Review of the supply of scientists and engineers

Key Issues Consultation Paper

Sir Gareth Roberts' Review

June 2001

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Key Issues Consultation Paper

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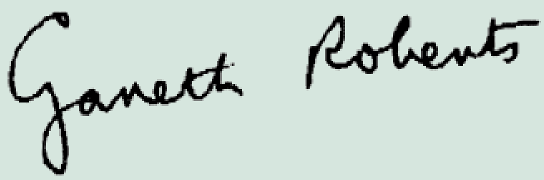
FOREWORD

Scientists and engineers make many vital contributions to the UK's economy, but one of the most important in today's high-technology world is that of innovative research and development (R&D). For the UK's world-class science base to provide a firm foundation for R&D, it is important that businesses, universities and the public sector are able to attract and retain high-quality scientists and engineers from the UK and around the world.

In response to concerns that innovative businesses in the UK sometimes find it difficult to recruit the skilled researchers they need, the Government has asked me to lead an independent review of the supply of scientists and engineers in the UK. As well as examining the numbers of scientists and engineers in the UK and the jobs they do, I will be looking at the skills needed by businesses for their R&D activity, and at the skills gained by science and engineering graduates and postgraduate students, particularly PhD students. A major focus of the work will be to investigate how businesses and universities communicate and collaborate in providing relevant training to students.

My team and I will be discussing the issues in this paper with people from business and universities, including students, in a series of meetings over the coming months. I would be very grateful for your comments on the key issues described here. Your views will inform future work, leading to a final report in February 2002 which is expected to influence the Government's next spending review. I very much look forward to hearing from you.



Professor Sir Gareth Roberts FRS
June 2001

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About this paper

What is this review about?

- The review is about possible mismatches between the supply and demand of scientists and engineers within UK businesses and universities, including the identification, communication and development of skills needs.
- The focus of this review is top-level graduates and postgraduates working as scientists and engineers, rather than technician-level skills.

Who should respond to this paper?

Responses to the key issues set out in section 4 are particularly sought from:

- graduate recruitment, research and development, and other senior staff within science and engineering businesses of all sizes;
- interested parties within Higher Education Institutions; and
- other organisations with an interest in innovation and the UK science base.

How can I comment on this paper?

- Comments on the key issues and accompanying suggestions for further analysis and policy measures should be sent to the Roberts Review team at HM Treasury. Contact details for the team are in **Annex A** on page 27.

The preferred deadline for responses is 31 July 2001. If you are unable to meet this deadline, your views would still be welcomed as soon as is practical.

1 INTRODUCTION

BACKGROUND TO THE REVIEW

1.1 Encouraging innovation is a key part of the Government's strategy for improving the UK's productivity performance, which is seen to lag that of other major industrialised countries. The Government has therefore introduced a number of measures specifically aimed at boosting innovation and research by businesses, universities and the Government, including:

- the research and development tax credit for small and medium sized firms (and its proposed extension to larger firms);
- work to encourage and strengthen interactions between universities and businesses through the establishment of a permanent third stream of funding for higher education institutions[1]; and
- investing directly in the UK's science base through launching, jointly with the Wellcome Trust and the devolved administrations, a major research investment programme in UK universities.

These specific measures complement other more general policies – most notably a stable macroeconomic environment – that help to create a strong climate for investment and innovation.

1.2 Ensuring that the UK has a plentiful supply of skilled scientists and engineers is vital to encouraging innovation and research and development (R&D) in the UK. Although the UK has a strong overall science base[2], the Government is alive to concerns expressed by some about the quality of science and engineering graduates and postgraduates, and about potential mismatches between the supply of, and demand for, such highly skilled people in particular specialist fields.

1.3 The Government therefore announced in the 2001 Budget that it had commissioned Sir Gareth Roberts to conduct an independent review of the provision of research scientists and engineers in the UK. The aim of the review is to ensure that businesses and universities can recruit and retain the right people to lead and conduct their research activities. The review will also consider the needs of employers partly or wholly in the public sector, such as health, defence and the nuclear industry. Sir Gareth is due to report in February 2002.

THE SCOPE OF THE REVIEW

1.4 The review will focus on the type of high level scientific and technical skills possessed by PhD-level or top Masters / first degree level graduates, although it is required to and will also consider science and technology teaching below honours degree level in order to understand the supply of suitable students to higher education. Although the review will focus on the supply of scientists and engineers from the UK higher education (HE) sector, the main source of such people for the UK, consideration will also be given to the supply from other sources, such as universities overseas and businesses in the UK and abroad.

[1] Funding for these activities comes from the new Higher Education Innovation Fund in England; the Knowledge Exploitation Fund and the HEFCW's forthcoming Higher Education Economic Development (HEED) Fund in Wales; and the Knowledge Transfer Grant in Scotland.

[2] *"Excellence and opportunity: a science and innovation policy for the 21st Century"* (DTI, July 2000), available from http://www.dti.gov.uk/ost/whatsnew/index.html.

I.5 The definition of 'science and engineering' intended to be used in the review covers the natural sciences, engineering, IT, and maths. It also covers medicine and subjects allied to medicine (SAMs), insofar as they contribute to the supply of researchers to innovative businesses. Moreover, although the review will therefore have a 'hard centre' of science and engineering, consideration will also be given to other skills such as information management, marketing and management that can be crucial for innovation in certain sectors of the economy.

I.6 Specifically, the review will aim to ensure that a framework exists for business to communicate any knowledge and skills gaps to the higher education sector, and which also enables the HE sector to respond to these needs. Some further measures may be required to deal with any current mismatches between the supply and demand of scientists and engineers, or difficulties faced by universities and innovative businesses in recruiting and retaining highly skilled scientists and engineers.

I.7 There is a wide range of parties with interests in the supply of scientists and engineers. These interested parties fall into four main categories:

- business (and other employers of scientists and engineers for R&D);
- education (particularly HE);
- government (including the devolved administrations); and
- the individual (student or researcher).

Clearly these sectors are interdependent rather than independent (for example, the Government is the principal source of funding for education) but all have distinct identities, aims and priorities. In finding solutions to any problems of supply and/or demand for researchers, it will be necessary to consider the balance of responsibilities between the various groups.

I.8 The full terms of reference for the review are set out in **Annex B**.

DEVOLUTION

I.9 Policy responsibilities for schools, skills and higher education, together with many aspects of science and innovation, have been devolved to the new administrations in Scotland, Wales and Northern Ireland. The Government and the devolved administrations are committed to working together to develop a knowledge-based economy, in part by ensuring that there is a strong UK science base supported by high quality science education. The devolved administrations will therefore work closely with the Review Team throughout the period of the review, and take account of any appropriate recommendations in its final report next year.

PURPOSE OF THIS PAPER

I.10 This paper seeks to identify key issues crucial to the supply and successful employment of scientists and engineers as researchers, without assuming any particular problems or solutions. It aims to stimulate comment and debate on these key issues in the higher education and business sectors. In particular, it is hoped that those receiving this paper will contribute their views on the issues outlined in subsequent sections, and suggest additional important points to be investigated. Comments will be used to guide the focus of the review and assist in the development of its recommendations.

1.11 **Section 2** of this paper illustrates the current position in the supply of scientists and engineers in the UK, and makes international comparisons, through various charts and statistics. This includes a view of how the supply of researchers is evolving.

1.12 **Section 3** depicts the current demands for scientists and engineers, including an indication of how their expertise is employed. It also explores the evolving demands of UK businesses.

1.13 The statistics used in sections 2 and 3 are not intended to be viewed as comprehensive, but rather to help respondents by presenting an overview of the main features of the 'market' for scientists and engineers. Where consistent data for the UK as a whole is not readily available, data is given for England only.

1.14 **Section 4** seeks to distil the key issues that emerge from the statistics and discussion in the earlier sections. These will be the main issues that the review will hope to explore in more detail over the coming months. These include:

- the range of skills acquired at degree level and above;
- how these skills correlate to the needs of business;
- how effectively innovative businesses communicate their needs to HE, and how well HE is able to respond; and
- student motivation and incentives (at all levels – secondary school, undergraduate, and postgraduate).

1.15 *Views and comments on all the key issues set out in **Section 4** are welcomed.* The preferred deadline for responses is 31 July 2001. If you are unable to meet this deadline, your views would still be welcomed as soon as is practical. It is hoped that this review and its recommendations will help UK businesses and universities to attract and retain innovative talent, and maintain the UK as a leading base for R&D businesses. The engagement of business and the higher education sector is vital, and this paper is intended to be the first step in this process. It is expected that a further, more comprehensive, consultation paper will be published later this year as policy proposals to address issues identified by the review are developed.

