level, the uptake of degree courses with the titles plant science or botany has remained at very low levels during the past ten years. This research has not found clear evidence of further decline in uptake of these subjects from the existing low level[10].

1.3.2 Within the sample of universities in this research, data collected about uptake of plant science modules within a range of undergraduate biological science degrees suggested fluctuating numbers during the past ten years, but no clear trend could be identified[11].

1.3.3 Data available through this research suggest that numbers of students pursuing postgraduate work in plant science over the past ten years in the universities sampled has fluctuated. The numbers engaged in plant science research represent only a small proportion of the postgraduate work in biological sciences, but this situation does not seem to have changed over the period, and no clear trend has been detected in this research.

1.3.4 Biological sciences remain a popular option showing growth in uptake at both undergraduate and postgraduate levels. Subjects within this category were reviewed for comparison. The findings included evidence suggesting a marked decline in uptake of genetics. There has also been some decline in the uptake of microbiology, food science and agriculture, especially in UK students, whilst the uptake of zoology has remained steady. Conversely, data for psychology and sports science show strong growth in uptake of these subjects.

1.3.5 A review of the available statistics, combined with indicative quantitative and qualitative data, suggests growing complexity and choice in undergraduate provision in biological sciences, within which plant science is distributed. There are indications that routes into plant science are becoming more diversified (e.g. through biochemistry, cell biology, chemistry and other subject routes). There may not be an easily identifiable 'supply chain' and caution is advised in drawing conclusions from individual data sets.

1.4 Other findings

1.4.1 There was some evidence drawn from interviews with plant scientists in the sample group of universities suggesting that employment opportunities in UK industry had declined. In the past ten years some major companies had relocated their plant science research outside the UK. Opposition in the UK to research into genetically modified (GM) plants was reported to be a factor in this. Other documentary and web-based evidence suggests that employment opportunities in specialised research centres may also have declined (although the development of the new Sainsbury laboratory in Cambridge will provide opportunities in the future).

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[10] Based on quantitative data from UCAS and HESA
[11] Based on interview data, with some quantitative examples from the sample group of universities

1.4.2 Qualitative evidence suggested that, in some universities, the low levels of demand from students for plant science compared to other branches of biology may influence strategic decision making about staffing, so that new appointments are less likely to be plant science specialists. This may have the medium or longer term effect of weakening the position of plant science in those particular universities. Plant science expertise could become increasingly concentrated in a smaller number of universities where there is a ‘critical mass’ representing plant science.

1.4.3 Linked to the previous two points, this research has not found any clear evidence that there is likely to be a current (immediate) shortage of plant scientists in the UK. This is supported by some respondents reporting that there was usually little difficulty filling posts for plant science staff in their university. However, a number of respondents believe that there could be significant increase in labour market demand for plant scientists in the next decade, based on the vital role of plants in relation to key global issues such as climate change and food production. If this were to take place, the UK may not be in a good position to respond, either in terms of student numbers, or in terms of UK employment base.

1.5 Conclusions

1.5.1 Plant science has, for many years, been chosen as a subject for study or research by only a small minority of people. This research has not found evidence of any significant change in this situation. Some indicators of possible decline (e.g. closure of some specific university courses) need to be balanced against re-distribution of plant science within overall university provision of biological sciences. This type of change is not only driven by the needs of plant science, but by considerations of how to organise modern biological science in the light of advancing knowledge. Whilst plant science is vulnerable on its own, greater integration, combined with high quality teaching and content, could help to secure its position.

1.5.2 Since plant science occupies a minority position in the university and research community for biological and biomedical sciences, it does appear to face particular challenges in securing funding and support for research in a competitive environment. Specialists in plant science identify a growing need for expertise in this field in the near future in order to address key environmental and global problems. However, qualitative evidence in this research supports a view that plant science is currently undervalued in education and research, as well as in the wider UK society. There is also some evidence indicating that this problem is more acute in the UK than in some other countries.

1.5.3 Most young people entering university to study biological sciences have little interest in plants. Pre-university experience does not engender any enthusiasm for plants in the majority of young people. Whilst there may be many aspects to this, their experience of biology at school does not inspire young people about plant science. Specific activities (e.g. field work) and programmes designed to enhance and enrich teaching and learning about plant science can have a positive impact, but such programmes are only accessed by a small minority of students in schools and colleges.

1.5.4 This research indicates that careers information advice and guidance relating to plant science is very limited and inadequate, and does not reflect or convey the current and future importance of plant science locally, nationally or internationally.

1.5.5 Within the community of plant scientists there is concern about the vulnerability of this subject, and the possibility of shortages in the supply of suitably qualified people for teaching and research. Within the limitations of the data in this research, no clear indication was found of a current shortage of qualified plant scientists. Indeed, employment opportunities within the UK appear quite limited, and may even have shown some decline in the past ten years. However, based on the continuing low uptake of plant science, there are grounds for concern about future capacity of the UK to respond to an increased demand for qualified plant scientists.

1.6 Recommendations

1.6.1 A significant effort should be made to raise public awareness about the vital role of plants and plant science in relation to the major challenges facing human populations (food supply and security, climate change, energy, medicines etc).

1.6.2 Further investment should be made to develop and enhance high quality support programmes and resources for plant biology education at all levels in schools. The re-focusing of the Science and Plants for Schools programme to concentrate on post-16 education will provide support for that age group, but it is also important to develop and enhance support for plant biology education at primary and early secondary level. Other research (The ROSE report (UK summary 2006) has indicated that pupil attitudes towards subjects are well developed by the age of 14, and also indicate that levels of interest in plant science are low at this early age. Support programmes and resources should place particular emphasis on the importance of plants in relation to the challenges facing human populations, as stated above. (The message might be: If you want to save the world, become a plant scientist).

1.6.3 Specific effort should be made to enhance and improve careers information, advice and guidance in relation to plant science. A variety of case studies, role models and examples should be used to illustrate the range and importance of work in this field. Use should be made of the recently established Future Morph website (www.futuremorph.org)[12] for developing and disseminating this material. Links between the plant science community and bodies representing careers professionals should be developed and enhanced.

1.6.4 Actions should be taken to develop and sustain better links between the plant science community and the education system at various levels. Links with school teachers should be further developed through involvement with the Science and Engineering Ambassadors programme, and Researchers in Residence. There should also be effort to develop and sustain more links with national agencies

[12] Established by the Science Council in 2008, the Future Morph website is intended to provide a major resource supporting careers in science, technology, engineering and mathematics (STEM)

responsible for the biology curriculum and assessment. For example, links with awarding bodies should be used to offer comment and advice on the plant biology content of course specifications.

1.6.5 There should be further development to establish and maintain strong links between plant scientists and the national network of Science Learning Centres, which has responsibility for providing professional development for science teachers. The plant science community should offer contributions of resources, examples and ideas, as well as direct input by scientists to professional development programmes.

1.6.6 A strategy should be developed to ensure a strong and co-ordinated response to consultations leading up to the next review of GCE A level biology in 2013. Also a strategy should be developed to provide support and access to contacts and resources for plant biology within the Science Diploma to be introduced in 2011. The 'lines of learning' for this will be published in early 2009, but there may be some scope to contribute comments and ideas relating to plant science as this development proceeds.

1.6.7 A strategy should be developed for action (possibly a campaign) to raise wider public awareness about the importance of plant science. As part of this process the inter-relationship between plant science research and its applications through agriculture, crop science, horticulture etc. should be highlighted. The strategy should provide a vehicle for plant science to compete more effectively for funding from research councils, government and other sources.

1.6.8 Universities and other providers of higher education offer a wide variety and choice of plant science provision. One area of risk identified in this research is in institutions where the plant science 'presence' is particularly small, relative to other branches of biological and biomedical science. This situation could threaten their provision of biological science courses which must maintain a balanced study of living organisms. It is recommended that some funding is identified for the strategic support of staffing where wider provision of biological science courses within an institution is threatened by capacity to maintain specialist plant science staff. Funding should provide interim support, and be subject to further development and organisation of provision that establishes a more secure position for plant science within that institution.

SECTION 2: Introduction

2.1 Outline of project

The Gatsby Charitable Foundation commissioned this research project to investigate trends in the uptake of plant sciences in the UK. The project was undertaken by the Centre for Education and Industry (CEI) in the University of Warwick.

The research was driven by concerns expressed amongst the plant science community at the low numbers taking up opportunities to study plant sciences, especially at the higher levels (undergraduate and postgraduate), and the possibility that this may lead to shortages of qualified plant scientists in the future. This generated the following **research questions**:

- Does the available data support the view that there is a problem in attracting sufficient well qualified people into plant science in the UK?

- Does the data show any trends over the past ten years that are likely to affect the supply of plant scientists in the UK?

- Is there a real or likely shortage of plant scientists in the UK?

This research investigation set out with the following **aims**:

- To provide a range of quantitative data on the recent and current uptake of plant sciences in education programmes

- To compare statistical data sets on the uptake and achievements of plant sciences compared to other sciences.

- To seek views from plant scientists to assist in the interpretation of the data.

Limitations of the research

Initial consideration of the scope of this research identified a wide range and variety of potential areas for investigation (e.g. biology education at school, undergraduate and postgraduate levels, levels of support for plant science research). The research had capacity to cover a proportion of these areas, as described in the methodology (Section 2.2). Within these areas, some restrictions were encountered in relation to the availability and use of numerical data where individual institutions might easily be identified, due to elements of commercial sensitivity. The research focused on data drawn mainly from within the past ten years. Some other areas have either not been covered, or have received only limited attention e.g. the more ‘vocational’ potential routes into plant sciences such as Higher National Diplomas in applied sciences. There is a brief reference (section 3.4.4, p64) to the very important role of specialist centres for research in plant sciences, but this area, including the effect of re-organisations and funding changes, deserves more detailed research in its own right.

2.2 Methodology

The methodology adopted the following approaches for gathering data.

1. The research team searched for existing statistical data on the uptake of, and achievements related to plant sciences. We investigated:
    a) Key Stage 3 (based on the compulsory SATS (Standard Attainment Tests in England for pupils at the end of year 9, aged 14. (These tests ran for the last time in 2008);
    b) GCSE qualifications taken at the end of Key Stage 4 (aged 16);
    c) University entrance qualifications (aged 18), focusing particularly on GCE A levels;
    d) applications and acceptances for undergraduate courses;
    e) enrolment on to undergraduate and postgraduate degrees.

2. Specific data was commissioned from the UCAS Statistics Unit[13]. This allowed access to a level of detail concerning applications and acceptances on to places for specific types of course that is otherwise not publicly available. Through the UCAS Statistics Unit, a detailed collection of data on the full spread of biological sciences was undertaken relating to the period 2002 –2008. The start date (2002) was selected for this survey as the UCAS data was categorised differently prior to 2002, so that direct comparisons are not possible between data pre and post 2002. The UCAS data survey covers applications and acceptances, for home and overseas students within certain specified JACS[14] coding categories. The selected categories are:

    a) The whole of JACS coding category C (biological sciences);

    b) Courses from JACS coding category C likely to include significant plant science content (e.g. biology), but excluding courses that are unlikely to include any plant science content (e.g. zoology, psychology);

    c) Courses from JACS coding C whose titles indicate that the content is exclusively plant science (e.g. botany);

    d) Courses from JACS coding category D (veterinary sciences, agriculture, and related subjects) that are likely to include plant science content (e.g. agriculture, forestry, cereal and vegetable science).

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[13] University and Colleges Admissions Service (UCAS) is the body responsible for organizing the selection process for all undergraduate admissions to Higher Education Institutions across the UK.

[14] UCAS subject classifications now employ the Joint Academic Coding System (JACS). JACS, introduced for 2002 entry, replaces UCAS' Standard Classification of Academic Subjects (SCAS), which was used up to and including 2001 entry. Usually presented by broad subject area (Subject group) or detailed subject of study (Subject line).

3. Specific data were analysed from the Higher Education Statistics Agency (HESA)[15]. This data referred to the number of students enrolled on higher education programmes in the UK, allowing access to detail for undergraduate, postgraduate, full time and part time. The HESA data also allowed access to detail for numbers of UK, other EU and non-EU students.

4. Interviews were carried out with 17 members of academic staff (specialists in plant science) in 17 different UK universities. The interviews (15 by telephone, and 2 face to face) were semi-structured, lasting between 35 and 60 minutes using a set of questions shown in Appendix 1 (p89). Information was also gathered by more informal discussion by telephone (2) or face to face (1) from 3 further respondents in 3 other universities.

5. Further data was collected through additional website searches (5 universities). Overall the research sample included 25 universities (12 'Russell Group', 5 other pre-1960 universities, 7 universities established between 1960 and 1990, and one post 1990 university).

6. Some additional data was gathered during attendance at the Gatsby Plant Science Network Annual Meeting (11th and 12th September 2008) through two discussion groups with postgraduate students.

7. The research team also undertook a limited search for texts and web-based information related to the uptake of, and provision for plant sciences.

Further detail on each of these methods, including the outcomes and limitations of each of these methods, will be discussed as applicable in the relevant section of the report.

Organisation of the report:

The report is organised into the following main sections:

[15] The Higher Education Statistics Agency www.hesa.ac.uk

SECTION 3: Research Findings – documentary and quantitative

3.1 Biology education in schools

3.1.1 Pre-16 education (Up to Level 2) – the biology curriculum

In UK education for pupils up to the age of 16, biology forms part of a broad education in science. Whilst arrangements for the overall curriculum does show variation between the nations in the UK (e.g. a statutory National Curriculum in England and Wales, and non-statutory in Scotland), the result is that virtually all pupils study some science up to the age of 16. Many pupils study science through integrated courses. Between the ages of 14 and 16, a minority of pupils, usually from the higher academic ability range, study the separate sciences of Biology, Chemistry, and Physics. Learning about plant science is integrated within the wider study of science and biology. The extent of pupils' school experience of plant science will be determined by the defined content of the curriculum, the specifications of courses leading to qualifications, and choices made by teachers about how to deliver the curriculum.

In England, wide ranging review and reform of science education and qualifications has been taking place since 2000, led by the Qualifications and Curriculum Authority (QCA). National Curriculum Science has been reviewed at Key Stage 3 (ages 11-14 years) and new programmes of study have been introduced from September 2008. These set out the broad parameters of the science curriculum at Key Stage 3 in terms of:

- Key concepts that underpin scientific study and 'how science works' (scientific thinking, applications and implications of science, cultural understanding and collaboration);
- Key processes (practical and enquiry skills, critical understanding of evidence, and communication);
- Range and content.

The range and content of the Key Stage 3 curriculum is only defined in broad terms[16]. Four sections are listed. These are:

- Energy, electricity and forces
- Chemical and material behaviour
- Organisms, behaviour and health
- The environment, Earth and universe.

This programme of study is much less prescriptive than the one it has replaced and it is intended that teachers should have greater freedom than previously to choose specific content, examples and approaches. This marks a significant change from a tightly

[16] Details can be found at http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/science/keystage3/index.aspx?return=/key-stages-3-and-4/subjects/index.aspx

prescriptive programme of study, and teachers will be adapting gradually to the new arrangements, with some support from professional development. There could be greater scope to enrich the plant science content of the curriculum, but this may only happen with support, encouragement and good resources.

At Key Stage 4 (age 14-16), the programmes of study have also been revised (from 2006). There is a strong emphasis on 'how science works', and strong linkage has been established across Key Stages 3 and 4 in terms of the key concepts. The Programme of Study itself is less detailed than its predecessor. It has been left to the awarding bodies to write detailed specifications for national qualifications, which are approved by the Qualifications and Curriculum Authority. In England there is now an extensive range of science options at National Qualification Framework level 2. These include:

- GCSE Science (core)
- GCSE Additional Science
- GCSE Applied Science
- Separate GCSEs in Biology, Physics and Chemistry (Triple Science)
- Various BTEC awards (e.g. entry, certificate, diploma in Applied Science
- Scottish Standard Grade in Science
- Separate Scottish Standard Grade in Biology, Chemistry and Physics

Within the range of GCSEs in science there are a number of options which offer different styles or approaches e.g. 21st Century Science GCSE which adopts a context-based approach, focusing on topical scientific issues.

3.1.2 Plant biology in pre-16 school education - assessment

Plant biology is included and integrated within courses of science and biology, and forms a compulsory part of the learning for all pupils. Assessment of learning focuses on the subject as a whole. The most detailed recorded assessments have been through Key Stage 3 SATs (Standard Attainment Tests) and GCSEs and other national qualifications.

The researchers have reviewed the available records (questions from past Key Stage 3 Science tests, and national performance data from these tests) to assess their potential in providing relevant information.

The Key Stage 3 SATs tests do not present 'item level data' for plant science assessment questions. Individual question scores are available through the National Assessment Agency (NAA www.naa.org.uk), and the test papers to which they relate can be found at
http://orderline.qca.org.uk/bookstore.asp?FO=1169415&action=SearchResults

A trial analysis of these data sources revealed that, whilst the question papers contained a complete spread of science questions, including plant biology content, there were very few biology-based questions which would allow fair comparison between plant and 'non-plant' biology. It was concluded that an analysis of Key Stage 3 tests and question scores would be an unduly lengthy process, and would be very unlikely to yield useful results. Also, during the course of this investigation, the government announced that all Key Stage 3 tests, including science would be abolished with immediate effect (2008). This avenue of enquiry was not followed further.

The researchers reviewed data relating to GCSE sciences during the period 2001-8, focusing on higher achievement levels in Double Science GCSE and in the separate GCSEs in Biology Physics and Chemistry. All show a rising trend in numbers of pupils attaining A* or A grades at GCSE. The data also shows much higher attainment in the separate science GCSEs than in the double award science GCSE. This probably reflects the highly selective nature of the relatively small separate science cohorts, drawn from academically high ability groups. These also show a consistently higher percentage of A* and A grades at GCSE than any other subject. For many subjects the percentage achieving A* and A grades is less than half than for the separate sciences. The grades for separate sciences and for double science showed a 'jump' in 2008. Whilst it is not possible to be sure whether this is a real change, it does coincide with the recent requirement for schools to highlight GCSE performance in science, as well as mathematics and English. Percentages of pupils achieving A* and A grades in separate sciences, double science, English and mathematics are shown in the table 1 below.

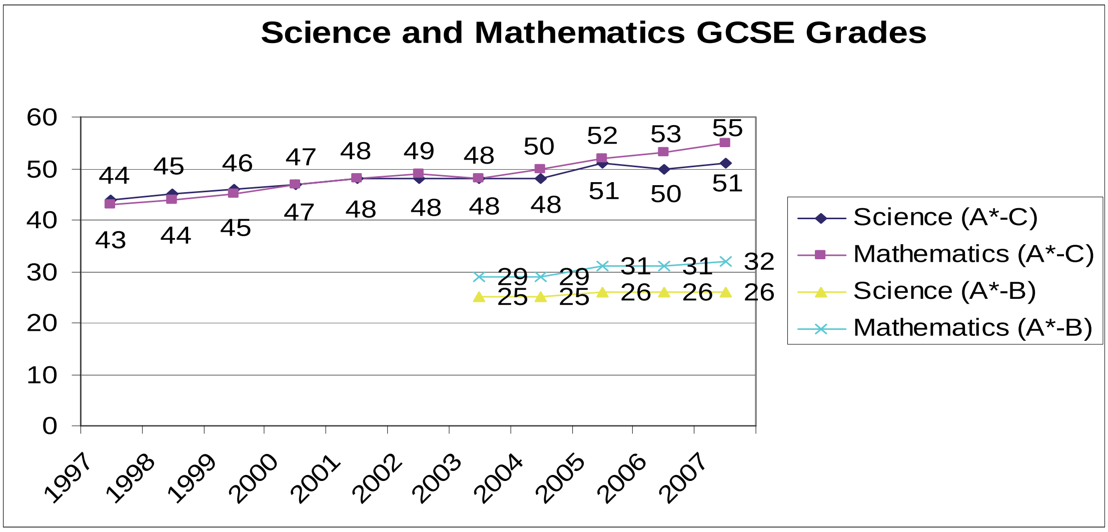
Table 1 Percentage of students achieving GCSE grades A* and A

	% achieving A* and A Grades at GCSE (all UK)					
	Biol	**Phys**	**Chem**	**Double Science**	**Eng**	**Maths**
2001	41.0	43.8	43.4	12.1	13.6	11.1
2002	41.7	44.8	43.7	12.2	13.5	11.9
2003	41.4	45.0	43.5	12.5	14.3	11.6
2004	43.6	46.5	45.9	12.7	14.7	11.8
2005	43.9	46.9	46.0	13.9	15.1	13.0
2006	44.2	46.8	45.7	14.6	15.2	13.2
2007	44.7	47.4	46.9	14.7	15.3	13.7
2008	48.5	51.6	52.7	21.9	15.5	14.5

Source: Joint Council for Qualifications

The continuing rise in GCSE grades in science and mathematics is shown below:

Chart 1



Source: DCSF 2008

Curriculum and assessment related to plant science is an integral part of GCSEs in Biology, and any of the courses with 'science' in the title. In GCSE examinations, whilst candidates are entered for different 'tiers' (3-6, or 5-7) according to their attainment against National Curriculum levels, they are usually required to answer every question in their test papers in almost all cases. There is little option for them to make choices between plant and 'other' questions. Awarding Bodies and the DCSF do not hold 'item level data' in a form that allows simple comparison between questions and question topics. A review of past examination questions shows a high degree of 'mixing' and integrating of plant and other topics within questions. In addition, in some cases questions are difficult to define. For example a question designed to test interpretation of data may use a plant example, but is not a 'plant biology question' in any other sense. It was concluded that, within the scope of this research, further analysis of GCSE data was unlikely to produce findings relevant to this investigation.

3.2 Post-16 school education (Level 3)

At post-16 level, whilst there are some integrated science courses (e.g. GCE A level in Applied Science, BTEC National Certificate and Diploma in Applied Science), most biology education is provided through separate subject studies, mainly GCE A levels in England and Wales, and Scottish Highers and Advanced Highers. The researchers focused mainly on the recent (since 1992) history of GCE A levels, with some comparison with Scottish Highers and Advanced Highers.

3.2.1 GCE A level biology curriculum content and course specifications

The detailed content of the GCE A level curriculum and specifications is written by the awarding body[17]. There can be variations in style, approach and detail between awarding bodies, but all must meet the subject criteria laid down by the Qualifications and Curriculum Authority[18] to gain approval for their specifications. The QCA criteria are not intended to specify detailed content. The QCA criteria for AS and A level (2006)[19] for the revised A levels introduced in 2008:

> *..set out the knowledge, understanding, skills and assessment objectives common to all AS and A specifications in a given subject. They provide the framework within which the awarding body creates the detail of the specification*
>
> QCA (2006) p3

In relation to A level Biology, the QCA criteria state that:

> *Biology specifications must ensure that there is an appropriate balance between plant biology, animal biology and microbiology and include an appreciation of the relevance of sustainability to all aspects of scientific developments.*
>
> QCA (2006) p8

[17] The main Awarding Bodies GCE A levels for England and Wales are Edexcel, AQA, OCR and WJEC

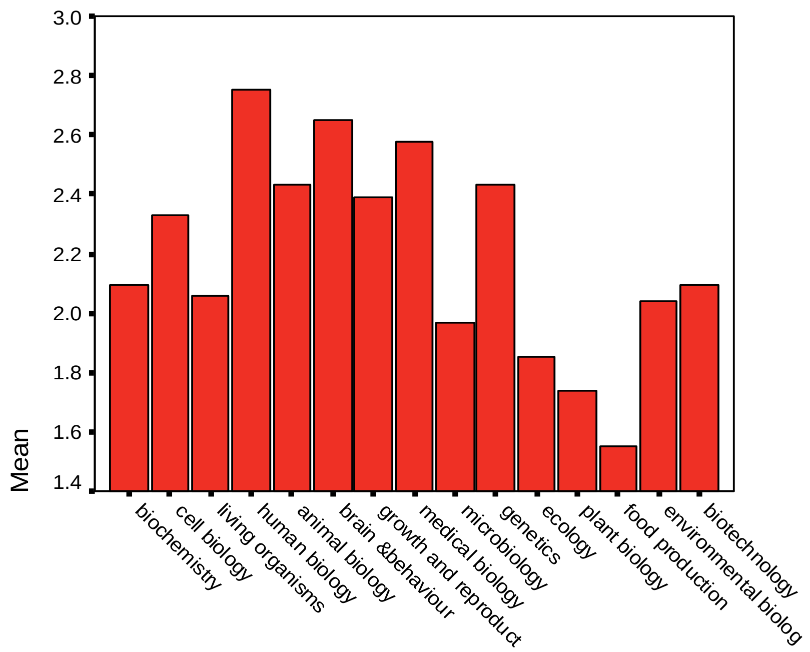
[18] The QCA and its functions are being split between two new bodies, The Qualifications and Curriculum Development Agency (QCDA) and Office of the Qualifications and Examinations Regulator (Ofqual) in 2008

[19] QCA (Sept 2006): GCE AS and A level subject criteria for science

The system in England operates through awarding bodies which compete with each other on a commercial basis. Schools and other education providers can choose which awarding body specification and qualification to offer to students. This opens the way for ‘demand pressure’ (from students and A level teachers) to exert some influence on the specifications that are produced. An awarding body producing specifications that place greater emphasis than their competitors on topics which are less popular with students and teachers is likely to lose out in the ‘market place’. Therefore, whilst all specifications must satisfy the QCA criteria, there is a tension in making decisions about detailed content between pure consideration of essential elements of the subject, and considerations of popularity of topics. In these circumstances, plant science occupies a weak position in relation to other topics in biology. This was shown in research carried out for the Wellcome Trust (2004) into student and teacher preferences in A level Biology topics[20]. In this research, data was gathered from 729 AS and A level students in 38 schools and 57 A level Biology teachers in 57 schools.

