Evidence to the Science and Technology Committee Inquiry into strategic science provision in English universities

January 2005

1. The Committee's inquiry into strategic science provision in English universities addresses a vital subject, and one that has implications wider than the current well-publicised problems. Issues that the inquiry needs to address include:

   - better coordination of education policy for the primary, secondary and tertiary sectors;
   - building capacity in the science teaching profession; and
   - the development of the UK undergraduate degree system within the evolving overall mission of universities to meet Britain's needs in the next few decades of the 21st Century, as the UK, along with the rest of the EU, strives to become a major knowledge-based economy.

   It is essential to consider the overall science and education systems and the many complex interrelationships within them. Furthermore, while some of the immediate problems are most obvious in England, the Society believes the more general issues have to be seen at least on a UK basis and often within the context of the European Union and the Bologna arrangements.

2. The structure of individual universities is not immutable, and the Society is not necessarily opposed to the closure or merger of science departments provided the welfare of existing students is safeguarded and the change can be justified in terms of improving the overall science provision locally, regionally and nationally. However it is concerned that some recent examples of closures did not apparently fulfil these conditions. Certainly, HEFCE's claim that they are merely a demand side problem is far too simplistic at the local level, although there is clearly a wider issue of whether sufficient young people are being attracted to university physical science, mathematics and engineering courses. It should be observed that enrolments on some science and engineering courses, particularly in the biological sciences, have increased and are to be welcomed. However, such rises do not necessarily offset the significance of the falls in other subjects, such as physics and chemistry.

3. Because of the interrelated nature of the issues underlying the Committee's specific questions, this response sets out some of the wider issues in the remaining paragraphs. The links to the questions in the Committee's press release are set out in paragraph 24. Some of the issues and their relationships are the subject of ongoing and planned Royal Society studies and so this input to the Committee is to that extent subject to refinement over the coming year.

University autonomy and Government direction

4. Ensuring that the education system as a whole will provide the educated and trained individuals to maintain economic and social well-being in the UK into the future is clearly the responsibility of Government. Equally, it is the responsibility of individual universities to

determine their own future development, taking into account *inter alia:* the general and financial policies of the Government; and universities' responsibilities for maintaining the highest standards in equal opportunities and for contributing to local, regional and wider economic development. There must be no question, except in the very direst circumstances, of Government intervening directly with a university, or taking over powers given to it within its Royal Charter or other governance document. Government is the single largest funder of universities and it is essential that when developing its policies, it and its funding bodies (primarily the Funding Councils and Research Councils) consider very carefully whether there may be perverse incentives or other unintended consequences of their action.

Demand for science and engineering graduates

5. Determining the future requirement for trained staff in any area in the extended timescales relevant to education policy is fraught with difficulties, bearing in mind the problems of determining the likely business structure in the second decade of the 21st century. Determining the demands for specialists in the public services and in education may well be easier. The EU has set an aspirational, perhaps unrealistic, target of increasing the Community's gross expenditure on R&D to 3% of GDP by 2010. This would require a significant increase in research staff (possibly 700,000 over the EU (Gago 2004), largely in the business sector). More realistically, but nevertheless still very ambitiously, the UK Government target in its 10-year strategy (HMT 2004) is for 2.5% of GDP by 2014. Even that would require about 50,000 additional research staff and, since many of these posts will be in applied research, there will also be a requirement for many other staff with S&T qualifications to exploit this activity.

6. Although it is difficult to estimate the overall numbers of researchers that will be required, and even more difficult to estimate the number in specific disciplines, the Society believes that the development of the UK as a major knowledge-based economy will require:

    - an excellent and vibrant university research base;
    - an adequate supply of specialist scientists, engineers and technicians; and
    - a good mix of discipline backgrounds, crucially including science and engineering, within the general graduate work-force.

    It is therefore essential to inform young people, especially the more able students, of the value of a science, mathematics or engineering degree within the labour market.

The supply network

7. The future of university science departments depends on the success of schools in supplying a sufficient quantity and quality of science students. While the traditional supply chain into universities has become a complex network of schools, Further Education Colleges, universities and employers, we are facing a long-term decline in the popularity of A-level subjects that provide young people with the most common route into the physical sciences, mathematics and engineering at university. For example, A-level entries in 2004 in Physics, Chemistry and Mathematics were respectively 34%, 16% and 22% lower than in 1991. Some schools and colleges may be facing the same dilemma as universities; where demand is falling, costs are high, and suitably qualified teachers are in short supply, they may find it increasingly difficult to continue offering physics A-level to their students. Therefore it is important that, as well as monitoring trends in numbers taking A-levels in science and maths, we also monitor numbers of institutions offering them.

