

5

KNOWLEDGE TRANSFER AND INNOVATION

Summary

5.1 UK business has access to a science base that is excellent, but there is an economic imperative to make sure that scientific knowledge is used by business to create wealth. That is why knowledge transfer – both the science base ‘push’ and business ‘pull’ – is such an important element of the Government’s science and innovation strategy. This chapter sets out the Government’s approach to developing a portfolio of connected national and regional policies which together should improve the effectiveness of the UK innovation system to transfer knowledge in support of public services and wealth creation.

Introduction

5.2 The UK has a strong and growing record of achievement on knowledge transfer out of its publicly-funded research centres. Following public investment and policy reforms in recent years, the UK science base, and within that the leading research-intensive universities in particular, are now playing a far more active and effective role in promoting knowledge transfer and interaction with the rest of the economy. The Lambert Review of Business-University Collaboration acknowledges that the Government’s funding of knowledge transfer has helped to generate culture change and increased capacity to engage with business, and that this is already delivering results. Almost a quarter of innovative enterprises in the UK, employing over 40 per cent of the workforce, now turn to universities as a source of information.

The table below shows that the working relationship between universities and business is continuing to improve.

Table 5.1: Business-university interaction

	1995- 96	1996- 97	1998- 99	1999- 00	2000- 01	2001- 02	increase 1999 to 2002
Business representatives on governing bodies (%)	N/A	N/A	N/A	35	34	36	3%
Full time equivalent staff employed in commercialisation/ industrial liaison offices	N/A	N/A	N/A	1,268	1,529	1,836	45%
Contract research income from business (£ million)	170	188	316	242	259	328	36%
Number of new UK patent applications*	306*	371*	628*	705	896	967	27%
Number of UK patents granted	45	56	162	188	234	199	6%

Number of licenses and options executed	139	177	473	581	728	615	6%
Gross Income from IP licensing (£ million)	12	11	19	23	18	33	43%
Number of spin-out companies (wholly or partially owned)**	28**	26**	-	187	248	213	14%
Number of SET students receiving enterprise training	N/A	N/A	3,000	12,000	11,500	24,000	100%

Source: Various, mainly Higher Education Statistics Agency, up to 1999-2000; the HE-Business Interaction Survey (HEFCE) from 2000-01 onwards. Not all data comparable across 1999-2000 and 2000-01.

*The UNICO survey, used up to 1998-99, includes patenting outside of the UK

** Calendar years.

5.3 Since 1997, there has also been a significant shift in the Government's approach to industrial policy, including support for R&D and innovation. The DTI has conducted a substantial review of its array of industrial interventions, resulting in a major streamlining down to ten business support products. Around half of these are directly related to improving business innovation performance. Over the same period, the Government has devolved an increasing responsibility to the Regional Development Agencies in England to deliver business support products and to shape their own strategies and interventions to improve their regional economic performance, including through knowledge transfer mechanisms.

5.4 In 2003, the DTI's Innovation Report and the Lambert Review both identified complementary actions which should be taken by national policymakers, Regional Development Agencies, universities and businesses to create stronger regional and national networks across the UK innovation system. There is now an opportunity to create even stronger synergies between these stakeholders to deliver a more cohesive approach to knowledge transfer, but one which continues to foster experimentation, enterprise and competition.

Technology Strategy

5.5 The Innovation Report outlined the need for the Government to adopt a more strategic approach to technology innovation and set out the criteria for developing strategic priorities. The Technology Strategy aims to provide a business-driven framework for identifying emerging technologies which will have a significant impact on sectors where the UK has the potential to exploit such technology and the research capacity to maintain a leading global position, as well as deriving wider economic, social or environmental benefits. By focussing on medium to long-term developments in selected technologies, the Strategy is most likely to address the market failures inherent in the UK innovation system.

5.6 The Strategy will be guided by a Technology Strategy Board, which will be independent of Government, business led, and expertly informed through engagement with stakeholders in the science base and business to provide clear and transparent

guidance to Government in setting funding priorities. It will be implemented mainly through two of the DTI business support products:

- the Collaborative Research and Development product, which will fund R&D projects undertaken collaboratively between businesses, universities and other potential contributors (building on the previous LINK scheme); and
- the Knowledge Transfer Networks product, which will support intermediaries in setting up a network bringing together businesses, universities and others with an interest in technology applications (building on the concept of the previous Faraday Partnerships).

5.7 The funding programme underpinning the Technology Strategy was allocated an initial £150 million over the first three years (2004-05 through to 2006-07), to deploy through open, competitive calls for proposals using predominantly the two new DTI business support products described above. A first call for proposals was announced in April 2004 with the priority technologies of:

- new and renewable energy technologies;
- technologies for environmentally friendly transport;
- advanced (composite) materials and structures;
- inter-enterprise (grid) computing;
- sensors and control systems;
- disruptive technologies in electronics and displays; and
- bioprocessing.

5.8 The advantages of such a strategic, coordinated approach are already beginning to emerge. Following the April call for proposals, strong interest is already being shown in the development of national networks in advanced composite materials, sensors, grid computing and bioprocessing. In addition, the programme has catalysed close working between business and UK and European standards authorities on emerging technology areas, such as nanotechnology standards. The DTI will build on this success in subsequent calls for proposals and through the National Standards Strategic Framework.

5.9 The aim is to ensure that all elements of the UK innovation system are active in helping the development and widespread dissemination of technologies which are critical to the competitiveness of British business. To achieve this goal will require a much more networked approach than hitherto, and closer links between stakeholders in the system, including the Research Councils, RDAs and government departments, as well as organisations responsible for developing metrology and standards in the UK. This will build on the coordination mechanisms already in place.

5.10 To develop the Technology Strategy further, resources available to fund priorities identified by the Technology Strategy Board will increase to at least £178 m by 2007-08.

5.11 Over time, the Government's aim is for the DTI Technology Strategy to be a focus of influence for a wide range of actions across Government which have as part of their objectives improving technological innovation in business. There should also be greater synergy between programmes and funding across Government which foster

collaborative business R&D in different fields. As a first step in this direction, DEFRA and DTI will work closely in the coming years to identify a range of R&D and knowledge transfer programmes which will help deliver the twin objectives of reducing business impact on the natural environment, through energy efficiency and waste minimisation, and enhancing UK business innovation, through the development and adoption of new technology. These programmes will be managed through the DTI Technology Strategy. DEFRA will provide up to £50m co-funding for the DTI Technology Strategy over the period 2005-08, from the resources raised through the landfill tax and recycled to business through this and a range of other channels.

Lambert Review of Business-University Collaboration

5.12 The Lambert Review of Business-University Collaboration, published in December 2003,¹ examined the barriers that might hold back business demand for universities' knowledge and skills outputs, and the ways in which universities and business might increase their collaborative efforts.

5.13 The Lambert Review concluded that business R&D is increasingly adopting collaborative forms of innovation, and in seeking out the best research and opportunities to innovate, they are increasingly going global. Capitalising on these trends means universities will have to play a more central role in research work of all kinds. Even though British universities have made real progress in their efforts to work with business, there are significant gains to be made by improving this further. Universities need to get better at identifying and communicating their areas of comparative research strength and at organising themselves in a way that will allow them to exploit their new opportunities in the most effective manner. Businesses must improve their communication of business needs. Overall, the Review concluded that the outlook for R&D in the UK was positive, as new industries and services such as biotechnology and the creative industries increase their investment.

5.14 The Lambert Review identified a number of barriers to greater business-university collaboration including the weakness of business investment in R&D and the need to ensure that research that is relevant to the needs of business is supported and sustained. The Review also emphasised the importance of knowledge transfer, in particular, more frequent and easy communications between business people and academics.

5.15 The Review identified barriers to commercialising university intellectual property (IP), including: a lack of clarity over ownership of IP, resulting in long and costly negotiations; universities setting too high a price on their IP; and variable quality of technology transfer offices where the research base in individual institutions may not be sufficient to support high quality offices on their own.

5.16 The Review recommended a greater role for RDAs in facilitating links between business and the science base, a view the Government shares. Universities are a potential driver of regional economic development. As described in Chapter 9, Regional Development Agencies are taking an active role in making links between business and universities, and are already investing significantly in science, engineering and technology-related activity. The metrics that are being developed for the volume and quality of universities' collaborative work with business (see paragraph 5.28) will help to

¹ Review commissioned by HM Treasury, DTI and DfES in November 2002, and conducted by Richard Lambert, member of the Bank of England Monetary Policy Committee and former editor of the Financial Times. Final report at http://www.hm-treasury.gov.uk/consultations_and_legislation/lambert/consult_lambert_index.cfm

guide and monitor work by RDAs to promote productive interactions between the science base and business in their regions.

5.17 The Review also examined the balance of funding of universities and highlighted the possibility of a negative impact on the level of business-university collaboration if funding for research activities were further concentrated on a small number of world-class research departments. The review recommended that a new funding stream be established, administered by the RDAs, to finance those university departments that can demonstrate strong demand from business for their research. The review also advocated that the Higher Education Innovation Fund should develop into a permanent third stream of funding for universities to build further capacity in the university sector for knowledge transfer.

5.18 Information is also vital to the flow of innovation opportunities. The review recommended new forms of networks between business people and academics. Universities also need to provide more information on student employability and earnings so that businesses and their needs play a greater role in influencing student choice, university courses and curricula.

5.19 The Government supports the conclusions and recommendations of the Lambert Review and the analysis presented. The full Government response to each of the recommendations made by the Review is set out in Annex C. Box 5.1 provides a summary:

Box 5.1: The Government's response to the Lambert Review

The Government agrees with the Lambert review that the **Regional Development Agencies** as business-led organisations are best placed to promote the needs of businesses within their regions and have an important role to play in encouraging greater interchange and engagement between universities and business, especially small and medium-sized enterprises (SMEs). RDAs will also have a strong role to play in facilitating cross-regional activity – a responsibility shared with the higher education (HE) sector. All the RDAs are now setting up Science and Industry Councils that will provide new opportunities for collaboration at a regional level and act as a link to national strategies and programmes. The Government will work with the RDAs to further develop their capabilities in this area.

The RDA's are responding to Lambert in different ways.

Building on current plans to support business innovation through links to the research base, the three Northern RDAs will aim to enhance those plans in response to Lambert to over £100 million by 2010, strengthening university-business collaboration and technology transfer across the North. To complement this and the growing engagement of all RDAs in this area of economic development, the Government will work with RDAs in the development of the new HEIF metrics (details set out in paragraph 5.28), to ensure that proper account is taken of measures underpinning Regional Economic Strategies and the RDAs' tasking framework, and that universities and the RDAs work in partnership to deliver this agenda.

Box 5.1 continued: The Government's response to the Lambert Review

The Government will task the Regional Development Agencies to help a broader spectrum of businesses develop more productive links with the university base, including through support for business-focused research. The RDAs have agreed that business-university collaboration will be one of the measures of RDA performance.

Working in close consultation with the HE sector, the RDAs' deployment of their own funds in this area should meet the following broad criteria:

- investment should be driven by demonstrated support from business;
- regional investment should complement national innovation priorities; and
- public support should not directly subsidise industry's near-market research that is rightly for business to fund.

The Government will support the RDAs in developing the right level of capacity to deliver their knowledge transfer role effectively, and encourage them to make best use of national science and technology strategies in shaping their own regional goals. Regional Science and Industry Councils will be key vehicles for collaboration at a regional level. However, collaborations between universities and businesses across regions must also be encouraged where this provides the best economic opportunities.