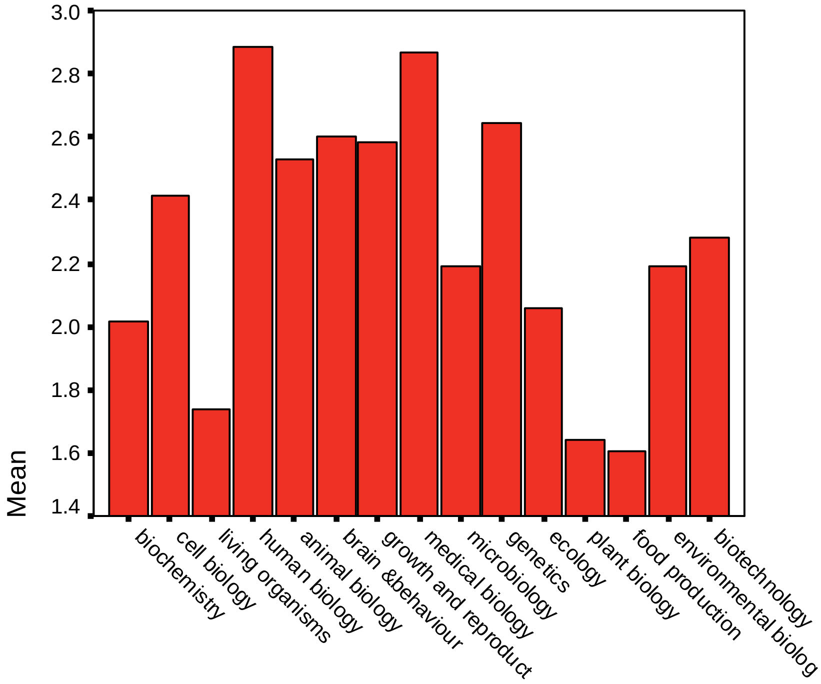
Comparing A level students and teachers level of interest in biology topics:
(Higher mean = Higher level of interest. The means were calculated from all questionnaire responses, using a 3 point scale where 1 = Not very/not at all interested, 2 = Quite interested, and 3 = Very interested)

Chart 2: Topic interest levels for A level students (data collected 2003)



[20] Stagg P, Stanley J, Leisten R (2004) Life Study: Biology A level in the 21st Century. (Full report available at www.wellcome.ac.uk/education/lifestudy The Wellcome Trust

Chart 3: Topic interest levels for A level teachers (data collected 2003)



The very low levels of interest of students and teachers in plant biology and food production (Charts 2 and 3), especially when compared to other topics such as human biology and medical biology amongst both students and teachers was one of the most striking features of the Life Study (2004) research. There is no evidence to suggest that there has been any significant shift in these areas in recent years. The outcome is that teachers are more likely to opt for GCE A level courses that offer greater scope for the more popular topics, and awarding bodies will be aware of this.

A review of the current content of GCE A level biology specifications shows how the QCA criteria are developed into full specifications. With regard to content, the QCA specifications[21] state that:

> *Living organisms, including plants, animals and micro-organisms, interact with each other and with the non-living world. The living world can be studied at population, organism, cell and molecular levels. There are fundamental similarities as well as differences between plants, animals and micro-organisms*
> (QCA 2006 p8).

The QCA criteria set out the content for AS and A2 biology, at the four levels, as shown in Table 2 (p20):

[21] QCA (Sept 2006): GCE AS and A level subject criteria for science: Appendix 1 Biology Knowledge and Understanding p8

Table 2: QCA criteria for GCE AS and A2 biology

	AS	A2
Population level	Biodiversity	Ecosystems
Organism level	Exchange and Transport	Control Systems
Cell level	Cells	Cellular control
Molecular level	Biological Molecules	Energy for Biological Processes

It should be noted that the 'knowledge and understanding' content makes up 60% of the total specification, with the rest covering a range of other aspects e.g. practical skills, how science works, and applying scientific principles.

A close reading of QCA criteria alongside awarding body specifications shows that different awarding bodies use different approaches (e.g. using different unit titles) in order to meet the QCA criteria. This also reveals that the QCA criteria could tend to encourage a rather 'fragmented' approach at the level of 'organism'. It could be argued that the criteria and resulting specifications focus on 'organ systems' rather than a focus on 'whole organisms'. The further detail given in the QCA criteria at the level of 'organism' illustrates this point.

Organism: Exchange and Transport (AS level)

a) Organisms need to exchange substances selectively with their environment and this takes place at exchange surfaces.

b) Factors such as size or metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems.

c) Substances are exchanged by passive or active transport across exchange surfaces.

d) The structure of the plasma membrane enables control of the passage of substances in and out of cells.

Organisms: Control Systems (A2)

a) Homeostasis is the maintenance of a constant internal environment.

b) Negative feedback helps maintain an optimal internal state in the context of a dynamic equilibrium. Positive feedback also occurs.

c) Stimuli, both internal and external, are detected leading to responses.

d) Coordination may be chemical or electrical in nature.

QCA (2006)[22]

[22] QCA (2006) GCE AS and A level subject criteria for science pp 9, 10

3.2.2 GCE A level biology examination - questions and assessment

The assessment objectives for AS and A level biology are defined by the QCA. The three assessment objectives for the new GCE A level[23] define the key parameters for the assessment, and state that this must cover the whole specification. However, they do not specify content by making any reference to plants, animals or other organisms. A strong argument can be made that it would not be appropriate for the QCA to do so. However, this does allow the possibility that, in practice, the teaching and learning within GCE A level biology may be skewed in the direction of student and teacher preference (i.e. away from more plant science), without contravening the requirements of the assessment. There are clear indications that plant science may 'lose out' within the A level, based on student and teacher preferences, and on experience and perceptions of staff in higher education.

The awarding bodies are expected to produce examination and assessment questions that provide a fair coverage of the course specification. The awarding bodies, QCA, Ofqual, and DCSF do not appear to collect or hold data that can reveal differences in performance or preference amongst candidates in relation to plant and non-plant biology. The researchers considered the potential of investigating the frequency of occurrence of topics within questions. The range of question papers is very broad. Two examples are shown in tables 3 and 4 (pp22, 23), covering papers between 2005 and 2008[24]. These samples were selected without any prior analysis or review, other than to choose units that could be expected to include both plant, and 'non-plant'-related questions.

[23] QCA (Sept 2006): GCE AS and A level subject criteria for science p5
[24] Question can be accessed through the AQA website at http://www.aqa.org.uk/qual/gceasa/biob_assess.php

Table 3: AQA Biology B Unit 3 – Physiology and Transport (number of marks available shown in brackets)

	June 2005	Jan 2006	June 2006	Jan 2007	June 2007	Jan 2008
Q1	Mammalian – control of breathing (6)	Mammalian – Heart/cardiac cycle (6)	Plant – Water movement and loss (6)	Mammalian – blood vessels / heart (6)	Mammalian – blood vessels and circulation (6)	Plant – Transpiration (6)
Q2	Mammalian – blood pressure (8)	Plant – transpiration (6)	Mammalian – cardiac function (7)	Mammalian – anaerobic respiration (5)	Biochemistry – respiration (mammal) (4)	Mammalian – control of breathing (6)
Q3	Plant – absorption of water and minerals (6)	Mammalian – Tissue fluid, Haemoglobin (9)	Plant – Water transport (8)	Mammalian – control of respiration (6)	Mammalian – tissue fluid and lymph (5)	Plant – Roots/ water absorption (5)
Q4	Plant – transpiration and water transport (7)	Plant – Xylem, water transport (8)	Plant – internal transport (7)	Plant – Transpiration (10)	Plant – water loss (9)	Mammalian – muscles and energy (8)
Q5	Mammalian – adaptations in diving mammals (9)	Mammalian – Respiration/ energy (6)	Biochemical – respiration (with mammalian muscle example) (5)	Mammalian – Heart (8)	Mammalian – heart (4)	Mammalian – Heart (9)
Q6	Mammalian – haemoglobin (7)	Mammalian – respiration/ carbon dioxide (8)	Mammalian – blood pressure (7)	Mammalian – circulation (8)	Mammalian – blood flow/ exercise (6)	Plant – Transport of organic molecules (9)
Q7	Plant – phloem and transport (10)	Plant – transport of carbohydrates (10)	Animal – fish haemoglobin (5)	Plant – roots and water uptake (10)	Plant – transport (8)	Mammalian – Tissue Fluid (10)
Q8	_____	_____	Mammalian – heart rate/ blood pressure (8)	_____	Mammalian - haemoglobin	_____
% marks for plant Qs	43% (23 of 53)	45% (24 of 53)	40% (21 of 53)	38% (20 of 53)	32% (17 of 53)	38% 20 of 53)

Table 4: AQA Biology B Unit 5 – The environment (number of marks available shown in brackets)

	June 2005	June 2006	June 2007	Jan 2008
Q1	Plant – growth and popn density (6)	Bacteria – nitrogen fixation and farming (6)	Food web – mainly invertebrates (7)	Farming – including plant (6)
Q2	Marine ecosystem (inc some plant) (9)	Farming monoculture (7)	Ecosystem and carbon cycle, including plants and fungi (7)	Plant succession (6)
Q3	Plant – nitrogen fixations (11)	Microbiology – water purification (8)	Plant distribution (9)	Water quality – invertebrates and microbiology (10)
Q4	Hedgerows and wildlife (inc plant)(10)	Food web – mainly invertebrate, but some plant (6)	Invertebrate distributution (some plant) (8)	Pesticides and food chains (6)
Q5	Plant – crops and pesticides (8)	Birds – competition (6)	Insects and pesticides (7)	Plant – weedkiller (8)
Q6	Plant – climatic adaptations (10)	Ecology of communities – plant example (8)	Crops / monoculture (5)	Plant – competition (7)
Q7	Eutrophication – plant related (10)	Competition – mammals only	Mammals and environment (10)	Plants, bacteria biochemistry (11)
Q8	____	____	Biological Oxygen Demand – Microbiology (12)	Population density – mammal (11)
% marks for plant Qs?	Unit 5 generally contains a substantial proportion of plant biology, including some applications (e.g. farming and crops). In every year, almost all questions contain at least some plant content. Microbiology also features in some questions. Very few questions have no explicit reference to plants (e.g. Q5 June 2005, Q8 Jan 2008). Even in these cases, reference to plants or plant animal interactions may be a relevant part of an answer.			

These questions are drawn from two units, from papers from one awarding body. The examples show some of the complexity in analysing content of examination questions in relation to the research questions in this research. In some cases, questions are difficult to categorise as ‘plant’ or ‘non-plant’. Also, variations in the plant biology content in one unit may be compensated by the content of other units. Awarding bodies have a clear responsibility to design examination papers that make a fair assessment of the whole specification. As previously stated (p17), these specifications must have met the QCA criteria for balance between plant, animal and microbiology. Previous research evidence e.g. the Life Study report for the Wellcome Trust (p20) suggests that plant biology may receive less emphasis in the teaching and learning of GCE A level biology, but, within the scope of this current research, it has not been possible to detect any bias away from plant biology in the sample of examination questions reviewed.

3.2.3 GCE A level Results

Biology has been, and remains a popular subject for students at school, and is the most popular of the three main science subjects at GCE A level. The following tables show the UK performance (A level grades) in biology, chemistry and physics, and the total numbers of candidates entered for the years 1992-2007.

Table 5:
A Level results 1992 – 2007 UK Percentage achieving each grade A-E: Biology.

Year	A	B	C	D	E	No. candidates
1992	12.4	15.2	16.5	17.5	16.1	48742
1993	13.0	15.4	15.8	17.2	16.0	47748
1994	13.8	15.4	16.9	17.1	15.9	50851
1995	14.3	15.7	17.0	16.9	15.2	52255
1996	14.0	18.8	19.0	17.9	14.8	52053
1997	14.9	19.6	19.2	17.7	14.7	56706
1998	16.5	19.5	19.1	17.2	13.9	57436
1999	17.8	19.2	19.4	17.4	13.6	55810
2000	18.2	19.8	19.5	17.1	13.5	54650
2001	19.3	19.9	19.5	16.5	13.2	52382
2002	21.6	19.6	19.7	17.9	13.3	52132
2003	21.4	20.7	20.2	17.1	13.2	51716
2004	22.4	21.3	20.4	17.0	12.3	52264
2005	23.1	21.5	20.4	16.8	12.1	53968
2006	24.4	21.6	20.3	16.6	11.5	54890
2007	26.2	21.6	19.9	16.4	11.0	54563

Table 6:
A Level results 1992 – 2007 UK Percentage achieving each grade A-E: Physics.

Year	A	B	C	D	E	N$^{o.}$ candidates
1992	15.1	15.5	15.8	16.6	15.4	41301
1993	16.7	15.9	16.3	17.0	14.4	38168
1994	18.2	15.6	16.7	16.7	15.1	36147
1995	21.3	16.6	16.9	16.1	13.5	34802
1996	20.7	19.2	17.8	15.6	12.8	33033
1997	21.6	21.6	18.4	15.5	11.5	33243
1998	22.9	21.1	18.6	15.3	11.1	33769
1999	24.6	20.2	18.7	15.1	11.2	33548
2000	25.1	20.2	18.5	14.9	11.1	31794
2001	25.1	20.0	18.4	14.6	11.5	30802
2002	26.8	20.1	18.6	15.8	11.9	31543
2003	27.2	20.7	18.3	15.8	11.6	30583
2004	28.4	20.7	18.8	15.2	10.9	28698
2005	28.6	21.0	18.5	15.3	10.8	28119
2006	29.4	21.3	18.2	14.8	11.0	27368
2007	30.8	21.0	18.4	14.6	10.4	27466

Table 7:
A Level results 1992 – 2007 UK Percentage achieving each grade A-E: Chemistry.

Year	A	B	C	D	E	N$^{o.}$ candidates
1992	16.1	18.3	16.2	15.8	14.0	42697
1993	16.8	18.3	16.0	15.6	13.2	40975
1994	18.1	18.5	16.3	14.8	13.2	41231
1995	19.4	17.7	16.8	15.6	13.0	42293
1996	20.1	21.0	18.3	14.9	11.9	40418
1997	21.4	21.5	18.3	14.8	12.0	42262
1998	24.1	21.4	18.4	14.3	10.9	41893
1999	25.3	21.8	18.6	14.6	10.4	40920
2000	26.2	22.2	18.4	14.5	10.1	40261
2001	27.1	21.9	18.4	14.1	10.3	38702
2002	28.4	23.1	19.1	14.4	9.7	36648
2003	28.8	23.9	18.9	14.1	9.4	36110
2004	29.9	24.1	19.0	13.8	9.0	37254
2005	29.5	24.6	19.0	13.8	8.7	38851
2006	31.3	24.1	18.8	13.4	8.5	40064
2007	32.4	24.2	18.6	13.2	8.0	40285

Reference to Tables 5, 6 and 7 shows differences in the attainment of the top grade between biology and other sciences. Between 1992 and 2007, the percentage of candidates achieving grade A in GCE A level biology increased from 12.4% to 26.2%. Over the same period the percentage of candidates gaining grade A in physics increased from 15.1% to 30.8%, and in chemistry it increased from 16.1% to 32.4%.

Table 8:
A Level results 1992 – 2007 UK Percentage achieving each grade A-E: All subjects.

Year	A	B	C	D	E	N°. candidates
1992	12.8	16.3	17.4	18.0	15.3	731240
1993	13.8	16.7	17.7	18.1	14.8	734081
1994	14.8	17.1	18.6	18.1	14.4	732974
1995	15.8	17.2	19.0	18.1	14.1	730415
1996	16.2	18.1	19.8	18.3	13.7	740470
1997	16.2	19.0	20.5	18.5	13.4	777710
1998	17.2	19.0	20.9	18.3	12.9	790035
1999	17.8	19.2	21.1	18.2	12.7	787732
2000	18.1	19.3	21.3	18.4	12.4	774364
2001	19.1	19.4	21.5	18.0	12.1	770995
2002	20.7	21.9	22.7	18.1	10.9	701380
2003	21.6	22.9	23.0	17.8	10.1	750537
2004	22.4	23.4	23.2	17.5	9.5	766247
2005	22.8	23.8	23.3	17.2	9.1	783878
2006	24.1	24.0	23.2	16.6	8.7	805698
2007	25.3	24.4	23.1	16.0	8.1	805657

The trends in numbers of candidates and the grades achieved can be seen in the following charts.

Chart 4:

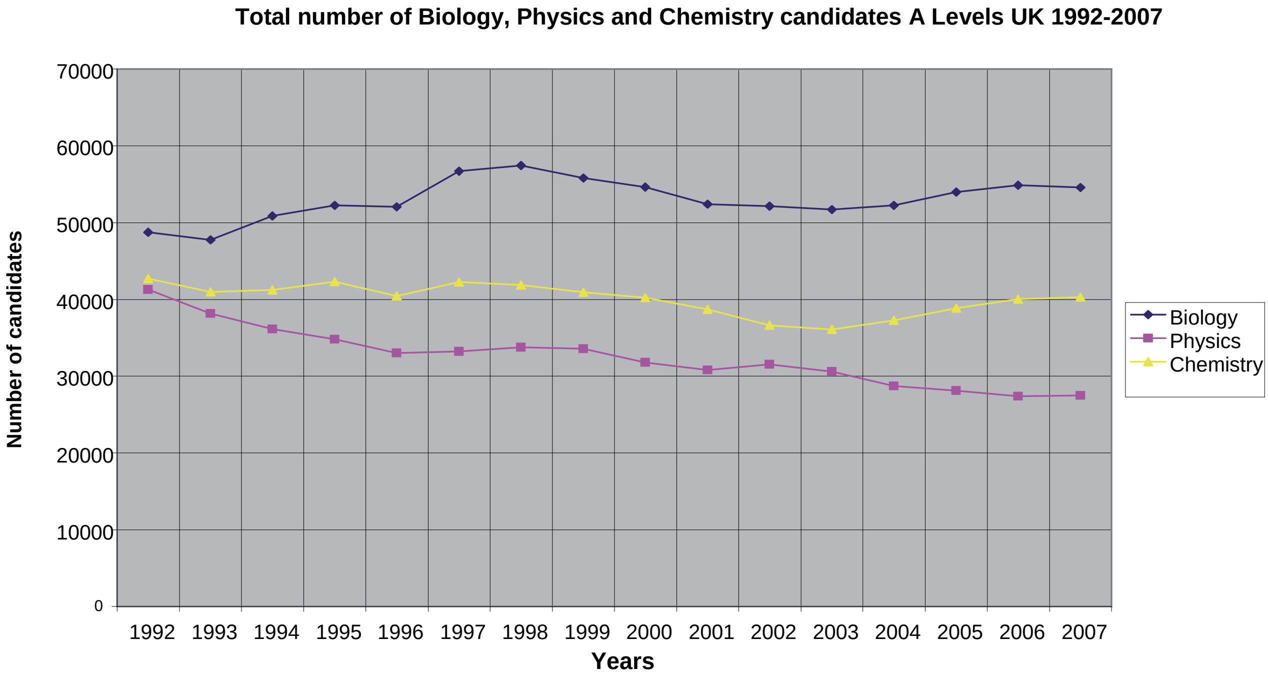


Chart 4 shows the sustained popularity of Biology A level and some recent recovery from a decline in numbers taking A level Chemistry. The decline in numbers taking GCE A level physics up to 2007 is clearly shown.

Chart 5:

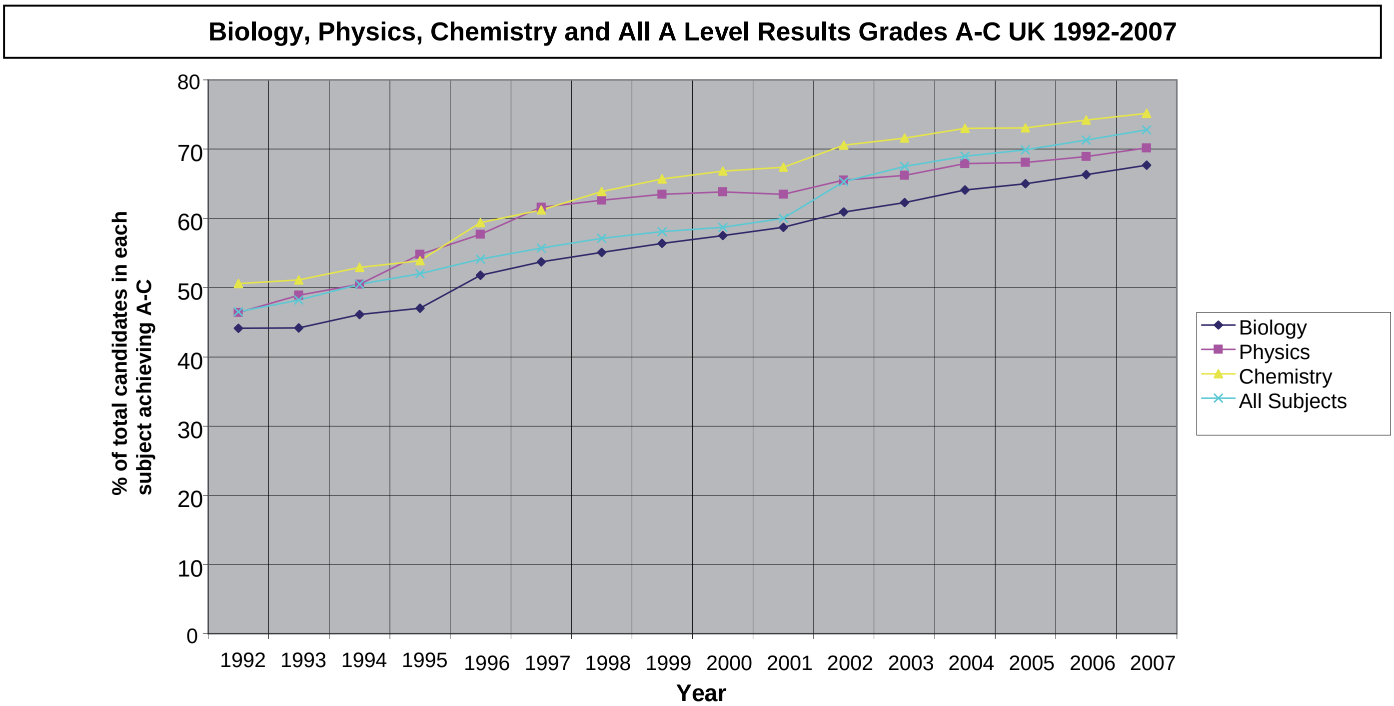


Chart 5 shows the percentages of candidates gaining grades A-C in A level Biology[25] (dark blue line), Chemistry (yellow line), and Physics (purple line). The trend for all A level subjects combined is shown in light blue. All show year on year increases in the percentage of candidates gaining grades A-C. The percentages for A level Biology are consistently below those for Chemistry, Physics, and for all subjects combined.

The evidence shows that the low take up of plant science study post-A level is not due to any lack of attractiveness of biology overall as a subject at A level. However, there is evidence from previous research (Stagg P, Stanley J, Lesiten R 2004) of clear preferences in both students and teachers at this level which channel young people away from plant science and towards the more popular areas such as human and medical biology. For many students, their choice of degree course at university will be influenced by these preferences, unless there are other effective influences acting on their decision-making. Furthermore, other previous evidence (The ROSE report summary 2006 pp15, 16)[26] has indicated that these student preferences are well established at an earlier age. (Most respondents in the ROSE research were aged 14 or 15 years).

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[25] This data (source Joint Council for Qualifications JCQ) for GCE A level biology includes entries for A level human biology. However, the proportion taking human biology has been small and declining from 8.75% in 2001 to 4.8% in 2008.

[26] Jenkins E W, Pell R G (2006) *The Relevance of Science Education Project (ROSE) in England: A Summary of Key Findings* Centre for Studies in Science and Mathematics Education, University of Leeds

3.2.4 Scottish Highers and Advanced Highers in Biology

There are significant differences between the education and assessment systems in England and Scotland. The principal biology qualifications at school level are administered by a single awarding body, the Scottish Qualifications Authority (SQA). Two of the key biology qualifications contributing to entry to higher education in the UK are the Scottish Higher and Scottish Advanced Higher[27].