THE REVIEW SECRETARIAT

1.16 Supporting Sir Gareth Roberts is a small team of officials drawn from the Department of Trade and Industry, the Department for Education and Skills, and HM Treasury. Contact details for the review team are included in **Annex A**.

2 The Supply of Scientists and Engineers

QUALITY AND QUANTITY OF SCIENTISTS

2.1 The information provided in this section is intended to give an overview of the supply of scientists and engineers, and mainly relates to the number of scientists being trained in higher education (HE), rather than their ability and the quality of the training they receive. This reflects the difficulty of defining and measuring "quality" in the context of skills and knowledge, although the review will examine this issue through relevant data (e.g. A level points scores) where possible.

2.2 An important issue for the training of scientists in general is the balance between detailed, systematic knowledge and understanding of scientific and mathematical principles on the one hand and transferable skills and entrepreneurial attitudes on the other. These are by no means mutually exclusive, and indeed can be developed simultaneously to some extent, but greater emphasis on one will ultimately require more time or less attention to the other. It should be noted that the 'softer' transferable skills in particular are learned in a variety of contexts, not just through formal teaching. It is also important to look at the delivery of core technical skills – for example effective Science, Engineering and Technology (SET) teaching requires access to suitably equipped laboratories and other equipment.

2.3 Comments on issues surrounding the quality of scientists and engineers are invited in Section 4.

SOURCES OF SCIENTISTS AND ENGINEERS

2.4 Highly-skilled scientists and engineers gain much of their formal knowledge through higher education; there is not thought to be a significant vocational (non-HE) route into top-level science and engineering research activity. The UK produces around 91,000 science and engineering graduates and 25,000 postgraduates each year. The market for top scientists and engineers is international; some who trained in the UK will leave (temporarily or permanently), and others will come to the UK from other countries. Issues of recruitment from outside the UK are explored further in paragraphs 3.13 and 3.14; this section focuses on the UK education supply chain, including overseas students in UK institutions (paragraph 2.22 and Table 2C on pages 12-13).

THE SUPPLY FROM UK EDUCATION

2.5 The typical education for a top scientist 20 years ago was O levels and A levels (or, in Scotland, Standard Grades and Highers), first degree and often a PhD. Since then the GCSE has replaced the O level, and the AS level has been first created and then reshaped, but the basic system remains much the same, albeit with some additional flexibility and far wider access. To understand the supply of scientists it is necessary to consider the whole education supply chain, not merely the HE portion of it.

COMPULSORY EDUCATION: GCSE AND SCE STANDARD GRADE LEVELS

2.6 The National Curriculum for England requires all 5-16 year olds in maintained schools to study mathematics and a balance of biology, chemistry and physics. Most pupils (77% in 2000) take the double award GSCE science (where pupils are awarded two GCSEs indicating achievement across the three subject areas of biology, physics and chemistry) while a minority (8% in 2000), who spend more time on other subjects, take the single award (where pupils are awarded one GCSE indicating achievement across biology, physics and chemistry). The content of the single and double science programmes of study is laid out in the National Curriculum for England. Independent schools have tended to offer separate biology, chemistry and physics GCSEs and do not require their pupils to maintain a balance across the sciences.

Table 2A: English GCSE results for single & double award science, separate sciences, and maths; number of people gaining grades A-C at each

	% 15 year olds in schools					
	Attempted GCSE			Achieved A*–C		
	97/98	98/99	99/00	97/98	98/99	99/00
English	90	91	92	51	53	54
Maths	92	92	93	43	45	46
Any science	91	91	92	45	46	47
Single award	9	9	8	2	2	2
Double award	75	76	77	37	38	39
Physics	6	6	6	6	6	6
Chemistry	6	6	6	6	6	6
Biological science	7	7	7	6	6	6
Other science	1	1	1	0	0	0

Source: Office for National Statistics/Department for Education and Employment (2001) Statistics of Education: GCSE/GNVQ and GCE A/As level and Advanced GNVQ Examination Results 1999/2000 England.

2.7 The double award GCSE, which covers biology, chemistry and physics, enables all pupils to gain a balanced scientific education. The move to the double award GCSE has meant that more boys than previously study biology at GCSE, and more girls than before study physics and chemistry. Over time, this is expected to reduce the gender imbalance in the sciences post-16 and already the number of girls and boys taking A level chemistry is almost equal. Some believe that double science GCSE does not give a secure grounding for science at A level and above, although research[3] has shown that other factors, such as pupil ability and motivation, have a greater effect on achievement at A level. However, the dual purpose of the school science curriculum, which is to provide the majority with a basis from which to become informed citizens and the minority with a basis for a scientific career, continues to be the subject of much debate.

POST-COMPULSORY EDUCATION

2.8 Until recently, students in England, Wales and Northern Ireland typically studied three A levels over a two-year period; potential scientists would sometimes take four, for example to learn additional mathematics. Following last year's re-emphasis on AS-levels as a means of broadening post-16 curricula, some students now sit four AS levels in their lower sixth year and specialise in three subjects at A level in the upper sixth, although independent schools have tended to keep to the traditional three linear A levels. Post-compulsory science education in schools in Scotland is described in detail in "Standards and Quality in Secondary Schools 1995-2000: The Sciences"[4].

[3] "*The transition from GCSE double award balanced science to A level in the sciences: a review of findings.*" QCA discussion paper no. 2 1998.

[4] Available at http://www.scotland.gov.uk/library3/education/sqss-00.asp

2.9 The number of A levels obtained in all subjects increased between 1993/4 and 1998/9 by 17%, and in science and technology (S&T) subjects by 20%, although the take up of individual sciences was mixed. For example, the numbers obtaining a computer science A level increased by 107%, while those obtaining a physics A level increased by only 3.6%. Furthermore, there remains a marked difference in the interest in physics and biology between men and women, with women making up 60% of those obtaining a biology A level in 1989/99, and men accounting for 78% of those obtaining physics A level in 1989/99. There are also markedly more men than women studying computer science and design and technology at this level.

Table 2B: English A level results – % change in number of A-E grades awarded to 16-18 year old students

	1994/95 – thousands			1999/00 – thousands			% change 1995-00		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Biology	13.2	20.6	33.8	15.5	25.6	41.1	17.4	24.6	21.8
Chemistry	16.7	12.8	29.5	16.4	15.8	32.1	–1.9	22.9	8.9
Physics	19.7	5.4	25.1	19.4	5.9	25.3	–1.6	8.7	0.7
Other science	2.5	1.9	4.4	2.6	3.3	5.9	–1.2	73	35.9
Maths	31.0	17.2	48.1	32.9	19.8	52.7	9.3	15.5	9.5
Total passes	240.4	264.8	505.2	276.2	325.7	601.9	14.9	23	19.1

Source: Department for Education and Employment (various years) Statistics of Education: Public Examinations

New post-16 Qualifications in England, Wales and Northern Ireland

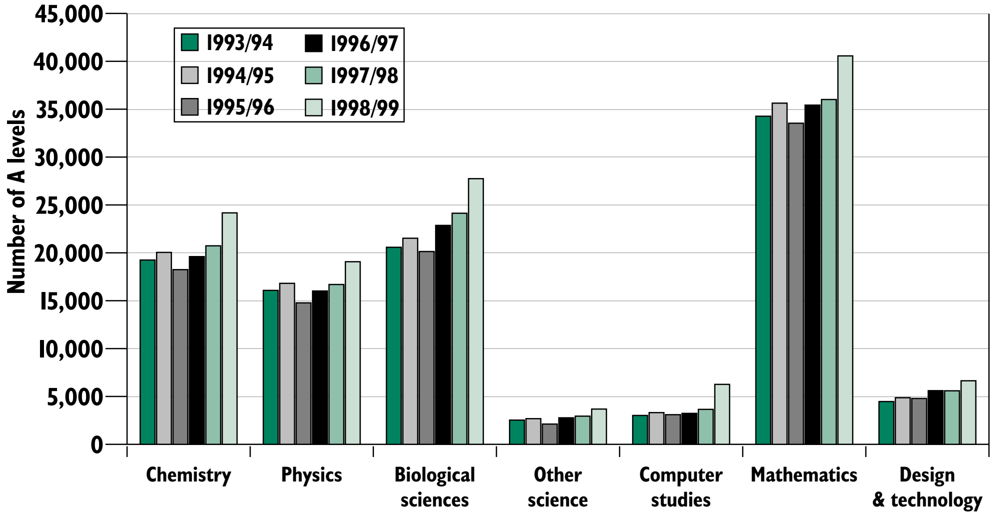
The post-16 qualifications reforms Qualifying for Success (also known as Curriculum 2000) were introduced in September 2000. They are designed to encourage young people to take a wider range of subjects at A level than the traditional two or three, or to study A levels and Vocational A levels alongside the new Key Skills qualification. The changes include:

- **New Advanced Subsidiary (AS) qualification represents the first half of an A level, designed to encourage take-up of more subjects in the first year of post-16 and reduce the number of students who drop out with nothing to show for their efforts;**
- **New A level specifications made up of six modules offer candidates the choice of linear (end-of-course) or modular (staged) assessment;**
- **The new 3-unit Vocational AS is available in a small number of subjects, and equivalent in size and demand to a single GCE AS level. The new six unit Vocational A level is equivalent in size and demand to one GCE A level and a 12-unit Vocational A level (double award) is equivalent to 2 GCE A levels; all are graded A to E like the GCE A level qualifications for the first time, encouraging parity of esteem; and**
- **New Advanced Extension Awards based on A level specifications are aimed at the most able students and replace 'special papers'. They will be available initially in 17 subjects and for first examination in summer 2002.**

The new Key Skills qualification is designed to encourage all young people to develop the essential skills of communication, application of number and IT, drawing evidence from their programme of study.

