# Science & innovation investment framework 2004 - 2014

July 2004

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# FOREWORD

The nations that can thrive in a highly competitive global economy will be those that can compete on high technology and intellectual strength - attracting the highest-skilled people and the companies which have the potential to innovate and to turn innovation into commercial opportunity. These are the sources of the new prosperity.

This is the opportunity. This framework sets out how Britain will grasp it. It sets out how we will continue to make good past under-investment in our science base - the bedrock of our economic future. More than that, it sets out not only how we intend to invest in this great British asset - the world-class quality of our scientists, engineers and technologists - but how we will turn this to greater economic advantage by building on the culture change under way in our universities, by promoting far deeper and more widespread engagement and collaboration between businesses and the science base, and by promoting innovation in companies directly.

While it would be easier to take the short term route - and fail to continue to make the necessary investments for the future - we propose to take the longer term view, to choose science and technology above many other spending priorities. So building on the investment since 1997, including £7 billion invested by Research Councils in over 130 UK Higher Education Institutions and £2.6bn invested in infrastructure in partnership with the Wellcome Trust by 2005-06 this paper sets out the Government's long term investment framework for British science, technology and innovation over the next decade.

At the Budget, we committed to raising science spending faster than the trend rate of growth of the economy. We can now announce that in total, the average annual growth rate for science funding, through the DTI and DfES, in this Spending Review is 5.8 per cent in real terms. DfES funding committed to research will rise to £1.7 billion in 2007-08. The DTI dedicated Science Budget will rise to £3.3 billion in 2007-08. Together, this represents an additional £1 billion funding for science over the Spending Review period.

And because we want Britain to be the most attractive location in the world for science and innovation, we are setting a new and ambitious target of increasing UK R&D investment as a proportion of national income from its current level of 1.9 per cent to 2.5 per cent by 2014 over the next decade.

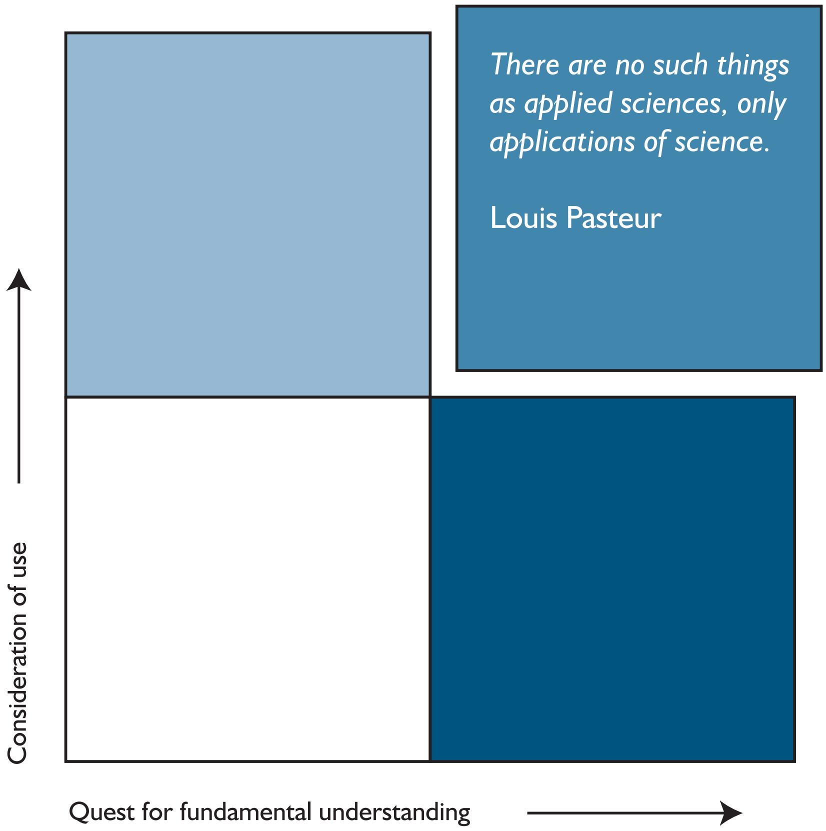
We recognise the role that Government can play in achieving this. But this stretching target will not be possible without partnership with, and investment from, our co-funders of the science base such as business and charities. So we will continue to work closely with science based companies, along with the scientific community and research charities, to meet this challenge together.

Today the Government responds to the Lambert Review, setting out an agenda for increasing business-university collaboration to create more routes to bring new skills into businesses and to bring new ideas successfully to the marketplace.

And we will set out our plans to drive up the numbers of skilled scientists and engineers; to put the science base on a sound financial footing through better financial management and investment in infrastructure; to support business R&D and to make the best of research across Government, especially in medical research.