Scottish Higher Biology specifications which have been in place since 2002, contain three 40 hour units, each with a value of one credit. These units are:

- Cell biology
  - Cell structure in relation to function
  - Photosynthesis
  - Energy release
  - Synthesis and release of proteins
  - Cellular response in defence in animals and plants

- Genetics and adaptation
  - Variation
  - Selection and speciation
  - Animal and plant adaptations

- Control and regulation
  - Control of growth and development
  - Physiological homeostasis
  - Population dynamics

Scottish Advanced Higher Biology specifications which have been in place since 2006 have a structure with mandatory and optional units.

Mandatory units
- Cell and molecular biology (40 hours, 1 credit)
- Environmental biology (40 hours, 1 credit)
- Biology investigation (20 hours 0.5 credit)

Optional Units
- Biotechnology (20 hours, 0.5 credit)
- Animal behaviour ((20 hours, 0.5 credit)
- Physiology, health and exercise (20 hours, 0.5 credit)

The SQA does not operate in a ‘competitive’ environment in the way that English awarding bodies do. Given the possible constraining influence on plant science of ‘market forces’ in the English system of curriculum and assessment (p20), one could question whether the Scottish system offers more support for the teaching and learning of plant science in schools. This research did not look in detail at differences between England and Scotland in the relevant biology curriculum specifications and assessment

[27] Details of the Scottish Higher and Advanced Higher in Biology can be found at http://www.sqa.org.uk/sqa/2571.html

processes. However, a small amount of qualitative evidence from postgraduate students (p75) suggests that there may be differences in students' experience of plant biology in Scottish schools compared to English schools. This may be worthy of further research.

3.3 Careers Information, Advice and Guidance

Careers information and advice and guidance (IAG) is one possible influence on young people's choices. However, evidence (cited below) indicates that, currently, this is very unlikely to encourage any additional uptake of plant science study at university, or much consideration of 'plant-related' careers.

Recent research for the Science Education Forum (AstraZeneca Science Teaching Trust) (Stagg 2007)[28] confirmed earlier concerns about the inadequate quality and quantity of careers information, advice and guidance for school students relating to science-based progression routes for further study and career options. This research concluded that:

- *Firstly, the information tends to be scattered, lacks coherence, and is often missing from the curriculum and qualifications experience of a large proportion of young people;*
- *Secondly, whilst an appropriate variety of 'media' is being used to disseminate careers information, access and use seems limited by a lack of awareness of where the information is located, and lack of time to explore it;*
- *Thirdly, the people in a position to provide science careers education may not be sufficiently well informed (e.g. science teachers, careers professionals), or their roles may not focus on science careers.*

(Stagg 2007 p5)

Other research into careers education and its influence in relation to science was carried out by Cleaves A (2005)[29], who investigated the formation of subject choices amongst a group of higher achieving students, following the development of their choices through years 9, 10 and 11. These students clearly had the potential to progress in science to A level, but Cleaves found inhibiting factors such as 'disappointment with school science'. In addition, this research:

> *…. suggests that two other powerful factors militate against a post-16 science choice. The first is a lack of knowledge about science occupations and science work, particularly amongst those who decide against taking science past the age of 16.*
>
> p483

[28] Stagg P (2007) *Careers from Science: An Investigation for the Science Education Forum,* AstraZeneca Science Teaching Trust
[29] Cleaves A (2005) 'The formation of science choices in secondary schools' Int J Sci Ed, 18 March 2005, No 4 pp471-486

Another earlier study by Munro and Elsom[30] in 2000 reported further important findings relevant to careers advice in science, including:

- The majority of careers advisers were graduates with a humanities or social science background;

- Science teachers do not see themselves as a source of advice about careers in science and technology;

- Science teachers did not feel able to keep up with careers information (there were careers 'people' to do this);

- There was very little planned contact between science teachers and careers advisers.

The Connexions Service is one of the main professional providers of careers information advice and guidance. Connexions has identified 23 'job families' to help structure and categorise advice and guidance in relation to careers. A review of the information available on the 'Jobs4U' website[31] reveals that:

- Under the 'Science, Mathematics and Statistics Job Family' (a list of 41 careers), the generic role of 'research scientist' is listed, but there is no mention of plant scientists, although there is an entry for 'botanist'.

- Under the career description for botanist, this statement is included: *"There are around 5,000 botanists in the UK and competition for jobs can be intense".*

This website also describes the work of a botanist as follows:

> *Botanists study plants, from trees and flowers to algae, fungi, lichens, ferns, grasses, and mosses*

The text goes on to say that:

There are many different roles for botanists. They can work in:
- *Field research – conducting scientific surveys of natural habitats, identifying, recording and monitoring plant species, and searching for new species*
- *Conservation – protecting, managing and enhancing plant life*
- *Laboratory research*
- *Lecturing*

It could be argued from this data that the profile of 'plant science' is nearly invisible on the web site specifically designed to inform young people of future career directions. Furthermore some statements under 'botanist' are not only an inaccurate reflection of the role and importance of plant science, but fail completely to connect with the aspirations many young people are known to have towards global and environmental

[30] Munro M and Elsom D (2000) 'Choosing Science at 16: the influence of science teachers and careers advisers on students' decisions about science subjects and science and technology careers' NICEC Briefing
[31] jobs4u Career Database can be found at: http://www.connexions-direct.com/jobs4u/

issues, where plant science has a vital role. The information on this website is at the least unhelpful for young people interested in careers in plant science, and probably actually harmful in terms of encouraging education choices in that field. The Gatsby Foundation might find it worthwhile to seek the upgrading of the information on this site or alternative sites (given the current re-structuring of the career services for young people).

3.4 Plant Science in Higher Education

3.4.1 Uptake of Plant Science at Undergraduate Level

Universities in the UK offer an extensive range of undergraduate degrees with plant science content. There is considerable variation in the way that universities organise their undergraduate provision within 'schools', faculties and departments, and in the way individual degree programmes are structured (e.g. combinations of compulsory and optional courses, units and modules). The titles of individual degrees, courses or modules are not necessarily clear indicators of their plant science content. In 2009, only a small number of higher education institutions will be offering 3 or 4 year specialist degree courses entitled botany or plant science. The UCAS course search facility shows nine institutions offering courses categorised under JACS code 200 (botany or plant science) from 2009. (It is important to point out that plant science does also feature within other codes e.g. the UCAS course search under 'all plant science' shows 42 courses in 18 institutions. However the range is very broad, including foundation degrees in amenity horticultural management and plant use and design).

The specific provision of plant science or botany degrees only conveys a small part of the total provision available. Units or modules which wholly or partly focus on plant science are provided through a wide range of degree programmes across biological sciences, genetics, biochemistry, cell biology, molecular biology and many others. There are also the more applied courses e.g. in agriculture, horticulture, crop science. These applied courses also include a range of other higher education qualifications such as Higher National Diplomas (HNDs).

Trends in the uptake of plant sciences will be linked to trends in the uptake of associated programmes in the biological sciences. This research has reviewed the recent uptake of a range of undergraduate degree programmes. The period covered is up to ten years.

Sample Data from UCAS survey (covering years 2002 – 2008)

These data samples show applications and acceptances for undergraduate degree courses. Data for applications is taken from 2002-2008[32]. Data for acceptances is only shown from 2002-2007 because the 2008 data was incomplete at the time of the research.

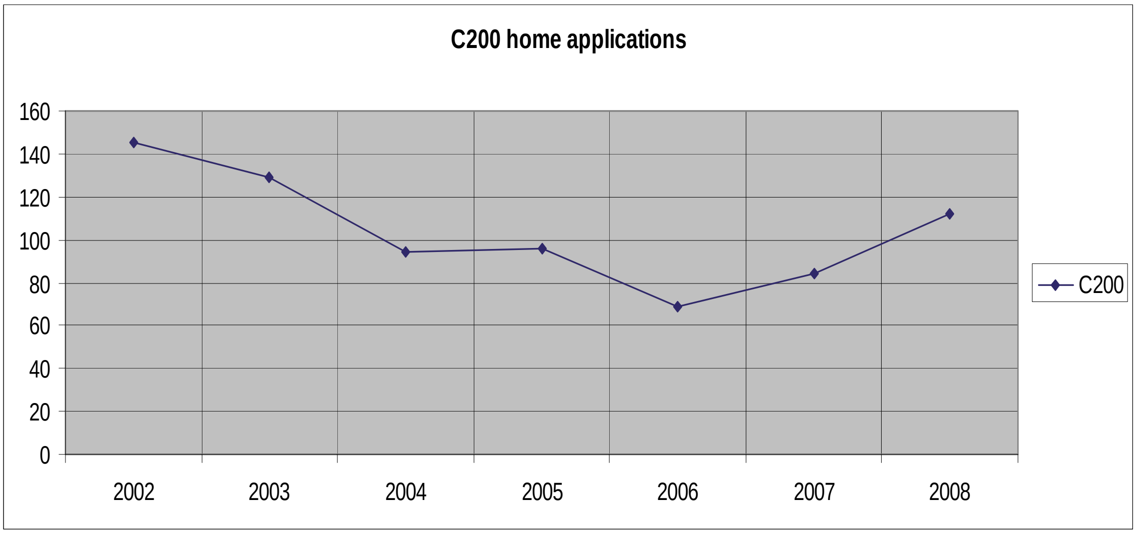
Table 9: Home applicants for undergraduate degrees–exclusively plant science

Home Applicants 2002-08							
course	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
C200 Botany/ Plant Sciences	145	129	94	96	69	84	112
C210 Applied Botany	2	1					1
C240 Plant Cell Science	3	5					
C250 Plant pathology	13	9	8	16	11	9	6
C290 Botany not elsewhere classified		5	4				
C750 Plant Biochemistry	7	1					
Totals	**170**	**150**	**106**	**112**	**80**	**93**	**119**

Table 10: Home acceptances for undergraduate degrees–exclusively plant science

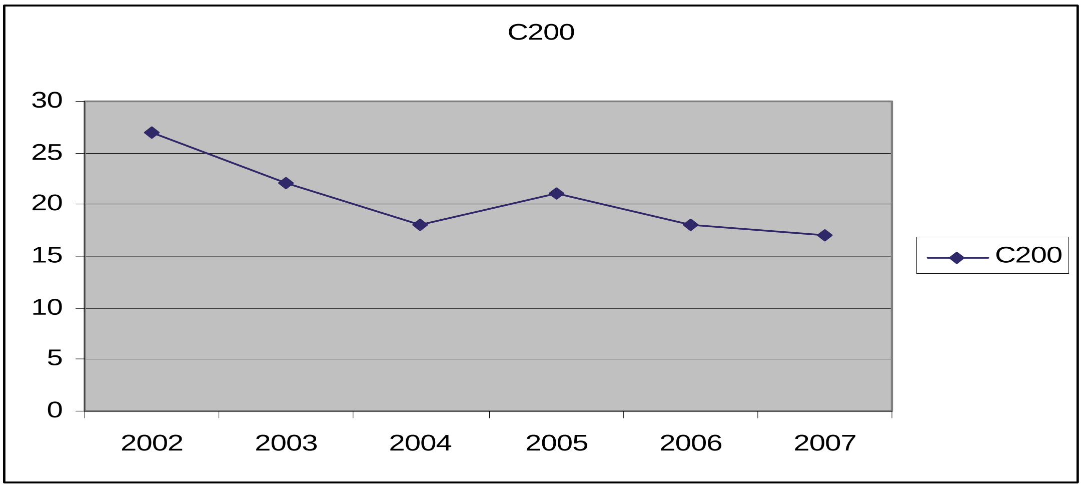
Home acceptances						
course	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
C200 Botany	27	22	18	21	18	17
C250 Plant Pathology	3	2		1	1	
C290 Botany not elsewhere classified		8				
Totals	**30**	**32**	**18**	**22**	**19**	**17**

Chart 6: Home applicants for undergraduate degrees – Botany (C200) 2002-08



[32] The data has been taken from 2002 because there were changes in the JACS coding prior to that date which would make previous data not comparable.

Chart 7: Home acceptances for undergraduate degrees – Botany (C200) 2002-07



JACS code C200 includes courses entitled Botany and Plant Sciences. At this stage, caution is needed in interpreting any trend, as the 2007 and 2008 applications data showed an upturn and the data does not include a figure for 2008 acceptances. Actual numbers are small.

Table 11: Home Applications – Various biological sciences and related subjects

Home applications							
course	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
C100 Biology	12271	11281	10607	11498	11262	11912	12870
C160 Freshwater and Marine Biology	2067	1725	1578	1435	1167	1219	1083
C190 Biology not elsewhere classified	125	486	484	658	890	833	707
C400 Genetics	1497	1541	1304	1237	1157	1124	1250
C700 Molecular Bio, Biophysics, Biochem	6195	6065	5934	6303	5871	6461	6741
C720 Biological Chemistry	1060	958	803	859	794	664	728
C900 Others in Biological Sciences (misc)	131	219	225	259	915	1041	1497
C990 Biol Sci not elsewhere classified	17	17	23	19	29	69	100
C300 Zoology	4758	4456	4677	4941	4433	5089	5582
C500 Microbiology	1065	987	829	746	630	705	727
C600 Sports science	17665	18539	17326	19866	18933	21079	22214
C800 Psychology	45039	51186	48198	53193	48544	53385	56642
C200 Botany/ Plant Science	145	129	94	96	69	84	112
D400 Agriculture	323	334	375	352	343	357	429
D500 Forestry	84	71	86	91	109	104	104

Table 12: Home Acceptances – Various biological sciences and related subjects

Home acceptances						
course	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
C100 Biology	2119	2026	1834	1956	1868	1970
C160 Freshwater and Marine Biology	331	256	256	221	167	171
C190 Biology not elsewhere classified (misc)	38	77	92	133	172	158
C400 Genetics	256	242	204	203	199	192
C700 Molecular Bio, Biophysics, Biochem	956	890	869	1049	960	1022
C720 Biological Chemistry	181	180	154	161	121	120
C900 Others in Biological Sciences (misc)	53	66	62	156	217	234
C990 Biol Sciences not elsewhere classified (misc)	24	25	20	18	23	64
C300 Zoology	756	764	786	747	720	797
C500 Microbiology	164	131	117	113	108	107
C600 Sports science	2951	2981	3036	3456	3400	3653
C800 Psychology	6751	7169	7057	7929	7634	8375
C200 Botany/ Plant Science	27	22	18	21	18	17
D400 Agriculture	114	121	133	102	106	101
D500 Forestry	31	25	24	40	52	41

Table 13: Home acceptances as percentage of home applications – various biological sciences and related subjects

Home acceptances as a % of home applications						
course	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
C100 Biology	17.3	18.0	17.3	17.0	16.6	16.5
C160 Freshwater and Marine Biology	16.0	14.8	16.2	15.4	14.3	14.0
C190 Biology not elsewhere classified (misc)	30.4	15.8	19.0	20.2	19.3	19.0
C400 Genetics	17.1	15.7	15.6	16.4	17.2	17.1
C700 Molecular Bio, Biophysics, Biochem	15.4	14.7	14.6	16.6	16.4	15.8
C720 Biological Chemistry	17.1	18.8	19.2	18.7	15.2	18.1
C900 Others in Biological Sciences (misc)	40.5	30.1	27.6	60.2	23.7	22.5
C990 Biol Sciences not elsewhere classified[33]	[34]141.2	147.1	87.0	94.7	79.3	92.8
C300 Zoology	15.9	17.1	16.8	15.1	16.2	15.7
C500 Microbiology	15.4	13.3	14.1	15.1	17.1	15.2
C600 Sports science	16.7	16.1	17.5	17.4	18.0	17.3
C800 Psychology	15.0	14.0	14.6	14.9	15.7	15.7
C200 Botany/ Plant Science	18.6	17.1	19.1	21.9	26.1	20.2
D400 Agriculture	35.3	36.2	35.5	29.0	30.9	28.3
D500 Forestry	36.9	35.2	27.9	44.0	47.7	39.4

[33] C990 contains a group of miscellaneous courses, some with limited plant science. Courses in C990 include Life Science, Sociology with Life Sciences, Neurobiology and Biomedical Science.
[34] Data for C990 may not be an error (over 100%). One explanation may be the acceptance of 'non-applicant' students onto this mixture of 'other' courses through the clearing process

Chart 8: Home applications – various UG degrees with plant science content

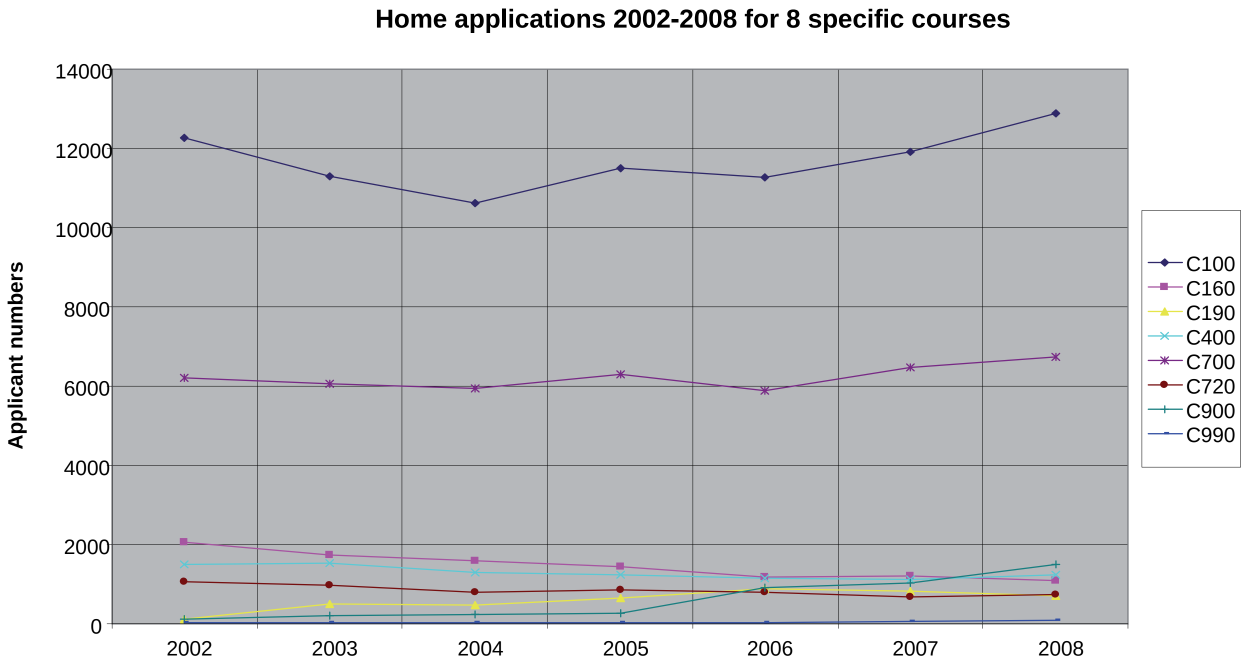


Chart 8 shows trends in applications for selected courses containing plant science. Biology (C100) is sustaining its position as a popular subject for undergraduate degrees. Many of the subjects (shown in Table 11) show fluctuations over these years, but few show dramatic changes. Some of the most marked changes appear to be in JACS categories that contain collections of ‘other’ or ‘miscellaneous’ (e.g. C900, C990, C790, C190), although the scales on chart 2a above do not show these very clearly. Whilst some of these courses may contain some plant science, the increases in these codes are not likely to be very significant for plant science. Code C900, for example contains some bioscience and ecology courses, but also a wide range of courses that will contain no plant science e.g. human and biomedical sciences, and even PE in the Community.

Chart 9: Home applicants – various UG degrees with no plant science content

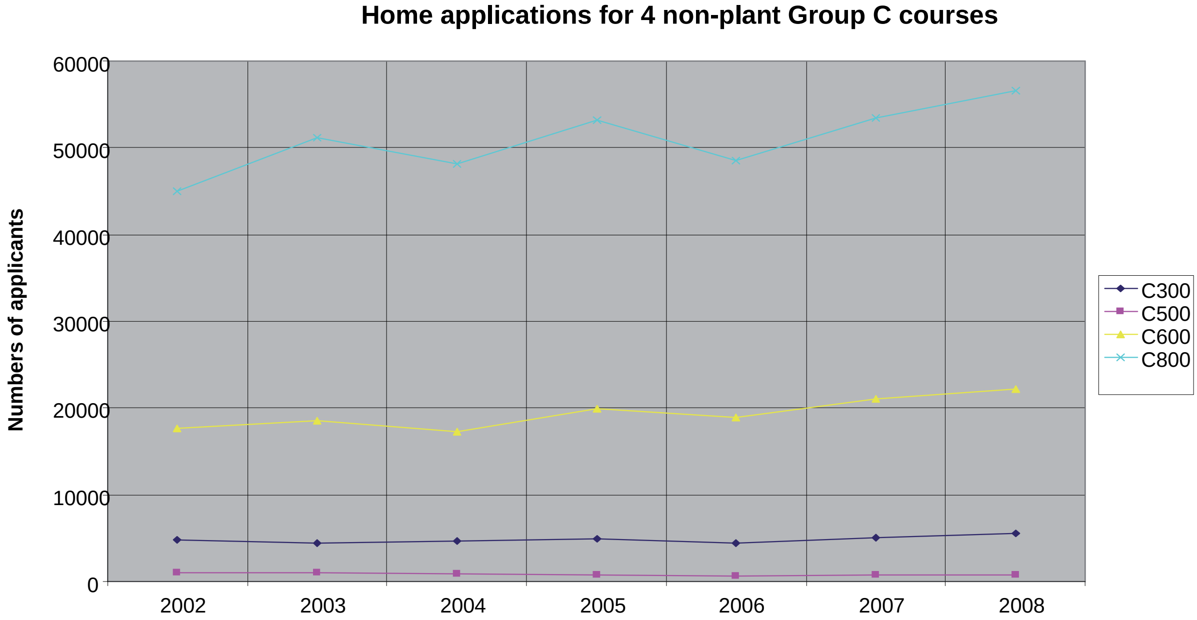


Chart 9 shows trends in applications for some other (non-plant) courses from JACS code C (biological sciences). C800 shows the high and rising popularity of psychology. Sports science (C600) is also very popular, and shows an upward trend in applications Applications for zoology (C300) appear steady. Data from table 11 suggest some decline in applications for microbiology.

Chart 10: Home applicants for UG degrees in Agriculture (D400) and Forestry (D500)

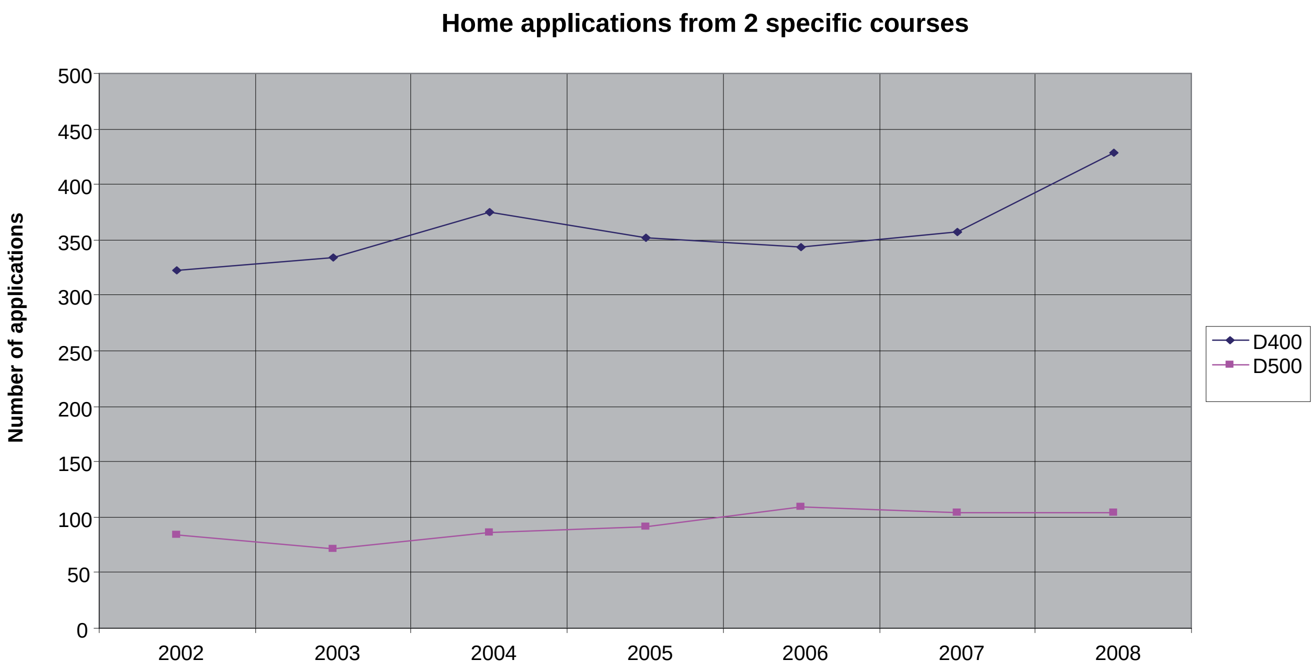


Chart 10 shows the number of applicants for Agriculture (D400) and Forestry (D500). There does seem to be a marked upward trend in applications for Agriculture, and some increase in applications for forestry. Agriculture and Forestry courses show a significantly higher percentage of acceptances against applications, compared to most other courses (see Table 13 p36).