2.10 The chart below focuses on the number of awards at grades A-C at A level, as these figures are appropriate when considering those most likely to become scientists. The number of A levels grades A-C in S&T subjects increased by 28% between 1993/4 and 1998/9, with the greatest growth between 1997/8 and 1998/9. Overall, mathematics was the most common subject achieved at this level followed by biological sciences and chemistry. (Naturally these trends need to be considered in the context of demographic changes, i.e. change in the size of the age cohort in the population over time.)

Chart 2A: A Levels (Grades A to C) in England by subject 1993/94 to 1998/99



Source: Department for Education and Employment (various years) Statistics of Education Public Examinations GCSE/GNVQ and GCE/AGNVQ in England

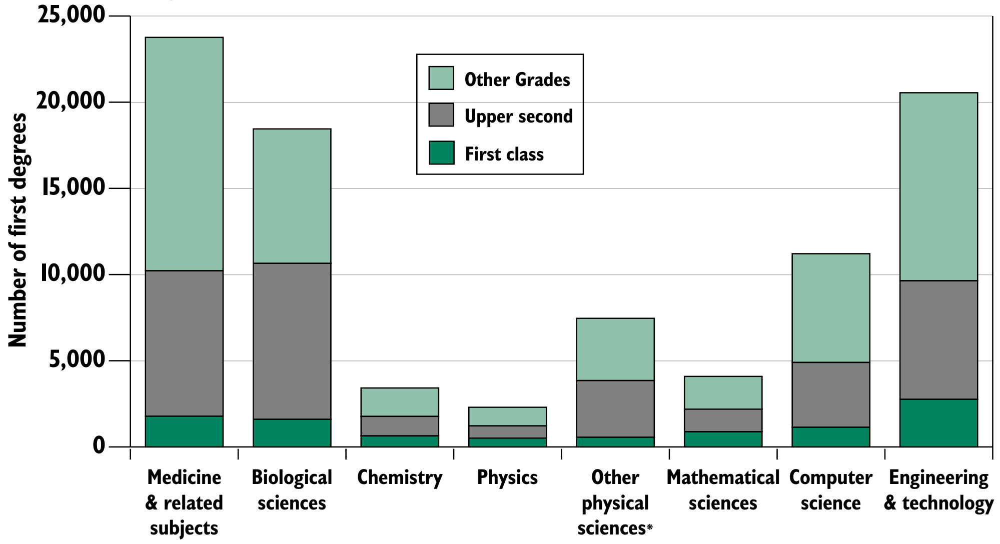
FIRST DEGREES

2.11 There were just over one million students working towards first degrees at UK Higher Education Institutions (HEIs) in the academic year 1999/2000. The historical pattern for most scientific subjects outside medicine has been a three-year course (four years for an honours degree in Scotland). Four year science courses are increasingly common, offering either increased breadth of study (e.g. sandwich courses involving a year in industry, language courses involving time abroad) or additional in-depth study following a BSc or BEng degree.

2.12 Chart 2B shows the numbers of people graduating in Science, Engineering and Technology (SET) subjects in 1999/00. Numbers in physics and chemistry have fallen in recent years, and the numbers graduating in engineering and technology have seen a more marked decline. However in these cases the numbers of first or upper second-class degrees have fluctuated to a lesser extent. Overall, the numbers of first and upper second-class degrees in science and engineering subjects has risen over this period. (Again demographic change in the number of young people in the population needs to be borne in mind.)

2.13 There is a clear gender divide between different sciences. During 1999/2000 women constituted 83% of students in subjects allied to medicine and 61% in biological sciences, whereas men made up 85% of engineering & technology students, 77% of computer science students, and were strongly represented in physical sciences (chemistry and physics) (63%) and mathematical sciences (63%).

Chart 2B: Full and Part-time Science and Engineering first degrees, 1999/00



*Notes: *Other Physical sciences include materials and environmental sciences*
Source: Higher Education Statistics Agency (2001) Students in Higher Education Institutions 1999/2000

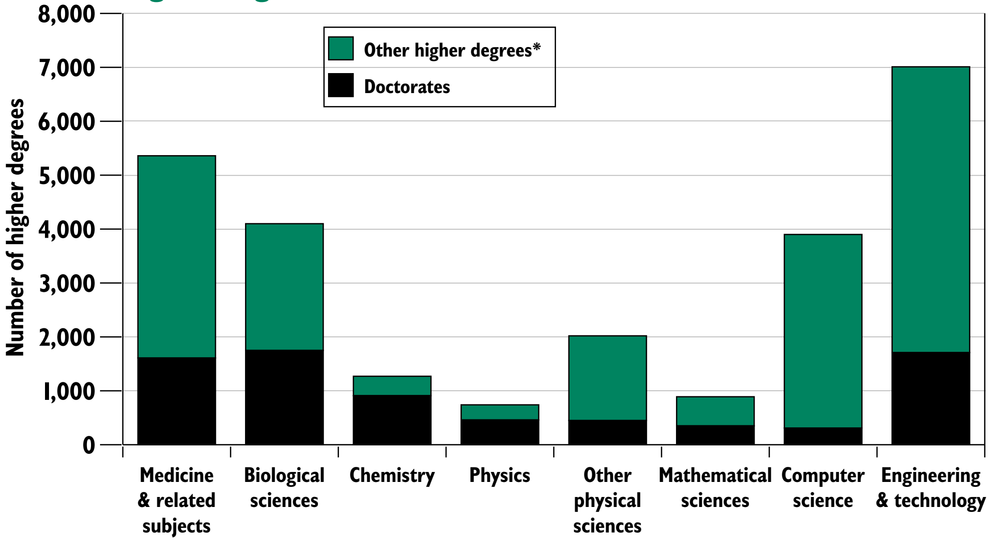
POSTGRADUATE STUDY

2.14 Postgraduate study in scientific subjects generally requires a first- or second-class degree in a relevant discipline. A First is often required for entry to a PhD, though a 2:1 can be sufficient, whereas entry to Masters courses can in some cases be obtained with a 2:2. A distinction should be made between taught Masters (e.g. MSc), generally one-year courses, and research-based Masters (e.g. MPhil) which are more often two years, although the MRes is a one year course. PhDs are generally three year programmes, although trials of a new three or four year format with a significant taught element are currently being supported by the Higher Education Funding Council for England (HEFCE) in ten English universities. Another increasingly significant doctoral qualification is the EngD, which aims to provide outstanding young engineers with intensive, broadly based, research training in collaboration with industrial companies, and is generally a four-year programme.

2.15 Of the 90,500 people who graduated in S&T subjects in the year 1998/99, the available first destination data suggests that within six months 14% went on to study towards a higher degree (6% a research-based higher degree and 8% a taught higher degree). Chart 2C below gives the numbers obtaining higher degrees in S&T subjects in 1999/2000. Overall numbers increased by 26% between 1995/96 and 1999/2000, this increase was mainly due to an increase of 27% in non-doctoral higher degrees (mainly Masters) compared with a 9% increase in doctorates.

2.16 As with first degrees, there was a decline in the numbers of postgraduates in the fields of chemistry and physics between 1995/6 and 1999/2000 (although less so for doctorates than other higher degrees). This decline was most noticeable amongst those studying for a physics 'other higher degree' where numbers fell by 26%. Numbers studying for postgraduate mathematics higher degrees also declined by 6% over this period (although this is explained entirely by a decline in 'other higher degrees' by 12%). There was an overall increase in postgraduate numbers in both computer science and engineering & technology.