The Government confirms its support for the **Higher Education Innovation Fund (HEIF)** as a permanent third stream of funding for universities in England to further build capacity in the university sector for knowledge transfer, and will increase HEIF to £110 million a year by 2007-08.

The Government has facilitated the establishment of an **Intellectual Property (IP)** working group comprising representatives from business and universities. The working group intends to draw up a range of model collaborative contracts and undertake work to develop an IP protocol. The working group has already begun its discussions and will continue to meet under the chairmanship of Richard Lambert. The group aims to have completed its work by spring 2005.

Management and governance in universities has improved in recent years, as has the process of strategic planning and resource allocation. The Review recommended that universities should develop a concise code of governance, representing best practice across the sector. The Government welcomes the work of the Committee of University Chairmen to revise its guidance on good governance, and fully supports a code that challenges the sector to meet best practice. The Government also recognises, however, that there is no one model for ensuring good governance and supports the recommendation that the code should be 'comply or explain', with institutions whose arrangements differ from those set out in the code using their annual reports to present to stakeholders how they are governed and why that structure is effective.

The Lambert Review proposed to the Government and the university sector that improved management and performance should be rewarded with greater autonomy and a lighter regulatory framework. The Government accepts that good regulation should be targeted and proportionate to variation in institutional performance and evidenced risk, and will continue to work with the sector in defining a new way forward, reporting on progress by the end of 2004.

Box 5.1 continued: The Government's response to the Lambert Review

As Chapter 6 sets out, increasing the number of young people engaged in science, engineering and technology (SET) subjects is vital to the future flow of innovation opportunities. As the Review recommended, in order to improve the market signals that might help students make better and **more informed choices about business demand for skills** when choosing which subjects to study at university, the Government will explore the most useful and efficient means of universities providing information on course quality and employment, and will report by the end of 2004.

Linking science push with business pull

5.20 Over the next ten years, it is critical that the levels of business engagement with the science base increase, to realise fully the economic potential of the outputs of our science base. Although innovation depends largely on the knowledge, risk-taking and creative energy of individuals and the private sector, Government will continue to put in place resources to encourage scientists and engineers to turn basic and strategic research into successful new products and services, and to engage more fully with business.

5.21 To do this, the UK needs to continue to build the capacity within universities and Public Sector Research Establishments (PSREs) to undertake knowledge transfer activity, for example by increasing the number of business-credible staff in university technology transfer offices and by investing in the training of knowledge transfer professionals. A solid platform of progress has been achieved in recent years in exploiting the science base, most recently with the second round of both the Higher Education Innovation Fund and the Public Sector Research Establishments Fund.

Higher Education Innovation Fund (HEIF)

5.22 In 2002, the Government consolidated funding for knowledge transfer for universities from a range of schemes into the single Higher Education Innovation Fund (HEIF).² The second round of HEIF (HEIF2, for academic years 2004/05 and 2005/06) attracted bids of over £300 million against the £187 million available, demonstrating the support in the university sector for developing knowledge transfer work. Around 116 English universities will be supported through HEIF2, including more than 100 universities working together in around 46 collaborations, reflecting the quality of knowledge transfer strategies developed by a wide range of institutions. The full results of the HEIF2 competition were announced in June 2004.³

5.23 In line with the Lambert Review recommendation that HEIF be increased in value, and that third-stream funding in future needed to be substantial, permanent and allocated to enable universities to make long term plans, **the Government will further increase the funding available for HEIF to £110 million a year by 2007-08.**

² HEIF is an England-only fund. The devolved administrations have similar programmes of support through their own Funding Councils (see Chapter 9).

³ http://www.hefce.ac.uk/Pubs/circlets/2004/cl13_04/

5.24 Recognising that knowledge transfer activity can take many forms, and that these will be reflective of the nature of activity in a university, HEIF2 included funding for activity promoting a strong and distinct role for less research-intensive departments/groups. This type of activity might include:

- concentrating on acquired knowledge/technology (potentially from more research-intensive HEIs or from other businesses) and working mainly with regionally-based companies, for example through consultancy rather than licensing new technology;
- acquiring leading-edge technologies and exploiting them by creating innovative solutions to real-world problems and needs;
- linking with business in ‘communities of practice’ as part of their day-to-day teaching and research;
- providing more routes to reach small and medium-sized enterprises (SMEs) and less technologically sophisticated businesses; and
- developing an appropriate balance between market-priced interactions and contributions to social and cultural knowledge transfer needs.

Public Sector Research Exploitation Fund

5.25 To stimulate knowledge transfer from the Public Sector Research Establishment base, which has Government investment worth some £1.6 billion each year, the Government has established the Public Sector Research Exploitation Fund (PSRE Fund). The range of organisations which will be funded for 2004-05 and 2005-06, from the PSRE Fund of £15m, included departmental laboratories, Research Council Institutes, NHS Innovation Hubs and a major museum, illustrating the range of research organisations included within the PSRE community. The PSRE Fund also encourages collaborative bids. These made up 10 out of a total of 16 funded proposals, including NHS Innovation Hubs (which provide innovation management services for the NHS Trusts and Primary Care Trusts in their regions), and were formed predominantly along sectoral rather than regional lines, reflecting both the geographical distribution of the establishments and sectoral focus of their work.

5.26 While there are many excellent examples of world-class technology translation among some PSREs, survey evidence suggests that the PSRE sector as a whole lags UK universities by up to five years in its development of knowledge transfer practices and strategies. The Government recognises that there is untapped potential for knowledge transfer in the PSRE sector and will work through the OST and the advisory services of Partnerships UK to help spread and embed best practice in this field. **The Government will increase the funding available through the PSRE Fund to around £20 million a year by 2007-08.**

Prospects for knowledge transfer from the science base

5.27 The Government’s aim for future policy is to create a funding regime that promotes and rewards high quality knowledge transfer, addresses demonstrable funding gaps inhibiting the translation of research and expertise into the market, and further embeds knowledge transfer as a permanent core activity in universities alongside teaching and research. The OST and DfES will work with the universities, PSREs and business to create a long-term career path for academics and technology

transfer professionals who wish to focus on interacting with business and external partners.

5.28 With these aims in mind, the Government will move towards a predictable funding allocation - to HEIs on a national basis - for this activity on the basis of research, commercialisation and other knowledge transfer metrics. This new allocations process will be introduced for a substantial part of the Higher Education Innovation Fund in 2006-7. OST, DfES and the Higher Education Funding Council for England (HEFCE) will take this forward, working with stakeholders through consultation. As part of this work, a robust basket of measures will be developed, building on the Higher Education Business and Community Interaction Survey, that focuses primarily on economic benefit, including metrics of the volume and quality of collaborative research with business, as well as of licensing, spin-outs and business perceptions, but which also reflects the broad range of knowledge transfer activity across the higher education base. The Government will continue to work with universities to encourage those institutions without a strong track record of knowledge transfer to develop, with funding support, effective strategies tailored to the research and teaching strengths of the particular institution.

5.29 Responses to the investment framework consultation revealed that there remains a concern about the availability of proof-of-concept funding. Three Research Councils – NERC, BBSRC, EPSRC – have piloted a ‘Follow on Fund’ to provide such funding. This £1.5m fund was heavily oversubscribed, showing that Research Councils support a tremendous amount of research that is capable of being commercialised, but which is not being fully exploited at present. The bids for HEIF2 funding also reflected strong demand for proof-of-concept funding. For example, Cambridge, Imperial College, Oxford and University College London have been awarded funding to establish collaboratively a proof-of-concept programme to develop technologies prior to licence or spin-out, and to explore and prove the commercial potential of technology-based propositions.

5.30 Lessons can also be learnt from the Cambridge-MIT Institute (CMI) project – a unique innovation in UK higher education. CMI has initiated a range of important and bold experiments, particularly in the multi-faceted interaction with industry areas of emerging technology. For example, in education, CMI has established a set of six one-year MPhil degrees that have a mixture of technical and business/entrepreneurial content. In research, CMI has constructed Knowledge Integration Communities (KICs) centred on selected emerging ideas, developed with industry with a consideration of use. In addition, CMI has developed a series of mid-career educational programmes aimed at delivering skills to support innovation, entrepreneurship and the profession of knowledge exchange. The Government recognises that changing culture and developing and disseminating models is a long-term project, and will therefore work with RDAs and other strategic network partners in the UK to assess and codify successes and fully disseminate the models of Knowledge Exchange developed by CMI.

5.31 To inform and support future policy development of third-stream funding activity, a comprehensive evaluation of all OST-funded knowledge transfer programmes is currently underway and will be completed by October 2004.

Research Councils

5.32 The Research Councils recognise they have a distinctive role to play in ensuring that research outcomes are fully exploited, to maximise the effect of successive increases in Science Budget funding for research activities. The Research Councils

directly support a broad range of knowledge transfer activity and acknowledge that there are opportunities for even greater levels of collaboration with the end users of the research that they fund. There is already a wide array of different approaches to knowledge transfer across the Research Councils, through collaborative research, commercialisation, knowledge networks and education, with the approach adopted varying from one area of research to another.⁴

5.33 Following the DTI Innovation Report recommendation, Research Councils UK (RCUK) is developing an overarching knowledge transfer strategy and each individual Research Council will agree with the Director General of the Research Councils (DGRC) plans and goals for increasing the rate of knowledge transfer and level of interaction with business. These new targets will become an integral part of the OST performance management system for the Research Councils and performance against targets will inform future spending reviews. To help Research Councils deliver these plans, the PSRE Fund will, for the period 2006-07 and 2007-08, provide funding to support the development of Research Council knowledge transfer capabilities.

5.34 Examples of current Research Council plans include:

- **the Arts and Humanities Research Board (AHRB)** will lead a two-year project on the **creative industries** with DCMS to identify the forms of knowledge transfer needed for a sector that does not fit classical knowledge transfer models, and will put in place pilot schemes and incentives as the project develops. The AHRB will also establish sector-based interaction networks; special incubator and proof of concept funding, in partnership where appropriate; and pre-KTP schemes⁵ to draw SMEs into engagement with university researchers. On **museums & galleries**, the AHRB will establish the first ever integrated strategy for research support for these institutions; and
- **the Engineering and Physical Sciences Research Council (EPSRC)** are planning to launch three 'Integrated Knowledge Centres' in partnership with the Funding Councils, DTI and RDAs. These centres will bring together academic excellence with business vision to allow a much richer interchange of ideas and experience. Centres would be chosen to populate different aspects of the technology spectrum essential to the UK's future needs, for example an emerging interdisciplinary technology, a technology gap, or a recognised technology of crucial future importance.

Coordination of knowledge transfer policy and practice

5.35 The previous sections have described the main elements of the UK innovation system which the Government funds. There are four separate, but related, areas where business has a vital interest in policy developments:

- the measures being taken by Research Councils to improve the uptake of technology coming from the science base ('technology push') and the efforts by the DTI to promote demand for new technology in the business community ('technology pull');

⁴ see for example 'Material World: Knowledge Economy', RCUK, 2004

⁵ Knowledge Transfer Partnership schemes of shorter duration (9-18 months) than a standard KTP (two years).

- the scope for Government Departments to give business a more coherent view of their demand for new technologies and, where possible, to pool their resources to foster technology development, for example the growing use of advanced communications technologies in a range of areas, including tackling congestion, healthcare, security and education (discussed further in Chapter 8);
- the growing RDA interest in innovation activities (discussed further in Chapter 9), which will be guided by Science and Industry Councils, and which, in the area of technology innovation, needs to provide cost-effective solutions regardless of region and, for leading edge firms, regardless of country; and
- the European Framework Programme (see Chapter 9) and its complementarity with the DTI's Technology Strategy.