Tables 14 and 15 set out more extensive listings of applications and acceptances from JACS code C (Biological Sciences).

Table 14: Home applications for UG degrees from JACS code C, which may contain significant plant science

course	2002	2003	2004	2005	2006	2007	2008
C100 Biology	12271	11281	10607	11498	11262	11912	12870
C110 Applied Biology	1187	1043	711	750	845	729	766
C130 Cell Biology	405	386	384	393	363	349	305
C131 Applied Cell Biology	110	163	170	205	72	76	70
C140 Developmental/ Reproductive Biology	20	26	62	51	53	42	19
C141 Developmental Biology			2	3	1	8	25
C142 Reproductive Biology	2	2		2	5	11	3
C150 Environmental Biology	874	790	740	616	420	416	514
C160 Marine/ Freshwater Biology	2067	1725	1578	1435	1167	1219	1083
C161 Marine Biology	629	689	693	585	454	520	651
C162 Freshwater Biology	167	178	164	135	117	82	104
C180 Ecology	603	469	395	496	397	498	402
C181 Biodiversity	30	41	40	56	33	39	43
C182 Evolution	32	17	21	31	41	90	87
C190 Biology not elsewhere classified	125	486	484	658	890	833	707
C200 Botany/ Plant Science	145	129	94	96	69	84	112
C210 Applied Botany	2	1					1
C240 Plant Cell Science	3	5					
C250 Plant pathology	13	9	8	16	11	9	6
C290 Botany not elsewhere classified		5	4				
C400 Genetics	1497	1541	1304	1237	1157	1124	1250
C410 Applied Genetics	211	264	227	201	189	160	148
C440 Molecular Genetics	17	27	32	51	35	42	40
C560 Biotechnology	76	88	72	79	67	92	73
C700 Molecular Bio, Biophysics, Biochem	6195	6065	5934	6303	5871	6461	6741
C710 Applied Mol Bio, Biophys, Biochem	153	36	19	16	10	39	62
C720 Biological Chemistry	1060	958	803	859	794	664	728
C730 Metabolic Biochemistry	27	41	30	30	36	29	29
C750 Plant Biochemistry	7	1					
C760 Biomolecular Science	173	166	143	203	208	126	144
C770 Biophysical Science	22	7	8	8	12	15	11
C790 Mol Bio, Biophys, Biochem not elsewhere classified	23	132	251	317	203	226	248
C900 Others in Biological Sciences (misc)	131	219	225	259	915	1041	1497
C910 Applied Biological Sciences	101	66	41	36	35	64	87
C990 Biol Sciences not elsewhere classified	17	17	23	19	29	69	100
Totals	**28395**	**27073**	**25269**	**26644**	**25761**	**27069**	**28926**

Table 15: Home acceptances for UG degrees from JACS code C, which may contain significant plant science

course	2002	2003	2004	2005	2006	2007
C100 Biology	2119	2026	1834	1956	1868	1970
C110 Applied Biology	239	167	148	203	202	187
C130 Cell Biology	101	90	94	104	91	95
C131 Applied Cell Biology	30	19	63	31	15	22
C140 Developmental/ Reproductive Biology	2	6	19	8	3	3
C141 Developmental Biology					1	1
C142 Reproductive Biology	1	1				
C150 Environmental Biology	180	140	113	93	62	70
C160 Marine/ Freshwater Biology	331	256	256	221	167	171
C161 Marine Biology	89	103	98	104	81	94
C162 Freshwater Biology	33	42	26	24	18	7
C180 Ecology	111	109	91	106	73	100
C181 Biodiversity	16	5	6	18	9	4
C182 Evolution	9	4	2	14	4	10
C190 Biology not elsewhere classified	38	77	92	133	172	158
C200 Botany/ Plant Science	27	22	18	21	18	17
C250 Plant Pathology	3	2		1	1	
C290 Botany not elsewhere classified		8				
C400 Genetics	256	242	204	203	199	192
C410 Applied Genetics	49	56	46	41	36	40
C440 Molecular Genetics	3	3	9	12	12	12
C560 Biotechnology	17	20	15	15	13	11
C700 Molecular Bio, Biophysics, Biochem	956	890	869	1049	960	1022
C710 Applied Mol Bio, Biophys, Biochem	18	4	2	7	2	10
C720 Biological Chemistry	181	180	154	161	121	120
C730 Metabolic Biochemistry	2	10	4	7	5	4
C760 Biomolecular Science	20	15	26	18	21	18
C770 Biophysical Science	6	6	2	4	1	3
C790 Mol Bio, Biophys, Biochem not elsewhere classified	4	30	46	52	70	74
C900 Others in Biological Sciences (misc)	53	66	62	156	217	234
C910 Applied Biological Sciences	23	3	4	1	1	13
C990 Biol Sciences not elsewhere classified	24	25	20	18	23	64
Totals	**4941**	**4627**	**4323**	**4781**	**4466**	**4726**

3.4.2 Undergraduate and Postgraduate Students

Sample Data from HESA (Higher Education Statistics Agency) Survey

The researchers carried out a survey of HESA data, focusing on selected programmes of study in, or including plant science. Data for some other 'non-plant' science programmes of study were also surveyed to provide comparisons. The HESA data record all HE students enrolled in a given year:

- By subject of study
- By level of study (undergraduate and postgraduate)
- By mode of study (full time and part time)
- By domicile (UK, other EU and non-EU)
- By gender

There were changes made to the way HESA categorised some of their data after 2001/2. Therefore sudden changes in the data occurring between 2001/2 and 2002/3 should be ignored.

Table 16: Botany

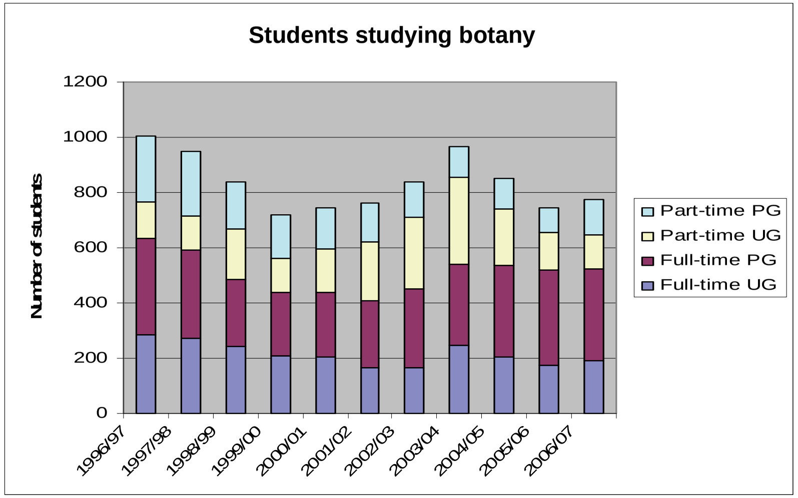
Botany						**United Kingdom**			**Other European Union**			**Non-European-Union**		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**1003**	287	349	129	238	**808**	424	384	**49**	22	27	**146**	58	88
1997/98	**950**	273	317	124	236	**749**	379	370	**45**	21	24	**156**	72	84
1998/99	**837**	244	242	180	171	**666**	378	288	**43**	23	20	**128**	58	70
1999/00	**710**	210	230	120	160	**550**	300	250	**50**	20	30	**110**	60	60
2000/01	**745**	205	235	155	150	**595**	350	245	**40**	20	20	**110**	50	60
2001/02	**750**	165	245	210	140	**615**	365	250	**40**	20	20	**95**	45	55
2002/03	**845**	165	285	260	130	**680**	415	265	**50**	25	25	**115**	60	55
2003/04	**965**	245	295	315	110	**795**	430	365	**45**	25	20	**125**	55	70
2004/05	**845**	205	330	205	110	**625**	340	280	**50**	30	20	**175**	75	100
2005/06	**750**	175	345	135	90	**540**	305	235	**70**	40	30	**140**	70	70
2006/07	**775**	190	335	120	130	**535**	295	240	**65**	40	25	**175**	85	90

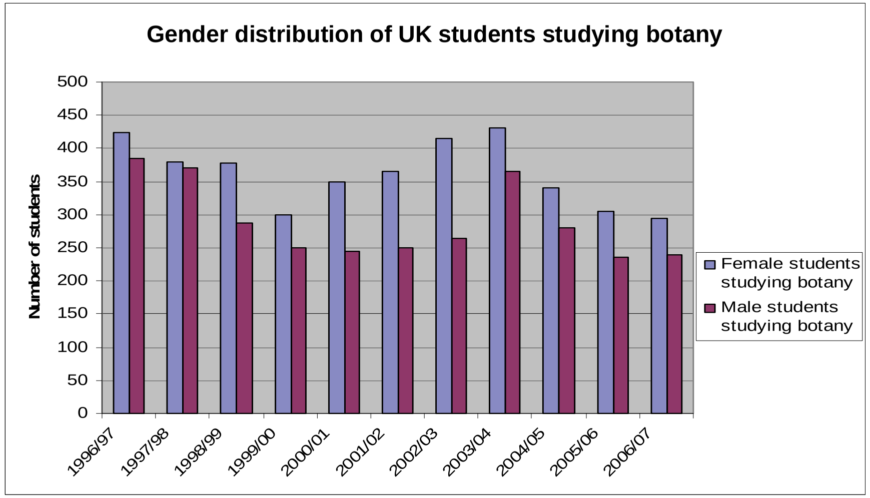
Comments:

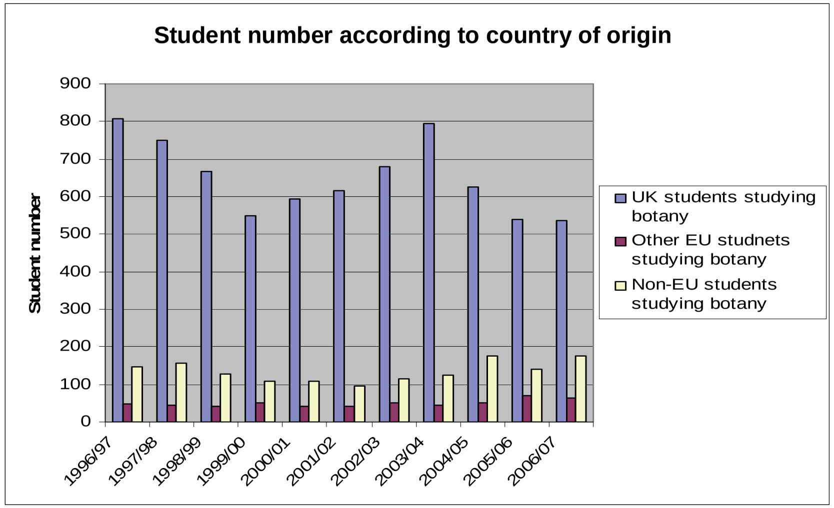
- The HESA data for botany show a ‘peak’ in enrolled students across the years 2003-5, due mainly to changes in the numbers for undergraduate UK students (full time and part time). The UCAS data for (new) applications and acceptances for botany do not show any such peak during this period. Additional numbers may be caused by undergraduates from other biological science courses opting to specialise in botany/plant science in the later years of their degree programme, but it has not been possible in this research to identify a cause of this peak in the HESA data, or whether this is of any significance. Neither the UCAS nor the HESA data indicate any clear trend.

- A chart has been provided for the gender split in botany, showing a consistent majority of female students studying botany. Gender breakdown has not been charted for the rest of the HESA data in this report.

Chart set 11: Botany







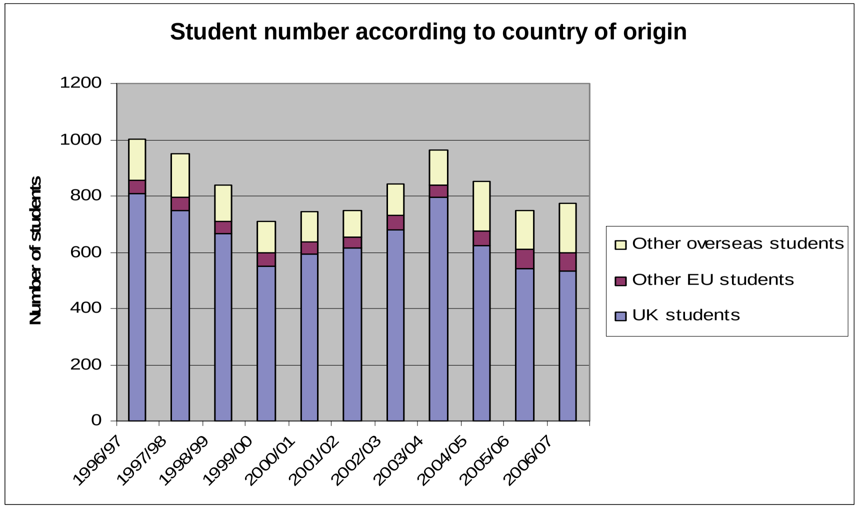


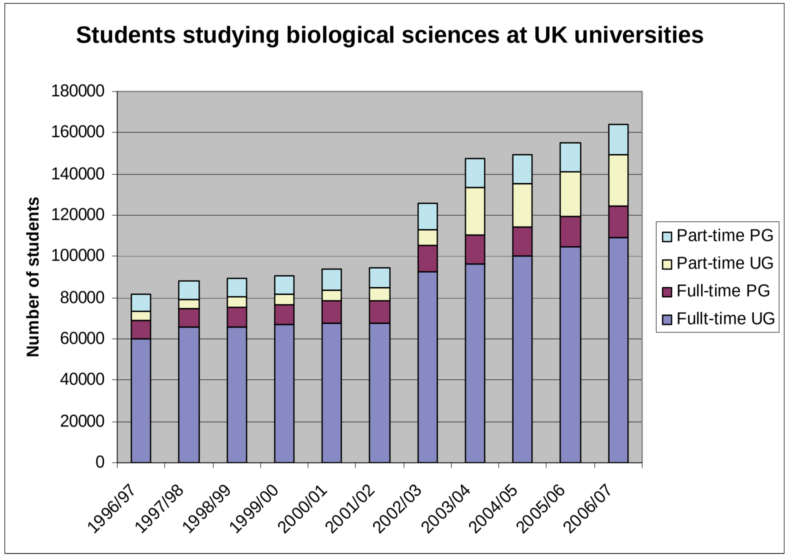
Table 17: Biological Sciences

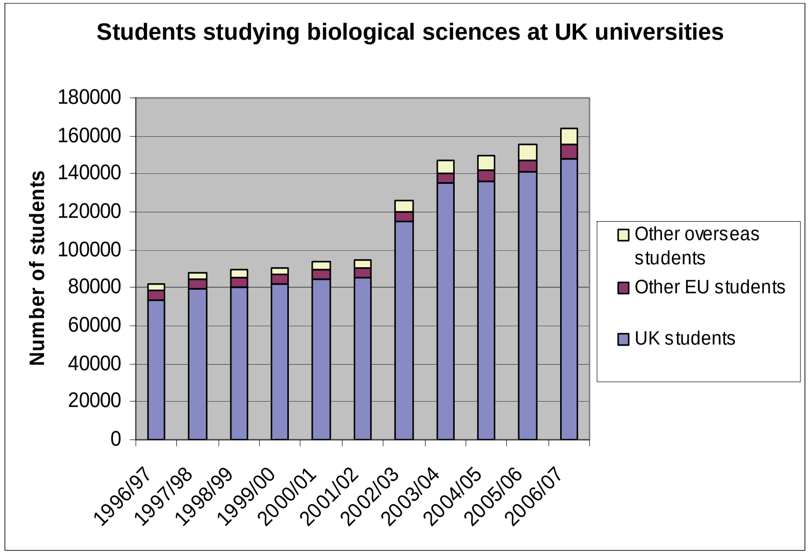
Biological sciences						United Kingdom			Other European Union			Non-European-Union		
year	Total HE students	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	Total	Female	Male	Total	Female	Male	Total	Female	Male
1996/97	**81750**	59853	8987	4477	8433	**73857**	43491	30366	**4319**	2740	1579	**3574**	1836	1738
1997/98	**87987**	65442	9208	4361	8976	**79315**	47310	32005	**4911**	3193	1718	**3761**	2048	1713
1998/99	**89338**	65999	9500	4708	9131	**80257**	48174	32083	**5260**	3408	1852	**3821**	2173	1648
1999/00	**90740**	66900	9900	4610	9340	**81620**	49570	32050	**5350**	3470	1880	**3770**	2150	1630
2000/01	**93730**	67460	10780	5680	9810	**84610**	52195	32415	**5220**	3395	1825	**3900**	2190	1710
2001/02	**94560**	67665	11070	5930	9900	**85415**	53350	32065	**4865**	3165	1700	**4280**	2435	1840
2002/03	**125860**	92340	12740	8215	12565	**114655**	72450	42205	**5590**	3695	1895	**5615**	3210	2400
2003/04	**147355**	96605	14010	23045	13695	**134820**	86315	48505	**5580**	3680	1900	**6960**	4035	2920
2004/05	**149520**	100050	14275	21115	14080	**135985**	87605	48380	**6155**	4045	2105	**7385**	4250	3135
2005/06	**155220**	104580	14920	21610	14115	**140720**	90555	50165	**6665**	4385	2280	**7835**	4535	3300
2006/07	**164215**	108830	15940	24395	15050	**147735**	94445	53290	**7610**	5040	2575	**8870**	5115	3755

Comment:

- Overall, ignoring minor fluctuations, there appears to have been continuing growth in numbers in biological sciences at both undergraduate and postgraduate levels. (The apparent step change after 2001/02 should be ignored due to a change in how HES categorised data before and after this date).

Chart set 12: Biological Sciences (NB HESA categories for data changed after 2001/02)





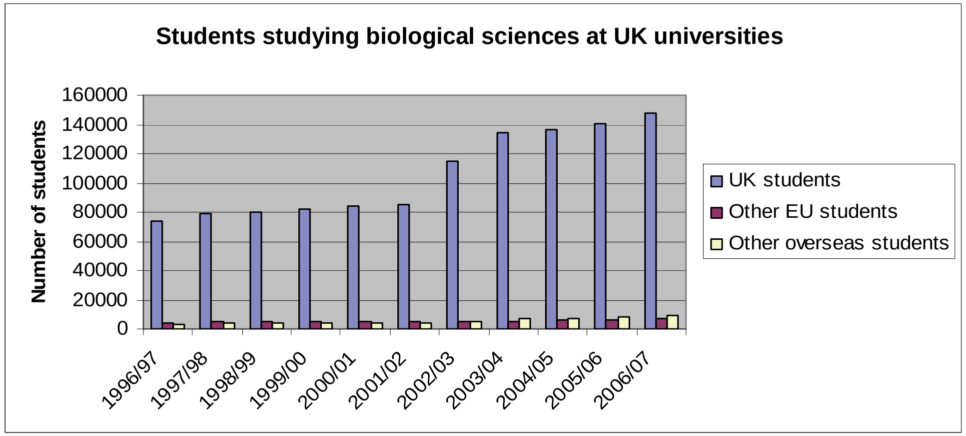
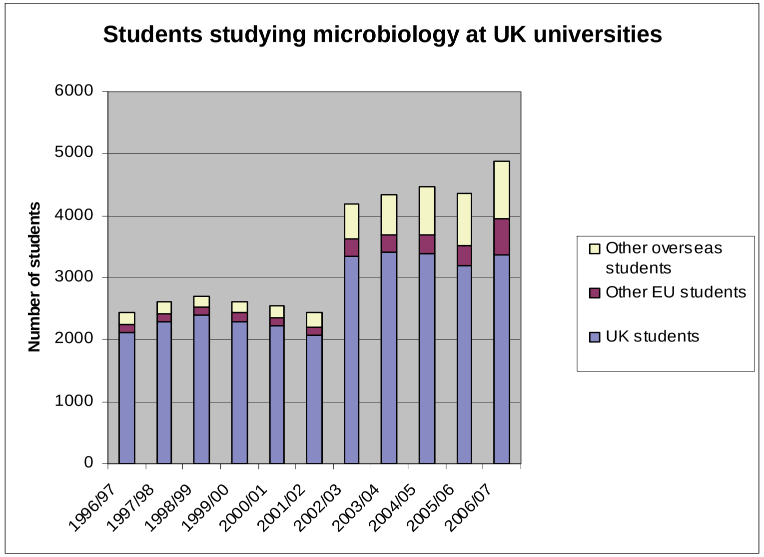
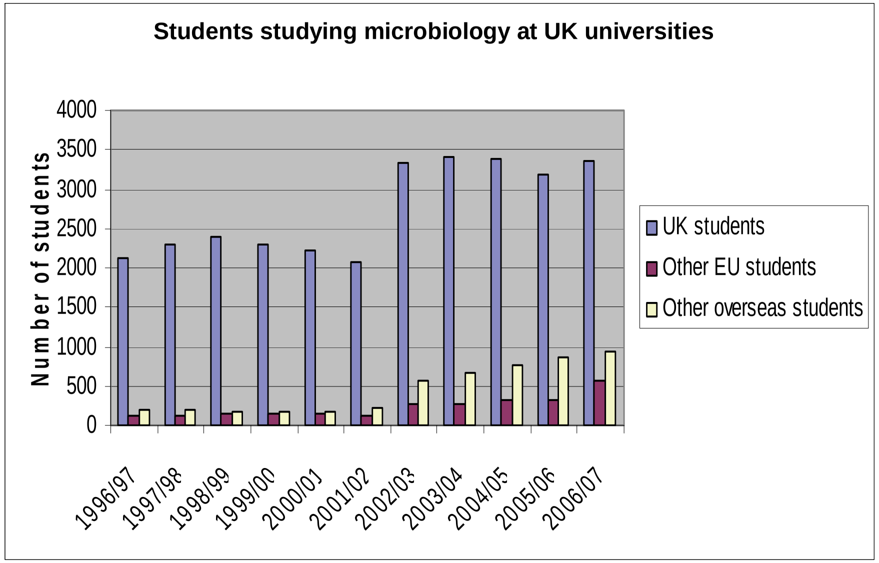


Table 18: Microbiology

Microbiology						United Kingdom			Other European Union			Non-European-Union		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**2445**	1597	360	54	434	**2118**	1189	929	**118**	72	46	**209**	120	89
1997/98	**2608**	1806	308	65	429	**2288**	1254	1034	**119**	74	45	**201**	117	84
1998/99	**2708**	1913	292	64	439	**2392**	1323	1069	**136**	83	53	**180**	114	66
1999/00	**2610**	1810	280	80	440	**2290**	1290	1000	**140**	90	50	**180**	100	80
2000/01	**2545**	1660	310	80	495	**2215**	1290	925	**145**	90	60	**185**	90	90
2001/02	**2435**	1525	335	90	485	**2080**	1225	855	**125**	80	45	**230**	120	110
2002/03	**4195**	2355	945	130	765	**3345**	1890	1455	**275**	165	110	**575**	260	315
2003/04	**4340**	2375	975	170	815	**3405**	1940	1460	**275**	160	115	**660**	320	340
2004/05	**4470**	2375	1090	175	830	**3385**	1940	1440	**315**	180	135	**770**	375	400
2005/06	**4370**	2290	1110	190	780	**3195**	1845	1350	**320**	185	135	**855**	380	470
2006/07	**4880**	2365	1090	175	1245	**3365**	1930	1435	**580**	390	190	**935**	420	515

Chart set 12: Microbiology (NB HESA categories for data changed after 2001/02)





Comment:

- The HESA data suggest no growth, and some possible decline in numbers of UK students in microbiology. The UCAS data for applications and acceptances (Tables 11 and 12 pp34, 35) appear to support this suggestion. The HESA data indicates that any downward trend is due to UK students. Overseas students do not reflect this trend, with non-EU student numbers showing strong growth.