Chart 2C: Full and Part-time Science and Engineering higher degrees, 1999/00



*Notes: *Other higher degrees are mainly Masters*
Source: Higher Education Statistics Agency (2000) Students in Higher Education Institutions 1999/2000

2.17 Finance for postgraduate training comes from a variety of sources: some students are self-funded; others are funded by one of the six Research Councils (BBSRC, EPSRC, ESRC, MRC, NERC and PPARC) and, in Northern Ireland, by the Department of Higher and Further Education, Training and Employment; by HEIs; by industrial sponsors; and/or by other organisations (e.g. charitable foundations). One example of collaboration between industry and the Research Councils is the CASE award which supports research students working on projects of between one and three years duration. The projects are jointly devised, financed and supervised by academic departments and co-operating bodies (industrial and commercial organisations in the public or private sectors, and local authorities and research council institutions and laboratories).

POST-DOCTORAL RESEARCH

2.18 Researchers remaining in the higher education sector on completing a PhD are often employed on short-term contracts (averaging a couple of years) and referred to as postdocs. There were approximately 30,000 science and engineering postdocs and short-term contract researchers in the UK during 1999/2000. The postdoc can be regarded as an intermediate stage between research training (PhD) and employment as a lecturer, though many postdocs leave the higher education sector for jobs elsewhere. The Research Careers Initiative has been working to improve the management and career development of postdocs and short-term contract researchers.[5]

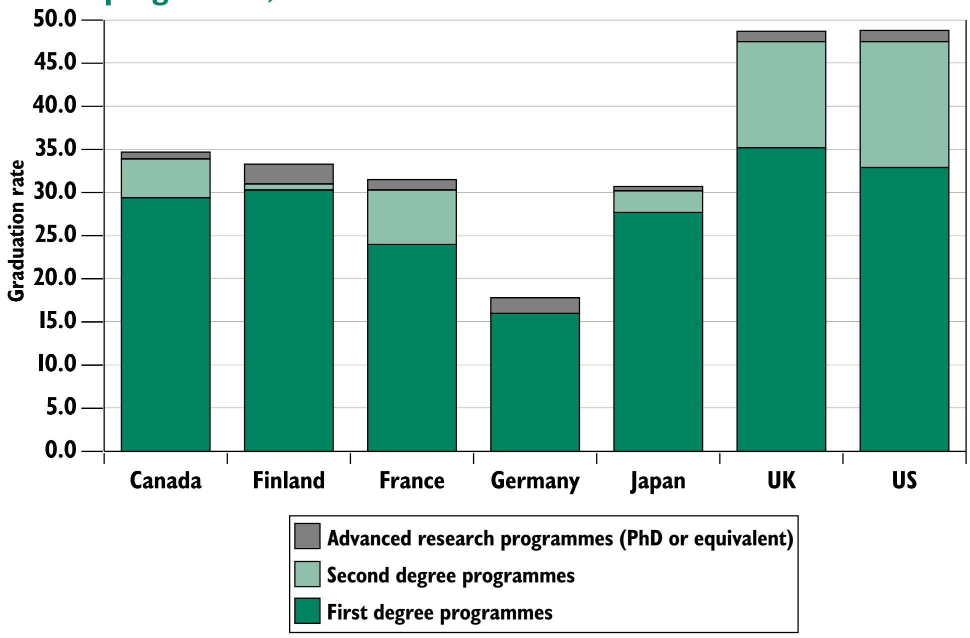
[5]For more information see http://www.universitiesuk.ac.uk/activities/rci.asp.

2.19 It is common in many disciplines for UK-domiciled PhD students to take up postdoctoral posts in other countries, particularly the United States, and for people from overseas to do postdoctoral work in the UK. A proportion of those leaving the UK do not return; similarly, a proportion of those coming to the UK will remain. The recent easing of work permit regulations for the highly qualified may mean greater numbers of overseas PhDs and postdocs entering UK employment.

INTERNATIONAL COMPARISONS

2.20 The information presented in this chapter so far has considered the education system across the UK in isolation. The UK has traditionally been viewed as having a strong science base compared to other countries; Chart 2D shows that in 1998 the UK had the highest overall net graduation rates at first degree and above levels (the bottom band of each bar). The UK had a 33% graduation rate in first degrees, meaning that at 1998 rates about a third of the population will complete a first degree over their lifetime. The first degree category includes qualifications which can take from between 3 to 7 years, while the second degree category includes qualifications which can take between one and 4 years additional study.

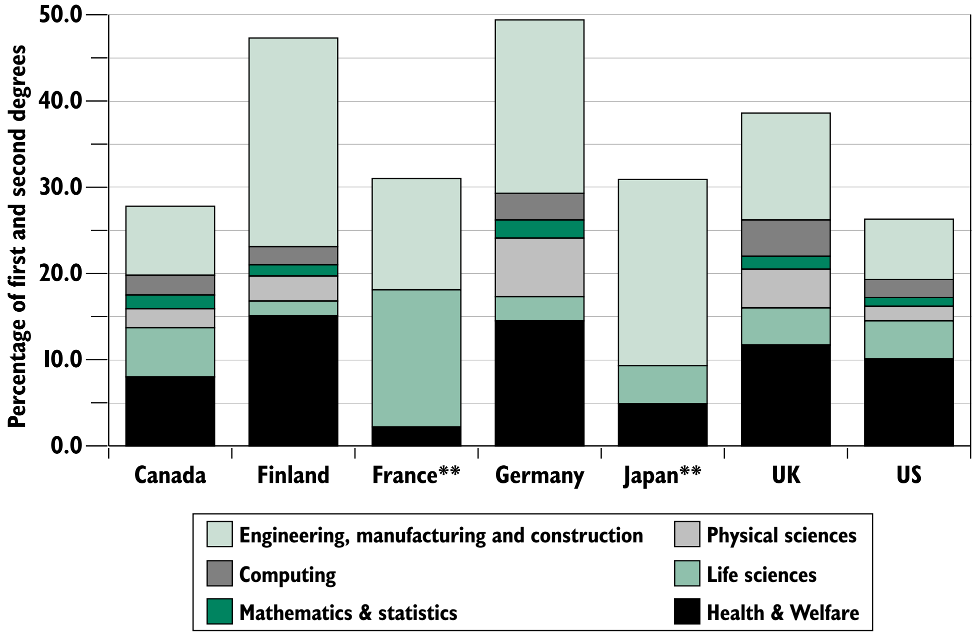
Chart 2D: Graduation rate* in tertiary education by type of programme, 1998



*Notes: *Graduation rate = graduates as a percentage of those of normal age of graduation*
Source: OECD (2000) Education at a Glance 2000

2.21 The high level of UK graduations at first degree level and above does not give the complete picture in terms of science and technology qualifications, since the subject mix of these qualifications varies considerably internationally. Key comparator countries are shown in Chart 2E, which demonstrates that apart from the US and Canada the UK has the lowest proportion of first degree to Masters level graduates (tertiary-type A qualifications) in engineering. On the other hand, of the comparator countries where the information is available, the UK has the highest proportion of computer science graduates.

Chart 2E: Percentage of Tertiary-type A* qualifications in science & technology subjects, 1998



*Notes: *Essentially first degrees*
***France and Japan all sciences included in Life sciences*

Source: OECD (2000) Education at a Glance 2000

2.22 The UK is an attractive location for international students: approximately a quarter of all postgraduate students and one in ten undergraduate students across all disciplines are from outside the UK. The recent changes to the UK's rules on work permits for overseas students, which complement increased Government support for scholarships and other measures[6], means that international students are increasingly potential UK labour market entrants. Table 2C gives the breakdown by nationality for science and technology subjects in 1999/2000. This shows that for S&T subjects a slightly higher proportion of students are from outside the UK. This is particularly the case for students from other EU countries. In terms of the individual subjects at the postgraduate level, 42% of engineering and technology students are from overseas, compared with 20% of biological science postgraduates.

[6]Further details at http://www.fco.gov.uk/news/newstext.asp?3246 and http://www.fco.gov.uk/news/newstext.asp?2561.

Table 2C: Nationality of Undergraduate and Postgraduate Science and Engineering Students Studying in the UK 1999/2000

	Undergraduates			Postgraduates		
	United Kingdom	Other European Union	Other Overseas	United Kingdom	Other European Union	Other Overseas
Medicine & related subjects	190,220	4,760	5,820	30,370	1,880	3,850
Biological sciences	66,310	3,620	1,570	15,300	1,730	2,200
Physical sciences	49,140	2,220	960	12,630	2,270	2,330
Chemistry	13,790	760	300	4,520	880	690
Physics	8,870	550	200	2,450	570	500
Other physical sciences	26,480	910	460	5,660	820	1,140
Mathematical sciences	15,190	660	690	2,430	550	780
Computer science	68,500	2,660	2,960	13,220	1,430	2,780
Engineering & technology	76,840	9,680	9,640	16,130	4,760	6,870
All Subjects	1,318,540	69,230	59,960	313,150	33,280	62,200

Source: Higher Education Statistics Agency (2001) Students in Higher Education Institutions 1999/2000.