5.36 Each of the stakeholders within the UK innovation system has developed mechanisms for allocating resources within its domain to improve its own performance, and for improving the transfer of knowledge to business. Examples include: RCUK's Knowledge Transfer Committee; a Research Council/RDA Co-ordinating Group; RDAs' Science and Industry Councils within their regions and, collectively, an Innovation Committee, involving DTI, to coordinate innovation policy; DTI's business-led Technology Strategy Board and, to implement its strategy, a Technology Programme Operational Group including stakeholders from the Research Councils, RDAs, OST and other Government departments. In addition, HEFCE administers HEIF, and through its Business and Community Committee and annual HE-Business and Community Interaction Surveys provides a measure of knowledge transfer activities in HEIs, including those encouraged and supported by HEIF.

5.37 It is the better coordination of such efforts, and the clearer perspective which government can give to business about its own plans for policy implementation, which will be an important factor in encouraging business to increase its investment in R&D at a much greater rate than hitherto.

5.38 To ensure that the Government's investment framework for science and innovation is developed in a way that fosters business R&D and innovation in the UK, **the Technology Strategy Board will prepare an annual report for publication on its own activities and on Government policies which relate to technology innovation and knowledge transfer.** This will include consideration of:

- the Research Councils' technology priorities in relation to business;
- the extent to which Government regulation and procurement policies provide clarity as to the challenges and opportunities for business innovation over the coming decade;
- an independent assessment of the regional mechanisms for strengthening technology innovation and the extent to which they are developing cost-effective solutions;
- the extent to which the National Metrology System and the National Standards Strategic Framework is contributing to early uptake of new technology; and

- the UK's priorities in the negotiation of the EU Framework Programme and its benefit to business.

6

SCIENCE, ENGINEERING AND TECHNOLOGY SKILLS

Summary

6.1 To support the UK's ambition to move to a higher level of research and development (R&D) intensity, it is crucial to ensure that the UK has the right stock and flow of skilled scientists, technologists, engineers and mathematicians, as well as technicians and other R&D support staff, generated from within the UK and attracted from abroad. A highly skilled, diverse workforce will contribute to business productivity and innovation, enabling UK businesses to exploit fully new technologies and scientific discoveries, achieve world-class standards and compete globally. Demand from employers for high quality individuals who will be deployed effectively in businesses, universities and the public sector is also critical. Focusing on both the supply-side and the demand-side, this chapter sets out the Government's approach towards achieving a step change in the level of science skills employed in the UK economy.

Introduction

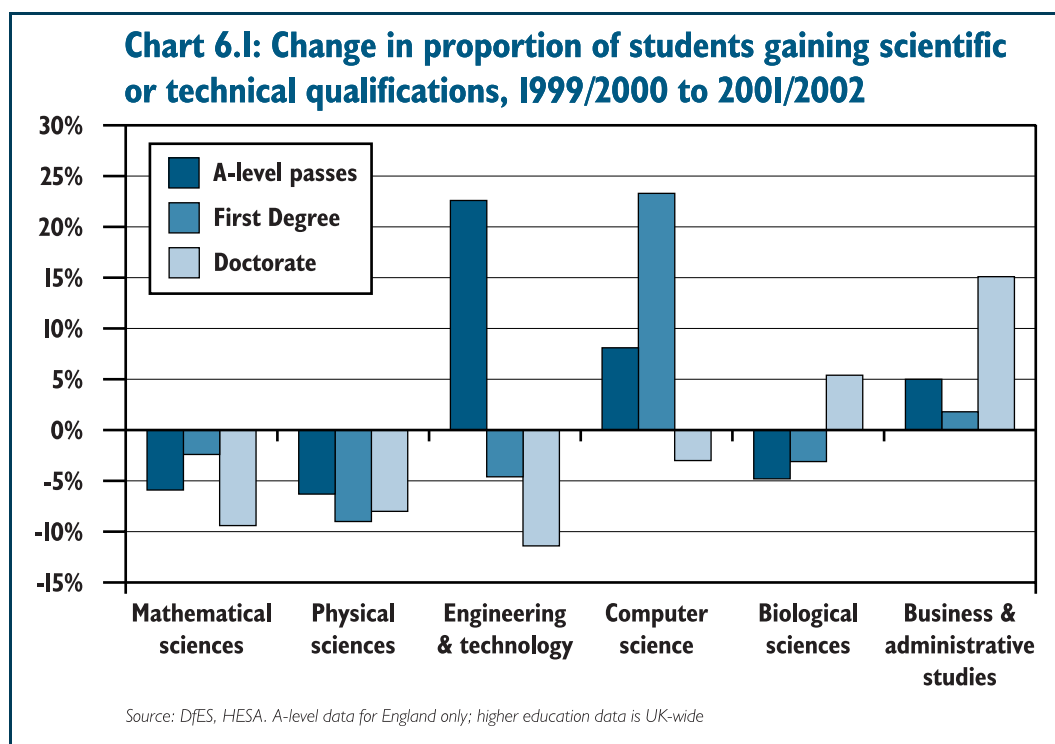
6.2 The Roberts Review¹, published in 2002, provided a detailed analysis of the current supply of science, technology, engineering and mathematics skills. The review found that fewer students in the UK were choosing to study many science and engineering disciplines. As a result of these trends, and increasingly attractive opportunities for skilled individuals to work outside research, the review concluded that emerging shortages in the supply to R&D employers would act to constrain innovation in the UK, not just in these disciplines, but also more widely, since much cutting edge research is multidisciplinary. The Government is currently implementing 'Investing in Innovation'², which incorporates its full response to the Roberts Review.

6.3 Whilst implementation of Roberts' recommendations has not yet had time to make a full impact, Chart 6.1 shows that data collected since publication of the review points to a continued trend of decline in the take up of physical and mathematical sciences and engineering, relative to other subjects. For example, the proportion of students gaining first degrees in physical sciences has fallen by 8 per cent from 1999/2000 to 2001/02³.

¹ Sir Gareth Roberts, SET for Success – The supply of people with science, technology, engineering and mathematics skills, April 2002

² HMT, DTI & DfES, Investing in Innovation – A strategy for science, engineering and technology, July 2002

³ Both references to academic years and financial years are made in this document. Using 2005 as an example, the notation used to depict an academic year, starting in September, is as follows: 2005/06. A financial year, starting in April, is depicted with a hyphen, for example: 2005-06



6.4 Set against this continued decline in the supply of students qualifying in science, engineering and technology (SET) subjects, future demand in the economy for those skills is likely to be strong. This demand is not just in private and public sector research, but also in teaching and in careers outside the science base in high-growth, knowledge-driven sectors for which numerical and scientific qualifications are valuable skills. Projections of the changing occupational structure of the UK economy⁴ suggest that, over the next ten years, the demand for managerial, professional and associate professional and technical occupational groups (including careers in science as well as financial services and consultancy) will see greatest expansion and future demand for skilled workers.

6.5 There has been a parallel decline in the study of mathematics. It is crucial both for the objectives of this framework and for the wider reasons identified in the recent Inquiry by Adrian Smith on post-14 mathematics⁵ that the Government also addresses the problems in mathematics. The DfES's response⁶ to the Inquiry in respect of England sets out complementary ambitions and commitments on mathematics.

6.6 Responsibility for improving scientific skills and education in Scotland, Wales and Northern Ireland is devolved and the devolved administrations are developing their own policies for tackling these issues. In these areas, the normal devolved funding arrangements apply and the Government intends to work closely with the devolved administrations in implementing the skills strategy set out in this chapter, including to identify and exchange best practice.

⁴ Working Futures: National Report 2003-4, Institute of Employment Research, University of Warwick

⁵ Making Mathematics Count, The Report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education, February 2004

⁶ Making Mathematics Count, The Department for Education and Skills' response to Professor Adrian Smith's Inquiry into Post-14 Mathematics Education, July 2004

Government's ambitions

6.7 If we are to meet our goals for increasing research intensity in the economy over the next ten years, all stakeholders – in the private and public sector – need to focus on the supply and demand for SET skills. Ensuring that there are strong market signals will attract individuals to develop these skills and use them to move into key sectors that develop high value products. The Government's vision is to create an education and training environment that delivers the best in SET teaching and learning at every stage and is responsive to the needs of learners, employees, employers and the wider economy⁷.

6.8 The Government's overall ambitions are to achieve a step change in:

- the quality of science teachers and lecturers in every school, college and university;
- the results for students studying science at GCSE level;
- the numbers choosing SET subjects in post-16 education and in higher education; and
- the proportion of better qualified students pursuing R&D careers.

6.9 Box 6.1 below sets out the key new commitments in this framework to ensure that the Government meets its ambitions. Table B.5 in Annex B sets out in full the indicators and goals the Government will use to track progress against these ambitions.

Box 6.1: Key new commitments in the framework

In Schools, the Government will:

- eliminate as far as possible the undershooting of the national Initial Teacher Training targets for science by 2007/08;
- double the number of science places on the Graduate Teacher Programme from 2005/06 (provided that sufficient demand from schools for places remains);
- increase the value of the teacher training bursary for science graduates from £6,000 to £7,000 from September 2005 and raise the 'Golden Hello' for new science teachers from £4,000 to £5,000 for trainees entering PGCE and equivalent courses from September 2005;
- deregulate the salaries of science Advanced Skills Teachers, including removing the cap on how much they may be paid (subject to the School Teacher Review Body's recommendations), resulting in science teachers on the advanced skills scale securing a high minimum pay of £40,000 (£45,000 in London);
- train a new cadre of science-specialist Higher-Level Teaching Assistants to enable every secondary school in England to recruit at least one by 2007/08;

⁷ Government ambitions for SET skills in this chapter refer to the policy goals of the DfES for England, and the Research Councils and OST goals for higher level research training across the UK

Box 6.1 continued: Key new commitments in the framework

- improve the quality of science teaching by expanding the continuing professional development opportunities available to science teachers, and enhancing support for the new Science Learning Centres; and
- expand substantially the number of undergraduate volunteers supporting pupils learning science, by 2006/07.

In Further Education, the Government will:

- undertake immediate research to understand why and when teachers join and leave the sector to inform a long-term strategy to reduce shortages, including in SET, with indications available by March 2005;
- continue 'Golden Hellos' for teachers in shortage subjects and increase the amount paid to science teachers (from £4,000 to £5,000) from 2005/06; and
- continue supporting, subject to forthcoming evaluation, the bursary scheme for trainee teachers with an expectation that future payments will be increased for science (from £6,000 to £7,000) once data is available on subject specialism from 2005/06.

In Higher Education (HE):

The Higher Education Funding Council for England (HEFCE) will:

- work to increase significantly the science links to schools by supporting Higher Education Institutions (HEIs), industry and scientific societies in their outreach activities to schools and colleges in order to increase physical sciences and engineering participation in HE; and
- take a more active role in examining the implications that falling science provision may have for student access at the regional level. HEFCE will now consider providing additional funding to university departments if there is a powerful case that falling provision in a particular region would hinder student access to disciplines that are important to national and regional development.

The Government will:

- ensure high quality information is provided to prospective students and will explore with HEIs and others the most useful and efficient means of providing information on course quality and employment and salary outcomes across subjects by each HEI, including through the Teaching Qualification Index web-site and HEIs' prospectuses, and will report back by the end of 2004;
- increase the PhD stipend in line with inflation over the SR2004 period and will also review the stipend rate over the period, implementing any further increases where appropriate; and
- maintain the funding for 'Golden Hellos' for new teaching staff in shortage subject areas beyond 2005-06, subject to the evaluation showing that the initiative is good value for money.