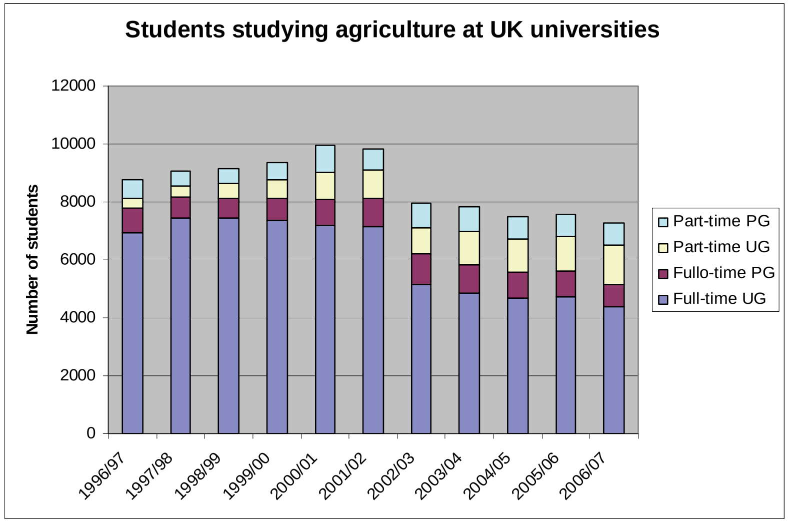
Table 19: Agriculture

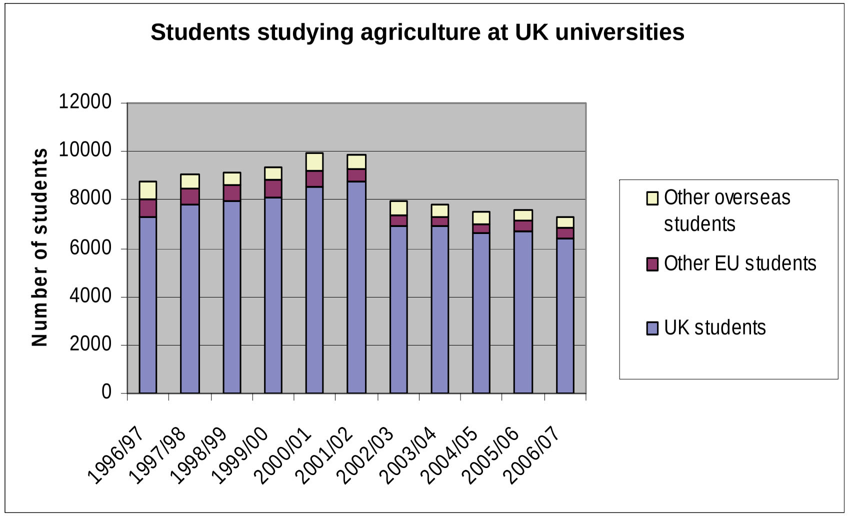
Agriculture						United Kingdom			Other European Union			Non-European-Union		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**8785**	6950	846	331	658	**7303**	3560	3743	**698**	226	472	**784**	157	627
1997/98	**9080**	7430	740	390	520	**7779**	3981	3798	**720**	253	467	**581**	131	450
1998/99	**9157**	7430	717	480	530	**7966**	4227	3739	**670**	238	432	**521**	135	386
1999/00	**9350**	7360	750	640	600	**8090**	4490	3600	**730**	280	440	**530**	150	390
2000/01	**9940**	7205	895	920	920	**8510**	4965	3545	**710**	320	390	**720**	235	480
2001/02	**9840**	7145	980	995	720	**8770**	5130	3640	**540**	235	305	**530**	195	335
2002/03	**7965**	5155	1070	890	850	**6930**	3515	3415	**450**	180	270	**580**	205	375
2003/04	**7810**	4860	955	1165	835	**6900**	3580	3320	**385**	175	215	**520**	190	330
2004/05	**7505**	4660	930	1130	785	**6610**	3480	3130	**415**	170	245	**480**	165	310
2005/06	**7595**	4725	880	1205	780	**6705**	3555	3150	**405**	185	220	**485**	170	315
2006/07	**7295**	4365	785	1370	770	**6435**	3445	2990	**385**	180	205	**475**	165	305

Comment:

- The HESA data suggest some decline in numbers of students in Agriculture since 2002. However, the UCAS data for applications and acceptances for this period (see Tables 12 and 13 p35 and Chart 10 p37) seem inconclusive.

Chart set 13: Agriculture (NB HESA categories for data changed after 2001/02)





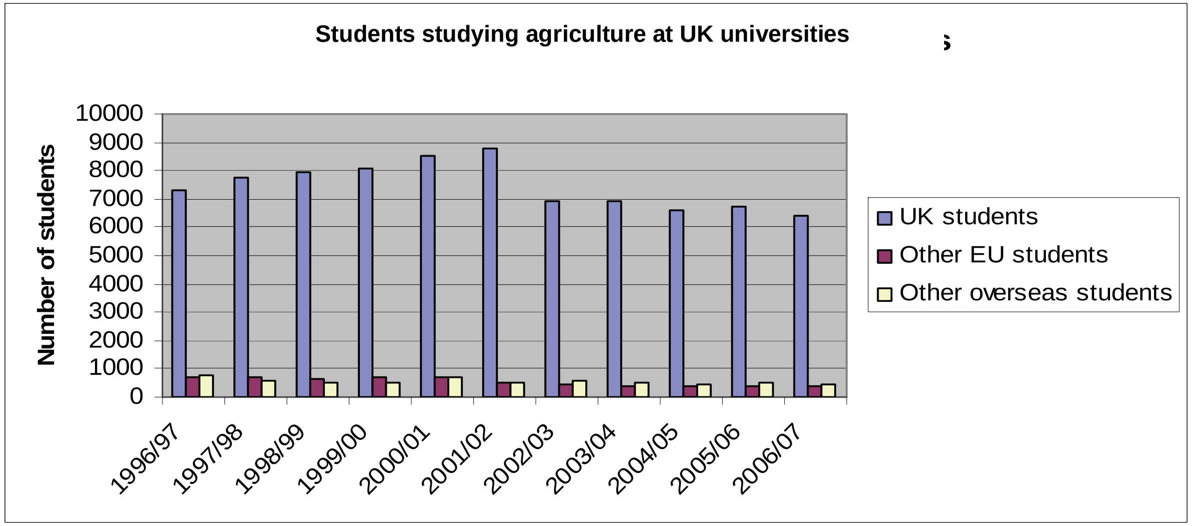


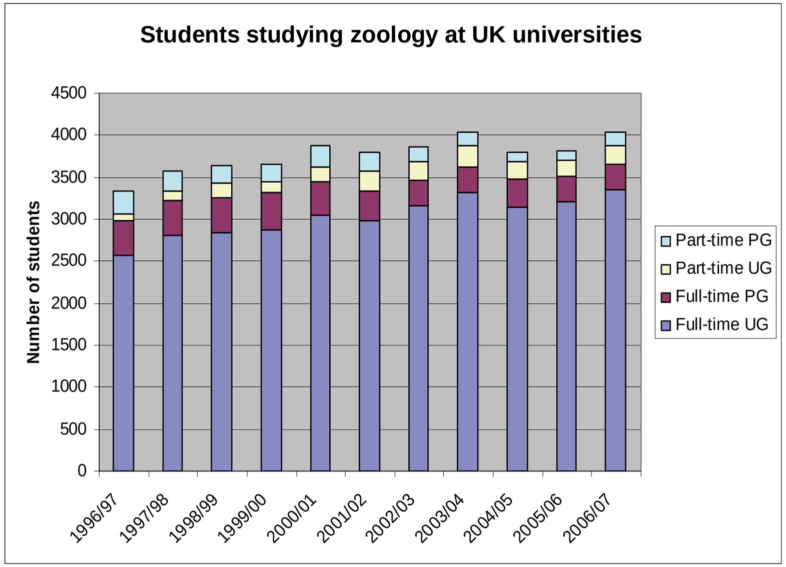
Table 20: Zoology

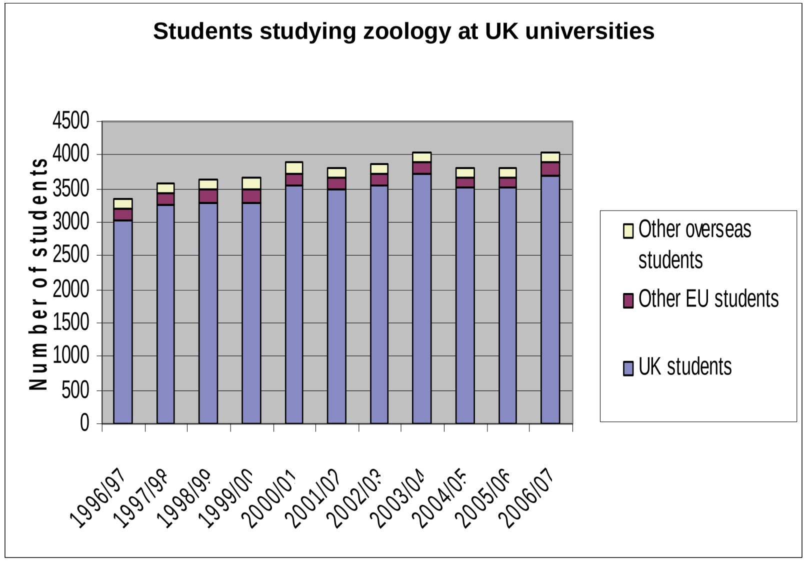
Zoology						United Kingdom			Other European Union			Non-European-Union		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**3337**	2570	421	70	276	**3033**	1656	1377	**163**	85	78	**141**	56	85
1997/98	**3581**	2809	421	105	246	**3250**	1831	1419	**178**	96	82	**153**	64	89
1998/99	**3644**	2835	422	180	207	**3295**	1903	1392	**194**	101	93	**155**	78	77
1999/00	**3660**	2880	440	130	200	**3300**	1960	1340	**200**	120	80	**160**	90	60
2000/01	**3880**	3040	400	185	255	**3540**	2135	1400	**185**	105	80	**155**	90	65
2001/02	**3805**	2985	350	240	230	**3495**	2200	1295	**170**	90	80	**140**	80	60
2002/03	**3865**	3165	295	230	175	**3560**	2290	1270	**170**	105	65	**135**	75	60
2003/04	**4030**	3315	300	270	150	**3735**	2380	1355	**150**	95	55	**145**	90	55
2004/05	**3800**	3145	340	200	115	**3510**	2240	1270	**150**	100	50	**145**	90	55
2005/06	**3810**	3210	305	180	115	**3510**	2215	1295	**160**	105	55	**140**	85	60
2006/07	**4040**	3355	305	220	160	**3705**	2315	1390	**185**	130	50	**155**	95	60

Comment:

- Ignoring slight fluctuations, numbers of students in zoology appear to have remained steady over the period.

Chart set 14: Zoology **(NB HESA categories for data changed after 2001/02)**





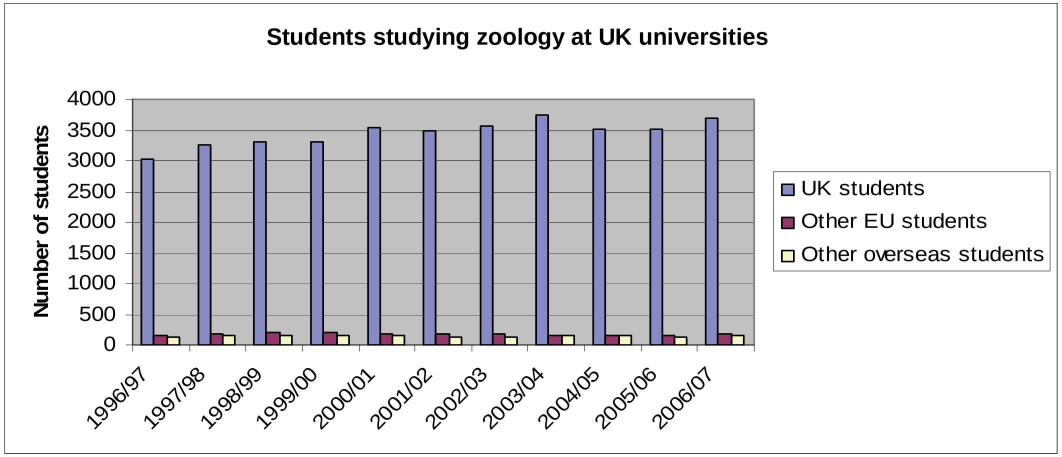


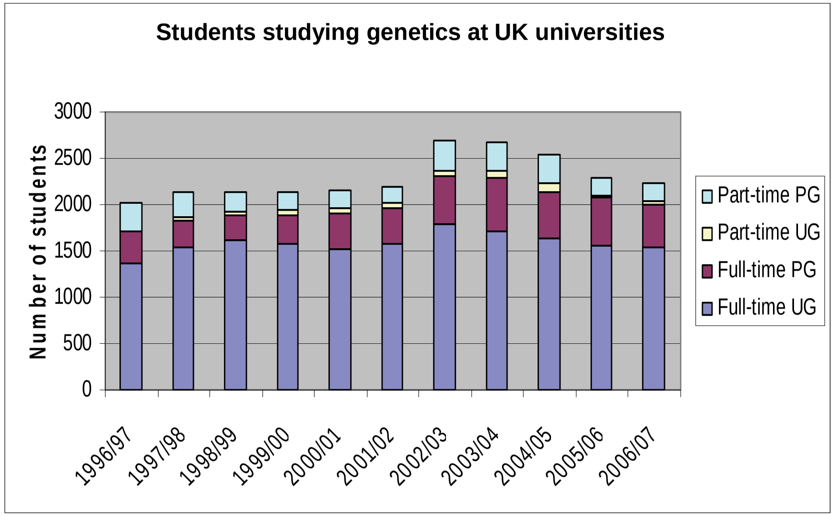
Table 21: Genetics

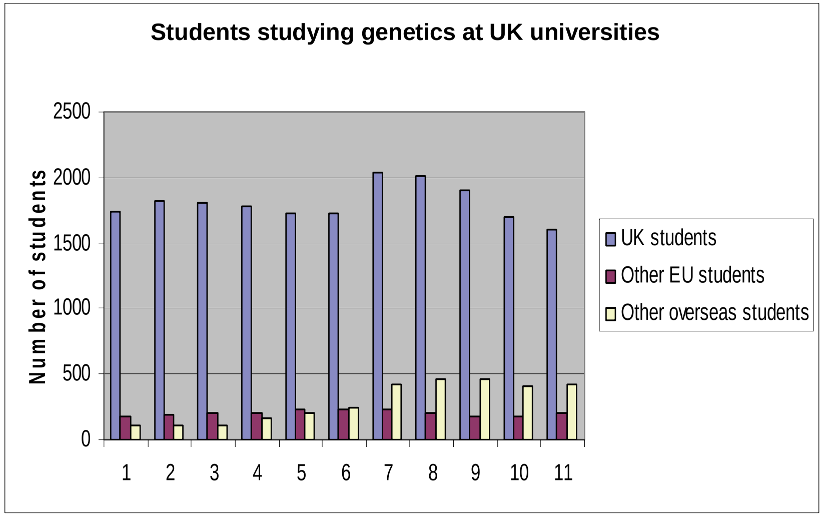
Genetics						United Kingdom			Other European Union			Non-European-Union		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**2024**	1356	349	12	307	**1735**	879	856	**174**	93	81	**115**	42	73
1997/98	**2134**	1536	299	31	268	**1826**	951	875	**193**	107	86	**115**	54	61
1998/99	**2133**	1617	270	37	209	**1808**	960	848	**210**	119	91	**115**	57	58
1999/00	**2150**	1570	320	60	190	**1780**	940	840	**210**	120	90	**160**	80	70
2000/01	**2150**	1525	380	50	195	**1725**	930	795	**225**	135	95	**200**	105	90
2001/02	**2195**	1570	400	40	190	**1725**	940	780	**225**	130	95	**250**	135	115
2002/03	**2695**	1790	515	55	335	**2040**	1135	910	**235**	145	90	**415**	195	215
2003/04	**2680**	1720	560	85	315	**2015**	1135	885	**200**	120	75	**465**	240	225
2004/05	**2550**	1635	505	90	315	**1905**	1065	840	**180**	110	75	**465**	260	205
2005/06	**2290**	1560	510	25	195	**1705**	935	770	**175**	100	75	**410**	240	170
2006/07	**2240**	1530	475	30	205	**1610**	890	720	**205**	140	70	**420**	240	185

Comment:

- The HESA data show a marked decline in numbers of students studying genetics both at undergraduate and postgraduate levels since between 2002/03 and 2006/07 (17% decline in total HE students). The decline seems most marked in UK students (21%), and less so in other EU (8.5% decline), and non-EU (some fluctuation, but stable). The UCAS data support this finding, (see Tables 11 and12 p34, 35), with applications for genetics falling 16.5% between 2002 and 2008, and acceptances falling 25% between 2002 and 2007.

Chart set 15: Genetics **(NB HESA categories for data changed after 2001/02)**





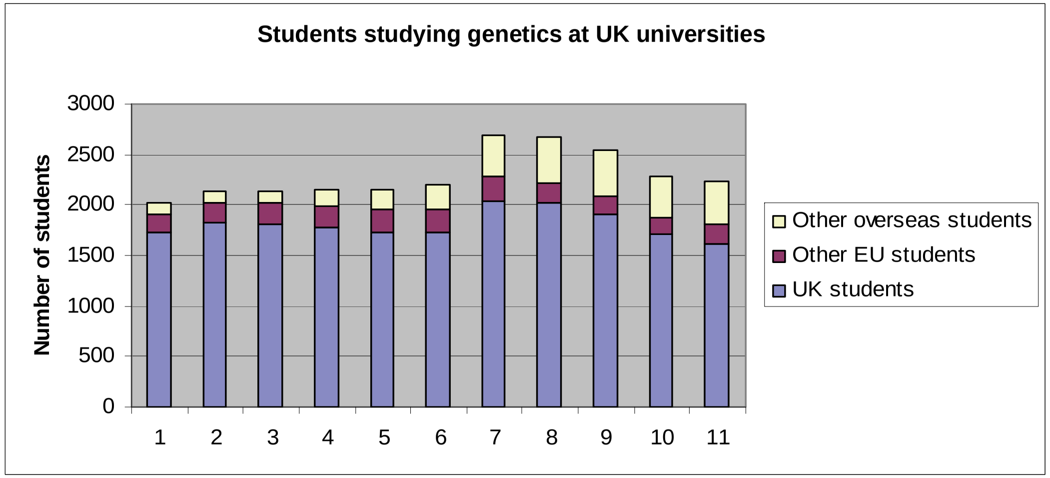


Table 22: Chemistry

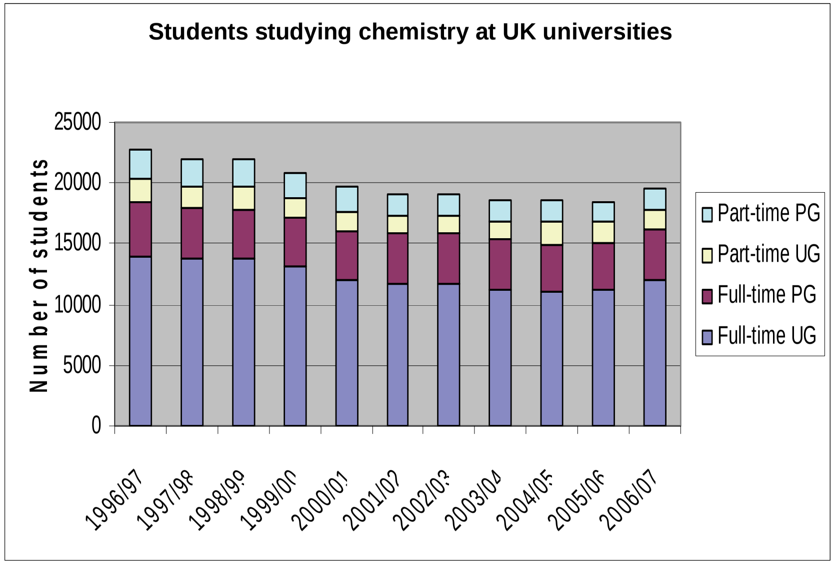
Chemistry						United Kingdom			Other European Union			Non-European-Union		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**22679**	13923	4432	2003	2321	**20232**	7264	12968	**1414**	654	760	**1033**	405	628
1997/98	**22010**	13714	4173	1762	2361	**19458**	7137	12321	**1516**	697	819	**1036**	436	600
1998/99	**21905**	13728	4058	1908	2211	**19324**	7273	12051	**1573**	738	835	**1008**	434	574
1999/00	**20910**	13110	3970	1730	2100	**18290**	7060	11230	**1640**	760	880	**990**	400	580
2000/01	**19660**	12030	4020	1565	2040	**17260**	6940	10320	**1380**	650	725	**1020**	425	595
2001/02	**19085**	11645	4160	1490	1795	**16620**	6835	9790	**1305**	580	730	**1155**	505	650
2002/03	**19015**	11625	4270	1380	1740	**16440**	6890	9555	**1250**	580	670	**1320**	555	765
2003/04	**18525**	11280	4115	1375	1755	**15830**	6850	8980	**1130**	530	600	**1560**	670	890
2004/05	**18520**	11070	3910	1770	1775	**15665**	6725	8940	**1205**	565	640	**1650**	725	925
2005/06	**18375**	11180	3945	1640	1605	**15495**	6515	8980	**1230**	590	640	**1650**	695	960
2006/07	**19585**	12055	4095	1620	1815	**16250**	6790	9460	**1345**	625	725	**1990**	840	1150

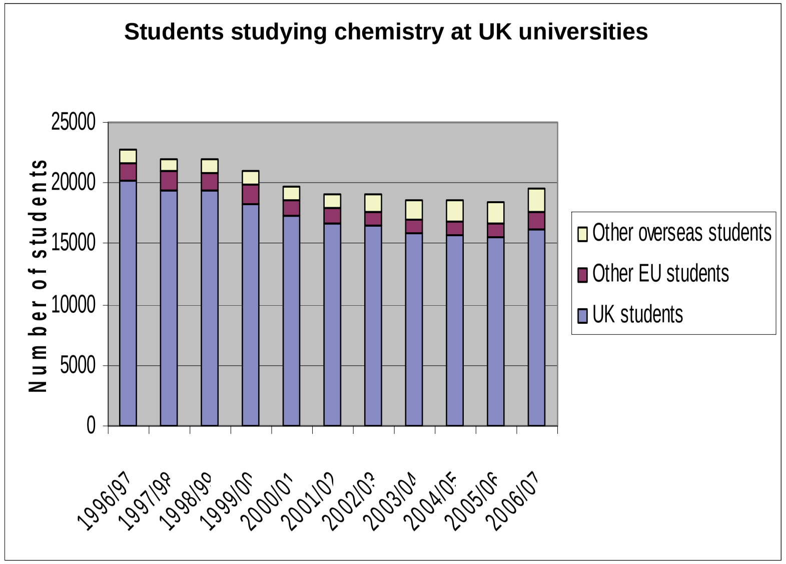
Comment:

- The HESA data suggest that, despite well publicised pressures on chemistry departments in UK universities in recent years, overall numbers of student enrolments did not shown any marked change between 2002/03 and 2006/07. The data does show strong growth in non-EU student enrolments in chemistry (increased by over 33%).

- Although direct comparison is not valid, this recent situation does seem to follow a period of declining numbers in chemistry between 1996/07 and 2001/02.

Chart set 16: Chemistry (NB HESA categories for data changed after 2001/02)





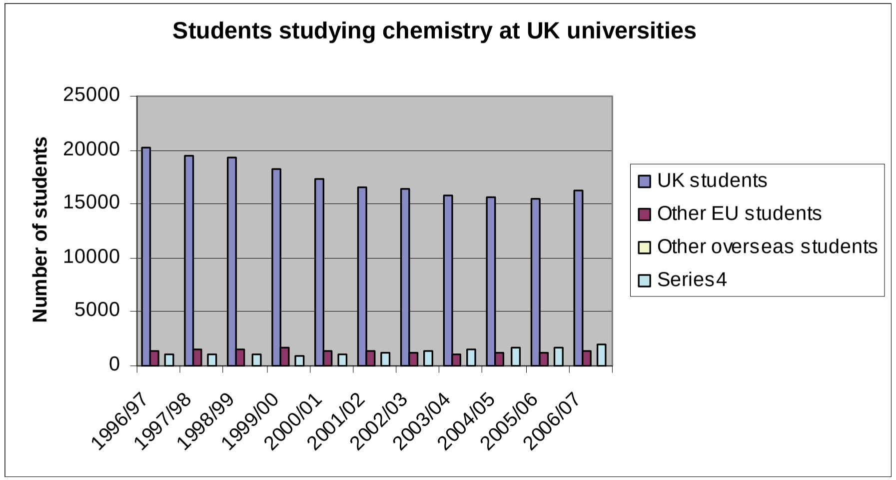


Table 23: Physics

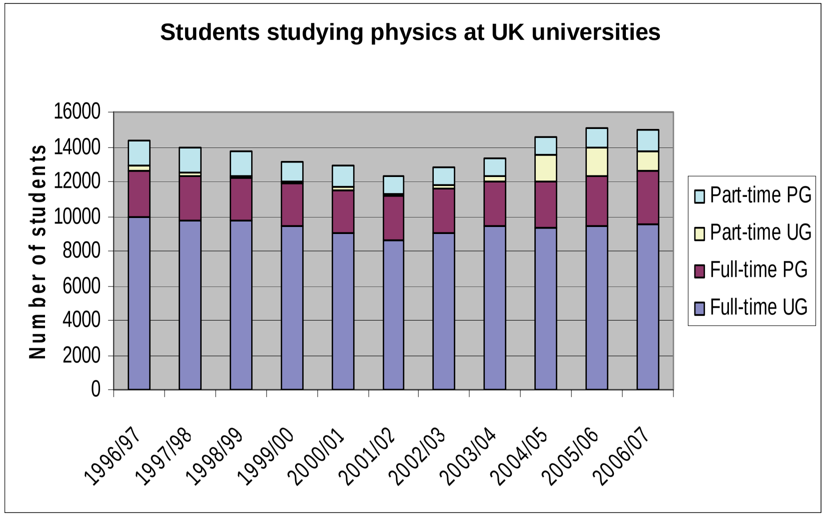
Physics						**United Kingdom**			**Other European Union**			**Non-European-Union**		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	**14366**	9990	2614	279	1483	**12372**	2383	9989	**1262**	261	1001	**732**	145	587
1997/98	**13982**	9731	2543	256	1452	**11962**	2298	9664	**1255**	274	981	**765**	156	609
1998/99	**13695**	9706	2457	170	1362	**11741**	2347	9394	**1199**	270	929	**755**	173	582
1999/00	**13150**	9480	2380	160	1140	**11320**	2260	9070	**1130**	250	880	**700**	160	540
2000/01	**12905**	9025	2485	220	1175	**11155**	2180	8975	**1015**	245	770	**740**	180	555
2001/02	**12310**	8605	2535	130	1035	**10675**	2115	8560	**870**	185	680	**765**	195	570
2002/03	**12830**	9045	2595	120	1070	**11215**	2350	8865	**755**	180	575	**860**	230	630
2003/04	**13360**	9400	2645	245	1070	**11660**	2525	9140	**755**	200	555	**945**	255	690
2004/05	**14610**	9350	2695	1475	1090	**12800**	2665	10140	**870**	240	630	**940**	260	680
2005/06	**15035**	9430	2875	1685	1045	**13105**	2720	10380	**910**	250	660	**1025**	295	730
2006/07	**14935**	9560	3055	1120	1200	**12680**	2610	10075	**1060**	305	750	**1195**	355	840

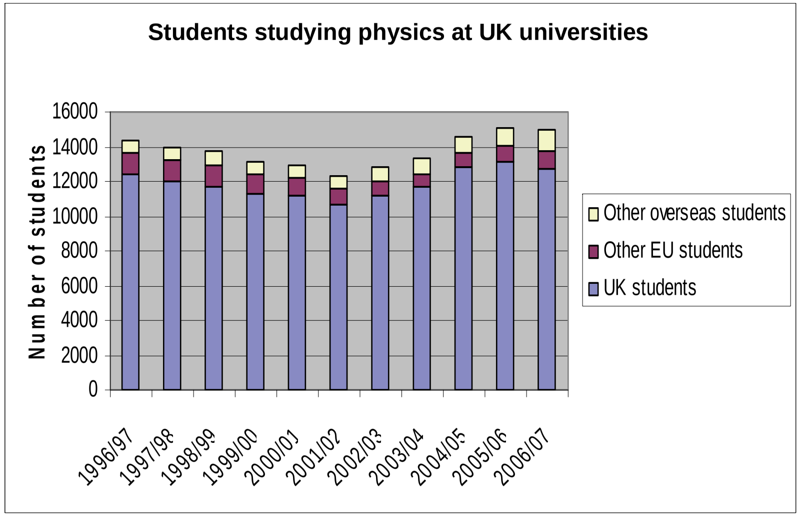
Comment:

- The HESA data show some growth in student enrolments in physics both at undergraduate and postgraduate levels between 2002/03 and 2006/07. The total HE students in physics grew by 16.5%% in this period (UK students by 13%, other EU students by 40%, and non-EU students by 39%).