We are delighted that over 200 organisations have contributed views to this consultation, including: universities; science, research and knowledge transfer organisations; businesses; non governmental organisations; charities; and RDAs – and we welcome further dialogue as we implement this framework over the coming months and years.

| | | |
|---|---|---|
| **Gordon Brown** | **Charles Clarke** | **Patricia Hewitt** |
| **Chancellor of the Exchequer** | **Secretary of State for Education and Skills** | **Secretary of State for Trade and Industry** |




Pasteur's Quadrant. Basic Science and Technological Innovation. Donald E. Stokes Brookings Institution Press 1997

# 1 SUMMARY

**'He that will not apply new remedies must expect new evils; for time is the great innovator'**

Francis Bacon[1]

**'The most basic proposition of growth theory is that in order to sustain a positive growth rate of output per capita in the long run, there must be continual advances in technological knowledge in the form of new goods, new markets, or new processes.'**

Aghion and Howitt[2]

## BUILDING BRITAIN'S KNOWLEDGE BASE

**1.1** Harnessing innovation in Britain is key to improving the country's future wealth creation prospects. For the UK economy to succeed in generating growth through productivity and employment in the coming decade, it must invest more strongly than in the past in its knowledge base, and translate this knowledge more effectively into business and public service innovation. The Government's ambition, shared with its partners in the private and not-for-profit sectors, is for the UK to be a key knowledge hub in the global economy, with a reputation not only for outstanding scientific and technological discovery, but also as a world leader in turning that knowledge into new products and services.

**1.2** At the core of the UK's knowledge base is its research and development (R&D) capacity, in the public and private sectors, which enables it to create, absorb and deploy new ideas rapidly. Working with partners in the business and not-for-profit sectors, the Government aims to build the UK science, research and innovation system in coming years to deliver the attributes of success set out in Box 1.1.

**1.3** This strategy is supported by clear targets for achievement on all these dimensions, against which the government and others will be able to track performance over the coming decade. The Government will publish an annual stocktake on progress against the attributes of the science and innovation system as set out in the framework, reaching a judgement on progress informed by a range of indicators. To inform periodic reviews of public spending, the Government will conduct every two years a detailed assessment of the progress towards the goals for each attribute. In drawing up this assessment, it will consult widely across departments, and with other stakeholders including the Funders Forum, to reach a balanced judgement about UK-wide progress on science and innovation, and the implications for future policy. This is summarised in Box 1.1 and described in more detail in Annex B. Many of these ambitions are dependent on the actions of other research funders, the private sector, and education institutions and professionals. The Government will therefore use this set of indicators and goals as the basis for a dialogue with stakeholders over the coming years, regarding progress and the contributions of public and private funding and other actions towards achieving the UK's longer term science and innovation goals.

[1] *Essays 'Of Innovations'*, Francis Bacon, 1625

[2] *Endogenous growth theory*, Philippe Aghion and Peter Howitt, the MIT press, 2000

**Box 1.1: Ambitions for UK science and innovation**

**World class research at the UK's strongest centres of excellence:**

- Maintain overall ranking as second to the USA on research excellence, and current lead against the rest of the OECD; close gap with leading two nations where current UK performance is third or lower; and maintain UK lead in productivity
- Retain and build sufficient world class centres of research excellence, departments as well as broadly based leading universities, to support growth in its share of internationally mobile R&D investment and highly skilled people

**Greater responsiveness of the publicly-funded research base to the needs of the economy and public services:**

- Research Councils' programmes to be more strongly influenced by and delivered in partnership with end users of research
- Continue to improve UK performance in knowledge transfer and commercialisation from universities and public labs towards world leading benchmarks

**Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent:**

- Increase business investment in R&D as a share of GDP from 1¼ per cent towards goal of 1.7 per cent over the decade
- Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU and US performance in each sector, reflecting the size distribution of companies in the UK

**A strong supply of scientists, engineers and technologists by achieving a step change in:**

- The quality of science teachers and lecturers in every school, college and university, ensuring national targets for teacher training are met
- The results for students studying science at GCSE level
- The numbers choosing SET subjects in post-16 education and in higher education
- The proportion of better qualified students pursuing R&D careers
- The proportion of minority ethic and women participants in higher education

**Sustainable and financially robust universities and public laboratories across the UK**:

- Ensure sustainability in research funding accompanied by demonstration by universities and public laboratories of robust financial management to achieve sustainable levels of research activity and investment

**Confidence and increased awareness across UK society in scientific research and its innovative applications:**

- Demonstrate improvement against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and acknowledgement and responsiveness to public concerns by policy-makers and scientists

The basket of indicators underlying these ambitions is set out in Annex B.

## Investment framework

**1.4** **The Government's long-term objective for the UK economy is to increase the level of knowledge intensity in the UK (as measured by the ratio of R&D across the economy to national gross domestic product), from its current level of around 1.9 per cent to 2.5 per cent by around 2014.** If achieved, this would put the UK in a position to secure a leading place among the major European countries, and substantially close the gap between the UK and the USA, the best performing innovation-driven major economy.