6.10 The Government remains aware that, as well as tackling overall levels of supply, the UK needs to improve the participation of women in science careers, making the most of their skills. In November 2002, the Secretary of State for Trade and Industry

commissioned a report on the position of women in science, engineering and technology by Baroness Susan Greenfield⁸. This chapter outlines what is being done to implement the Government's response to that report and sets out **the Government commitment to invest £2.4 million in a new resource centre for women over the next three years, to help employers make SET a more attractive career for women.**

6.11 It will be important to bring coherence and coordination to the many science, engineering, technology and mathematics initiatives across the education system. A new high-level strategy group jointly chaired by the Minister of State for Lifelong Learning, Further and Higher Education and the Minister for Science and Innovation will take this work forward ensuring explicit links are made across the education system and with employers, and that any gaps in policy identified are addressed. **The Government will review, with key stakeholders, the evidence on student participation in shortage subjects in schools, further education and higher education, and workforce employment, annually, and will judge the relative balance between supply and demand for those skills over the medium-term and recommend whether there is a need for further action by Government or by others.**

Schools – enthusing pupils to achieve in SET

6.12 School level experience of science is crucial to pupils' aspirations. Science results are improving with just under 70 per cent of pupils achieving level 5 by age 14, comparing well with English results at that age. At GCSE level, 48 per cent achieve A*-C in any science in comparison with 56 per cent gaining an A*-C grade in English. However, as industry and academia reinforced through the consultation, it is the overall experience young people have of science, as well as their results, which influences decisions. It is important that we enthuse and inspire young people and enable them to become informed citizens or scientists of the future, willing and able to engage with science.

6.13 The Roberts Review identified the main factors that influence pupils' achievements and enthusiasm for particular subjects as: teachers and their style of teaching; the teaching environment; the curriculum; public and media perception; and careers advice. Science subjects are also often seen by young people as 'more difficult' and 'less relevant' to their outside lives. The consultation responses on this framework echoed these findings. The responses also suggested that there is a lack of encouragement in schools for girls to study science subjects, and that they continue to receive careers advice which pushes them towards a narrower range of careers than boys.

6.14 The Government aims to improve young peoples experience of school science by enhancing learning and raising standards to ensure that young people have: sufficient knowledge and enthusiasm to pursue further science study post-16; an understanding of the importance of science and technology to the world around them; the relevant skills to move into the labour market; and an understanding of the career opportunities offered by science skills.

⁸ SET Fair – a Report on Women in Science, Engineering and Technology, from the Baroness Greenfield CBE to the Secretary of State for Trade and Industry, July 2002

A new relationship between government and schools

6.15 We need strong foundations within our schools in which science education can flourish. The Government is now looking again at the relationship between schools and central and local government. This will mean that underperformance in science can be identified and schools will receive the support they need. The Government will build a new relationship with the profession which:

- builds the capacity of schools to be learning institutions through self-evaluation, collaboration and effective planning for improvement;
- rests on an intelligent accountability framework that is rigorous but lighter touch, giving both schools and parents the information they need;
- makes it easier for schools to access the support they require without being subject to duplicative bidding, planning and accountability systems;
- puts in place a simpler streamlined school improvement process based around a school's own annual cycle of planning, development, reflection and evaluation; and
- enables a unified dialogue to take place between schools and the wider education system, pinpointing and disseminating best practice.

6.16 With these new arrangements, based on an intelligent accountability framework, the Government will be better able to pinpoint schools that are underperforming in science. The Government will also be more able to ensure that schools are able to access the support they need to address this and deliver high quality science teaching and learning.

6.17 It is also vital to we learn from the best schools and the best teachers. The network of increasing numbers of specialist schools will play a key role in disseminating best practice amongst schools. There are currently 224 designated Specialist Science Colleges, 35 Engineering Colleges, and 545 Technology Colleges. Specialisation allows pupils to experience a creative climate for learning and allows schools to develop innovative practice in teaching and learning and offer extended curriculum opportunities. The Government aims for every school to become a specialist school.

6.18 The Government's arrangements for professional development are also key to improving teaching and learning and disseminating best practice. These will ensure that professional development is integral to raising standards and delivering a personalised approach to science learning. A closer integration between strategically focussed professional development, performance management and school improvement will help raise standards of teaching and learning within schools. At Key Stage 3 the National Strategy framework and curriculum materials already help teachers to teach engaging, challenging and inspiring lessons, and to establish high expectations for their pupils. The Science Learning Centres will also play an important role in disseminating best practice in science teaching.

Creating a better school environment

6.19 The Government also recognises that pupils are more likely to thrive in a good quality physical environment. The Government will continue to improve the quality of school buildings, creating inspiring science learning environments that accommodate practical science and provide access to cutting edge ICT equipment by:

- renewing all secondary schools in England, including science provision, through the Building Schools for the Future programme, in a ten to fifteen year programme starting in 2005-06;
- providing capital funding to schools and authorities to meet the Roberts Review target of bringing school labs up to a satisfactory standard by 2005-06 and to bring them up to a good or excellent standard by 2010;
- providing a range of exemplary designs for secondary schools which will benchmark school design standards to meet the teaching and learning needs of the 21st Century in flexible and sustainable ways; and
- using 'Classroom of the Future' projects to challenge established thinking and provide models of exciting new ways of providing science teaching environments.

Ensuring a good supply of well qualified science teachers

6.20 A good supply of high quality science teachers is crucial to achieving results in the classroom. In recent years there have already been real improvements in the recruitment of new graduates and career-changers into science and mathematics teaching. In 2003/04, 2,910 people had started science initial teacher training courses, which represents an increase of 7 per cent on 2002/03 and a 23 per cent rise since 1999/2000. The Government also supports and encourages individual schools' efforts to use existing pay flexibilities in order to recruit and retain high calibre teachers. However, the Government acknowledges that, in the past, some of the greatest teacher recruitment challenges have been seen in these areas. This was echoed in the consultation responses which emphasised the importance of eliminating teacher shortages and ensuring a good supply of high quality teachers over the longer term. The Government is encouraged by recent progress in science teacher recruitment and is committed to ensuring that teacher shortages in science becomes a thing of the past.

Box 6.2: Science Teaching

The Government recognises that the remuneration graduates in SET can command elsewhere in the economy may have been an obstacle to recruiting the right quantity and quality of science teachers in the past.

Recent incentives to attract graduates to train and teach in shortage subjects (science, maths, English, modern languages and technology) have been successful. Since introduction of these incentives, there have been real improvements in the recruitment of new graduates and career-changers into science teaching. In 2003/04, 2,910 people had started science Initial Teacher Training (ITT) courses, which represents an increase of 7 per cent on 2002/3 and a 23 per cent rise since 1999/2000. The Government believes that this represents real progress towards reducing shortages and is committed to ensuring this continues over the next ten years. Since 2000/01, the Government has offered graduates:

- £6,000 training bursaries during their Post-Graduate Certificate in Education (PGCE) courses; and
- for shortage subjects, 'Golden Hellos' of £4,000 lump-sum payments normally made after one year teaching.

The Government believes this package of incentives has brought about a real change in recruitment into science teaching. However, in January 2004, there were still 240 unfilled science teaching posts in England, more than for any other subject except mathematics.

The Government is committed to making further progress. **The Government will increase the value of the teacher training bursary for science graduates from £6,000 to £7,000 from September 2005 and raise the 'Golden Hello' for new science teachers from £4,000 to £5,000 for trainees entering PGCE and equivalent courses from September 2005 onwards, and commits to eliminate as far as possible the undershooting of the national ITT targets for science by 2007/8.**

There are also an increasing number of people choosing to move into teaching from other careers. The Graduate Teacher Training Programme offers those moving from other professions into teaching a salary of £13,000 (outside of London) while they train. Places on the programme have grown each year since its inception in 1998 and the programme is still significantly oversubscribed. This is very encouraging and **the Government now commits to double the number of science places on the Graduate Teacher Programme from 2005/06, provided that sufficient demand from schools for places remains.**

The Government has given schools more freedom to reward their best teachers. They can now pay any teacher whatever recruitment and retention incentives and benefits they wish. The Government strongly supports and encourages individual schools' full use of these pay flexibilities.

6.21 The Government also believes it is very important to reward and retain good teachers. It will continue to recognise excellent science teachers, giving them the opportunity to become Advanced Skills Teachers (ASTs). ASTs move on to a higher pay scale while continuing to teach their subject and they spend a day a week working with teachers in neighbouring schools to raise standards of teaching and learning. Over time the aim is for 3-5 per cent of all teachers to become ASTs. The Government will work with key partners to encourage the effective deployment of ASTs to ensure that their work with other teachers is well planned so that their expertise is passed on to other science teachers, disseminating and sharing good practice. **The Government is now committed, subject to the School Teachers' Review Body's recommendations, to**

deregulating the salaries of science ASTs. This will remove the cap on how much science ASTs will be paid and guarantee a high minimum of £40,000, and £45,000 in London.

6.22 To allow all teachers to give maximum focus to their teaching, the Government will, through the National Agreement on Raising Standards and Tackling Workload, move over the next three years to a reformed workforce with significantly reduced burdens of bureaucracy. As part of this reform, the Government will guarantee every teacher in England dedicated time away from the classroom, to plan and prepare lessons of even greater quality in science and related subjects. The Government and key partners will also develop other members of the schools' workforce, including support staff.

6.23 The Government will also increase the support available to science teachers by employing more and better trained support staff. The new Higher Level Teaching Assistant (HLTA) role will make better use of existing expertise among support staff. There will be 7,000 funded HLTA training places by the end of 2004/05, rising to 14,000 in 2005/06 and 20,000 in 2006/07. **The Government will recruit, train and support, through ongoing continuing professional development, a new cadre of science-specialist HLTAs to enable every secondary school in England to recruit at least one by 2007/08.**

6.24 The Government also believes that, to sustain a high quality teaching workforce, professional development must be valued as an integral part of a school's success strategy. The Government is developing a vision for a mainstreamed and strengthened professional development framework for teachers, supported by rigorous new teaching and learning reviews. The Key Stage 3 Strategy continues to offer significant continuing professional development and other support opportunities for science teachers. The science strand helps teachers build more effectively on pupils' earlier learning, ensuring progression for all whilst developing a broader understanding of science that is relevant and exciting. The target is for 80 per cent of pupils to achieve level 5 or above in Key Stage 3 science by 2007.

6.25 Science Learning Centres will also play a key role in providing subject specific professional development to teachers and technicians, encouraging innovative and exciting teaching practice. All ten centres will be open by 2006, with each regional centre delivering between 750 and 1500 training days per year, according to the size of the region. **The Government is improving the quality of science teaching by expanding the continuing professional development opportunities available to science teachers, and enhancing support for the new Science Learning Centres.** The Government will evaluate how best to target this support to help the centres maximise their impact, for example through intensifying provision or targeted subsidies.

Creating a curriculum that enthuses and inspires pupils

6.26 A science curriculum that is relevant and imparts key knowledge and skills is critical, if we are to excite young people about science. It also needs to be flexible enough to meet the needs of all individual students and enable teachers to use creative and innovative approaches and resources. There are already important changes taking place, for example, the Applied Science GCSE and the pilot GCSE Science for the 21st Century. From 2006, teachers will have even greater flexibility to support creatively all students with the introduction of a new Programme of Study for science at Key Stage 4 containing significantly less detailed content.

6.27 The Working Group on 14-19 Curriculum and Qualifications Reform, chaired by Mike Tomlinson, is developing a diploma framework which will include: the generic skills needed by everybody for any further learning, employment and adult life; and the specific subjects and areas of learning in which young people want to progress. This will set the agenda for any further changes in the curriculum. The Government is committed to ensuring that the right opportunities to study science, and to carry on with future study in these areas, will be available.