- As with chemistry (See pp53, 54), although direct comparison is not valid, this recent situation does seem to follow a period of declining numbers in physics between 1996/07 and 2001/02.

Chart set 17: Physics (NB HESA categories for data changed after 2001/02)





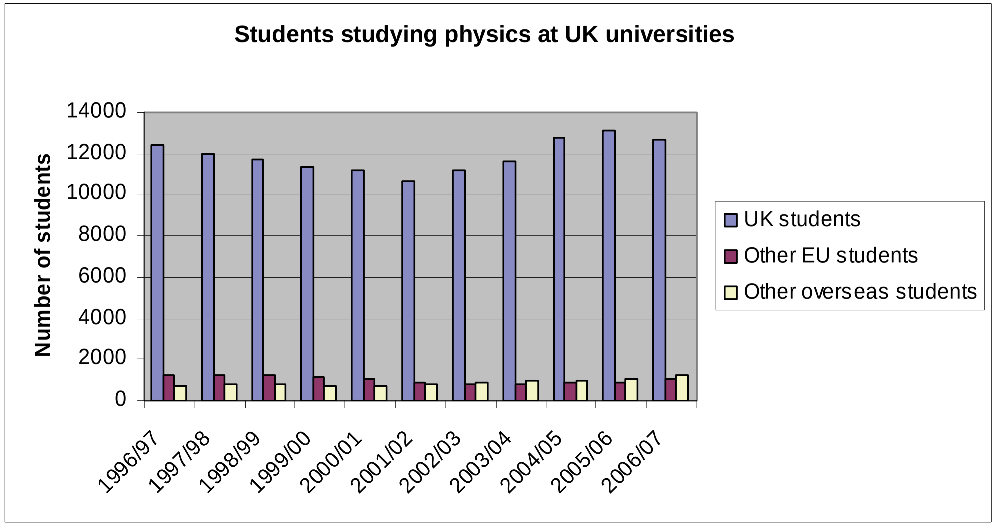


Table 24: Food Science

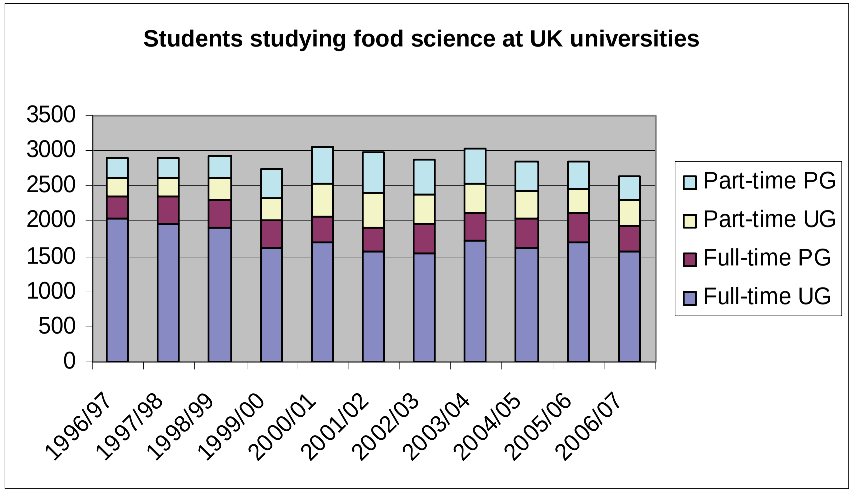
Food science						United Kingdom			Other European Union			Non-European-Union		
year	Total HE students	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	Total	Female	Male	Total	Female	Male	Total	Female	Male
1996/97	**2894**	2033	327	240	294	**2407**	1497	910	**268**	152	116	**219**	114	105
1997/98	**2888**	1946	403	258	281	**2371**	1545	826	**282**	167	115	**235**	131	104
1998/99	**2924**	1895	398	317	314	**2414**	1621	793	**278**	162	116	**232**	125	107
1999/00	**2740**	1630	380	310	420	**2230**	1490	740	**280**	160	120	**230**	120	110
2000/01	**3045**	1685	380	460	525	**2530**	1690	840	**230**	130	105	**280**	150	130
2001/02	**2965**	1555	360	475	575	**2455**	1625	830	**245**	140	110	**265**	145	120
2002/03	**2865**	1540	415	420	495	**2305**	1550	750	**250**	140	110	**310**	175	140
2003/04	**3020**	1725	390	430	475	**2390**	1690	700	**225**	130	95	**405**	245	160
2004/05	**2850**	1620	420	385	420	**2145**	1490	655	**305**	200	105	**395**	235	160
2005/06	**2830**	1710	395	350	380	**2100**	1460	640	**310**	210	105	**420**	240	180
2006/07	**2650**	1565	370	375	335	**1945**	1310	635	**260**	170	90	**445**	265	180

Comment:

- The HESA data suggest a decline in student enrolments in food science, especially in UK students, in the period 2002/03 to 2006/07 (15.5% decline for UK students). Enrolments from other EU countries appear to have fluctuated, but not declined overall in this period.

- In contrast, there appears to have been marked growth in the number of student enrolments from non-EU countries for food science between 2002/03 and 2006/07 (increasing by over 40%).

Chart set 18: Food Science (NB HESA categories for data changed after 2001/02)



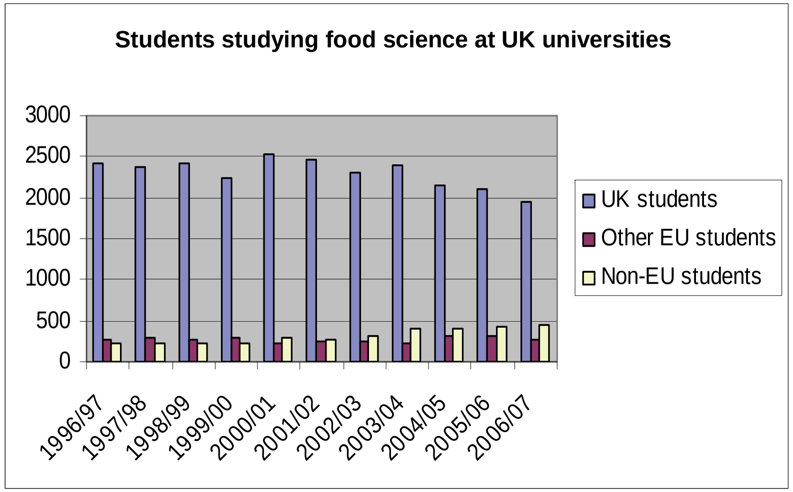


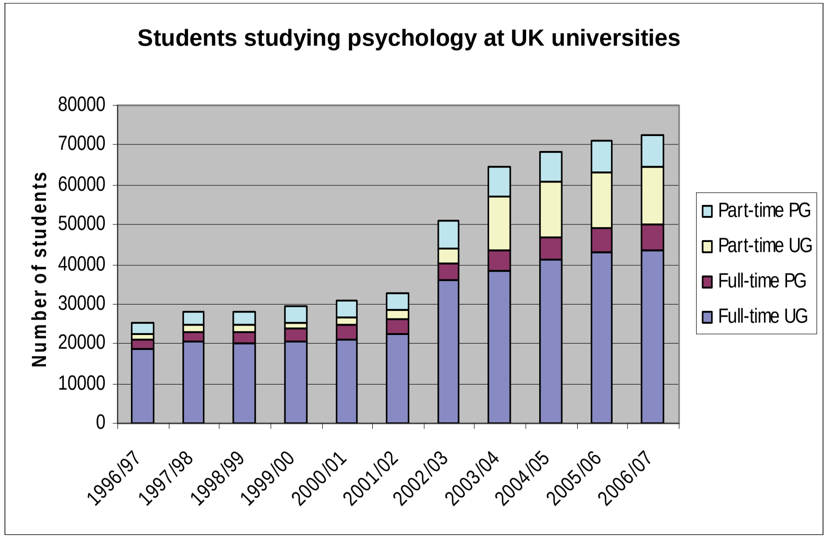
Table 25: Psychology

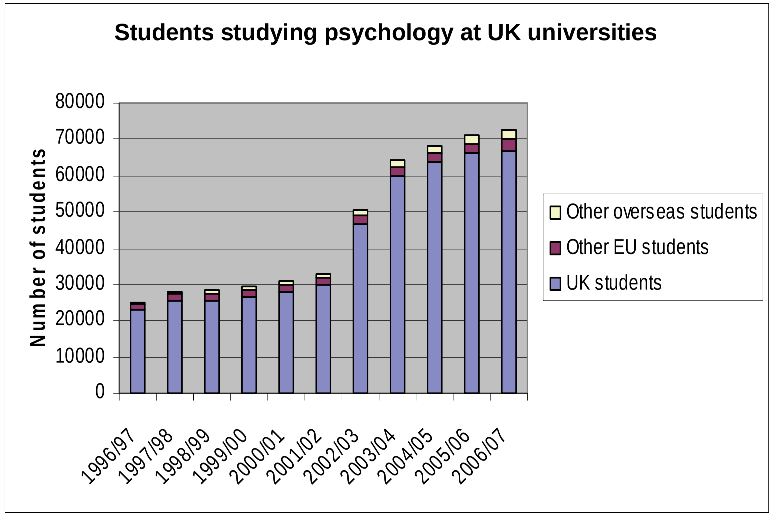
Psychology						United Kingdom			Other European Union			Non-European-Union		
year	Total HE students	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	Total	Female	Male	Total	Female	Male	Total	Female	Male
1996/97	**25120**	18711	2111	1494	2804	**23042**	17007	6035	**1304**	1043	261	**774**	567	207
1997/98	**28133**	20667	2370	1597	3499	**25594**	19216	6378	**1648**	1324	324	**891**	668	223
1998/99	**28244**	20333	2672	1676	3563	**25503**	19564	5939	**1758**	1395	363	**983**	753	230
1999/00	**29340**	20720	2970	1740	3910	**26540**	20740	5800	**1770**	1400	380	**1020**	770	250
2000/01	**31045**	21285	3455	2060	4240	**28175**	22310	5865	**1885**	1475	405	**985**	740	245
2001/02	**32820**	22690	3625	2045	4455	**29900**	23820	6080	**1810**	1430	385	**1105**	845	260
2002/03	**50780**	35795	4635	3735	6615	**46860**	37195	9665	**2335**	1825	505	**1585**	1215	370
2003/04	**64480**	38580	5120	13495	7290	**60110**	47555	12555	**2360**	1870	490	**2010**	1570	440
2004/05	**68265**	41175	5470	14125	7500	**63580**	50485	13095	**2560**	2035	525	**2130**	1625	505
2005/06	**71185**	43200	5800	14180	8005	**66085**	52445	13635	**2845**	2265	585	**2255**	1735	520
2006/07	**72475**	43725	6415	14290	8045	**66890**	53250	13640	**3070**	2445	625	**2520**	1915	605

Comment:

- The HESA data show that student enrolments in psychology have grown substantially in the period 2002/03 to 2006/07 in all categories (undergraduate, postgraduate, UK, other EU and non-EU countries). The overall growth in this period has been 42.7%. UK student enrolments have grown by the same amount (42.7%).

Chart set 19: Psychology (NB HESA categories for data changed after 2001/02)





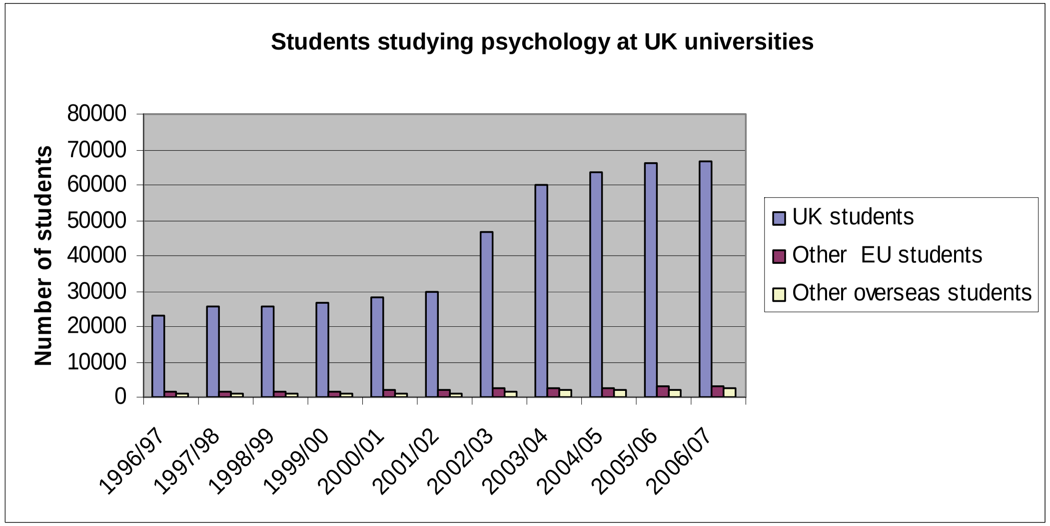


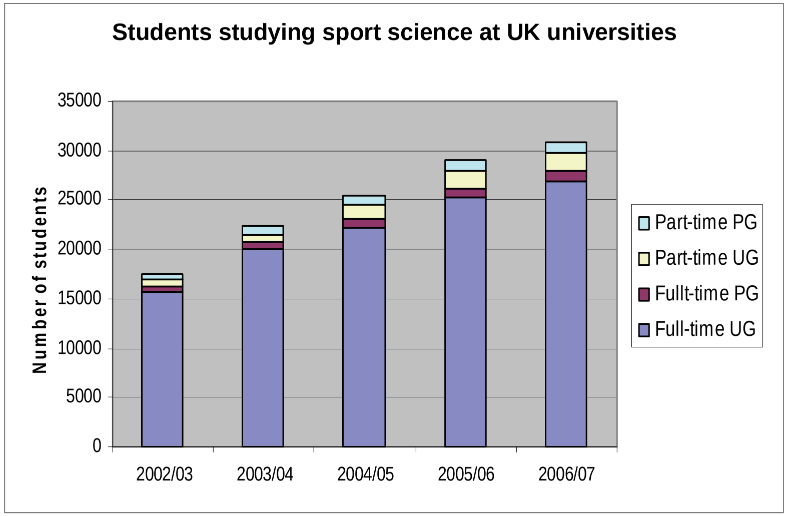
Table 26: Sports Sciences

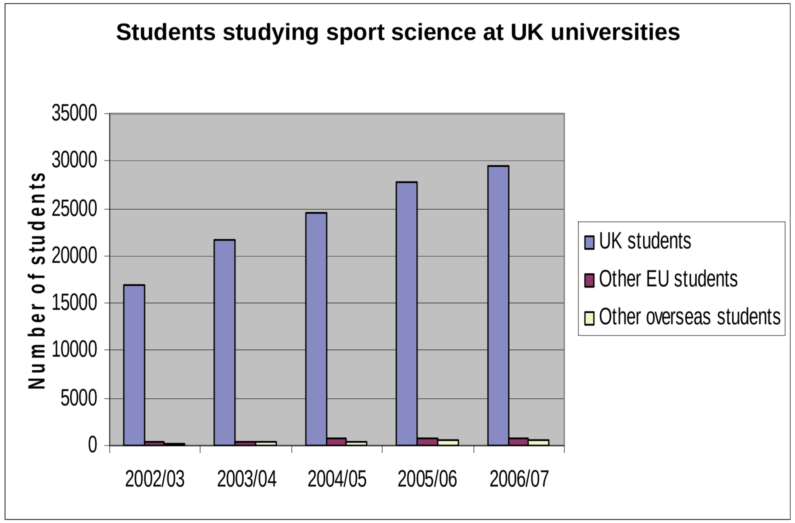
Sport Sciences						United Kingdom			Other European Union			Non-European-Union		
year	**Total HE students**	Full-time undergraduate	Full-time postgraduate	Part-time undergraduate	Part-time postgraduate	**Total**	Female	Male	**Total**	Female	Male	**Total**	Female	Male
1996/97	no category													
1997/98	no category													
1998/99	no category													
1999/00	no category													
2000/01	no category													
2001/02	no category		Not available											
2002/03	**17585**	**15755**	525	595	710	**16985**	6820	10165	**340**	165	175	**260**	120	140
2003/04	**22325**	**19980**	710	795	840	**21600**	8310	13295	**435**	200	235	**290**	115	175
2004/05	**25505**	**22135**	870	1525	970	**24445**	9125	15320	**690**	270	415	**370**	140	230
2005/06	**29050**	**25175**	945	1840	1090	**27820**	10365	17455	**745**	295	450	**485**	200	285
2006/07	**30835**	**26915**	975	1850	1095	**29530**	10950	18580	**820**	290	530	**485**	185	305

Comment:

- Sports science was included as a HESA data category from 2002. Since that time student enrolments in sports science have grown very strongly, for undergraduate, postgraduate, UK, other EU and non-EU countries. The total HE student enrolments grew by 75.3% between 2002/03 and 2006/07. The growth in UK student enrolments in this period was 73.8%.

Chart set 20: Sports Sciences (Only included as a HESA category after 2002)





3.4.3 Provision of Plant Science in UK Higher Education – Institution level

There are now only two Universities in the UK (Oxford and Cambridge) that have separately identified departments of plant science. A number of other universities contain centres for research in plant sciences, or have special relationships with plant science research centres. Plant science is, of course, provided in all higher education institutions offering undergraduate or postgraduate programmes in biological sciences.

The table below shows the numbers of higher education institutions offering courses which were called 'botany' or specifically included the word 'plant' in their titles.

Table 27:
UK HEIs offering any courses in/with Plant Science (named in title) 2002-2008 (JACS codes 200-290, plus various combined courses)

Numbers of HE Institutions offering courses 2002 – 2008						
2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
n = 18	**n = 16**	**n = 14**	**n = 15**	**n = 6**	**n = 9**	**n = 10**

The courses included cover a wide range of plant related studies including botany, plant science and plant biology, as well as courses such as ecology with plant science, and plant biology and conservation. Also included is a small number of 'combined courses (plant science with a modern language, and plant science with psychology). On the surface, the data appear to indicate a sharp decline between 2002 and 2006, followed by some growth. However, this data does not provide any information about type of course or scale of provision, and care is needed in interpreting the data. Further research would be needed to identify reasons for the changes.

3.4.4 Specialist Research Centres

This research project has focused principally on plant science provision through the mainstream school and university system. However, specialist research centres play a very important role in plant science provision, especially in areas such as agriculture, crop science, horticulture and environmental biology[35]. Centres such as Rothamstead, the John Innes Centre, and Warwick HRI (a department of the University of Warwick) are major contributors to this area of work. At the time of this report Warwick HRI, for example, had 13 researchers for plant science, 22 researchers for crop and environmental science, and 11 researchers for applied microbial science.

Further research would be needed to draw out a clear picture of the current role of specialist research centres, and how this has changed and developed over time. Key questions could include:

- How has the overall provision through specialist centres changed over the past 10-15 years, and how has funding changed?
- What sort of relationships exist between these specialist research centres and provision of plant science and plant science research in UK universities?
- What is the likely impact on plant science in the UK
- What further role could specialist centres play in raising the profile of plant science in the UK?

There is cause to ask whether specialist centres are being adequately maintained and supported, with evidence of re-organisation and closures in the past 10 years suggesting that capacity may be reducing rather than expanding. Changes in recent years include the closure of the Efford Horticultural Research Institute HRI (Hampshire) in 2003. (Up to 2003, HRI had five sites). The Wellesbourne and Kirton sites now form Warwick HRI. According to the Trade Union, Prospect[36], the government driven changes to HRI led to a staffing reduction of almost 200. A more recent change (2008) has been the absorption of the Institute of Grassland and Environmental Research (which previously had 3 sites) into Aberystwyth University.

The examples given above suggest that the past decade has seen some decline in plant science research capacity through specialist centres. Evidence, illustrated by the following quote from the qualitative research suggests that this is a longer term issue:

> *Career structure for plant scientists….there isn't one. Centres of excellence for plant and agricultural research have shut down….Long Ashton is now a housing estate. The government has a lot to answer for because not only did they neglect this, but they decided it wasn't a priority…we are paying for decisions made, probably 20 years ago.*
>
> (Senior lecturer, Russell Group)

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[35] A list of major research centres for plant science is provided in Appendix 3 p93
[36] Reference can be found at http://www.prospect.org.uk/doclib/campaign_materials/public_science/prospect_science_briefing_transferring_public_sector_science_labs_to_universities?display=original&revision=1.

Further research, using a range of sources, is needed to reveal the full picture in relation to specialist centres.

In terms of future development, the Gatsby Charitable Foundation, in agreement with the University of Cambridge will be making its largest ever commitment (over £88million) to plant science in the development of a new Sainsbury Laboratory in the grounds of the Botanic Gardens in Cambridge. This is expected to provide facilities for over 120 plant scientists.

SECTION 4: RESEARCH FINDINGS - from the qualitative data

Qualitative research sample

A total of 25 Universities were included in the sample for qualitative research, comprising 22 in England, 2 in Scotland and one in Wales. The data collection methods included semi-structured telephone or face to face interview, plus a small number of additional informal discussions (3) and website searches (5). The sample, which is not representative of all plant scientists, was selected to provide access to data from a range of different universities, offering a variety of provision in the biological sciences. It also aimed to gather data from plant scientists with a range of different specialisms. Details of the sample are shown in table 28 below.

Table 28

'Types' of university	12 'Russell Group' 5 other pre-1960 7 1960-1990 1 post 1990
'Types' of staff	7 Professors 1 Associate Professor 4 Admissions Tutors (who were also plant scientists) 8 Senior Lecturers 2 Readers
Subject specialisms of staff (NB Categorisation is approximate. There is overlap between specialisms and some individuals have more than one specialism)	3 Botany/plant science 5 Plant developmental biology 3 Molecular biology 4 Genetics/ applied genetics 2 Cell biology 1 Environmental biology 1 Biodiversity 1 Plant physiology 1 Biotechnology 1 Biochemistry 1 Agricultural Sciences
Methodology for gathering data	15 semi-structured interviews (telephone) 2 semi-structured interviews (face to face) 2 informal discussions (telephone) 1 informal discussion (face to face) 5 additional website searches (course provision)

The semi-structured interviews used a set of questions shown in Appendix 1 (p89).