### Table 1.1: Public and private sector investment in R&D as a percentage of GDP, 2002

| % of GDP | UK | France | Germany | USA |
|---|---|---|---|---|
| Business | 1.24 | 1.37 | 1.73 | 1.87 |
| Public sector | 0.62 | 0.83 | 0.78 | 0.80 |
| **Total** | **1.86** | **2.20** | **2.51** | **2.67** |

**1.5** To achieve this target requires substantial growth in business R&D in the UK. This in turn requires a similarly significant growth in the underpinning investment in the public science base, both to supply the skills and research results into the economy, and also to attract mobile business R&D investment into the UK. As this framework sets out, it will also require a continued strengthening of the linkages between the public and private sector research bases.

**1.6** On the government side, this Spending Review represents a further very substantial investment in the public science base, **increasing funding, through the DTI and DfES, at an average annual rate of 5.8 per cent in real terms over the Spending Review 2004 period (2004-05 to 2007-08)**. At the same time, there are encouraging signs that, following decades of decline, private sector R&D in the UK is beginning to grow again. The Government is committed to driving this partnership with the private sector forward - the central aim of this ten-year framework.

**1.7** **The framework sets out the Government's intention to increase investment in the public science base at least in line with the trend growth rate of the economy through the ten-year period, increasing science spending as a proportion of GDP.**

**1.8** **However, the Government's overall ambition - that overall levels of R&D in the economy should reach 2.5 per cent of GDP - would require a higher rate of annual growth than this across the aggregate private and public sector research bases - an average annual rate of around 5 ¾ per cent from now over the coming decade.**

**1.9** **This scenario represents a considerable challenge both for Government and for UK business. It can be achieved only if this commitment from Government to invest substantially in the science base is matched by the private sector and leading charitable funding, and in particular that it is clear that private sector R&D funding is on a new and growing trajectory. This investment framework therefore sets out the Government's plans continually to monitor the implementation of the proposals in this framework as well as progress towards the 2.5 per cent target**. These are summarised in Box 1.1 and set out in full in Annex B.

**1.10** Achieving this goal would result in a major increase in UK-based R&D, resulting in a stronger platform for the economy to develop higher value-added knowledge-based products and services and to deliver public services more effectively. Moving from 1.9 to 2.5 per cent of GDP invested in R&D would increase UK-based R&D by around £16½ billion (in real terms, 2004-05 prices), some 75 per cent higher than the current level of investment of around £22½ billion.

## Strengthening the UK science base

**1.11** The UK science base is one of the most productive and influential systems of publicly funded research in the world. The Government wants to build on this success, by supporting those institutional structures that have underpinned this success to date, and providing the secure and rising investment which will enable successful research centres to grow with confidence. To ensure that the UK's scientific excellence is fully able to inform and be shaped by the challenges facing business and public services in the UK, the Government will take forward a series of reforms to enhance further the translational impact of science into innovation.

**1.12** To fund this development in the next three financial years, the Government is increasing investment in both the core funding of universities and the strategic funding for Research Councils and other programmes sponsored by the Office of Science and Technology. **The average annual growth rate in science funding, through the DTI and DfES, in the Spending Review 2004 period is 5.8 per cent in real terms.**

| | 2004-05 | 2005-06 | 2006-07 | 2007-08 |
|---|---|---|---|---|
| **DTI Office of Science and Technology** | | | | |
| Departmental expenditure limits[3] (£ million cash) | 2,575 | 2,913 | 3,067 | 3,282 |
| Average annual real growth rate since 2004-05 | | | | 5.6% |
| **DfES funding for research and knowledge transfer in English universities** | | | | |
| Departmental expenditure limits (£ million cash) | 1,326 | 1,465 | 1,589 | 1,709 |
| Average annual real growth rate since 2004-05 | | | | 6.0% |
| **UK Total science spending[4]** | 4,201 | 4,701 | 4,998 | 5,356 |
| Average annual real growth rate since 2004-05 | | | | 5.7% |
| **UK science spend as a proportion of GDP (per cent)[5]** | 0.36 | 0.378 | 0.382 | 0.390 |

**1.13** At the heart of the UK science base, the Government remains committed to developing the Dual Support system as the organising principle for funding university research, combining growth in core annual funding for institutions through the Higher Education (HE) Funding bodies, with growth in project and programme funding from the Research Councils. The Government will continue to work with the university sector and all research partners to deliver stronger research outcomes and financial management through reforms aimed at delivering the attributes of a successful science and innovation system, as set out over the following pages.