Working in Partnership

6.28 Partnerships with key stakeholders, including employers, universities, science centres, learned societies and Research Councils are an important way of enhancing science teaching and learning. Attitudes to science are often formed before people leave school and these partners have a vital role in demonstrating to young people some of the exciting and inspiring opportunities that studying science can lead to, as well as helping to make science relevant and encouraging them to debate current issues. The Government will encourage schools to pursue challenging science learning experiences outside the classroom, working through local partnerships.

6.29 Since its inception in 1999, the Student Associates Scheme has been placing an ever growing number of high quality university students who are passionate about their subject, into schools. By bringing cutting-edge research into the classroom, these students have helped to inspire both pupils and teachers alike. By 2005/06, the scheme will offer 10,000 places to higher education students, a high proportion of which will be in the shortage subjects of mathematics, science, modern languages, design and technology, and information and communications technology. **The Government will expand substantially the number of undergraduate volunteers supporting pupils learning science, by 2006/07.**

6.30 SETNET (the Science, Engineering, Technology and Maths Network) coordinates the UK-wide network of some 50 SETPoints, which are tasked with ensuring that science and technology activities are made available to schools. The Government wants to encourage more support for this scheme from industry and also to ensure that SETNET modernises its delivery to engage with Specialist Science schools and Science Learning Centres to enthuse more young people to follow scientific careers and equip all to be active, informed citizens of the future. By working with other networks, including Science Learning Centres and Specialist Schools, SETNET will enable better co-ordination of external resources on science learning for schools.

6.31 SETNET also operates the Science and Engineering Ambassadors (SEAs) programme which encourages young scientists and engineers to visit schools to discuss their work. This is a successful initiative with schools, Ambassadors and their employers. The number of Ambassadors has increased dramatically from 657 in December 2002 to the current figure of over 6,000 (of these some 35 per cent are women and about 40 per cent are under 35 years old). The programme is on track to achieve a target of 12,000 SEAs by March 2005. The scheme will continue to seek to ensure young people are stimulated by meeting and hearing from role models who are using science skills in their working lives, including employees from some 600 organisations, including GSK, Microsoft, BAE Systems, Astra Zeneca, BP, BT, Thales, Rolls Royce, Pfizer, Severn Trent Water and many universities, including Oxford, Cambridge, Central England and Imperial College.

6.32 Subject to its continuing performance, the Government will continue to provide financial support at the current level of around £3 million a year to SETNET and will also provide funding of up to £1.8 million over three years to enable it to improve their delivery by introducing ten regional coordinators.

6.33 Many individual employers and higher education institutions participate in their own individual partnerships and programmes with schools, such as Imperial College and GlaxoSmithKline's INSPIRE scheme. The Government recognises the huge amount and range of good work that the R&D industry undertakes in partnership with schools to encourage pupils to engage in science and provide work experience and advice about careers in these areas. The Government fully supports industry's ongoing efforts to share best practice in this area with a view to strengthening and broadening the scale of this engagement. In particular, the Government encourages participation in the Science and Engineering Ambassadors programme. The Government will also encourage industry to work with the new Science Learning Centres.

Box 6.3: Careers Advice

For young people to make sound decisions about learning and career choices, they need access to good quality careers education and guidance – which helps them develop the knowledge to make successful choices, and manage transitions in learning and into work. Through partnership between schools, the Connexions Service and employers, the Government will work to raise the effectiveness of careers education and guidance, and to ensure that quality information, advice and learning opportunities are available to help young people decide how to build on their science education through training, further or higher education or in employment.

The curricular reforms currently being developed will open up a much wider variety of learning options to young people in schools. In order to ensure that pupils have access to good quality advice at key decision points before and during the 14-19 phase, the Government will build on the recommendations of the current review of careers education and guidance, which will report to Ministers in summer 2004.

From September 2004, the statutory duty of all maintained schools to provide planned careers education for all pupils in years 9-11 will be extended to include years 7 and 8.

Maintained schools, further education and sixth form colleges are required to work in partnership with the Connexions Service to make impartial careers guidance available to students, ensuring they have access to information and advice – either through careers advisors or available through libraries, the Internet and other sources – on issues that might affect their progression through learning and into working life.

The Connexions service also offers a conduit for good quality careers information from employer organisations or sector bodies. With employer support, students will be taught increasingly about industry's needs, and in a business environment. The Government will work closely with Connexions and join forces with the Science Council to build on some of the excellent work which is already being taken forward in promoting SET. The Government will exploit the knowledge gained through research reports commissioned by Engineering and Technology Board such as Ready SET Go, which explores the role of careers services in making SET more appealing, especially to women and the Government will work with the Science Council on developing a science careers website.

The Government will track progress in the Schools area by monitoring:

- **Science GCSEs** – to improve science GCSE results
- **Recruitment into science teacher training** – to eliminate as far as possible the undershooting of the national Initial Teacher Training target by 2007/08
- **SET participation at A-level and other level three equivalents** – to increase the number of young people choosing to study these subjects

Post-16 Sector – encouraging and supporting SET

6.34 Over the past ten years, student choices at A-level have been moving away from maths and science subjects. Since 1995, there has been a 13 per cent drop in the number of students choosing to study A-level maths, a 13 per cent drop in physics and a 15 per cent drop in chemistry⁹. Against this, very strong growth has been seen in students choosing design and technology, business studies, psychology and media/TV/film studies, with a more modest growth in English. In order to reverse this decline, the focus of the Government's efforts will start in schools. In tandem, ensuring a high quality post-16 system, well equipped to teach and inspire, will act as an incentive for learners to pursue further education and training in these areas and as a driver for learners to continue to study these subjects in higher education.

6.35 The post-16 sector is important not only because it delivers one third of A-level provision, but also because it provides vocational pathways for studying SET for those who enter the workforce with intermediate qualifications. There are identified skills shortages within the UK economy, in particular at intermediate skills levels and related to SET areas such as skilled technicians¹⁰.

6.36 Apprenticeships offer a work-based learning route with opportunities to progress from level 2 on to level 3 (an Advanced Apprenticeship) and for those with the ability and ambition to do so, enter Higher Education. These progression routes are particularly well developed in the engineering sector, where good use is being made of Foundation Degrees. SEMTA, the Sector Skills Council (SSC) for Science, Engineering and Manufacturing Technologies, has been funded by the DfES to develop a Foundation Degree, and both SEMTA and e-Skills UK (the SSC for IT, telecoms and contact centres) are among the sectors involved in compacts to offer seamless progression routes from Apprenticeship to Foundation Degree, to inform best practice. These compacts will run until 2006.

6.37 The Government will continue to improve the quality and effectiveness of further education and training through the joint DfES and Learning and Skills Council (LSC) strategy, 'Success for All'¹¹. This is a far reaching reform agenda to improve the quality and effectiveness of post-16 SET provision. Mechanisms to do this include Strategic Area Reviews and three year funding agreements with providers. There will also continue to be rigorous inspection of post-16 provision by Ofsted and by the Adult Learning Inspectorate. The Government will also work to improve the skills of the UK workforce through the implementation of the 2003 White Paper '21st Century Skills:

⁹ DfES, data is for all ages

¹⁰ National Employer Skills Survey 2003, Learning and Skills Council

¹¹ Success for All – reforming further education and training, DfES, November 2002

Realising our Potential'. The Government has already taken forward curriculum reforms described in '14-19: opportunity and excellence'. These three strategies lay sound foundations for improving the quality of teaching and learning in SET.

Ensuring a good supply of high quality SET teachers

6.38 The Government is committed to ensuring a fully qualified, good supply of post-16 teachers in SET. A key aim of Success for All is that by 2010, the existing learning and skills sector workforce, including SET teachers, will be fully qualified. However, there is a lack of robust national data on the recruitment and retention of SET post-16 teachers. The Government recognises that this is needed urgently. **To further understand why and when teachers join and leave the sector, DfES will undertake rapid, focused research to fill information gaps about the SET workforce in the post-16 learning and skills sector. Early indications will be available by March 2005.**

6.39 There are currently a limited set of centrally managed recruitment and retention incentives similar to those in schools – including targeted 'Golden Hellos' and teacher training bursaries. **The Government commits to continuing 'Golden Hellos' for teachers in shortage subjects and from September 2005 onwards will increase the amounts paid for science teachers from £4,000 to £5,000.**

6.40 Subject to forthcoming evaluation, the Government will also continue to support the teacher training bursary scheme with an expectation that future bursary payments will target shortage subject areas, and be increased from £6,000 to £7,000 for science teachers, once data is available on subject specialism from 2005/6.

6.41 Creating and developing excellent leaders in the post-16 sector will also be key to achieving a good quality workforce. The Centre for Excellence in Leadership (CEL) will deliver face-to-face teaching, on-line learning, conferences and master classes for leaders and potential leaders in the post-16 sector. CEL will also provide clarity on leadership roles in the sector and will be supporting individuals to lead SET, and other, curriculum areas effectively and to identify career paths in SET subjects.

6.42 In 2004, it is expected that the Lifelong Learning Sector Skills Council (LLLSSC) will be established. The LLLSSC will progressively ensure that professional standards are set for workforce development for FE, HE and the wider learning and skills sector. They will include standards for SET teachers, technicians and curriculum managers.

6.43 As part of 'Success for All', the DfES Standards Unit, in consultation with experts, stakeholders and practitioners from the sector, will also improve teaching and learning in post-16 science, engineering and ICT provision. This includes identifying, developing and disseminating best practice; developing associated programmes of professional development for teachers; improving initial teacher education in science, engineering and ICT; and strengthening provision through improving links with industry and extending the use of e-learning. Funding for continued professional development (CPD) and training for teaching staff, including in SET, has now been devolved to college core funding. There will be effective professional networks of post-16 science teachers based around the Standards Unit regional network and the new Science Learning Centres.

The Government will track progress by in this area by monitoring:

- **Post-16 learner success** – to improve success rates in SET
- **Qualifications of the post 16 workforce** – to achieve a fully professionally qualified FE and training workforce in post-16 SET teaching
- **Post 16 inspection results** – to improve the number of institutions graded outstanding or good on the quality of SET teaching and learning
- **Recruitment and retention of SET teachers** – to reduce shortages

Higher Education – increasing participation in SET

6.44 In support of measures to sustain and encourage student participation in schools and colleges, the Government will lay the foundations to increase the numbers of SET graduates and postgraduates in higher education (HE) and will support the sector in increasing the numbers taking up SET careers.

Informing students

6.45 It is important that Higher Education Institutions (HEIs) and sector bodies help students to make informed decisions at the point of entering higher education. The Government welcomes the development of the new Teaching Quality Information (TQI) web-site which will, from 2005, provide detailed information to applicants about the quality and standards of courses, to help them make informed choices. It will include data about the employment of graduates and postgraduates from each subject at each HEI. It will be linked to the UCAS site and publicised to all applicants from summer 2005.

6.46 The Government welcomes the recommendation of the Lambert Review to increase information to students. **The Government will ensure high quality information is provided to prospective students on course quality and employment across subjects by each HEI, by 2006 at the latest. Information on salary outcomes is also valuable for students and this data is being collected systematically for the first time this year. The Government will work with HEIs and the sector bodies to explore the most useful and efficient means of them providing all this information, including through the TQI web-site and HEIs publishing it in their prospectuses, and will report by the end of 2004.**

Increasing the responsiveness of HE provision

6.47 Securing a strong future supply of scientists and engineers will require coordinated action from business, scientific societies, charities, government and Higher Education Funding Council for England (HEFCE) to ensure that HE teaching is well supported to meet the needs of the economy. The consultation responses raised concerns that the capacity to teach science is being lost at a worrying rate. For example, analysis by the Department for Trade and Industry¹² estimates that over the past ten years, approximately 15 physics and 11 chemistry departments have closed.