In addition to these interviews, the researchers spoke to a group of postgraduate students (individually and in two discussion groups) attending a Gatsby Summer School. Data from these interviews are included to illustrate aspects of student voice on the same range of issues raised in the staff interviews. However it should be stressed that the students were not a representative sample of either all plant science students or of the group attending the summer school.

This section on qualitative data also includes some remarks concerning the Gatsby Summer School and the Science and Plants for Schools (SAPS) programme.

The data (based on responses from the interviews) are presented under the following headings:

4.1: The provision of plant science courses, student recruitment and staffing
4.2: Factors affecting attitudes to plant sciences – students, schools, course titles
4.3: The student voice – reflections of some postgraduate students
4.4: Responses and the way forward – in HE, Gatsby summer school, the SAPS programme
4.5: The challenges and opportunities for plant science
4.6: The way forward – suggestions from university staff

4.1 HE Course Provision and Plant Science

4.1.1 Undergraduate Course Provision

The UCAS course search facility for JACS code 200 (botany/plant science) lists just nine higher education institutions in the UK offering courses for 2009 with this coding. Six of these were included in the sample (25) surveyed in this research. Three other universities in the sample offer the opportunity for students to graduate with degrees with 'plant science' in their title by specialising in plant science usually in the final year of their programme, having initially enrolled on a more general biological sciences programme. In 2009, a number of universities (8) in the sample were offering a specific undergraduate degree in zoology, as well as biology or biological sciences, but have no separate degree in botany or plant science.

The only two universities with a separately identified department of plant science are Oxford and Cambridge. The University of Cambridge has a separate Department of Plant Sciences, which provides the teaching for plant and microbial sciences within the University's Natural Science Tripos. The University of Oxford also has a separate Department of Plant Sciences, which works with the Department of Zoology to provide teaching for the BA (Honours) Oxon within which students can opt to specialise in plant sciences.

Those (6) universities within the sample that do offer full time degrees in botany or plant science all report that very low numbers (usually two or three) students enrol in any one year. These programmes are only maintained through modular provision in which viable teaching groups are achieved by including students from a range of other programmes in the biological and related sciences. In contrast, undergraduate degrees in zoology continue to recruit sufficient numbers to make them viable as a separate degree programme.

None of the respondents from universities offering separate plant science undergraduate degrees were expecting direct recruitment (initial enrolment of school leavers) into these courses to increase in the near future. The research did indicate that there is pressure on this type of provision. Within the sample, two universities previously offering ‘pure’ plant science degrees have ceased to do so within the past five years. In addition, a third university from within the sample will not be offering this type of degree after 2008. No university within the sample is considering starting up a ‘pure’ plant science degree.

However, despite this apparent picture of decline, there is evidence of re-organisation rather than the elimination of plant science studies. Re-structuring and re-organisation of faculties, schools and departments has led increasingly to the integration of plant science within other programmes over the past decade. Whilst the position of plant science may have been a factor in some of these reorganisations, there have been wider factors involved (e.g. greater integration of other areas of biological sciences, new ways of thinking about the relationship between different areas of biology and related subjects). These sometimes offered opportunities to re-position plant science within overall provision. Each university has developed its own strategy for dealing with the challenges it faces, leading to a wide range of approaches. The following examples are illustrative:

Example 1: One Russell Group university has made a deliberate decision to retain the BSc degree in botany, despite the fact that only about three students per year may graduate in this subject. The approach is based on a belief in the value of preserving the integrity of the subject as a visible option, despite recognising that the term ‘botany’ is not attractive to many, and that young people may worry about the perceived risk that this would limit their career options.

“We think that for the very small number of students who really want to be called botanists, we should preserve it. And as one of the older universities, we have a responsibility to maintain classic subjects for as long as we can”

Within this university the wider provision of biological sciences, botany and plant science has not shown any discernable decline over the past decade. In fact, there have been recent increases in the uptake of certain modules e.g. plant development, and flowering plants. The university has given careful consideration to the content and approach for plant science teaching e.g. greater focus on global issues.

Example 2: One 1960s university has not offered separate provision in plant science for many years, despite having a well established centre for plant and agricultural.research. The development of provision at this university is based on a view that modern biology is becoming more integrated, and more molecular, and therefore they have moved away from an approach based on ‘Kingdoms’ (plant, animal). However, despite harbouring concerns about plant science being *“under-valued”*, the respondent believed that plant science provision was being maintained. For example, first year courses in developmental biology, physiology and genetics all contain considerable plant science content, and are compulsory for all students in biological sciences.

Example 3: In the 1980s, one university founded in the nineteenth century merged separate botany and zoology departments into a department of biological sciences, but still offered separate degrees in zoology and plant science. The numbers enrolling on the plant science degree was always very small (3-5 graduates per year), and the university has ceased to offer this within the past three years. This has been associated with a detailed reorganisation of courses, part of which has involved re-positioning the plant science provision. For example a plant biology module in the second year is now compulsory for a range of degree programmes, including biology, ecology, cell biology and microbiology. In the final year, students can choose a laboratory study, and this can be purely plant science. Plant science has been maintained and developed through this process, and the university retains a strong research base for plant science through high quality staffing and strong recruitment into PhDs.

It is quite typical for plant science to be offered as compulsory or optional modules for students studying for a wide range of degrees in biological sciences. The way that many universities have responded to the changing situation was described by one respondent as follows:

> *The (previous) plant molecular development module folded when x (member of staff) left. We have taken part of that and incorporated it into a larger plant and animal biology module in the first year. So we have introduced 10 new plant biology lectures in the first year, and we have a completely revamped plant molecular development module in the 2nd year. So we have effectively increased the amount of undergraduate teaching in plants*
>
> (Senior lecturer, Russell Group university)

The decline of specialist plant science degrees was recognised by another respondent, but alongside an acceptance that there could be other ways to develop plant science in the future.

> *What I see around me in the UK, is plant science degrees falling off the map, and the number of universities offering a plant science degree is greatly diminishing. But at the same time I don't really see why we have to teach plant biology as a separate discipline. There is no reason why it cannot be integrated into other life science units. I think that that is the way we might have to do it………….. We could be being our own worst enemy in wanting to maintain plant biology as a separate discipline*
>
> (Senior lecturer 1960s university)

A further relevant factor has been the development of undergraduate provision in undergraduate biomedical programmes. A number of universities have departments of biomedical sciences alongside biological sciences. One university within the sample had only a biomedical science department. The development of biomedical course provision had been a response to demand from students, and recruitment is strong. Plant science as a discipline is in the position of competing with the full range of other options within biological sciences, some of which, notably biomedical sciences, are very popular with young people considering higher education options.

Overall, the interview evidence indicates that, whilst plant science is not a popular course choice for students, especially on entry to university, underlying provision is being protected, despite pressures. Universities have responded strategically to meet this challenge through the way they organise their provision.

4.1.2 University staff perceptions of student recruitment - undergraduate and postgraduate

The interviews explored some issues relating to recruitment of students into plant science courses. At undergraduate level:

- This research has not found evidence of any clearly identifiable change in the overall ‘quality’ of recruits (in terms of ability and potential) to undergraduate programmes that include plant science, although a majority of respondents expressed strong concerns about plant science in the GCE A level, and many feel that new entrants are not well prepared for undergraduate work in plant science. Their experience was that most new entrants to HE have very limited interest in, or knowledge of plants.

- There has not been any tendency amongst universities to make any downward adjustment to entry requirements in order to attract more students into plant science. On the contrary, where entry requirements have changed they have tended to reflect higher grades.

At postgraduate level:

- No clear evidence was found within the sample of any perceived significant change in overall numbers of students undertaking postgraduate study in plant sciences;

- It was reported that the proportion of students undertaking postgraduate research in plant science remained relatively low in comparison with other fields of biological and biomedical sciences;

- Most respondents reported little difficulty in recruiting good PhD students when studentships were available. The main difficulty was encountered in securing funding to support studentships;

- Several (4) interview respondents described a situation in which plant sciences are struggling to compete for funding to support PhD studentships alongside other biosciences. The reasons given included the following:

    - the sources of funding to support plant science research are limited (e.g. BBSRC), whereas other areas (e.g. biomedical) can draw on a wider range of sources (Medical Research Council, Wellcome Trust etc);

    - plant science staffing and provision is often in a minority within a university school or department placing the subject in a weak bidding position when only a certain number of studentships are allocated across the biological sciences.

4.1.3 Staffing for Plant Science in Universities

A survey carried out previously through the Gatsby Plant Science Network (Langdale J. 2005[37]) looked into trends in staffing over a ten year period by comparing the years 1990- 1995, with 2000-2005. This survey identified 9 universities where staff numbers

[37] (Langdale J (2007) *The State of UK Plant Sciences*

had declined, 3 in which numbers had remained steady, and 3 in which staff numbers had increased. In the current research it was possible to collect only a very limited set of data (from 10 universities within the sample) about staff numbers in the ten years up to 2008. Of these, actual figures were collected from 5, and reported 'trends' from the others. This data suggested that during the past ten years numbers of staff had increased slightly in 3 universities (2 Russell Group and 1 pre-1960), had remained stable in 5 (all Russell Group), and gone down in 2 (1 Russell Group and 1 pre-1960).

The interviews allowed further data to be collected from respondents within the sample about their experience of trends and pressures on staffing in plant science. Taking account of the limited quantitative data, and the interview responses, the evidence suggests that:

- There is no conclusive evidence of any clear trend in numbers of plant science staff in the past ten years. Some universities do report a decline in numbers. For example, one Russell Group university which had seven plant specialists in 1995, now has only two staff working full time in plant science teaching and research. However, it is important to note that there are two other full time staff still employed, who are plant specialists, but now teach in other programmes. This change was driven, at least in part, by the need to secure and maintain funding. A respondent in another university (1960s) providing degrees in biology currently has no staff whose direct specialism is in plant biology, although there is considerable strength in cell biology, molecular biology and microbiology.

- Plant scientists may be becoming more 'flexible' in the way they work. The example given above is a case in point. The respondent in that case expressed the view that funding arrangements and student numbers may be putting pressure on plant scientists to diversify (e.g. teaching cell biology and molecular biology on 'non-plant' courses). The need for plant scientists to diversify was also stated by another respondent (*"…because there's not enough students to teach")*.

- There was no evidence from respondents within this sample, apart from an isolated specific example (plant ecologist), that universities were currently having difficulty in recruiting staff for plant science posts. It does not seem that plant science provision is currently threatened by a shortage of staff, based on the uptake of courses by students. Seven respondents specifically reported no current shortage of staff, but six of these also expressed concern about the future, anticipating a possible increase in demand for plant scientists linked to global issues such as food shortages and climate change.

4.2 Factors affecting attitudes to plant sciences

4.2.1 Student attitudes to plant science – perceptions of university staff

The evidence from this and other research[38] indicates that a majority of school leavers who have studied biology to the age of 18 arrive at that stage showing little interest in plants, and regarding plant science as dull. Almost all university staff interviewed in this

[38] Stagg P, Stanley J, Leisten R (2004) Life Study: Biology A level in the 21st Century. (Full report available at www.wellcome.ac.uk/education/lifestudy

research perceived this as a negative attitude in many students towards plant science, and a major inhibitor for the uptake of the subject.

Staff in universities had some interesting perspectives on the origin of these negative attitudes towards plants and these fall into three categories: 'empathy', 'exposure' and 'experience'. In the first place, respondents argued that young people's strong interest in biomedical science is entirely to be expected, as this focuses directly on themselves. Animal biology was also seen as holding a natural attraction for young people. Many young people have experience of keeping pets, and develop an affinity with animals. In contrast, most young people in the UK have very limited experience of plants. The characteristics of plants do not attract attention in the same way that animals do. They can appear dull and uninteresting, as they are perceived as static, and 'not doing anything'. One respondent spoke in terms of 'empathy' expressing the view that young people find it relatively easy to empathise with animals (even invertebrates), because they behave in ways that we, as humans, can recognise (e.g. they can run away when threatened). Plants, on the other hand, respond in very different and less visible ways, and this may contribute to the lack of affinity young people feel towards plants.

Secondly, some respondents (3) referred to differences in presentation in the 'media' (e.g. documentary television) where human and animal biology receives extensive coverage, likely to stimulate scientific interest. By contrast plants tend to be covered through non-scientific programming such as travel or gardening.

Thirdly, some respondents (3) reported experiencing greater motivation towards plant science in overseas students. Although it has not been possible to investigate this issue in detail, there is some evidence from the interview data suggests that people from overseas are more motivated towards plant science (especially applied plant sciences) and are attracted to study this at higher levels (e.g. PhD). This is not necessarily restricted to those from less developed countries. One respondent reported this experience with students from Canada, USA, Germany and Greece.

> *The major challenge is to get students interested in plant science relatively early in their career. I have noticed a big difference between British and non-British students in how willing they are to embark on plant science courses…….Students who come through British schools are not excited about plant science when they arrive at university. If we had to rely on the students who actually put down plant science on their UCAS forms, we'd be totally out of business (About one a year).*
>
> (Professor, Russell Group University)

4.2.2 The influence of plant biology education in schools – perceptions of university staff

Almost all respondents who were plant scientists teaching and working in universities, expressed considerable frustration with biology education in schools in general, and GCE A level in particular. In their view, not only does biology education in school fail to excite and motivate young people in plant science, but it actually generates negative attitudes about plant science, which the universities must then deal with. The following quotes are illustrative:

> *The A level system is so poor on plant biology that when they leave school and start on their degrees they really don't know much about plants at all, and they think they are boring.*
>
> (Reader, Russell Group University)

> *A level is just a nightmare. That's where the problem lies* …….*"We've almost washed our hands of plant biology at A level – we start right at the bottom. We don't assume that they know anything….They know bits and bobs….It's all scattered around.*
>
> (Admissions Tutor Russell Group University)

> *There is no doubt that their experience of plant science is terrible (pre-university)….and is no more than gardening*
>
> (Reader 2, Russell group University)

> *The A level system is so poor on plant biology that when they leave school and start on their degrees they really don't know much about plants at all, and they think they are boring.*
>
> (Associate professor, Russell Group University)

> *They arrive* (in HE) *extraordinarily hostile to plants.*
>
> (Head of School, Professor 1960s University)

> *I think that plants are not very well taught in schools, and they (new entrants) mostly come either wanting to cure cancer or save the planet. I don't think it's because they don't like plants, but I think it's because they have no idea about them.*
>
> (Professor 1960s University)

This negative situation was believed to be compounded by the (unintentional) influence of many biology teachers. About half of the respondents expressed views that teachers of biology A level were not well equipped (knowledge and resources) or pre-disposed (interest and incentive) to inspire students in plant biology. A combination of possible factors were identified in the interview data including:

- A majority of biology teachers have a (relatively) weak background in plant science, and this may affect their own preferences in choice of examples etc.

- Biology teachers without a strong plant science background are likely to lack confidence in teaching plant aspects of the course. Lack of confidence reduces the ability to 'inspire'.

- Biology teachers need to motivate students in order to achieve their best grades. Many students are pre-disposed to show preference for biomedical and animal biology. The teacher response is likely to be to select the course and examples which maximise potential for the topics in which students show most interest.

The situation for teachers of A level biology was described by two respondents as follows:

> *What you see in the A level papers is 20 or 30 years old……They've got this plant biology distributed….it's done topic-wise, so you do circulation, and you'll do interesting things like the heart, done alongside xylem and phloem done in a very old fashioned way……..The modern context (for plant biology) is not well described, and is not known by the teachers. The bottom line for this is that you've got to get up-to-date modern material to the teachers in an environment where there is less assessment.*
>
> (Associate Professor, Russell Group)

> *A lot of biology teachers are not trained specifically in plant science, and I think they struggle to find interesting practical exercises in schools to do with plants. And therefore the plant parts of the curriculum are taught in probably a rather dry way without any real passion or interest.*
>
> (Professor, Head of School, 1960s university)

Furthermore the new A level, introduced from 2008, following a review, did not seem to be regarded as much of an improvement. One respondent felt that the plant science 'community' had rather *"missed an opportunity"* to influence the A level during the review process.

Almost half of the respondents indicated a feeling that school biology education fails to develop in young people any concept of the plant as a whole organism. They tend to experience plants as a rather dull, disconnected (and incomplete) set of structures and processes. A number of respondents (3) referred to the importance and potential of field work in setting the whole plant in its environment and helping to build understanding. However, the provision of field work for school students has been greatly reduced over the past 20 years due, at least in part, to a number of non subject-relevant factors e.g. cost and safety concerns. In consequence many students, especially in the state education sector complete GCE A level biology without experiencing any field work.

4.2.3 The influence of course titles – perceptions of university staff

Most respondents in this research argued that students are strongly influenced by the title of a course, and the image this presents to them. This suggests that the challenge for plant science may at least partly be a question of 'marketing' and presentation. This is similar to the situation facing some other traditionally unpopular study routes e.g. into engineering employment.

Most of the plant science staff interviewed believed that many undergraduate entrants are 'put off' by degree titles like botany and plant science, perceiving that these would narrow their future options for progression. The greater integration of plant science within broader biological science programmes is seen by many respondents as an appropriate strategy, keeping the student's options open, but still allowing specialisation in plant science as a choice during progression through the course.

The importance of a title was illustrated by one respondent as follows:

The (previous) module called Transgenic Approaches in Modern Agriculture.….the numbers fell pretty much exponentially in terms of attendance, until we renamed it two years ago Transgenic Techniques, so we lost the "Agriculture"….The syllabus is the same, but the numbers trebled.
(Senior Lecturer, Russell Group)

This respondent believed that anything with *'plants'* or '*agriculture*' in the title is not popular, but also that this problem is not restricted to the plant sciences. The same respondent cited another example:

But it's not just us. There was a module here called Industrial Microbiology, and they had one or two people. So they renamed it Microbiology and Pharmacology, and they had 20 people taking it…..So it's all about the marketing. The question is why are people attracted to anything that is biomedical, and repulsed by anything that is not?

Another respondent reported the positive effect that careful choice of title can have:

There are now many modules that actually may be 80-90% plant content, but they don't have the word 'plant' in the title, and more students do them as a consequence of that. And the interesting thing is that once they are in the module, they love them.
(Professor, Head of School, 1960s university)

This evidence suggests some aspects of plant science e.g. agricultural and horticultural science, crop breeding etc.) may suffer through association with the wider lack of appeal in the UK of certain 'practical', 'applied' and 'industrial' activities. These types of activities have long held relatively low status in UK education and society.

4.3 The 'student voice' - Reflections from post graduate students

The researchers ran two discussion groups with postgraduate students at the Gatsby Plant Science Network Annual Meeting (11^{th} and 12^{th} September 2008, group sizes 7 and 10 students). Questioning and discussion were based on a topic guide (Appendix 2 p91). Additionally, a small number of individual students were spoken to.

The students were asked about the factors that had influenced their choice to study plant science. The influences quoted included good teachers at school (6), and positive experiences within the family (4), which featured gardening, growing plants in a conservatory and a climbing club in which some members had an interest in botany. Others were attracted by good teaching and experience at university. Three other students had been positively influenced in choosing plant science by experience of field work. Another student, motivated by a desire to contribute something 'useful' in terms of career, had been influenced by a visit to a plant science laboratory during the first year of her degree. She observed that the research work there was 'really useful', was solving problems and having an impact. This student also stated that many other students find plants 'boring'.

The students were also asked about the influence of the biology they studied at school. Whilst some were positively influenced by good teachers, students who had studied

GCE A level biology in school had not been inspired by the course content. Their recollection of A level plant science was as separate topics (e.g. photosynthesis,). In the focus group of seven students it was interesting to note the contribution from a student who went to school in Scotland, who felt his experience differed from that of the others.

> *I did a Scottish Higher, and there was quite a bit of plant biology in what I was doing. I also had SAPS in my school*

None of the other students in this focus group who went to school in England had encountered the SAPS programme, whilst at school. One of these students said:

> *My girlfriend's a mathematician who did her Highers in Scotland, and she had a lot of plant science as well, and found it very good, although she didn't go on to do it*

The sample size is too small to draw any firm conclusion about the differences between biology education in England and Scotland, although the possible significance of these differences has been raised previously (p30). Comparisons of the specifications and teaching and learning of biology in England and Scotland could be the subject of further research as part of preparing for consultation for the GCE A level review in 2013 (see recommendations).

A number of students (4) made comments that showed they were aware of doing something relatively unusual in studying plant science. Their experience was of going in a different direction compared to the majority of people studying biology. The response of one student illustrated this feeling of 'going against the trend', and also sheds some light on the attitudes of other young people to plant science. She reported being asked (by some other students):

> *why don't you do something useful like cancer research instead of researching plants?*

This student had responded to this comment by pointing out that a cure for cancer might be found in plants.

The students were asked about advice and guidance they may have received in relation to progression routes in plant science. Responses indicated that the two main potential sources at school were careers advisers and biology teachers, neither of which had been very effective for these students. One student was blunt about the experience of careers advisers in relation to plant science (*"They don't know a thing"*). In this specific role, biology teachers were regarded rather as well meaning, but not very well informed. Overall, these students seemed to feel that plant science was not seen as an area rich in career opportunities outside academia. In relation to career opportunities in industry, one student who had come into plant science through chemistry rather than biological sciences commented that there were a lot of opportunities through industrial applications of chemistry, and it was more difficult to see a career path through plant science.

4.4 Positive influences on student attitudes to plant science

Despite the fact that most university staff interviewed in this research reported encountering negative views towards plant science in many students entering university, almost half of interviewees showed confidence in their ability and that of their colleagues to have a positive influence on this, though providing good plant science teaching at university. There was a belief that it was possible to arouse greater interest in plant science in at least a proportion of students through good quality teaching and good choice of modern content. About a third of respondents described situations in which a good university experience of plant science had significant positive impact on students. In one university an optional Year 2 module in plant disease recruits very strongly (85 out of 126 students in 2007-8). These included some students following the zoology degree, and their experience prompted a few students to switch from the zoology degree to the biology degree to allow them to do more plant biology.

Comments from other respondents included the following:

> *One of the most common things we hear, after they have done the plant development course in the second year is 'Oh, we really enjoyed that. We had no idea….*
>
> *"As soon as they do some graduate level plant science they think it's amazing".*

Or, in a positive, but measured effect:

> *The student feedback we get on the second year unit is really quite good, and I think that's because they come in with low expectations, and they find that it's an interesting and exciting subject, but it's not enough, it seems, to pull the majority over into the plant science ranks in the 3rd year.*

The problem of negative attitudes towards plant science in newly enrolled students is so familiar to the university staff in this sample that they have come to anticipate it. Several respondents described how they make a point of selecting their most inspirational teaching staff to provide input on plant science in the first year of undergraduate courses.

4.4.1 Enriching the content in HE plant science courses – e.g. the Gatsby Summer School programme

In seeking to improve the image and appeal of plant science for students most respondents believed there was a need for providers of undergraduate degree courses to respond by maximising the quality of teaching, and reviewing the content of plant science programmes. It was not seen as sufficient to make superficial changes such as a new course title (although this can be surprisingly effective as described above). It was not just a question of 'marketing'. About a third of respondents referred to young people as being very aspirational, with strong motivation towards human, societal, and environmental needs particularly with a global dimension. Since A level biology seems to fail to connect with these aspirations in relation to plant biology, there may be an opportunity for undergraduate programmes. Two respondents gave examples where undergraduate provision was being developed to offer greater opportunities to focus on the crucial importance of plants in the major global issues such as food production, and climate change.

With reference to a 2nd year module on plant disease one respondent said:

It's taught from a global….., it talks about world food problems, and disease, it talks about GM approaches, and non-GM approaches, diagnosis and plant pathogens, and how you might tackle them, and it also deals with the geo-political aspects. The students absolutely adore that course, and it converts a lot of our zoologists to come and change from a zoology (to a biology) course because of that.

(Reader, Russell Group University)

Other respondents referred to the need to enhance and enrich students' experience of plant science. This could be achieved through special programmes or field work. The limited access to field work at school level has already been reported.. At undergraduate level an example of the influence of enhancement and enrichment activities is provided by the Gatsby Plants Summer Schools.

The fourth annual Gatsby summer school took place in 2008. Places are offered to first year undergraduate students from UK universities. Students are drawn from across the biological sciences, and not limited to those committed to plant science. The summer schools do tend to recruit the most able students. The programme is residential, with appropriate facilities to provide all the key components (lectures, practicals, field work (ecology) and a careers session focusing on career potential in plant sciences). The Gatsby Plant Summer Schools have proved very successful in promoting more positive attitudes in the students towards plants. The evaluation in 2008 showed that:

- *97% of the students (n = 78) felt that the summer school had introduced them to new ways of thinking about plants;*
- *97% felt that the summer schools had made them more positive about plants, or confirmed an already present interest;*
- *69% of students agreed that they would be re-considering their 2nd year options to include more plant based modules (equating to 75% of those who had not already chosen plant based modules.*

Gatsby Plants Summer School – student feedback report (2008)

The positive influence of the Gatsby Summer Schools was borne out by one member of staff in a university that sends students on the programme:

It would be worth somebody coming to get some sound bites or interviews from some of our undergraduates once they have done a bit of real plant science…..We send people to the Gatsby Summer School who aren't really sure whether they like plants, and they are so excited afterwards, and they can't believe the way they have been misled about what plant science is.