## World class research at the UK's strongest centres of excellence

**1.14** UK research funding from Research Councils and HE funding bodies will continue to be driven by excellence wherever that may be found. Increases in Research Council and HE Funding Council investments over a sustained period will enable the UK's major research-intensive universities to plan and deliver their own research

[3] Full resource budgeting basis, net of depreciation

[4] Actual outturns are subject to spending decisions by the devolved administrations. In Scotland, Wales and Northern Ireland, funding other than that provided by Research Councils is a devolved matter for their respective administrations. Total funding by the devolved Funding Councils in higher education research and knowledge transfer totalled £354 million in 2004-05, some 21 per cent of the UK total.

[5] Excludes non cash items

strategies more effectively. **A comprehensive performance management system being developed by the Office of Science and Technology will provide a more robust mechanism for translating the overall strategic priorities for the science base into specific aims and objectives for the Research Councils and other delivery agents, and will allow the balance of investment across the Science Budget to be adjusted in response to a more strategic view of new priorities.**

## Financially sustainable universities and public laboratories

**1.15** Recognising that, without some change, the high productivity of the UK science base is not sustainable, the Research Councils will be funded, through to 2007-08, to increase the share of full economic costs which they provide to universities for the projects they sponsor. In turn, universities will need to identify more clearly the full economic costs of projects. **Proposals to Research Councils will be made on a full economic cost basis, funded at a higher proportion of that cost than at present, from September 2005. Thereafter, the Government will provide resources over subsequent spending review periods to enable Research Councils to provide close to the full economic costs of their university-conducted research by early in the next decade, thus enabling universities to invest more of their core funding in supporting projects from other external funders and their own self-directed work. Spending Review 2004 allocates an additional £80 million as the next tranche of investment towards this goal.**

**1.16** **The funding bodies will work with the research charities to close the gap between the full cost of charity-sponsored research and the funds currently available from universities and charities. This will entail both rebalancing the support from charities towards infrastructural elements and increasing the public funding support for such research provided through the funding bodies, by up to £90 million in the first stage by 2007-08.**

**1.17** **The renewal of the UK's research infrastructure in universities will continue to be supported through a dedicated capital fund of £500 million a year, and a parallel renewal process across Research Council Institutes will be supported through additional capital funding of £50 million a year by 2007-08, accompanied by a more strategic approach to capacity planning for Public Sector Research Establishments (PSREs).**

**1.18** The Government will continue to work to ensure that UK researchers have access to large scientific facilities. Where substantial UK investment is required for this, priorities will be guided by the Large Facilities Road Map, and funding committed only where there is a good value for money case for investment, as balanced against other research priorities.

## Greater responsiveness of the research base to the economy

**1.19** Securing the growth and continued excellence of the UK's public science and research base will provide a platform for successful innovation in the UK by business and public services. The Government's ambition is to foster a strong, vibrant research base which attracts both talented individuals and corporate investment into the UK, and supplies trained personnel and knowledge for the economy. Better integration of the research base with the evolving needs of the economy should support growth in

business R&D and innovation through encouraging multinational firms to invest in the UK, supporting mid-sized firms in raising their R&D intensity towards the best in their industry, and fostering the creation of new technology-based sectors through the creation and rapid growth of new enterprises.

**1.20** **The Director General of the Research Councils will agree with each Research Council plans and goals for increasing the rate of knowledge transfer and level of interaction with business, with explicit targets for each Research Council to grow their proportion of collaborative research. The level of interaction with business for each Research Council will be subject to peer review within Research Councils UK (RCUK) and to external challenge by a group which includes business representatives.**

**1.21** **The new approach to assessing research, through reforms to the Research Assessment Exercise, which will form the basis of the HE funding bodies' allocation of research funding from 2008, will provide greater reward, and thus stronger incentives, for academics to work on both research relevant to users and work which crosses disciplinary boundaries.**

## Increased business investment in R&D, drawing on UK science

**1.22** **Building on the substantial work of the DTI Innovation report and the Lambert Review of Business-University Collaboration, both published in 2003, the Government will commit additional resources through to 2007-08 to help bridge the funding gap between commercial application of new technologies and the underpinning research.**

**1.23** The DTI Technology Strategy will provide a clearer framework for setting priorities and improving the effectiveness of support for business innovation. **With funding rising to at least £178m by 2007-08 for collaborative R&D and knowledge transfer networks**, the DTI will work closely with business to pull through and exploit technologies from the UK and international research base. The Technology Strategy will provide a clear focal point to draw in expert views from business, government and the science base, and in turn will influence national and regional partners in shaping their own investment plans.