3 THE DEMAND FOR SCIENTISTS AND ENGINEERS

EMPLOYMENT OF SCIENTISTS AND ENGINEERS

3.1 There are some 450,000 economically active people with science degrees (excluding engineering, medicine and subjects allied to medicine) in the UK, of whom nearly 145,000 described themselves as employed in a science occupation[7]. This figure excludes science and maths teachers and HE staff who identified themselves as 'HE teachers' rather than scientists in particular disciplines, as well as those working in science-related managerial, service or other roles. In other words, at least a third of economically active people with a science degree in the UK make direct use of it in their employment.

3.2 The Mason Report on 'The Labour Market for Engineering, Science and IT Graduates: Are there Mismatches of Supply and Demand?' (NIESR for Department for Education and Employment, September 1999) concluded that:

> *The great majority of mismatches between supply and demand for technical graduates are attributable to quality problems rather than any overall shortfall in quantity. A partial exception to this is electronic engineering where the annual new supply has grown very slowly in recent years in spite of high levels of employer demand for graduates in this subject. However, even in electronics, there is evidence of recruitment difficulties being partly due to qualitative factors as well as the relatively slow growth in graduate output.*

This would suggest that the overall number of graduates in these disciplines is adequate, but does not address concerns about the supply of the most highly qualified scientists and engineers and the extent to which time spent in HE equips these individuals for employment.

3.3 The review will be looking at businesses' priorities for high-level researchers' skills, including the balance between knowledge and understanding of fundamental science and transferable skills discussed in paragraph 2.2, and how these compare with more general skills requirements (in particular, the skills required by researchers in higher education).

COMPETING DEMANDS

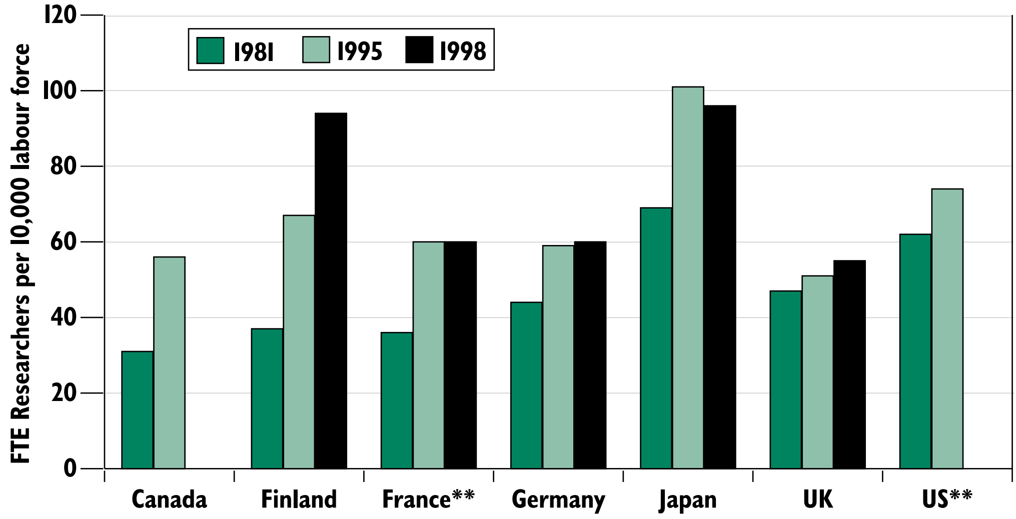
3.4 Highly qualified scientists and engineers are sought after by a range of organisations, not just businesses interested in their specialist knowledge; for example, it has been suggested that financial and IT firms are increasingly choosing to recruit skilled scientists and engineers. The review recognises that there is considerable value in these other roles which scientists and engineers fill. This section presents information on the initial destinations of highly qualified graduates and postgraduates.

3.5 The chart below illustrates the trend in the relative employment of Full-Time Equivalent (FTE) researchers in comparator countries over the last two decades. This shows that despite the higher production of S&T graduates shown in the previous section, the UK had by 1995 the lowest levels of FTE researcher employment per 10,000 employed. Given that the data is only available up to 1998 the impact of recent UK Government initiatives are not yet visible in the data. Where the data is available for 1998 this suggests that the levels in France and Germany had plateaued, while the levels in Japan had declined (but were still ahead of those in the UK). However, the data for Finland indicates that rapid and continuing growth was occurring there. This relatively poor showing for the UK in 1995 and 1998 is

[7] *Source:* Pearson, Jagger and Aston, DfEE Skills Task Force Research Paper 17: Science Skills Issues, 1999.

despite having higher levels than Canada, Finland, France and Germany in 1981. Although there is not a one-to-one relationship between the FTE number of researchers and R&D spend, a similar pattern occurs in terms of the percentage of GDP assigned to R&D. Of the comparator countries in 1998 only Canada spent a lower percentage of GDP on R&D than the UK's 1.83%.

Chart 3A: FTE* Researchers per 10,000 labour force 1981, 1995 and 1998



*Notes: *FTE = Full Time Equivalents*
***France 1997 rather than 1998 and US 1993 rather than 1995*

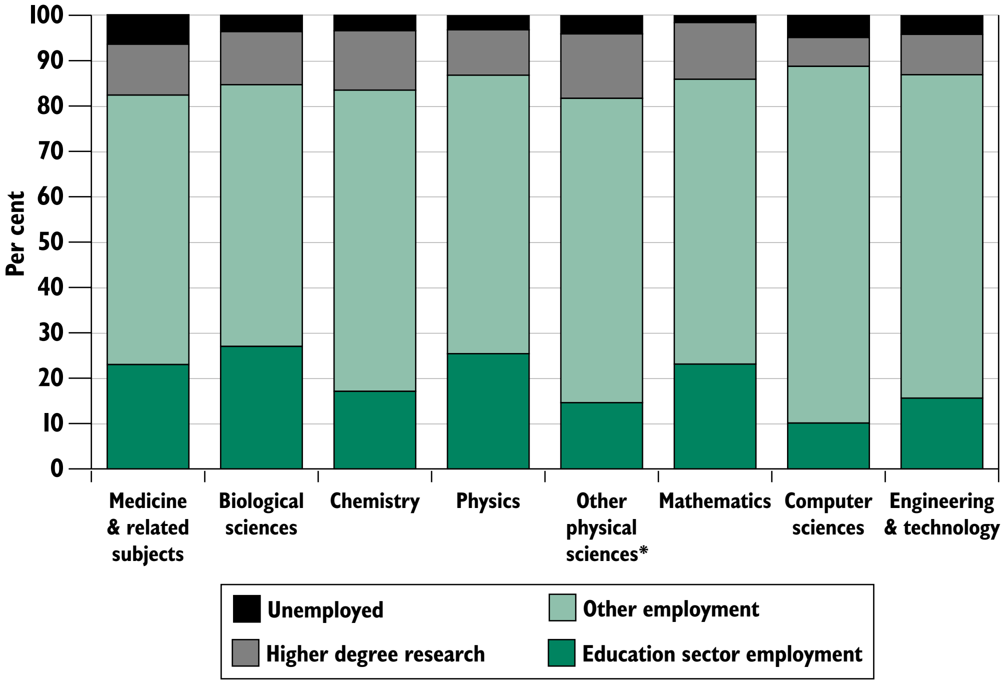
Source: OECD (2001) Main Science and Technology Indicators

FIRST DESTINATIONS OF UK POSTGRADUATES

3.6 Between 1994/95 and 1998/99 there has been little change in the number of postgraduates seeking employment having obtained their higher degree. However, there has been a decline in the numbers of medical postgraduates entering employment other than in the higher education sector and the NHS. There has also been a decline over this period in the number of postgraduates continuing higher degree research in the subject areas of chemistry, physics, computer science, and engineering & technology, while there has been a rise in the subject areas of medicine and biological sciences. However, there is insufficient data at this stage of the review to identify the number of postgraduates undertaking research-based employment, or indeed employment within their field of study.

3.7 Relatively low proportions of those S&T postgraduates whose initial destination in 1989/99 was known were unemployed. As Chart 3B indicates, mathematicians were relatively less likely to be unemployed, while computer scientists and those graduating in medicine and subjects allied to medicine were more likely to be unemployed than other scientists and engineers.