8. Research has established that there are many influences on young people's post-16 educational choices (reviewed in the Ready SET Go report (ETB 2003)). For example, the complex questions of whether science is harder than some other subjects and whether it is more difficult to gain a good A-level grade in a science subject than in some other subjects have long been a focus for research at the Curriculum, Evaluation and Management Centre at the University of Durham. Their research indicates that while the proportions of students achieving A-grades in the physical sciences exceeds those gaining A-grades in many arts subjects, fewer physical science students achieve a grade A at A-level than would be expected from their average GCSE scores. Many factors could be responsible for this, and there is a need for research to be undertaken into the underlying causes and their relative effects.

9. The gulf between education at the 16-19 stage and that at university is already a wide one for some students, and risks becoming wider in the sciences as concerns increase over financial pressures and the lack of necessary skills being developed in the average school experience, particularly in mathematics and practical experimentation. In its response to the White Paper on the future of HE (RS 2003), the Society warned about the possibility of science and engineering subjects being disadvantaged by top-up fees, and this needs to be monitored. Even if the more expensive subjects are not disadvantaged through differential fees, their students might find it relatively more difficult to minimise debt and supplement their income because of the content and length of degree courses. For example, questions of how universities will apply bursaries, and whether the four-year MChem/Phys/Eng courses will remain attractive when the full impact on student debt is clearer, need to be explored as a matter of urgency.

10. The priority for increasing capacity in the school/college sector is to ensure science teachers with appropriate backgrounds are recruited, retained and given access and entitlement to professional development throughout their careers. A skilled, enthused and appropriately deployed teaching profession will be able to tackle some of the weak points in the supply network: maintaining interest in science through the notoriously difficult transition from the end of Primary school into Secondary school; raising the profile of vocational science and engineering courses; and motivating students to continue with physics, chemistry and maths post-16 despite perceptions of their relative difficulty or relevance. A recent report for the Royal Society of Chemistry (RSC 2004) notes that in the past two decades, targets for recruitment to science teacher training have only been met in the three years 1991-1993 when the country was in deep economic recession. The proportions of trainees with a chemistry or physics background have dropped significantly since 1984. The likely outcome of this pattern of recruitment, and associated losses from the profession, is that the balance of expertise is skewed towards biology at Key Stage 4 when most pupils are studying balanced science. However, the authors admit that drawing conclusions from 'inadequate official data' was difficult, and the Society eagerly awaits the results from new DfES research into: the motivation, deployment and development of science and mathematics teachers in secondary schools, as reported to the Education and Skills Committee (HoC 2004); and the flow of SET teachers in and out of the post-16 learning and skills sector (HMT 2004). Moreover, as the Society recommended last year (RS 2004), the Government must commit to the long-term survival and development of the newly-established national network of science learning centres, and the analogous structure for mathematics, currently under consideration.

11. Schools and colleges have a fundamental role to play in preparing the next generation of scientists, but so do universities, funders and employers by supporting outreach programmes and work-based learning, and careers advisors and parents in ensuring young people are

making their choices based on the best possible information about science and the prospects and challenges it offers. A stream of reports over the past 3 years[1] has made recommendations and promises, with notable reference to: science and mathematics teachers' entitlement to Continuing Professional Development; improvements in performance in science GCSEs; and increases in numbers taking SET subjects at A-level and equivalent. DfES will shortly be announcing its plans for 14-19 education, following the recent report from Mike Tomlinson (Tomlinson 2004), which gave no prominence to science during this key phase in the preparation of future scientists. The Society expects to see evidence of co-ordination and communication between the Treasury, DTI and DfES, and a commitment to delivering success for science.

Academic staff

12. Just as it is important for good science graduates to be attracted into school science teaching, it is essential to ensure that sufficient high quality staff are retained within universities. The Society has a range of programmes designed to help some of the highest quality scientists and engineers at key transitional stages (see paragraph 23), but it has major concerns that academic careers are no longer sufficiently attractive to secure the future faculty of the university system. While the Government's response to the Roberts recommendations (HMT 2002) has gone some way to improving the situation at post-doctoral levels, more needs to be done to improve the attractiveness of permanent academic teaching posts.