## Knowledge transfer and innovation

**1.24** **Universities will be incentivised to build on the progress made in commercialising their research and working collaboratively with business, through increased funding for the Higher Education Innovation Fund, which will rise to £110 million a year by 2007-08**. Public sector research laboratories will be similarly encouraged and funded to develop their own knowledge transfer missions. In addition, responding to the recommendations in the Lambert Review on ways to promote business-relevant research. RDAs will continue to build their capacity to promote science and innovation as a key driver of economic growth. The first steps towards this will be assessed in their tasking framework, which will be finalised in autumn 2004. Each RDA will have a Science and Industry Council by the end of 2004.

## Science, engineering and technology skills: more responsive supply

**1.25** Moving the UK to a higher level of R&D intensity over the coming decade relies fundamentally on improving the flow of people into the economy who are educated in science, engineering and technology (SET) subjects, and on a stronger demand from employers, reinforced by the clear market signals to attract those people into high-value sectors. **As a central part of this framework, 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.**

**1.26** 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 mathematics[6] that the Government addresses the problems in mathematics. The DfES's response[7] to the Inquiry in respect of England sets out complementary ambitions and commitments on mathematics.

**1.27** The Government recognises that focusing on teaching and learning outcomes in schools is vital to engaging young people in science and increasing the number of young people studying science. Both a relevant curriculum that gives teachers flexibility to meet the needs of their individual students and a good supply of high quality science teachers are crucial to achieving our overall aims for science.

**1.28** There has already been real improvement in recent years in the recruitment of new graduates and career-changers into science teaching. In addition, the Government strongly encourages schools' efforts to use existing pay flexibilities to recruit and retain high calibre teachers, including in shortage subjects. In this framework, the Government sets out new commitments to:

- **eliminate as far as possible the undershooting of the national Initial Teacher Training targets for science by 2007/08;[8]**
- **double the number of science places on the Graduate Teacher Programme from 2005/06[8] (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 (ASTs), including removing the cap on how much they may be paid (subject to the School Teacher Review Body's recommendations), resulting in scientists on the advanced skills scale securing a high minimum pay of £40,000 (£45,000 in London);**

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

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

[8] 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

- **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;**

- **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.**

**1.29** The Government also encourages the work by business to develop and promote a model of best practice for their partnership work with schools, including participating in the Science and Engineering Ambassadors programme and giving support to the new network of Science Learning Centres to improve the professional development of science teachers.

**1.30** It is crucial that we ensure students have access to high quality post-16 education in SET. The ability of the sector to recruit and retain a good quality workforce is key to this aim. The Government is already implementing a reform programme for the sector and sets out new commitments in this framework to:

- **undertake immediate, focused 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 early 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.**

**1.31** The post-16 sector also plays a key role in responding to the needs of employers. With input from employer-led Sector Skills Councils, new Regional Skills Partnerships will focus learning providers on meeting skills shortages to help employers meet their need for SET skills at intermediate levels.

**1.32** Higher Education Institutions (HEIs) and the other stakeholders that collaborate closely with them have a crucial role to play in better informing students about the choices they have on entering higher education and in delivering high quality courses. To build on these roles, this framework sets out the following new commitments:

- **the Government welcomes the recommendation of the Lambert Review and 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 Teaching Quality Information web-site and HEIs publishing it in their prospectuses, and will report by the end of 2004;**

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

- **HEFCE will now 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; and**

- **HEFCE will set up an expert group, including business and scientific leaders, to review how falling SET provision will affect long-term economic development and the roles to be played by all stakeholders in securing future SET provision.**

**1.33** HEIs are developing a more flexible approach to managing their workforces, backed by investment from the Government of £0.5 billion over 2001-06 to support their human resource strategies. To maintain a good stock of high quality staff in SET subjects, it is important for HEIs to adopt a responsive approach to remuneration. In support of their efforts, the Government will commit to:

- **increasing the PhD stipend in line with inflation over the SR2004 period and reviewing the stipend rate over the period, implementing any further increases where appropriate; and**

- **maintaining 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.**

**1.34** A major issue for the UK is the considerable under-representation of women in SET education and the workforce. This contributes directly to the skills shortage and, left unaddressed, would have a considerable negative economic effect on the UK. The Government will therefore push forward its strategy for **increasing women's participation in SET, including investing £2.4 million in the new resource centre for women over the next three years, to help employers make SET a more attractive career for women.** It will also develop a strategy to address the under-representation of ethnic minorities.

**1.35** It will be important to bring coherence and coordination to the many science, engineering, technology and mathematics initiatives across the education system and review success. **The Government will review, with key stakeholders, the evidence on student participation in shortage subjects in schools, post-16 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 the Government or by others.**

## Public confidence in and engagement with science and technology

**1.36** In pushing forward the boundaries of science and breaking new ground in technological progress, the public needs to have confidence in the ethical and regulatory framework within which these advancements are being made. This

document sets out how the Government promotes public understanding of and engagement with the science base and stresses the need for regulatory and ethical issues to be considered at the emerging stages of new science, when action can be taken to address them head-on.