Chart 3B: First Destinations of UK Domiciled Men and Women Obtaining a Full-time Postgraduate Degree, 1998/99



*Notes: *Other Physical Sciences include materials and environmental sciences*

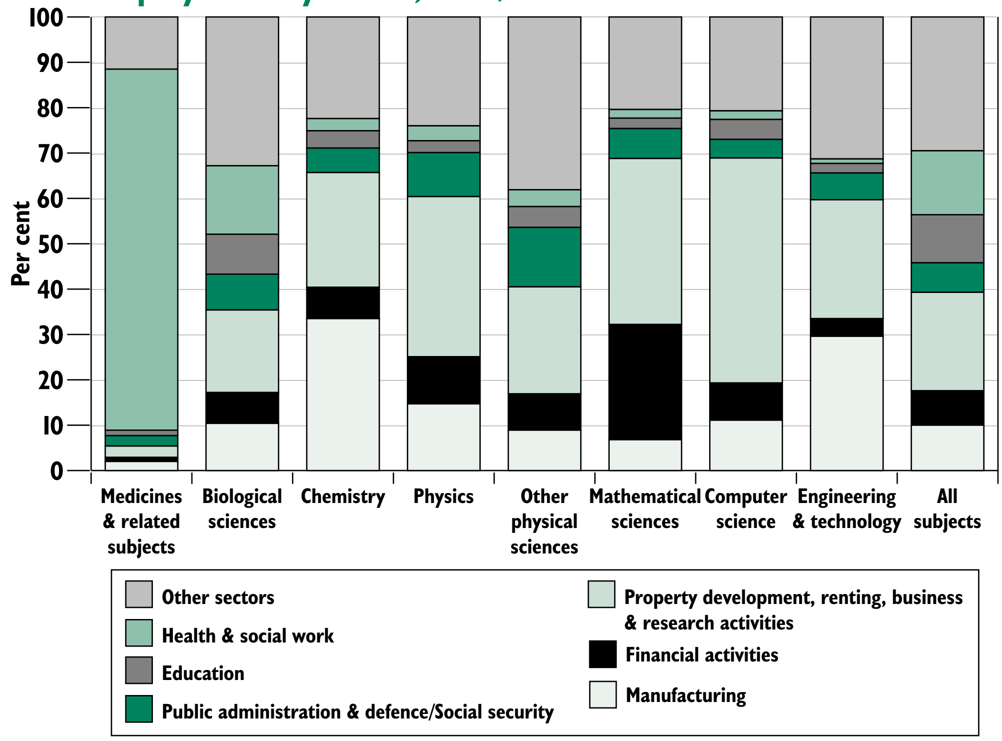
Source: Higher Education Statistics Agency (various years) First Destinations of Students Leaving Higher Education Institutions

3.8 Postgraduate destinations in science and technology need to be seen in the context of first-degree destinations, which are illustrated in Chart 3C. The first destinations of S&T graduates entering UK employment reflect the subject studied; perhaps unsurprisingly, the bulk of first degree graduates in medicine and subjects allied to medicine entered employment in the heath and social work sector. Relatively few first degree graduates immediately entered the manufacturing sector. Of course, first destination data can only reflect part of the picture of careers taken up by scientists and engineers since people tend to move between careers. It is however a reasonable proxy for measuring how closely the careers chosen by science and engineering graduates and postgraduates are aligned to their qualifications.

3.9 Biological science graduates had a strong showing in the heath and social care sector but 18% entered the property development, renting and research activities sector (the catch-all sector that includes R&D establishments and consultancies). However, the subject in which graduates were most likely to enter this sector was computer science (50%). The discipline from which the highest proportions entered manufacturing was chemistry, followed by engineering and technology. On the other hand mathematicians were the most likely to enter the financial services sector, followed by physicists.

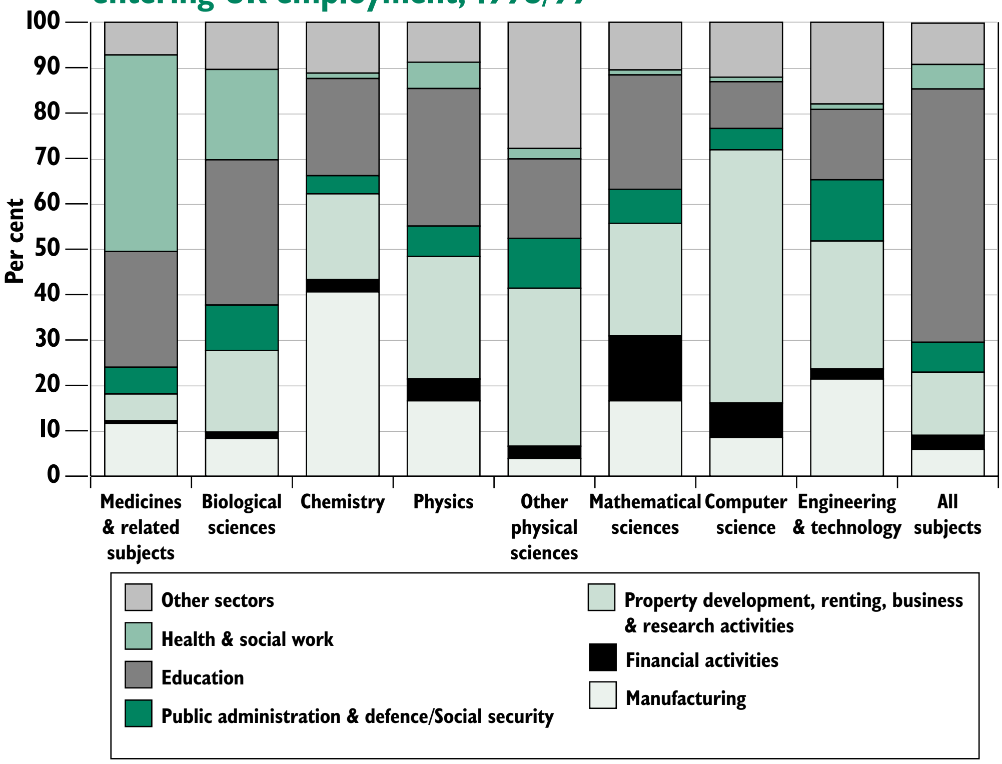
3.10 As would be expected there is a different pattern of sectors for postgraduates entering UK employment, as shown in Chart 3D. Overall, the education sector is much more important; this is to be expected as both teaching (in further and higher education and in schools) and academic research are covered by this category. Chemistry remained the most important discipline in terms of manufacturing employment, mathematics in terms of financial services employment and computer science in terms of consultancy-type employment.

Chart 3C: Destination of first degree graduates entering UK employment by sector, 1998/99



Source: Higher Education Statistics Agency (2000) First Destinations of Students Leaving Higher Education Institutions 1998/99

Chart 3D: Destination of postgraduates by sector for those entering UK employment, 1998/99



Source: Higher Education Statistics Agency (2000) First Destinations of Students Leaving Higher Education Institutions 1998/99

RESEARCH REMUNERATION

3.11 Recent data from the New Earnings Survey below gives comparable earnings data for a range of occupations as defined by the 1990 Standard Occupational Classification (SOC). This suggests that on average natural scientists earned less than those in other professional occupations and less than managers and administrators, while engineers and technologists earned more than other professional occupations but less than managers and administrators. Also, under this measure, university and polytechnic teaching professionals appear second in the list, behind medical practitioners.