¹² The analysis is based on data from several sources, including the Research Assessment Exercise and UCAS

6.48 Although a large part of the decline in capacity is a market response to falling student demand for these course, this can have a varying impact in different regions. The Government believes that sharp falls in science capacity may significantly reduce student access to provision in particular regions and reduce the responsiveness and sustainability of the overall HE teaching base in meeting future changes in student demand as they begin to feed through.

6.49 The Government expects HEFCE to explore with HEIs and bodies representing HEIs' interests the possibility of making a notice period of 12 months before the closure of any department a condition of grant.

6.50 HEFCE will take a more active role, working with HEIs and Regional Development Agencies (RDAs), to evaluate the implications that falling science provision may have for student access at the regional level. **HEFCE will now consider providing additional funding to particular departments if there is a powerful case that weakening provision in a particular region would hinder student access to disciplines that are important to national and regional economic development.** This may mean for example taking into account actions by the RDAs to develop student demand (e.g. through student bursary support) in certain subjects that they deem crucial to the development of their region.

6.51 Since these issues require closer deliberation by many stakeholders, **HEFCE will set up an expert group, including business and scientific leaders, to review how falling SET provision will affect long-term regional and national economic development, and whether there is a greater role to be played by business, funding councils, HEIs and other stakeholders.** This group will report to the high-level ministerial strategy group, jointly chaired by the Minister of State for Lifelong Learning, Further and Higher Education and the Minister for Science and Innovation, referred to in paragraph 6.11.

6.52 In addition, HEFCE is reviewing its teaching funding method. This fundamental review will take into consideration a wide range of issues, including the full costs of teaching and collaboration, innovative means of delivery, the impact of market forces in shaping provision, and the role of the HEFCE in ensuring national teaching capability and capacity, so that it adequately meets the needs of students, employers and society. The review will consider the views of a broad range of stakeholders, including those of employers, regional bodies and HE and FE institutions.

Partnerships with schools

6.53 There are many partnerships being taken forward between HEIs, industry, learned societies and schools. For example, the Royal Society of Chemistry is being supported by HEFCE in developing efforts to: initiate better regional and national collaboration between HEIs and industry into schools and colleges, including role models from industry as well as undergraduate volunteers; develop activities that motivate pupils; and ensure that HEIs have access to resources at the subject level, in particular targeting schools and colleges and groups that are currently under represented.

6.54 To increase physical sciences and engineering participation in higher education, HEFCE will work to increase significantly the science links to schools and colleges by supporting HEIs, industry and scientific societies in their outreach activities.

Fostering scientific talent and improving the attractiveness of careers in HE

6.55 The supply of a sufficient quality and quantity of doctorates, researchers, and permanent academic staff into HE teaching and research, in a broad portfolio of disciplines, is vital. Effective science teachers and researchers are necessary to produce the next generation of highly trained personnel and underpin the UK's R&D capacity. Following consultation on proposals to improve standards in postgraduate research degree programmes, the UK Funding Bodies have established minimum threshold standards for the training of post-graduate research degree programmes which will be incorporated within the Quality Assurance Agency (QAA) institutional audits from 2005. HEFCE has implemented the 2003 HE White Paper commitment to support the staff development of promising researchers, through the allocation of a total of £5 million in 2004-05 to 62 institutions, as part of their Human Resource budgets.

6.56 Talented scientists and engineers face high incentives to pursue careers in the non-academic professions (both teaching and research) and to accept international posts – this is a major and continuing challenge to renewing the quality of the UK's HE workforce in SET subjects. The consultation on the investment framework reinforced this conclusion. In the four most problematic areas of recruitment and retention identified by the UCEA, 70 per cent of respondents¹³ reported a recruitment problem in business subjects, but significantly 28 per cent and 29 per cent reported recruitment problems in engineering and science, respectively.

Table 6.1: UCEA survey¹⁴ of recruitment and retention – four most problematic areas

Percentage of HEIs finding a recruitment or retention problem for academic staff				
	Business	Engineering	Science	Medicine & allied
Recruitment	70	28	29	39
Retention	52	14	13	21

6.57 Doctorate, researcher and academic career paths and salaries are shaped and funded through a number of different channels: Research Councils, Funding Councils, business, scientific societies, charities and universities. It is therefore important that all parties coordinate efforts and ensure that they offer career opportunities that will attract and retain high calibre teaching and research staff.

6.58 Universities are reacting to this competitive environment through their human resource practices. The Government welcomes the new pay Framework Agreement agreed by the HE employers and unions. This should make progress in ensuring there is harmonisation of different pay structures and conditions of service between HEIs, while also allowing for greater local flexibility, by making the use of market supplements more transparent and directly relating pay to an individual's responsibilities in post.

6.59 The Roberts Review identified concerns that a research career was, for many postgraduate students, an unattractive prospect. This is mainly due to low remuneration, limited development opportunities, and a poor career structure. The

¹³ This report is based on responses from around three-quarters of all institutions, 57 pre-1992 universities, 31 post-1992 universities and 38 colleges.

¹⁴ The Universities and Colleges Employer Association (UCEA) Survey of Recruitment and Retention in Higher Education, 2002/3

Government responded to this report by providing money to the Research Councils to: increase minimum PhD stipends from £8,000 per annum in 2002-03 to £12,000 in 2005-06, with further increases in areas with particular recruitment difficulties; raise average postdoctoral salaries by £4,000 between 2002 and 2005; provide funding for transferable skills training; and support 1,000 new academic fellowships to provide more stable and attractive routes into academia. The newly formed Research Careers Committee will monitor trends and encourage best practice relating to HE research careers.

6.60 To build on the measures in the Roberts Review, the Government will commit to reviewing regularly and up-rating when necessary over the next ten year period, PhD stipends awarded through Research Councils, in light of labour market developments both in and outside the science base, and to provide sufficient financial support to keep a strong flow of researchers moving through the HE system. **As a first step in support of this commitment, the Government will increase the PhD stipend in line with inflation over the SR2004 period and will also review the stipend rate over the period, implementing any further increases where appropriate.**

6.61 To encourage more attractive and effective research career pathways for our best researchers, and ensure that a higher proportion pursue careers in the delivery of high quality research, the Government will ensure that **Research Councils report in two years time to both the Minister for Science and Innovation and the Minister of State for Lifelong Learning, Further and Higher Education on the effectiveness of the Academic Fellowships and Research Council funded postdocs salary increases in supporting increased participation by high quality postdoctoral researchers.**

6.62 Government will also seek to work with research employers to encourage and enable a reduction in the current reliance on short-term contracts. In particular this will require incentives for better strategic planning and continued professional development.

6.63 To support HEIs in addressing persistent recruitment and retention problems in specific subjects and locations, the Government will:

- **maintain funding for ‘Golden Hellos’ for new teaching staff in shortage subject areas beyond 2005-6, subject to the evaluation showing that the initiative is good value for money; and**
- **through HEFCE, support all HEIs in maintaining progress in full implementation of their HR strategies.**

The Government will track progress in this area by monitoring:

- **Graduates in SET** – to increase the numbers qualifying
- **PhDs per head of population** – to maintain international rank and remain above the average for the G8 countries over 10 years
- **Quality of researchers** – to increase the UK ranking of citation share in nine research fields to top three in G8 in 7-9 standard units of assessment by 2006
- **Proportion of women and ethnic minorities in higher education** – to increase at various levels, including among researchers, lecturers, professors, and senior professors
- **Recruitment and Retention trends in HE institutions** – to monitor with particular regard to shortages reported by the UCEA

Accessing scientific talent from abroad

6.64 High-skilled migration brings important economic benefits. Migrants fill key skill gaps and are a source of innovation and enterprise. So it is not surprising that governments are increasingly encouraging high-skilled migrants into their countries. In the UK, the Highly Skilled Migrant Programme launched in January 2002, draws on the experience of Australia, New Zealand and Canada, to select skilled, adaptable individuals who are likely to make a substantial economic contribution to the country. Unlike the Work Permit system, no prior offer of employment is necessary, allowing high-skilled individuals the opportunity to come to the UK to look for work or to start-up their own businesses. To be successful, individuals need to score highly against criteria including education and past earnings, ensuring that the contribution to the UK economy is maximised. The Government has also streamlined the Work Permits system to make it easier for employers to recruit from abroad. Following a series of simplifications and improvements, the UK Work Permit system is now widely regarded as one of the most successful and responsive schemes in the world.

6.65 As the market for scientists has become increasingly global, the **Government has responded to the national need for high quality scientists by announcing that foreign science and engineering graduates studying in specific shortage subjects in the UK will have the automatic option of working in the UK for one year following graduation.** This is crucial as increasing numbers of students come from abroad to study in UK universities – nearly half of all engineering and technology doctorates are already awarded to non-UK nationals.

Ensuring women and ethnic minority groups are fully represented

6.66 There is a clear correlation between under-representation of women and skills shortages. Widening recruitment to women in male-dominated sectors offers a solution to skills shortages. However, while proactive recruitment of women is essential, it is also vital that the working environments to which they enter are encouraging and supportive and ones in which they feel they have an equal right to participate and advance.

6.67 The Commission for Black Staff in Further Education established that minority ethnic staff are significantly under-represented at all levels in colleges, and this is particularly marked at management positions. The Further Education (FE) sector has already begun the process of targeted action and aims to ensure that FE is leading the way on increasing the numbers of middle and senior level black and minority ethnic staff in the sector and is also providing positive role models for learners. The Government will also draw on the good practice emerging from the Ethnic Minorities into Science and Technology Working Group.

6.68 In higher education, the limited data available exposes that the Black Caribbean group are particularly under-represented in maths, medicine and dentistry, and the Bangladeshi group are under-represented in architecture. A further concern is the under-representation of all minority ethnic groups and the adverse knock-on effect this has in terms of the availability in schools of minority ethnic role models and for raising aspirations.

6.69 Work is already underway to increase the numbers of ethnic minorities into SET. DTI is developing a strategy, including a Royal Society conference, to explore the issue of minority ethnic involvement in SET education and employment. In their recent report, SET 4 Equality¹⁵, SEMTA, the sector skills council for science, engineering and manufacturing technologies, has set out a number of challenges and recommendations aimed at increasing ethnic minority participation in SET. These range from improving the uptake of SET degrees and employment opportunities in the science, engineering and manufacturing sectors to staff development and career prospects for SET professionals.

6.70 Women are under-represented in post-16 SET Apprenticeships and in SET A-level choices. For example, in 2002/03 the male/female split of those taking chemistry was roughly equal, but less than a quarter of physics A-level entrants were female and only 37 per cent of maths entrants were female. The Equal Opportunities Commission (EOC) are currently conducting a General Formal Investigation into gender segregation in Work Based Learning, with a particular focus on Apprenticeships and five heavily gender segregated industries, including engineering and ICT. The first phase of this Investigation suggests there is a clear correlation between under-representation of women and skills shortages. The findings and recommendations of this report will inform the approach the government takes to address these issues, and there is a positive synergy between a number of the EOC's recommendations and the reforms to Apprenticeships announced in May 2004.