**1.37** **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 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. 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.**

**1.38** This document also reiterates the Government's determination to protect legitimate research activities from animal rights extremists. **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.**

## Science and innovation across government

**1.39** Science and innovation underpin evidence-based policy development and improved service delivery. Within this, excellent horizon-scanning of current science and technology, looking at opportunities and threats at least five to ten years ahead, and often considerably beyond that, is essential to the effective governance and direction of Government policy, publicly funded research and many of the activities of the private sector, and to the interactions between them. Building on the work already taking place in the OST's Foresight Directorate, in Government more widely, and in Research Councils UK (RCUK), **the Government's Chief Scientific Adviser will work with RCUK, the Prime Minister's Strategy Unit and Departmental Chief Scientific Advisers across Government to build up a single centre of excellence in science and technology horizon scanning.** This will feed directly into cross-government priority setting and strategy formation, improving Government's capacity to deal with cross-departmental and multi-disciplinary challenges. It will also inform and be informed by the Government's strategy for public engagement with science.

**1.40** Government departments' own science and innovation strategies are important components of the UK-wide R&D framework, as are the significant investments in research for the public good made by the charities, particularly those with a health mission. The Government's investment framework for science and innovation should provide a secure backdrop against which public bodies and charities can plan their own research investment strategies. Stronger science base and business R&D in the UK will create good scope for complementary investments by other research partners in the public and not-for-profit private sector. The Government will build on reforms to departmental science in recent years to ensure that even stronger partnerships across government and between public and private sectors are built into the Government's R&D portfolio.

**1.41** Charities play a central role in funding university research in the health arena. As part of the Dual Support system of research funding for the sector, they currently invest some £⅔ billion in the UK science base, of which around £½ billion is placed in

universities. In recognition of this, the Government will (as highlighted above) develop stronger public funding for charity-sponsored work, in return for a long-term commitment from the medical, and subsequently other, research charities to sustain investment in the UK science base and rebalance their funding towards the research infrastructure needed to support the science they sponsor.

**Box 1.2: The Wellcome Trust: investing in UK science in partnership with Government**

Since 1998, the Government has developed a productive partnership with the Wellcome Trust to deliver on their shared goals of securing a strong UK science base to meet the country's needs in the biomedical sciences. The Wellcome Trust has invested over £600 million into major capital renewal of the UK's university research infrastructure and major facilities in partnership with the Research Councils. It has also invested with DfES in science learning centres to support professional development of science teachers, and supported joint research programmes with Government (for example, in veterinary science).

Looking forward, the Government's aims for the UK science & innovation investment framework are very closely aligned with those of the Wellcome Trust. In recognition of the current and prospective quality of the UK science base, underpinned by the Government's increased financial support, the Wellcome Trust expects, assuming current levels of investment return, to commit at least £1.5 billion in the UK over the coming five years, with the UK remaining the strong centre of gravity for the Trust's research activity over the next decade. The Wellcome Trust will continue to work with the Government in securing stronger outcomes for health, the economy and public services from investment in the research base, through a series of partnerships including:

- translating research into patient benefit through investment in clinical research, as part of the UK Clinical Research Collaboration. The Wellcome Trust currently spends around £100 million on clinical research and training each year. The Wellcome Trust hopes to build on this investment with further commitment, totaling a further £13 million, in state-of-the-art clinical research infrastructure over the next five years;
- building on the Wellcome Trust's £50 million commitment in public health research and training over the past five years. The Wellcome Trust in looking to the future expects to develop, in partnership with Government and other agencies, innovative schemes to support training and research in the public health sciences;
- using UK research strengths to support international development. Working in partnership with DfID to combat malaria through research, the Wellcome Trust expects to commit around £10 million over the next five years, matched by DfID investment. The Trust is also exploring with DfID the joint development of a capacity building initiative for health research in sub-Saharan Africa; and
- working to secure a robust and vibrant UK university research base, in partnership with other public and private sector funders to promote greater financial sustainability through balanced funding across research activity and infrastructure.

The Wellcome Trust will also continue to work with government to create a regulatory environment that fosters and promotes biomedical sciences in the UK.

**1.42** Building on the Government's strong investment in the National Health Service, and the world class excellence in medical research in the UK's academic and business sectors, the Government is creating a stronger network of public, charitable and private partners to improve the health and wealth benefits from medical research in the UK.

The creation of the UK Clinical Research Collaboration (UKCRC) brings together the Health Departments and the NHS, the Medical Research Council, medical charities, industry and the public to transform the clinical research environment in the UK, providing leadership and taking strategic oversight of clinical research, identifying gaps and opportunities for action, and working in partnership to take advantage of these opportunities.