Financing of university teaching

13. It is the Society's view that there needs to be a full investigation of the level of funding provided for teaching in science and engineering subjects. There is evidence that teaching has had to be subsidised from other income in at least some universities, especially in laboratory-based projects in the final year of an honours BSc course, and that this causes problems when for example research income from the Funding Council is cut. The situation has been exacerbated by the revision of the formula for calculating the block-teaching grant for laboratory-based subjects, reducing the weighting from 2 to 1.7 from 2004 to 2005 (HEFCE 2004). Furthermore, it seems that the attempts to encourage wider participation, which the Society fully supports, were not resourced with sufficient additional money. This apparently required HEFCE from 2003 to reduce the funding base for teaching students with more than 17 A-level points, which has hit funding for honours degree courses where it is necessary to recruit well qualified students. Both of these changes send a clear negative message about science and engineering courses to university senates and councils.

14. A key feature of higher education teaching is the high level of scholarship[2] required, and the necessary staff time for this activity is insufficiently taken account of in central funding, exacerbating the shortfall on the funding of teaching. The issue is complicated by the relationship of scholarship with other activities that enhance it, such as: active research; and professional development, including close interaction with innovative employers of relevant graduates, attendance at international meetings, and collaboration with professional colleagues in the public services and business sectors. Research is an important factor in science disciplines and has also featured in the discussions on recent closures, and the

[1] Roberts 2002, HMT 2002, Smith 2004, DfES 2004, HMT 2004

[2] There are many definitions of scholarship. For the purpose of this submission it is defined as "a deep understanding and ongoing engagement with the concepts, ideas, methodology and analysis being taught".

relationship between teaching and research is considered further in the next section.

Teaching, research and the development, maintenance and transfer of knowledge

15. The prime responsibilities of a university are to teach, to maintain and develop the corpus of knowledge relevant to their activities and to transfer this knowledge, not only though teaching, but also other activities targeted for example at business and the public services. These are all interconnected activities and there are obvious dangers in trying to make policies in one area without understanding the interdependence on other areas. The treatment of teaching and research and the application of research in the HE White Paper (DfES 2003) was a good example of this over simplification.

16. Too often the interdependence of teaching and research has been discussed at an individual teacher level, with attempts to see if there is a correlation between excellence in teaching and in research on the basis of individual members of faculty. Rather, as the Society explained in its response to the White Paper (RS 2003), while all teachers should undertake scholarship, the linkage between teaching and research should be made at the departmental level, and be in terms of its value in contributing to a stimulating learning environment, not least through the attraction and retention of faculty, and the exposure of students to the frontiers of knowledge. This view has been supported by the Higher Education Research Forum's report of June 2004 (HERF 2004) on the relationship between Research and Teaching in Institutions of HE, which received a positive response from Ministers.

17. There is a wide range of research activity at varying costs. The country needs research stars who make a major international impact, and this work can be expensive and demands selective funding. But not all research needs to be expensive in terms of local facilities. For example: it may be conducted at regional, national or international scientific facilities; undertaken via broadband links to major computing or database centres; or through collaboration with another university or research institute. The key requirement is staff time, and this has to be resourced from the HEFCE QR research block grant (a unique UK arrangement) or cross-subsidised from elsewhere. It is not clear that the shape of the current HEFCE selectivity is optimal. Arguably, in England, after the 2001 RAE, instead of cutting grants severely or completely at the lowest ratings, the burden of any additional funding for 5*, and the large increase in 5 rated departments, should have been shared more equally across the 5, 4 and 3a departments. Certainly it is difficult to defend the huge gap in funding between 5 and 4 rated departments, since, in reality, there is a continuum in the quality scale across the two grades. The RAE 2008 arrangements address this issue, but the funding based on that exercise is some way off for institutions and departments facing major financial problems, and the Government should consider some short-term interim arrangements to ease such difficulties. Furthermore, it is essential that funding policies should encourage, rather than deter, research collaboration between institutions.