4.4.2 Enriching the content in school plant science courses – the SAPS programme (Science and Plants for Schools)

University staff responding in this research also believed that it was important to enrich the teaching of plant science in schools. Respondents familiar with the wider work of Gatsby were aware of the SAPS programme.

At school level, the SAPS programme provides support for teaching and learning in plant science. Supported by core funding from the Gatsby Charitable Foundation since 1990, the SAPS website has provided access to ideas and resources for primary and secondary age students and professional development opportunities for teachers. A review of the SAPS programme by the Trustees (2007-8) has led to a 'refocusing' of SAPS priorities towards support for plant science in schools at the post-16 level. This is a specific response to the inadequacies of post-16 biology courses, of which the GCE A level is the predominant course:

"Following an extended review of SAPS activities, the SAPS Trustees wish to announce a refocusing of its support for plant science education in the UK. The Trustees have become very concerned about the dilution of the plant science content of post-16 courses, and regard changes to future course specifications as the top priority of SAPS…………The principal aim of the Gatsby Plant Science Programme is to ensure a flow of young people through the school and university system into plant science research. Deficiencies in post-16 plant science education are seen as a major impediment to the aims of the programme." SAPS (Dec 2007)[39]

In England support for SAPS comes almost exclusively through the Gatsby funding, whereas in Scotland there is additional support from the Scottish government.

The evidence gathered through this research indicates the need to do more to support plant science education at the post-16 level, in order to stimulate greater interest and appreciation of the importance of plant science amongst young people at this stage.

The revised GCE A level in biology was introduced in September 2008. There will be a further review in 2013, with opportunities for stakeholders to contribute to the consultation process in advance of that date.

Other opportunities exist to influence the curriculum at both pre-16 and post-16 stages. The new Key Stage 3 curriculum[40] will allow greater freedom for teachers to select content and examples, and so may offer better opportunities to develop and enhance plant biology. The next major innovation in 14-19 science education will be the introduction of a Science Diploma from 2011. The main 'lines of learning' for this will be published in January 2009. The nature of the Diploma, with greater emphasis on applied learning could offer opportunities to influence the development of plant science content.

4.5 The challenges and opportunities for plant science - university staff perceptions

The respondents were asked about the extent to which plant science in the UK was facing a 'challenge'. The 17 responses received indicated that people working in this field see both threats and opportunities. The key points raised are summarised below:

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[39] SAPS Announcement on website (Dec 2007) http://www-saps.plantsci.cam.ac.uk/docs/SAPS_Dec2007.pdf
[40] Details available at http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/index.aspx

- A majority of respondents believed that plant science faces *significant* challenges or threats now and into the future. Those identified included:

    - Continuing weakness in student recruitment due to young people's lack of interest in plants. Changes in biology at school had not been seen as helpful;

    - Pressure on staffing levels (plant specialists) in HE especially where the plant scientists were a small minority in biological sciences. This placed them in a weak position to compete for funding, new appointments and resources for programme development;

    - Lack of awareness in young people about the potential career opportunities in plant science;

    - Serious erosion of the UK industry base for plant science research, which has reduced employment opportunities outside academia. A number of major companies have moved their plant science research activities to other countries. A number of respondents cited the UK negative attitude towards genetic modification (GM) in food production as a significant factor in this move;

    - A general tendency for plant science to be under-valued in UK industrialised society (not seen as a high priority), with low status for key associated industries such as agriculture, horticulture and forestry;

    - A poor public image of plant science, tarnished by 'bad news' stories e.g. the GM debate and 'Frankenstein foods';

    - Some respondents identified a further potential challenge as the ability to recruit enough plant scientists in order to respond to an anticipated upturn in demand given their importance of plant sciences in relation to key global problems.

- Just over half of respondent to this question believed that there were grounds for optimism and good opportunities for plant science in the future. (A number of respondents described both threats and opportunities). These opportunities were linked to a variety of factors including:

    - Anticipated growth in public awareness of the critical importance of plants in relation to major global issues (climate change, food shortages, food security, biofuels, pharmaceuticals etc.);

    - Anticipated growth in demand for plant scientists, linked to the issues listed above;

    - Opportunity to relate to young people's aspirations, if we can raise awareness of the importance of plants in relation to global issues.

The overall picture presented is one in which plant science currently has great opportunities and potential if the 'message' can succeed in reaching public perceptions. The following quotes from respondents are illustrative of respondents concerns and aspirations:

My view is that plant science is shockingly under-valued in general…..if you want to solve world problems, plants are more important than cancer.
(Professor 1960s University)

Referring to poor public image and impact on career choices:

Plant science? – that's an evil thing to go in to….the message coming over is that it's bad for the environment.
(Reader, Russell Group University)

The real irony of the GM debate, is because I know so many people who were passionate about GM as being the way to reduce inputs and have sustainable agriculture, and to have them cast as the villains in white coats was a tremendous shock for a lot of people working in plant science, who were really motivated by the greater good.
(Head of School 1960s University)

Industry has pretty much shut down in the UK in the last 5 to 6 years because of the GM controversy. All the plant biotech companies, with one or two exceptions, took their research out of the UK and in many cases out of Europe as well. So there are no industry destinations for people who want to do plant biotech.
(Senior Lecturer Russell Group University)

Referring to the opportunities and future potential:

There has never been a better time to be a plant scientist, because it's so easy to make your case now, but that's going to take a few years before a critical mass is realised at the academic level, and the chances are that the flow of graduates will begin to follow.
(Professor, Russell Group University)

4.6 The Way Forward – Suggestions from university staff

Plant science staff interviewed in this research were asked for their recommendations for action in relation to the future development of plant science. Responses covered a range of issues including:

- The need to build stronger links between plant science in HE and schools e.g. through outreach work, Researchers in Residence, role models, open days for schools, contributing to professional development for school teachers.

- The need to address the way students experience plants at school, through the curriculum and examinations, notably GCE A level, so that there is a greater focus on the 'whole plant' and greater awareness of the importance of plants and plant science in solving global problems.

- An aim to develop further the potential of key research centres (e.g. the John Innes Centre, Rothampstead) in providing support for plant science education in schools. For example, an increased involvement with the 'Researchers in Residence'

[41]programme, where scientists spend time working in a sustained relationship with a school. Also it would be useful to extend the opportunities for teachers and students to visit specialist plant research facilities.

- The need to achieve a balance of priorities in plant science research between the need to continue research through ‘model plants’ (Arabidopsis), but also to raise the profile of ‘applied plant science’ especially in relation to agriculture, crops, use of plants in drug development etc.

> *We have to do lots of applied plant science, that we haven’t been doing very much of in the last 10-15 years, because most people have been working on Arabidopsis, (as a model organism for plant science)”. We need to keep doing that work, but at the same time there are loads of very important things that we can’t do in that model. We can’t do nodulation, can’t work on nitrogen fixation very well, we can’t do fruit ripening properly, we can’t do wood or fibre formation……… We need to carry on doing this model plant research, probably at a similar level, but at the same time we need to significantly expand other areas of plant science.*
>
> (Reader, Russell Group)

- Recognition and communication of the changing nature of plant science e.g. greater integration between different fields of biology and other sciences.

> *We are asking people to make a choice between microbiology, zoology and plant biology, when what we should be doing is being a bit more innovative and thinking about how we could integrate these three different strands into a common theme. And there are many common themes….. There is no reason why we could not have plant breeding or crop improvement as part of our general genetics unit. We could be being our own worst enemy in wanting to maintain plant biology as a separate discipline.*
>
> (Senior lecturer, 1960s university)

- The need to work to change public perceptions of plant science by active and positive contributions to key debates such as genetic modification.

- Explore ways to support plant science staffing in universities where the number of specialists has fallen to a critical level, below which the provision of biology and biological sciences is threatened.

- Present a case to secure more funding for plant science research from a wider range of sources (e.g. the Wellcome Trust).

[41] www.researchersinresidence.ac.uk

SECTION 5: Research funding for Plant Science

One possible indicator of trends in plant science is the level of research funding made available to this area. Some data were collected in this research from the Biotechnology and Biological Sciences Research Council (BBSRC). The BBSRC is the principal funder of plant science in the UK. Other funding sources can make important contributions, including private sector industry. Some qualitative evidence in this research (p81) suggests that funding for plant research in the UK from industry may have declined in the past 5 to 10 years. Further research would be needed to gain a fuller picture of trends in funding for research in plant sciences, but the BBSRC data does provide some insight into the situation.

The BBSRC funds the following areas of research

- Plants
- Microbes
- Animals (including humans)
- Tools and technology underpinning biological research

Table 29 and Chart 21 (pp84, 85) show a summary of spending between 2000 and 2008 by the BBSRC to support crop science and other plant science research. It shows spending in relation to Core Strategic Grants (CSG)[42] and other research grants, including initiatives and fellowships.

Table 30 and Chart 22 (p86) show BBSRC research funding through seven Research Committees[43]:

- Agri-food
- Animal sciences
- Biochemistry and cell biology
- Biomolecular sciences
- Engineering and biological systems
- Genes and developmental biology
- Plant and microbial sciences

[42] Core Strategic Grant is funding paid to a specific group of research institutes

[43] From 15 October 2008 the BBSRC has reorganised its committee structure under different headings http://www.bbsrc.ac.uk/organisation/structures/committees/index.html

Table 29: Summary of BBSRC spending on crop science and other plant science research from 2000

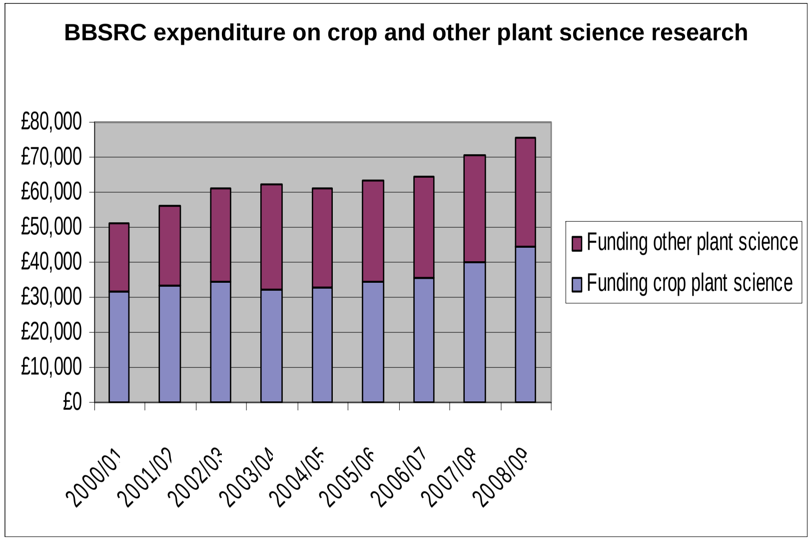
	Estimated spend (£K)								
	2000/01	**2001/02**	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**
CSG									
Crop Plants	£20,737	£20,555	£20,555	£18,709	£20,953	£23,502	£23,464	£22,820	£24,493
Other Plant Science	£3,803	£4,567	£5,028	£5,493	£5,476	£6,310	£6,386	£6,197	£5,163
Total	**£24,540**	**£25,122**	**£25,583**	**£24,201**	**£26,428**	**£29,812**	**£29,850**	**£29,016**	**£29,657**
Grants									
Crop Plants	£11,141	£12,693	£13,983	£13,767	£11,712	£11,150	£12,292	£17,159	£20,079
Other Plant Science	£15,210	£18,095	£21,427	£24,332	£23,199	£22,323	£22,143	£24,246	£26,066
Total	**£26,351**	**£30,788**	**£35,410**	**£38,099**	**£34,911**	**£33,473**	**£34,435**	**£41,405**	**£46,144**
All									
Crop Plants	£31,878	£33,248	£34,538	£32,476	£32,665	£34,653	£35,756	£39,979	£44,572
Other Plant Science	£19,013	£22,662	£26,455	£29,824	£28,674	£28,633	£28,529	£30,442	£31,229
Grand Total	**£50,891**	**£55,910**	**£60,993**	**£62,300**	**£61,339**	**£63,285**	**£64,285**	**£70,421**	**£75,801**

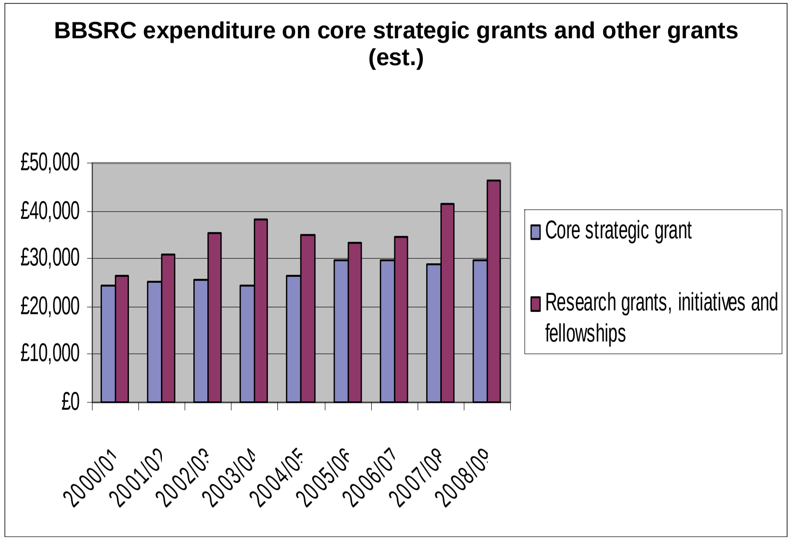
Comments:

Key features indicated by this data and displayed in the Charts (p85) are:

- Total BBSRC funding remained fairly flat between 2003 and 2005, but since 2006 has risen at a greater rate, both for crop science and other plant science research
- Funding for research grants, initiatives and fellowships showed a marked decline (real terms) between 2003 and 2005, followed by strong growth between 2006 and 2008.
- Overall BBSRC expenditure on crop science and other plant science appears to have been depressed in the middle years of the current decade. There has been stronger growth in funding since 2006.
- Growth in the Core Strategic Grant for this area of work has been slow throughout the period 2000-2008 (average growth 2.6% per annum overall), and probably represents a slight decrease in real terms allowing for inflation over the period

Chart set 21: BBSRC spending 2000- 2008 (£K)





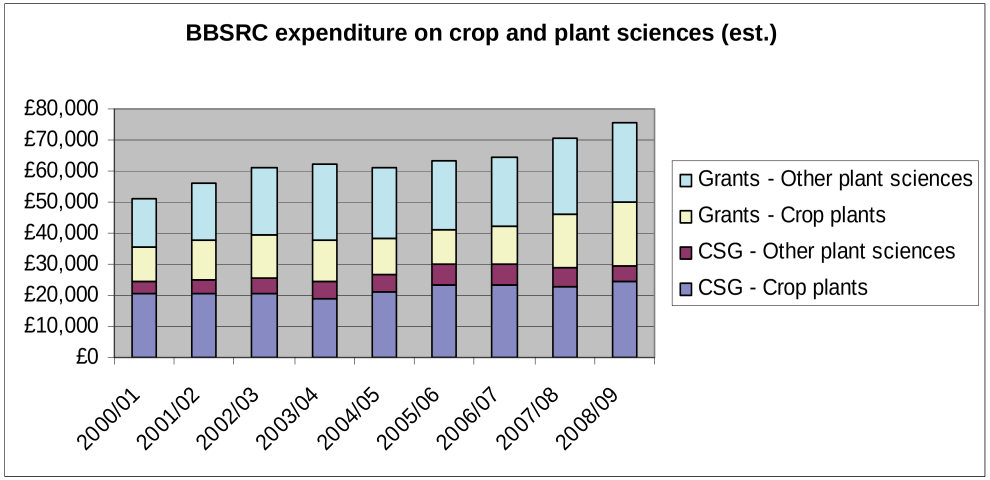
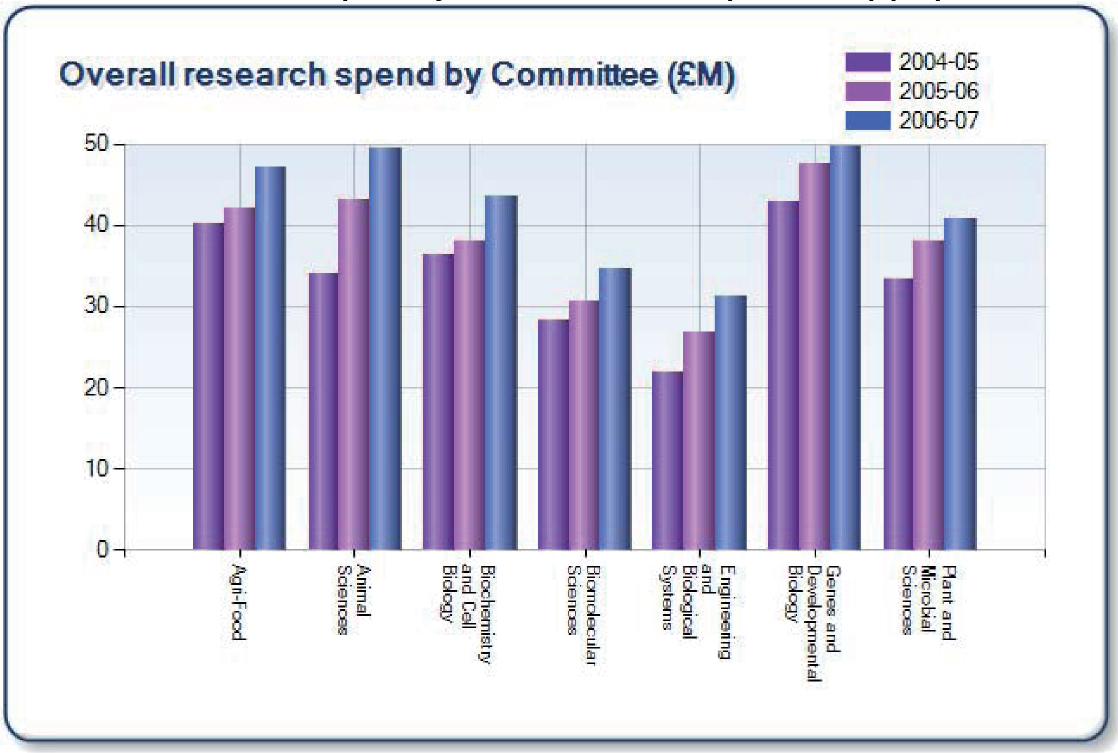


Table 30: Research Spend by BBSRC Committee (2004-2007) (£M)

Committee	Overall BBSRC Research Spend (£M)		
	2004/5	**2005/6**	**2006/7**
Agri-food	40.2	42.0	47.2
Animal Sciences	33.9	43.1	49.5
Biochemistry and Cell Biology	36.3	38.1	43.6
Biomolecular Sciences	28.3	30.7	34.7
Engineering and Biological Systems	21.8	26.8	31.2
Genes and Developmental Biology	42.9	47.5	49.8
Plant and Microbial Sciences	33.4	38.0	40.7
TOTAL	**236.7**	**266,3**	**296.7**

(Source: BBSRC)

Chart 22: Research Spend by BBSRC Committee (2004-2007) (£M)



(Source: BBSRC)[44]

[44] From BBSRC (Dec 2008) http://www.bbsrc.ac.uk/organisation/spending/trends.html

The BBSRC committee spending between 2004 and 2007 shows funding increasing across all areas, with funding for animal sciences, and genetics and molecular biology consistently maintaining a higher level of funding than other areas, including plant and microbial sciences.   One notable feature shown by the data is that spending for research on animal sciences increased substantially more over this period than did the spending on plant and microbial sciences. In 2004 spending on animal sciences (£33.9M) was not much higher than that on plant and microbial sciences (£33.4M). However in 2007, spending on animal sciences had risen to £49.5M (a 46% increase), whilst spending on plant and microbial sciences had only risen to £40.7M (a 21.8% increase).

It should be noted that a separate committee has provided a funding stream for Agri-food, through which further plant related research funding could be accessed. Therefore, only a partial comparison can be made between the figures for spending on animal sciences and plant and microbial sciences.

From October 15th 2008, the BBSRC has reorganised its committee structure. This reorganisation has included the formation of single new committee for Plants, Microbes, Food and Sustainability. It is too early to tell what may the implications of this change for the funding of plant science research.

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APPENDIX 1

Gatsby Plant Science Research
Telephone Interview and Topic Guide - for plant scientists in sample universities

1. Please list/ describe the undergraduate plant science courses/ programmes offered at your institution
   - Has provision changed over the past 10 years (e.g. stand alone honours to joint degrees, or modules)?
   - What are the reasons for changes in provision? (e.g. falling applications. Lack of other resources)

2. Please list / describe the postgraduate plant science courses/ programmes offered at your institution
   - Has provision changed over the past 10 years (e.g. stand alone honours to joint degrees, or modules)?
   - What are the reasons for changes in provision? (e.g. falling applications. Lack of other resources)

3. What is your experience of 'trends' or change in the students taking up plant science courses at undergraduate level over the past 10 years?

   a) In numbers of applicants, and acceptances onto courses, and arrivals and completions (can you provide actual statistics?)

   b) In calibre of applicants (A level performance etc.)

   c) In students' choice of courses and options (joint degrees etc)

   d) In students' commitment to progression in plant science within the undergraduate programme

   e) In students' performance in these courses

   f) In students' routes after graduation – if known

4. What is your experience of 'trends' or change in the students taking up plant science courses/ research at postgraduate level over the past 10 years?

   a) In numbers of postgraduates (can you provide actual statistics?) (Any breakdown into Masters, PG Diplomas, PhDs?)

   b) In calibre of postgraduates

   c) In postgraduate students' choice of research topic

   d) In postgraduate students' performance and outcomes

   e) In students' routes (post doctoral etc)– if known (continuing work in plant sciences?)

5. Do you believe that ‘plant science’ is facing a challenge in terms of *demand/interest* from suitably qualified people wanting to enter? What evidence do you base your views on?

6. Do you believe that plant science is facing a challenge in the *supply* of high quality courses - are enough lecturers being attracted in to provide courses

7. What do you think needs to be done to secure adequate future provision and ‘output’ of qualified people in this area?

8. Any other comments?

Thank you for your help

APPENDIX 2

Gatsby Plant Science Research

Topic Guide for Student Discussion Group Session (12 Sept 2008)
Adapted for PG group

PhD students:

- What attracted you to plant science
    - What factors influenced you towards plant science?
    - How significant was your school experience (positive or negative) in relation to plant science?
    - What are your views of the plant science content of your GCSE/ GCE A level programmes? (or previous education)
    - What were the attitudes of you Biology A Level colleagues towards plants and plant science
    - Did you receive any advice which influenced your choice towards plant science? (sources of advice?)

- What are your plans and ambitions for your future career?
    - Are you already linked to an employer through your current work e.g.PhD?
    - How likely is it that you will continue to work in plant science?
    - Do you know what the prospects are like for people wanting to work in plant science in the UK? (or in other countries?)
    - Where can you get advice about careers in plant science?

APPENDIX 3

Research Centres and organisations active in plant science research in the UK

Centre/ Organisation	Notes
Central Science Laboratories (CSL)	Established 1992, with purpose built laboratory at Sand Hutton, near York. Focus on sustainable land use, safe food supply and environmental issues
Centre for Ecology and Hydrology	Has 5 sites (Wallingford (Oxfordshire), Oxford, Bangor, Edinburgh, Lancaster). Focus is on research in terrestrial and fresh water ecosystems, and their interaction with the atmosphere
East Malling Research Centre	Located in Kent. Providing research development and consultancy in relation to the food chain and land use. 'Innovative solutions' especially in relation to food, environment, and non-food crops and products
Forestry Commission	Has 2 research centres (Alice Holt Centre, Farnham, Surrey, and the Northern Research Centre, Roslin, Midlothian). Focus on research and development in sustainable forestry.
(Institute of Grassland and Environmental Research)	Now (2008) absorbed into University of Aberystwyth
John Innes Centre	Based in Norwich, JIC is a centre of excellence in plant science and microbiology. JIC hosts 3 other organisations: **The Sainsbury Laboratory** – Joint venture between Gatsby, University of East Anglia, BBSRC and JIF (Joint Investment Framework, East of England) **Plant Bioscience Ltd** **The Norwich Bio-Incubator**
Rothampstead Research	Located in Harpenden, the largest agricultural research centre in the UK. Also operating the Broom Barn Research Centre (Bury St Edmonds) and the North Wyke Research Centre (Okehampton, Devon)

Royal Botanic Garden, Edinburgh	Focus on research into plants and fungi, taxonomy and biodiversity. Also has sites in Benmore (Argyll), Logan (near Stranraer) and Dawyk (near Peebles)
Royal Botanic Gardens, Kew	Research focusing on world-wide collections of both living and preserved plants. Expertise in taxonomy and horticulture. Offers major education programmes for schools
Warwick HRI	A devolved department of the University of Warwick. Focus on horticultural research and development. Created through changes in earlier provision (Horticultural Research Institutes), taking in two HRI sites (Wellesbourne, Warwickshire, and Kirton in Lincolnshire)