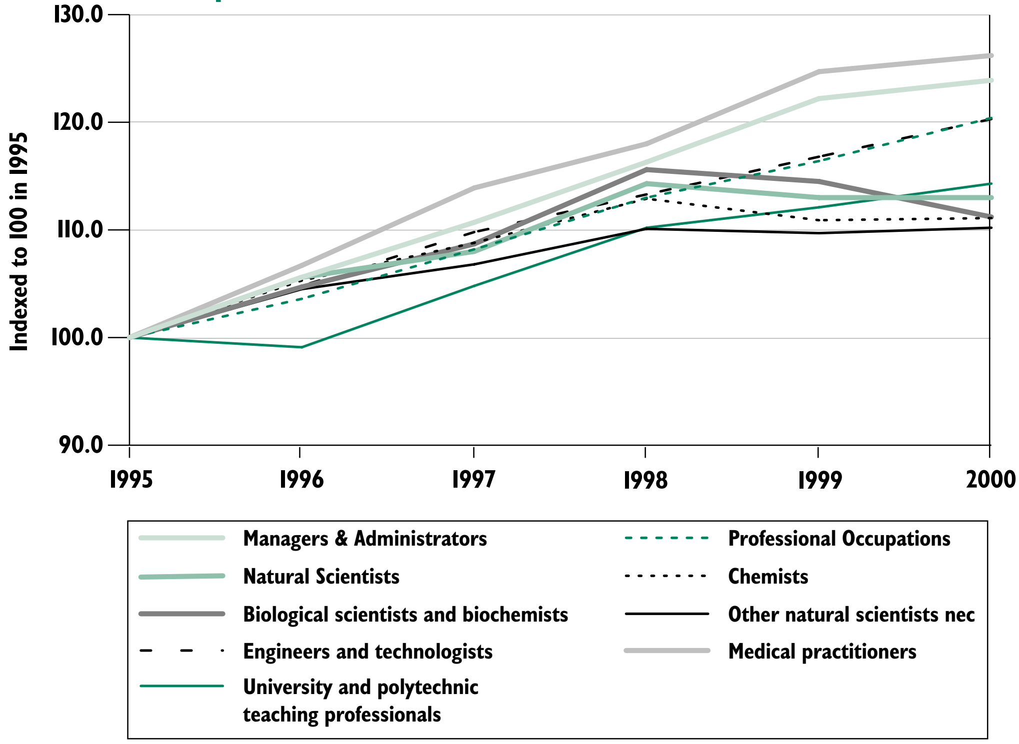
Table 3A: Gross hourly wages for Full-time Employees on adult rates whose pay was not affected by absence, 2000

SOC 1990 OCCUPATIONS	Gross Hourly wage (pence)
Medical practitioners	963.5
University and polytechnic teaching professionals	635.0
Managers & Administrators	608.1
Engineers and technologists	573.3
Professional Occupations	559.6
Chemists	552.3
Natural Scientists	528.6
Biological scientists and biochemists	511.1
Other natural scientists nec	488.4

Source: Office for National Statistics (2001) New Earnings Survey

3.12 Chart 3E, which looks at the changes in salaries, suggests that while salaries for managers and administrators, medical practitioners, engineers and technologists, and those in professional occupations have continued to rise since 1995, those for natural scientists and chemists declined after 1998 and have since reached a plateau, and those for biological scientists and biochemists peaked in 1998, and have since been in decline.

Chart 3E: Relative pay growth for scientists, engineers and other professionals*



*Notes: *On rates (in cash terms) for adults in full-time employment whose pay was not affected by absence*
Source: Office for National Statistics (various years) New Earnings Survey

INTERNATIONAL MARKETS FOR TOP RESEARCHERS

3.13 R&D businesses operate in global markets, both for their products and for the researchers they need. If UK-based firms are unable to recruit in the UK, many of them will look to employ scientists and engineers from elsewhere or relocate. Indeed, some companies actively recruit non-UK nationals for their UK operations, valuing the diversity of approach and experience and also the different skills mix. The review will therefore be comparing UK skills supply and demand, salaries, and other related factors with the picture in the UK's main competitors (the US, Japan, Canada, and leading European states). Particular attention will be given to the motives of scientists and engineers who are trained in the UK but choose to temporarily or permanently pursue a career abroad.

3.14 Furthermore, given the global market for highly skilled scientists and engineers, the review will need to examine the ease with which UK employers can recruit and retain non-UK residents – considering both direct recruitment from overseas and also the recruitment and retention of overseas students studying at UK universities. In this context, the review will need to take into account the recent overhaul of the work permits regime, intended to ease previous recruitment difficulties.

4 KEY ISSUES FOR CONSULTATION

This section sets out the key issues which it is believed the review should explore, looking at the UK's current and future needs. The Review Team intends to discuss these issues with universities, businesses and students and other interested parties; clearly, there will be variation between business sectors, between academic disciplines, and between companies of different sizes (small, medium, large and major multinational). The issues set out below reflect preliminary discussions with key stakeholders in business and higher education.

In addition to specific comments and suggestions on each of the issues identified below, comments are invited on which of the issues set out below are the most important for the review, and on any areas not described below which the reader believes to be particularly relevant. Suggestions for further pieces of analysis and proposals for policy measures to address specific issues are also welcomed. Any evidence which can support comments on the individual questions would be warmly received.

For ease of interpreting responses, it would be greatly welcomed if comments could reference the relevant key issue mentioned below.

The review may wish to publish responses to this consultation. If you would prefer some or all of your comments to be kept confidential, please indicate so in your response.

THE KEY ISSUES ARE DIVIDED INTO SIX SECTIONS:

A. Skills and skills dialogue (employers' skills needs; including dialogue between business and universities about course availability, style and content).

B. Recruitment and retention of researchers (factors affecting the attractiveness of R&D employment relative to other jobs).

C. The education system (factors affecting the supply of researchers, including quantity and quality).

D. Roles and responsibilities (the aims of particular groups such as government and individuals, and the share of responsibilities each has for the development of researchers' skills and knowledge).

E. International dimensions (the supply of scientists and engineers via universities' intake of students from outside the UK and from business recruitment and relocation to the UK from overseas, including students and researchers leaving the UK).

F. Substitutes for scientists and engineers (additional factors which affect the supply of and demand for researchers in S&T, including the skills possessed by non-scientists and the balance between investment in research equipment and spending on research staff).

A. Skills and skills dialogue

In order to influence the skills that researchers learn in universities, innovative businesses need to communicate their needs to universities, and universities need to respond.

The key issues are:

a) What skills does business value most in its researchers? (including issues of how accurately businesses can identify skills needs, and how far in advance)

b) What skills is a researcher expected to have, and how can they be acquired? (e.g. training in business, in HE, through other interests etc.)

c) Are there sufficiently robust processes for communication between business and HE, and how might any deficiencies in these processes be addressed?

d) Are universities able to respond to changing demand from businesses and/or students, and what incentives do they have for doing so?

The major elements in understanding these issues are:

1. Skills needs

1.1 What skills are most important for scientists and engineers in R&D? (Specific scientific/technical, general scientific/technical, interpersonal, management, business, or others)

1.2 What skills is a researcher expected to have, and how can they be acquired? (Formal education, work experience/placement, extra-curricular activities, etc.)

1.3 What skills do scientists have that are valued by other (non-research) employers?

1.4 Do the skills required by academic researchers and business R&D researchers vary, and if so how?

1.5 How do businesses build on the skills that scientists and engineers arrive with as newly employed (post)graduates?

2. Communication mechanisms

2.1 Who should be the partners in the skills dialogue? (roles of Government and devolved administrations, learned societies, Research Councils, NTOs, students etc. alongside HE and business)

2.2 How effective are existing mechanisms for skills dialogue? (on a variety of scales: contact with individual research groups, university departments, HEIs or the HE sector as a whole; knowledge gained by students/required by businesses)

2.3 How could dialogue on skills be improved? (including informal flexible contacts as well as formal, more structured approaches)

2.4 Given that many trained scientists take jobs which do not use their detailed scientific knowledge, how much influence should 'non-scientific' employers of scientists have on the skills dialogue?

3. Planning horizons

3.1 Are the timescales on which business assesses its future skills needs consistent with the time taken for universities to produce people with those skills? This breaks down into two questions:

- Can businesses estimate their skills needs sufficiently far in advance to influence universities' provision of skilled scientists and engineers?
- Can universities respond to businesses' skills requirements in a timely fashion?

3.2 How could the ‘fit’ of HE and business timescales be improved?

3.3 Can the research community (including universities, the Research Councils and public sector research establishments) stimulate businesses’ skills requirements in a timely fashion?

B. Recruitment and retention of scientists and engineers

Scientists and engineers have a range of skills which are in demand not only from universities and firms engaged in R&D, but other professions (teaching, finance and the City, government, etc.). The key issues in recruitment and retention are:

a) Why do people choose the careers they do?

b) Which are the most important factors in researchers’ and potential researchers’ career choices?

c) Is the overall pattern of careers adopted by scientists and engineers a problem for businesses’ R&D activities? (e.g. too many leaving science at postgraduate levels, or moving from R&D to non-technical jobs)

The major elements in understanding these issues are:

1. Pay and financial incentives (as set against financial circumstances, e.g. student debt, and covering SMEs, large businesses, City firms and academic pay);

2. Perks and non-monetary incentives (including quality of workplace/facilities);

3. Stimulation of job (affected by level of responsibility, variety of work, intellectual challenge etc.);

4. Career path (speed of progression, possible directions within a career path, training provided, exit routes);

5. Individual and societal attitudes to particular sectors, professions etc. (e.g. nuclear physics, whole-organism biology, teaching, medicine/healthcare);

6. Job location(s) and individual mobility;

7. Sources of researchers (mobility between HE and business, immigration, on-the-job training/Continuing Professional Development); and

8. Patterns of recruitment and job-shedding in particular sectors, and other labour market issues.

C. The education system

Scientists and engineers are ultimately the product of the whole education system, and the supply of researchers is influenced by the school system and further education as well as undergraduate and graduate education.