18. The selectivity of the 1990s led to some helpful rationalisations in the system, but there are important limits to the optimal degree of concentration of research in UK universities. The recent demise of some departments rated 4 in the 2001 RAE has meant the loss of good units with high reputations for their undergraduate courses where the demand had kept up well. Furthermore, some members of faculty in these departments had international standing and had received significant Research Council grants. The departments themselves were amongst those that had been chosen as a base by the Society's University Research Fellows. Many 4 rated departments are relatively small and have established important and innovative niche research programmes. Some of the EPSRC international reviews of UK research

disciplines have highlighted the important role of small departments.

Geographical Provision

19. Science provision can be considered at a range of levels - EU wide, UK, country or region. To some students and large firms the location of a particularly attractive university course or research programme is irrelevant. However, the advent of a mass higher education system, the reduction in individual student support, and the imperative to provide equal opportunity of access to higher education mean that local teaching provision is very important. The formation of regional 'deserts' created by closures of university departments increases the risk of discrimination against those who may need to stay near home because of family commitments, cultural or financial pressures. Furthermore, without local university departments in the physical sciences and engineering, the opportunities for increasing university-school links in these subjects, as promised in the science and innovation investment framework (HMT 2004), will be severely reduced in some areas.

20. While larger companies can access information on a world-wide basis, SMEs can be very dependent on their local universities. Hence, it is still relevant to consider what provision is required at least to the level of the English regions.

Relevant Current and Ongoing Royal Society Activities

21. The Society's ongoing policy work has already been mentioned, and we will keep the Committee informed of progress. The Society also has a number of activities and schemes that are highly relevant to the issues underlying this inquiry.

22. Concerning the need to make science and mathematics more attractive to school pupils, the Society is committed to excellence in science and maths education, and has a range of projects aiming to support effective teaching and learning in schools and colleges. These include: supporting collaborations between scientists, engineers, teachers and their pupils through our Partnership Grants scheme and recent good practice guide for SET role model schemes; production of unique resources, such as the Acclaim pack and sc1 website, that help teachers bring the work of real scientists into the classroom; offering opportunities for post-16 students to meet some of today's leading researchers at our annual Summer Science Exhibition; encouraging and supporting partnership projects throughout the science community, for example the development of the Science Council's careers website, the work of the Advisory Committee on Mathematics Education, and the Nuffield School Science Bursary scheme; and engaging with the Government and professional and learned societies on key science education policy issues such as 14-19 education.

23. The Society also has a number of schemes, funded both from the Science Budget and from its own resources, to support academic research careers. The Society believes that the key to the highest scientific achievement lies in the recognition and fostering of individual quality. The Society's largest funding programme, the University Research Fellowships, aims to provide stability for promising researchers and the freedom to build independent research careers. The scheme has been running since 1994 and during this time just over 800 researchers have been funded. Currently the scheme offers up to ten years' support in the form of salary and research expenses. The Society also aims to provide schemes to retain scientists within academic research at different points during their careers:

    - **Dorothy Hodgkin Fellowships** provide a first step into an independent research career for excellent scientists and engineers for whom career flexibility is essential.

- **UK Relocation Fellowships** aim to help researchers who wish to move to follow a partner who has changed place of work and moved a significant distance.
- **Professorships** provide long-term support for world-class scientists, allowing them to focus on research and collaboration.
- **Royal Society/Wolfson Research Merit Awards** aims to attract key researchers, with great potential or outstanding achievement, to this country or to retain those who might seek to gain higher salaries overseas. The awards provide funding for salary enhancement and some research expenses.

Links to the questions posed in the Committee's press release.

24. The Society believes that the issues connected with strategic provision of science disciplines go wider than the questions posed in the press release, especially in the area of student demand. The paragraphs of this submission relevant to the Committee's questions are:

    - The impact of HEFCE's research funding formulae, as applied to Research Assessment Exercise ratings, on the financial viability of university science departments; **paragraphs 17 and 18.**

    - The desirability of increasing the concentration of research in a small number of university departments, and the consequences of such a trend; **paragraphs 15 – 20.**

    - The implications for university science teaching of changes in the weightings given to science subjects in the teaching funding formula; **paragraph 13.**

    - The optimal balance between teaching and research provision in universities, giving particular consideration to the desirability and financial viability of teaching-only science departments; **paragraphs 14 – 20.**

    - The importance of maintaining a regional capacity in university science teaching and research; **paragraphs 19 and 20.**

    - The extent to which the Government should intervene to ensure continuing provision of subjects of strategic national or regional importance; and the mechanisms it should use for this purpose; **paragraph 4.**

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