**1.43** To support this work, the Department of Health (DH) has committed to increase NHS funding for R&D by £25 million per annum for the next four years – an additional £100 million by 2007-08. The DH will in addition work with the NHS to put R&D on a sustainable and transparent footing. This will provide a stronger platform for growth in government investment in medical research, including through the Medical Research Council (MRC), and will complement business and charity-funded clinical research efforts. This should allow the combined budget for medical research and for R&D within the NHS to rise to around £1.2 billion a year by 2007-08.

**1.44** **To ensure stronger synergies between the MRC, the Department of Health and NHS on the translation of R&D into patient benefit, the Government has commissioned the creation of the Joint MRC/DH Health Research Delivery Group, working with the Health Departments in the devolved administrations.** With a remit to support the work of the UKCRC, this will provide a more coordinated, strategic approach between Government funders of medical research, with resources used effectively and organising joint delivery where appropriate. Taken together, the creation of the UKCRC and the Delivery Group will help to deliver world-class research to benefit patients and the economy, and to ensure that the UK remains a leading player in medical research and the pharmaceutical and biotechnology industries that it supports.

## Global partnerships, devolved administrations and the regions

**1.45** The Government's aim is that the UK should be a 'partner of choice' for global businesses looking to locate their R&D, or foreign universities seeking collaboration with the science base or business. Given the devolved nature of UK research funding and industrial policy, it is also important that there are strong connections between international and national R&D networks and the economic plans of the UK's countries and regions. The Government will adopt a more strategic approach to achieving these aims.

**1.46** **The Government's Chief Scientific Adviser will lead a cross-government Global Science and Innovation Forum to develop an international strategy based on an analysis of UK performance.** This will ensure that UK actions and priorities make the most of international opportunities and take account of the changing economic and research environment, including European action on innovation and R&D, and the Government will pursue a more strategic approach to investment in large research facilities. The Government and devolved administrations will continue to work together with the RDAs on science and innovation policy. This includes following up the Lambert Review's recommendations on building capacity in knowledge transfer and business/HEI interaction, both within and across regions.

## Future developments

**1.47** The achievement of the economic and scientific outcomes targeted by this investment framework will require sustained collaborative working across Government on a range of policies to manage public R&D spending better and secure greater impact for public services and business innovation. This is a core theme of a continuing joint project by the Prime Minister's Strategy Unit (PMSU) and the DTI on wealth creation from innovation and the knowledge economy.

**1.48** Following Spending Review 2004, the PMSU/DTI project team, alongside the Government's Chief Scientific Adviser and his team from the Office of Science and Technology, will carry on work to identify how best to build on the proposals identified by this investment framework. This includes working with departments on their science and innovation strategies, and on how best to secure benefits from collaborative working across Government and with business to make the most efficient use of R&D spend.

## Conclusion

**1.49** The Government is committed to building the UK's capacity to innovate and create wealth for the future through investing with private sector partners in the country's research base. With growing global competition for, and mobility of, capital investment and human talent, this is an increasingly pressing issue for UK economic policy. The Government is committed to following through on the long-term investment framework set out in this document, linked to reforms to improve the operation of the UK innovation system.

**1.50** By its very nature, the precise returns from this innovation system cannot be predicted or managed precisely, and ultimate returns from investments today in education, training and fundamental research will take decades to materialise fully. However, the Government is fully committed to working closely with stakeholders in the research base, business and not-for-profit sector to assess progress on an annual basis towards the long-term goals set out in this framework, and thereby create constructive feedback into the formulation of future policy and funding decisions. The Government believes that, working together, the public and private sectors can successfully increase the knowledge intensity and innovation performance of the UK economy over the coming decade.

# 2 A VISION FOR WORLD-CLASS RESEARCH: CHALLENGES AND OPPORTUNITIES FOR THE UK SCIENCE BASE

## Summary

**2.1** This chapter examines some of the key challenges and opportunities for UK science over the next decade. The UK starts from a position of strength in many fields, and has a reputation for highly productive research with high academic impact. However, it faces growing competition from emerging scientific nations, as well as developed nation peers. It also faces domestic challenges in renewing the stock of talented people leading the UK's research and development efforts in public and private sectors, and marshalling its research resources to tackle some of the major multi-disciplinary challenges facing the economy and society in the coming decade. Against this backdrop, the Government's vision for UK science over the coming decade is described in Box 2.1 below:

**Box 2.1: Vision for UK science**

By 2014:

- building on current strengths in research and exploiting the dominance of the English language in all international scientific communications, the UK should have the state-of-the-art facilities and laboratories, and the skilled workforce, necessary to make the UK the best location globally for research, development and innovation;
- these strengths will be recognised by the economic contribution of a growing high technology manufacturing sector and the influence of R&D on the UK's services industry. Improvements in healthcare, in security and the sustainability of the environment, and an increase in the number and diversity of young people seeking careers in science, engineering, medicine and technology will also be seen;
- through engagement, openness and dialogue, substantial and sustained progress will have been made towards building a society that is confident about the governance, regulation and use of science and technology;
- the development of the UK's knowledge base through research and scholarship will have made a strong impact on the way UK society is viewed around the world, extending influence in Europe and the rest of the world;
- through knowledge transfer and capacity-building activities the UK will be making significant contributions to the sustainable development and stabilisation of a world in which issues of poverty, education, water provision, population growth and global warming are tackled; and
- the ability to mine effectively into recently developed knowledge from the research base so as to analyse for opportunities and for risk avoidance will be fully developed so as to enable the UK Government to make informed policy decisions on the basis of the best available evidence, and to deliver on these decisions.