6.71 Although increasing numbers of women are choosing SET subjects in HE, numbers in certain key disciplines such as engineering and ICT, remain very low. The occupations associated with these degrees are too often perceived as being not 'female-friendly.' The attrition rate of women entering and remaining in the SET workforce continues to be a cause for concern. In 2002, only one in every three SET graduates were women. This gender trend continues into the work environment. In 2002, there were 412,000 male SET degree holders employed in SET occupations compared to 81,000 females.

6.72 In addressing the area of diversity in science and technology and in response to the Greenfield report, SET Fair, the Government published a strategy for women in science, engineering and technology. To push forward with implementation of this strategy, the Government has already announced a new UK Resource Centre for

¹⁵ SET 4 Equality, Ethnic Minorities into Science, Engineering and Technology, April 2004

Women in SET. The main objective of this new centre is to advise and support SET employers in industry and academia on how to effect cultural and structural change, enabling them to recruit and retain the skills and expertise of women and in all areas of SET and for those women to reach their full potential. **Over the next three years the Government is investing £2.4 million in the Resource Centre to help employers make SET a career of choice for women and ensure their successful recruitment, retention and progression.**

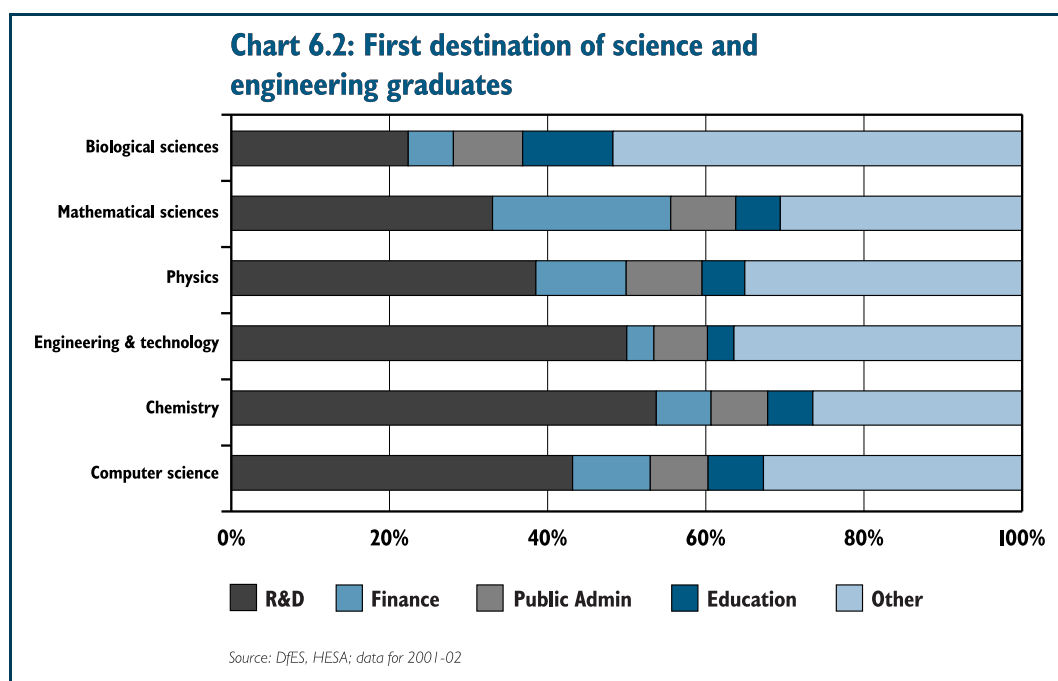
6.73 DfES has contributed £200,000 to the Resource Centre to support HEIs to put measures in place that aid retention and progression of female undergraduates on SET courses into the SET labour force, including: grants to assist HEIs in running mentoring schemes; placements in industry and research; focused tutor and peer support systems; and work with employers.

Responsiveness to Employers and Skills needs of the Workforce

6.74 The Government is committed to an increasingly demand-led system to make sure that the skills delivered are the skills employers need. Working closely with government and key partners, employers can exert a real influence to improve the match between skills demand and skills supply. To the extent that potential future shortfalls in skills supply in particular areas can be identified, it is important for employers to work with government to encourage and influence future demand from students, regarding decisions about choices of curriculum, course and career.

6.75 The most highly skilled scientists and engineers have many career options. It is important that enough choose to remain in science and engineering, not only to produce research and innovative output, but also, in schools, colleges and universities to train future generations.

6.76 Chart 6.2 shows that less than 50 per cent of graduates with SET degrees go into private sector R&D and, alongside mathematics graduates, a significant number move into financial services.



6.77 It is vital to the success of SET workforce development that the Government works closely with research intensive businesses in order to better understand the value of science skills in a business context. In particular, the Government thinks it is important to articulate and provide clear market signals to attract those with high quality SET skills and ensure mechanisms are in place to allow greater employee mobility between HE and industry.

Ensuring post-16 education and training provision is responsive to businesses' needs

6.78 The Government is working to establish an independent influential employer-led Sector Skills Council (SSC) in each major sector of the economy. The key SSCs with a remit for SET are: SEMTA (science, engineering and manufacturing technologies); Cogent (chemicals, nuclear, oil, and gas, petroleum and polymers) and e-skills UK (IT, telecoms and contact centres).

6.79 Through Sector Skills Councils, employers will contribute to identifying the specialist and generic skills required to meet their current and future business needs – particularly those which will improve business performance, productivity and competitiveness. In turn the supply side – schools, FE, HE and work-based learning – will be increasingly flexible in meeting the skill needs identified by employers. The key mechanism will be Sector Skills Agreements (SSAs), through these, SSCs will work with planning, funding and delivery agencies to make sure that training and qualifications are designed to meet employer needs. The focus will be on simplifying the system and making it more responsive to what employers want, giving them opportunities to shape training provision and coherent progression routes. Both SEMTA and e-skills UK are developing SSAs. Other SSCs will begin development work during 2004 and, in the long term, every SSC will be invited to develop an SSA.

6.80 The LSC, in consultation with SSCs, is also developing a network of high quality training Centres of Vocational Excellence (CoVEs) across England to ensure they meet employers' local, regional, sectoral and national skills needs. The Government is two thirds of the way to its target of 400 by March 2006. The network includes, for example, CoVES for Biotechnology, Applied Science and Polymers.

6.81 Ensuring regional and local skills needs drive local post-16 provision in particular is important to meet the intermediate skills needs of the wider economy, including in SET. New Regional Skills Partnerships are tasked with bringing together Regional Development Agencies, the Learning and Skills Council and other key stakeholders to integrate skills needs into regional economic strategies and ultimately influence local post-16 provision. Sector skills agreements will feed in and influence this process. The network of Regional Skills Partnerships are currently in the process of being set up. SET skills are recognised as important in all regions. The Government is committed to ensuring that these Partnerships simplify the system and focus resources on skills needs, and expects Partnerships to show how they are achieving this.

Raising SET skills among those in the workforce

6.82 The DTI Innovation Report¹⁶ identified the need to raise the skills of leaders and managers in the SET sector, especially in SMEs. A range of initiatives have been launched, including work with the HE sector, colleges and other providers to promote knowledge transfer to industry and to develop the ability of leaders and managers to

¹⁶ Competing in the global economy: the innovation challenge, DTI, December 2003

understand the potential of capitalising on innovation and its place in a business context. However, it is equally important to ensure that that scientists and engineers emerge from universities with an understanding of the context in which research can be capitalised and promoted. Based on the responses to the ten year framework consultation, DfES and DTI will now jointly develop further actions to support the SET sectors.

6.83 Following approval of the new National Occupational Standards for Management and Leadership in May 2004, every sector will work to improve relevant aspects of qualifications frameworks – this will benefit all levels from first line supervision to directors. Support to encourage managing directors of SMEs to undertake personal leadership and management development will be available in at least 17 pathfinder Business Link areas by June 2004, and nationally from September 2004. This is expected to stimulate wider workforce development in leadership and management.

6.84 The Government will work towards achieving even closer relationships with employers and providers to develop further their role in relation to training, development and career and pay structures for SET employees and focus on changing attitudes within business. The Government will seek commitment from senior people in industry, for example through representation on the high-level ministerial strategy group, referred to in paragraph 6.11.

6.85 To ensure that the economy gains the best from adults already in the labour force with SET skills, the Government and partners need to provide people with clear, flexible and accessible routes into skilled work in this sector. Access to high-level skills training will aid retention and career progression for adults already in the workforce.

6.86 Foundation Degrees are one route for raising skill levels. It is anticipated that there will be around 50,000 places by 2005/06. Companies who need high level technical staff and associate professionals are already expressing an interest in the potential of the Foundation Degree to enable them to develop their own staff. Working with employees recruited locally they can use the flexibility and work-based learning offered by Foundation Degrees to develop internal talent to meet their technical and managerial needs. In the public sector, employers are also looking to Foundation Degrees to ensure they have the staff with the necessary technical and scientific knowledge and skills. The Foundation Degrees Task Force will report in 2004 with an assessment of the likely future supply of Foundation Degree places needed to support employer and learner demand up to 2010.

Summary

7.1 The potential rewards that society can reap from science and technology have never been more important or more rapidly evolving. The ‘endless frontier’ of research is opening up an array of new opportunities and ways of addressing societal challenges. However, there is sometimes understandable unease about the direction of research and the development and regulation of technology. This chapter highlights the importance the Government attaches to taking action to achieve greater public confidence and improved engagement in science and technology. This includes intelligent regulation of research, openness, dialogue, effective communication with the public and responsiveness to public priorities and concerns.

Achieving public confidence and engagement in science and technology

7.2 The UK public is generally supportive of science. For example, 77 per cent of those surveyed in 2000¹ believed that because of science, engineering and technology (SET) there will be more opportunities for the next generation, and 67 per cent believed that science and technology are making our lives healthier, easier and more comfortable. However, there is sometimes unease about scientific and technological developments, and whether government is able to regulate and control them effectively. Recent controversies, such as those surrounding BSE and mobile telephone masts, have exposed deep public concerns over the governance and regulation of science and the quality and use of scientific advice in government, and have illustrated how citizens can feel disconnected from decision making on important issues.

7.3 The Government’s Science and Society agenda encompasses achieving public confidence and engagement in science, and sustaining the science workforce. The Government’s commitments to promoting science for young people, promoting the role of women and ethnic minorities in SET and promoting research careers are set out elsewhere in this strategy – principally in Chapter 6: Science, Engineering and Technology Skills. The remainder of this chapter deals with public confidence and engagement.

7.4 Over recent years the focus of the Government’s Science and Society public engagement activities has moved forward from simply promoting public understanding of science to the wider agenda of facilitating public engagement with science and its application. This has the aims of: government and scientists responding proactively to public priorities and concerns; people having greater confidence in the benefits offered by science; greater engagement with major issues facing society, such as climate change; and careers in science becoming more attractive to both adults and children.

7.5 The Office of Science and Technology’s Public Engagement work programme addresses these issues through: offering public engagement grants to widen participation to include people from across the diverse spectrum of social groups in the UK; supporting science activities that can achieve a positive national impact; undertaking new research to identify public attitudes to science and scientists;

¹ OST - Wellcome Trust survey, *Science and the Public*

investigating whether the public is getting what it wants from public engagement; and promoting best practice in the media coverage of science and technology.

7.6 This agenda is currently pursued through support for organisations such as:

- Research Councils UK (RCUK) and the individual Research Councils;
- the Royal Society, the Royal Academy of Engineering and other learned societies;
- Alpha-Galileo, a pan-European service linking researchers to the media;
- the British Association for the Advancement of Science (see Box 7.1); and
- the National Museum of Science and Industry (see Box 7.2), the Natural History Museum, Ecsite-UK (the UK association of interactive science and discovery centres), and the interactive science centres themselves.