The key issues are:

a) What factors in the education system affect the supply of researchers who have the skills required for businesses’ R&D activities?

b) Should more young people in general, or more high achievers in particular, be encouraged to study science and engineering to graduate and postgraduate level, and if so, how?

c) Should more be done by businesses and/or higher education institutions to encourage top science and engineering undergraduates into research, and if so, how? (This also involves the issues around recruitment and retention covered in part B.)

d) Does research training in a university fit researchers for careers in business and/or in academia?

e) Are universities able to respond to changing demand from businesses and/or students, and what incentives do they have for doing so?

The major elements in understanding these issues are:

1. School systems

1.1 Quality of science teaching (including quality of school laboratories, teaching of science by non-scientists, or specialists in other disciplines, e.g. biologists teaching physics; the number and quality of science teachers in secondary schools).

1.2 Form of science teaching (e.g. National Curriculum, dual-award science vs. individual GCSE sciences, mixed-ability teaching, AS and A levels).

1.3 Level of science teaching (e.g. is it too difficult relative to other A levels, or not challenging enough for top students? Does it provide adequate preparation for a science-based degree?).

1.4 Careers advice and science awareness (e.g. adequate information about value of science qualifications, what scientists do, rewards and career paths, nature and value of SET courses in HEIs).

2. Undergraduate education

2.1 Quality of science teaching (including quality of teaching labs, number and quality of teaching and support staff in HE).

2.2 Length of undergraduate degree (increasingly 4 years, with 3-year BSc or equivalent followed by an MSci or similar, to provide additional research experience).

2.3 Content of undergraduate degree (industrial relevance, access to cutting-edge research, access to up-to-date equipment, teaching of 'soft' skills and business/entrepreneurship, quality of teaching and teaching facilities, attractiveness relative to other disciplines in terms of style, content, workload etc.).

2.4 To what extent do financial considerations steer first degree graduates away from higher research degrees into full-time work?

2.5 Careers advice (options for further study/training, careers in science and engineering, placements in industry).

2.6 The funding system for undergraduate courses (including the funding of students and of actual courses).

3. Postgraduate education & training

3.1 Length of postgraduate course (1 year taught Masters or MRes, 2 year MPhil, 3 year PhD, 4 year EngD and new 3 or 4 year PhD with taught elements; issues of over-running).

3.2 Are enough of the best undergraduates being attracted onto postgraduate courses, particularly PhDs? (issues of stipend level, training offered, attractiveness of research and academic careers etc. – also relates to issues of recruitment and retention in part B).

3.3 Quality and content of postgraduate course (including taught vs. research-based courses, requirement for innovative research, quality of teaching and of research supervision, access to business/'soft' skills).

3.4 Careers advice and prospects (options for careers in academic or industrial research, placements in industry).

3.5 The funding system for postgraduate courses (including the funding of students and of actual courses).

4. Post-doctoral researchers

4.1 Quality and content of postdoctoral work (e.g. quality of research supervision, access to business/'soft' skills and other continuing professional development and training).

4.2 Careers advice and prospects (including options for careers in academic or industrial research, and how effectively postdocs are prepared for them).

4.3 The funding system for postdoctoral researchers.

D. Roles and responsibilities

A wide range of bodies, all with distinct identities, aims and priorities, have interests in the area of the supply of scientists and engineers. These interests fall into four main categories: business (and other employers of scientists and engineers), education (particularly HE), government (including the devolved administrations) and the individual (student or researcher). Clearly these sectors are interdependent rather than independent (for example, government is the principal source of funding for education), and the framework of roles and responsibilities is therefore necessarily complex, as illustrated by the wide range of sources of funding for PhDs briefly described in paragraph 2.17.

The key issues are:

a) Is the current division of responsibility for training and development of researchers between and within government, business, the education system and the individual a strength or a weakness in ensuring that innovative businesses can recruit and retain scientists and engineers with the relevant skills?

b) Do roles and responsibilities need to change in order to address any problems with the supply of trained scientists and engineers, and if so how?

E. International dimensions

The market for highly skilled scientists and engineers is increasingly a global one, with businesses actively seeking to recruit suitable people from other countries. Universities, too, seek to access other countries not only for academic staff but also for well qualified students.

The key issue is:

- What challenges are brought about by the increasingly global market for highly skilled scientists and engineers, and how can the Government help the UK economy adapt?

The major elements in understanding this issue are:

1. What are the factors that lead businesses and universities to recruit from other countries?

2. How do UK employers access the skills of non-UK residents and what are the difficulties faced by employers in doing so?

3. Have the recent changes to the UK work permit system (aimed at making it easier for UK employers to recruit high skilled workers from abroad, and for overseas students graduating from UK universities to stay and work in the UK), affected employers' recruitment practices and the supply of scientists and engineers in general? (And if not, why not?)

4. What factors affect decisions by scientists and engineers to work in other countries?

F. Substitutes for scientists and engineers

R&D requires the talents and knowledge of trained researchers. This needs to be looked at in the wider context. One potential way to alter the balance between supply and demand for researchers would be to improve the skills of non-scientists so they can compete better with research-trained scientists and engineers for jobs outside research. For example, numerical ability and IT literacy are among the skills for which scientists and engineers are valued; training more non-scientists of the same calibre in these skills might lead to greater competition for jobs (e.g. in the financial sector), resulting in fewer scientists and engineers being employed outside science and hence more being available to work in R&D. Another factor affecting the demand for researchers is the structure of work in innovative businesses. Would there be scope to free up some of the time of research-trained scientists by recruiting or training skilled technicians, or by investing in more modern research equipment, for example?

The key issue is:

- Apart from direct intervention in the education supply chain by Government and/or business, what other ways are there to affect the supply of and demand for researchers in S&T?

The major elements in understanding this issue are:

1. What skills do non-research businesses value scientists for?

2. Could non-scientists acquire more of these skills, and if so how?

3. Would more scientists and engineers being available to work in R&D lead to more scientists and engineers working in R&D? (relates to recruitment issues in part B about the attractiveness of R&D careers vs. others)

4. What roles do trained scientists and engineers undertake in innovative companies?

5. Could more be done to restructure R&D work, to make better use of scientists' time?

6. Would reduced demand for researchers to work in non-R&D fields (such as firms in the City) alleviate any problems in the recruitment of researchers for traditional R&D fields? (issues of quality of researchers, quality of jobs, recruitment and retention in general)

A

Annex A: Contact Details

The preferred deadline for responses is 31 July 2001. If you are unable to meet the deadline, your views would still be welcomed as soon as is practical.

Please email or post responses to this consultation paper to:

email:	roberts.review@hm-treasury.gov.uk
address:	The Roberts Review Team Room 316 HM Treasury Allington Towers Allington Street London SW12 5EP
fax:	020 7270 4414

Telephone enquiries: please call 020 7270 1383.

Further copies of this paper can be obtained from http://www.hm-treasury.gov.uk/docs/2001/scientists_2006.html

Members of the review team

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B ANNEX B: TERMS OF REFERENCE

The study should:

1. compare the current demand for, and supply of, high-level scientific and technical skills in the UK, focusing on the type of skills required by businesses to lead and underpin their research and development activities (including examining the demand for highly specialised knowledge and skills in particular fields; for broad subject knowledge and for more generic skills);

2. investigate how the demand for, and supply of, these skills is likely to evolve over the next ten years by identifying the major sources of demand (including non science-related employment);

3. understand any factors (other than shortfalls in overall supply) that may hinder innovative companies in recruiting and retaining the highly skilled scientists and engineers with the relevant skills;

4. investigate the mechanisms through which businesses in the UK identify their needs for specific high-level scientific and technical skills and communicate these needs to the higher education sector (primarily, but not exclusively, higher education establishments and organisations in the UK);

5. investigate the way in which the higher education sector – in collaboration with other sections of the education sector – currently responds to these demands (including the process by which those in higher education can access the academic and business research opportunities available to them);

6. propose improvements, if necessary, to these mechanisms to ensure that the higher education sector can and does respond effectively to future shifts in the demand of businesses for particular skills; and

7. analyse whether, over and above any such proposals to improve to these mechanisms, more needs to be done in the short term to seek to address:

   i. any mismatch between the overall demand for particular scientific and technical skills and their overall supply; and

   ii. any factors that hinder the ability of innovative businesses to recruit and retain scientists and engineers with the relevant skills.

The final report will be sent by February 2002 to the Chancellor, the Secretary of State for Trade and Industry and the Secretary of State for Education and Skills.