Box 7.1 The British Association for the Advancement of Science (BA)

Established in 1831, the BA is a unique UK-wide membership organisation dedicated to “connecting science with people”. It aims to ensure that science and technology are accessible to all. The BA also promotes openness about the role of science in society and engages people directly with science and technology and the issues raised.

The OST currently provides core funding to the BA - amounting to some 28 per cent of the BA's total income - to support the BA's work in running national, regional and local events, and a programme for young people in schools and colleges. For example:

- National Science Week celebrates science and its importance to society, and provides opportunities for people of all ages across the UK to take part in activities, including hands-on experiences with science, lectures, demonstrations and debates and dialogues on topical science-related issues;
- the BA Festival of Science is one of the UK's biggest science festivals. It attracts 400 of the best scientists and science communicators from home and abroad who discuss the latest developments in research with a wider audience. This year's festival takes place in Exeter in September with the theme of *The responsibility of being a scientist*; and
- the Young People's Programme aims to make science exciting, accessible and relevant to people aged 5 to 19. The BA provides support for teachers and science club leaders, resources, award schemes and events.

The way forward

7.7 The Government's goal is for the UK public to be confident about the governance, regulation and use of science and technology, by both government and business, to be positively engaged with science activity and feel that its views are valued. In order to achieve this goal, and to ensure that areas of research that could yield important quality of life and economic benefits are not held back, the Government's next steps in this field will be in two key areas:

- understanding, through careful monitoring, and then responding, to the population's developing concerns and expectations of science and technology; and

- working harder on horizon scanning to identify key upcoming developments in science and technology and any likely concerns surrounding them.

7.8 To better understand concerns and expectations, efforts will be focussed on enabling public fora where the ethical, health, safety and environmental impact of new science and technologies can be debated. The Government wants constructive, inclusive and open public debate and dialogue on these issues, so that the public can be satisfied that science and technology is being developed responsibly and responsively, and that their concerns are being addressed. To do this, the Government will work to move the debate forward – beyond simplistic notions of the public being ignorant of science, or being either pro-science or anti-science; and beyond crude notions of a particular technology being either ‘good’ or ‘bad’. The Government will also work to enable the debate to take place ‘upstream’ in the scientific and technological development process, and not ‘downstream’ where technologies are waiting to be exploited but may be held back by public scepticism brought about through poor engagement and dialogue on issues of concern. The Council for Science and Technology will work with the Government in considering how better use can be made of public debate and dialogue in developing policies for science and technology.

7.9 To identify key upcoming developments in science and technology, OST will take steps to strengthen technology foresight and horizon scanning. As described in Chapter 8, building on lessons from the office of Science and Technology’s Foresight programme, the Government will ensure that the UK’s national horizon-scanning capacity is enhanced. This will involve working with the Research Councils through RCUK, with government departments, and with wider business and public dialogue, including the Technology Strategy Board in DTI. There will be stronger links with EU research programmes, particularly through the EU Science and Society Action Plan.² This will establish a flexible system of shared horizon scanning across the research base to spot emerging opportunities and threats early, to get ahead in enabling research, and to be more proactive in stakeholder and public engagement to address public and business concerns and priorities arising from new areas of science and technology, for example research into ageing, neuroscience and environmental technology.

7.10 These approaches have proved to be very successful in the pioneering work led by Baroness Warnock on human embryology and fertilisation in the 1980s and more recently in the work of the Human Genetics Commission led by Baroness Kennedy. Key elements of the Government’s forward-looking Science and Society agenda will be to pursue similar strategies in relation to the development of nanotechnology, the use of animals in medical research and the long-term implications of intelligent and pervasive information technologies, as identified in Foresight projects.

² Science and Society Action Plan. European Commission, 2002. www.cordis.lu/science-society

Box 7.2: The National Museum of Science and Industry

The UK's national museums, science centres and galleries are world-leading cultural institutions which make an important contribution, as centres of learning and expertise, to culture and education. Research is fundamental to many of their activities. An example is the National Museum of Science & Industry (NMSI), a family of three world-class museums – the Science Museum in London, the National Railway Museum in York, and the National Museum of Photography, Film and Television (NMPFT) in Bradford. A fourth, Locomotion, in County Durham, will be opened in September. Together they have contact with over ten million people each year, 40 per cent of them onsite visitors and 60 per cent connecting online. Of those who visit NMSI's museum locations, 1.5 million are children.

NMSI is a leader in the development of informal, interactive, science-based programmes. These harness information, communications and broadcast technologies to creatively engage its audiences with science and scientists. For example:

- the Dana Centre, a collaboration between the NMSI, the BA and the European Dana Alliance for the Brain opened in November 2003, is a forum for scientific debate between specialists and the public. Topics are addressed in dynamic and often experimental formats, with events to date including demonstrations of the most advanced humanoids;
- Sparking Reaction was developed by NMSI for British Nuclear Fuels Ltd. at its Sellafield Visitors' Centre. The exhibition looks at the complex issues surrounding the way we generate power. Through interactive displays and the 'immersion cinema', visitors can actively participate in thinking through science and technology questions such as how they would prioritise future energy sources; and
- the Youth TV initiative in Bradford brings socially and educationally excluded young people into NMPFT's broadcast studio to acquire basic media production skills. The programme can re-engage young people in learning and change their aspirations.

Regulation of scientific research

7.11 There are, and will continue to be, areas where proper constraints must be placed on scientific research. Such regulation reflects society's demands for an ethical and safe approach to research and the application of science and technology. Recognising this, by designing and implementing regulations intelligently, the Government intends to encourage rather than deter research in the UK by creating confidence for universities, business and other firms and research organisations to pursue world-class science. For example, the careful regulation of stem cell research has allowed this important work to go ahead in this country, and attracted foreign scientists to work here. A clear ban remains in the UK on human reproductive cloning.

7.12 The UK must continue to be open to new ways of extending human knowledge and reaping the benefits of this through new products and processes. Science and innovation must continue to be set within a robust legal framework operating within boundaries set by society through government. The Government will ensure that the regulatory framework governing the conduct of research is proportionate, while at the same time inspiring public confidence.

7.13 In the immediate term, the Government will deliver the new Science and Society agenda by focussing on the following areas.

Nanotechnology

7.14 The UK Government is committed to supporting the development of nanotechnology, studying and working with matter at an ultra-small scale (a nanometre is just one-millionth of a millimetre in length). It is vital that, as this technology develops, the public feels confident about it. With this in mind, in June 2003, the Government commissioned the Royal Society and the Royal Academy of Engineering to examine whether nanotechnology raises any ethical, safety, health or environmental issues that are not covered by current regulations, and whether, therefore, there is a need to introduce new regulations.

7.15 A number of elements have been built into the study in order to engage the public; independent and representative focus groups have been convened and a survey undertaken. In addition all interested parties (including the public) can comment via a dedicated website on any of the information posted there, or raise issues relating to nanotechnology in general or about the study itself. The study is expected to be completed later in 2004, and the Government expects it to include recommendations for further research on impacts and public engagement.

Animals and medical research

7.16 The use of animals in medical research is key to the understanding and treatment of human and animal disease. The Government believes that animal experiments are currently necessary to develop human and veterinary medicine, and to protect humans and the environment. It is essential, however, that they are tightly controlled. The UK has one of the most rigorous licensing systems in the world, and the use of animals is only permitted where absolutely necessary.

7.17 At the same time the Government believes that a major opportunity now exists to make progress in improving animal welfare and the 3Rs: replacement of animal use, refinement of the procedures involved, and a reduction of the numbers of animals used. Consequently, in May 2004 the Government announced the establishment of a national centre for research into animal welfare and the 3Rs, the National Centre for Replacement, Refinement and Reduction of Animals in Research.

7.18 The existing publicly funded Centre for Best Practice for Animals in Research (CBPAR) will form the core of the national centre. Ministerial responsibility for the new Centre will move from the Home Office to the Office of Science and Technology. Funding for the 3Rs will double from £330,000 to £660,000 this financial year, with further increases expected thereafter, as a result of increases in contributions from the Medical Research Council and the Biotechnology and Biological Sciences Research Council, and budget transfers from the Home Office.

7.19 The Government is committed to ensuring that the use of animals in scientific procedures only takes place where absolutely necessary. At the same time the Government will take strong action against those with extreme views who threaten and harass scientists who carry out experiments legally.

7.20 To this end, the Government has introduced changes to legislation to strengthen police powers to deal with intimidatory protests and office occupations, and is looking further at how to strengthen police powers to deal with protests outside private homes

and to protect those targeted in their homes. Police action is also being stepped up. The Government, police, prosecutors and the judiciary are working closely together through a National Forum to ensure the most effective coordinated response to this issue. **The Home Office will publish shortly a document setting out in full the approach by the Government and the police to tackling animal rights extremism.**

Box 7.3: Scientific Advice to government

The ways in which government seeks and uses scientific advice in policymaking and the presentation of that advice, have an important bearing on public confidence in science. Under the Guidelines 2000³, government departments are enjoined to obtain a wide range of advice and to publish that advice and all relevant material.

The Agriculture and Environment Biotechnology Commission (AEBC) and the Human Genetics Commission (HGC) are good examples of how modern UK Government advisory committees operate and contribute to the public's engagement with science. Their terms of reference make explicit that they are forward looking, outward facing, and engage with the public. Members of both committees are from diverse backgrounds with a wide range of skills and experience. They work in an open and transparent way and draw on good practice in public engagement.

AEBC has a wide-ranging remit to consider strategic issues in relation to biotechnology affecting agriculture and the environment, including advising government on the ethical and social implications arising from these developments and their public acceptability. The HGC advises on genetic technologies and its remit is to give Ministers strategic advice on the broader questions raised by human genetics, with a particular focus on social and ethical issues.

Developing public engagement capacity

7.21 Building on the success of previous schemes, **the Government will launch a new grants scheme to build the capacity of citizens, the science community and policy makers to engage in the dialogue necessary to establish and maintain public confidence in making better choices about critical new areas in science and technology.** The new grants scheme will identify and propagate good practice in public engagement through collaboration and networking; ensure that people from a diverse range of social groups can participate; and encourage informed media coverage of science. The programme will direct an increasing proportion of funding to enabling dialogue and debate on issues arising from horizon-scanning activities, with a shift away from responsive-mode funding. The Government will also work closely with others in the public, charity and private sectors to promote coherence in the growing range of initiatives for encouraging public engagement with science and technology.

7.22 The Government intends to increase the scale of its activities in advancing the Science and Society agenda. To support the new grants scheme, and to build upon the Government's other activities to promote public confidence and engagement in science and to sustain the science workforce, **the Office of Science and Technology's Science and Society expenditure will increase from £4.25 million per year in 2005-06 to over £9 million per year by 2006-07.**

7.23 The Wellcome Trust is also an important partner with whom the Government has worked in delivering its public engagement activities; the Trust expects to commit

³ Guidelines 2000: Scientific Advice and Policy Making, Office of Science and Technology, July 2000.

around £15 million over the next five years in grants for public engagement. **Building on previous collaborations, following Spending Review 2004 the Office of Science and Technology will be exploring with the Wellcome Trust opportunities for further joint working on public engagement activities.**

Measuring Success

7.24 The Government will also work to improve the evaluation of public engagement and confidence over the next ten years, and is currently considering a range of indicators for this. These include:

- independently measured trends in public attitudes towards key science and technology issues;
- independently measured trends in public confidence in science and technology policy;
- evidence of greater acknowledgement and responsiveness to public concerns by policy-makers and scientists; and
- trends in media coverage of science and technology issues.