**2.2** This chapter sets out some of the key challenges to creating the attributes and operation of the UK science and innovation system that will be necessary to deliver this vision.

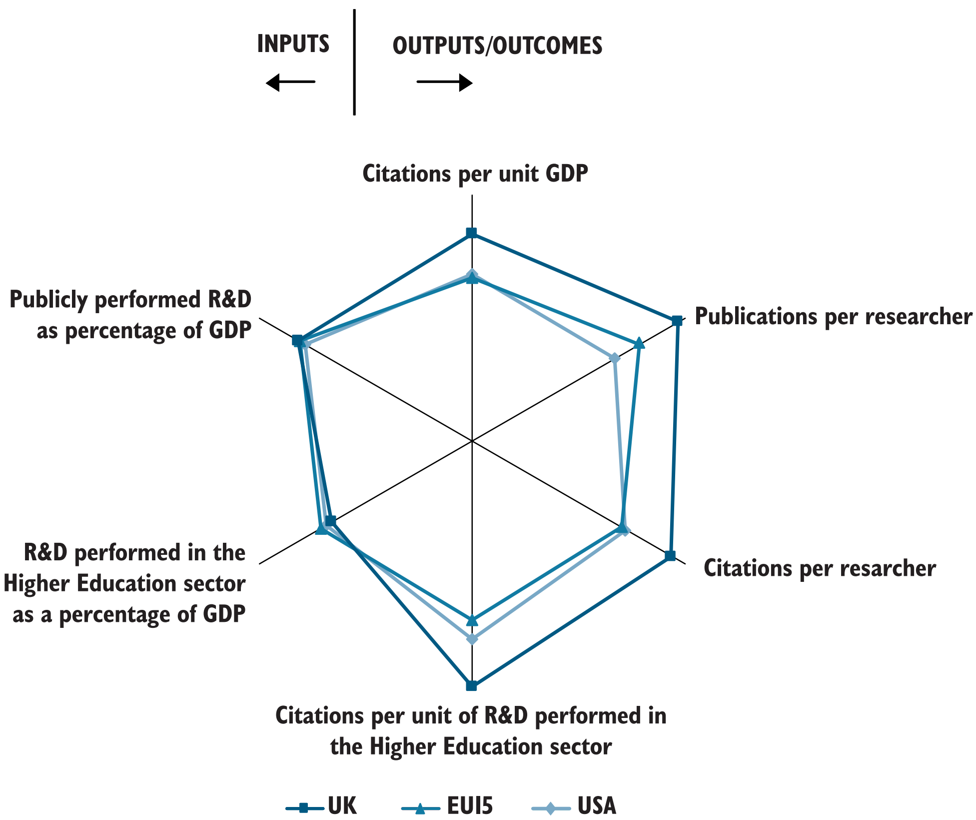
## Maintaining and developing world-class excellence and core strengths

**2.3** An international benchmarking study commissioned by the Office of Science and Technology (OST) concluded that the UK research base retained its:

"….strong relative international performance in terms of achievement, productivity and efficiency. We are probably strongest overall in the natural sciences, and on many indicators are second only to the USA. Where the UK has been overtaken by other nations, we still have a more consistent performance across fields than those countries. Our strong international performance has been achieved with lower average investment compared to our competitors and with relatively lower availability of people with research training and skills" [1]

**2.4** The UK's share of citations – the generally accepted measure of research excellence – is second only to the USA. The UK is also efficient in terms of its research outputs, with generally fewer (and a declining share of) lower quality papers than its competitors. The UK has the second highest share of the world's most highly cited papers in six of the nine main research fields. In mathematics, the UK is third, and in the physical sciences and engineering the UK is fourth. The UK is also the best performer in the Group of Seven leading economies per unit of R&D spend.

### Chart 2.1: Research footprints




*Source: Thomson ISI® and OECD analysed by Evidence Ltd*

[1] Evidence Ltd PSA Target Metrics for the UK Research Base 2003, www.ost.gov.uk/research/psa_target_metrics2.pdf

**2.5** Measurements of world publications are a readily measurable output from public expenditure on science. The UK's share is around 8.5 per cent. Having been second to the US for a long period of time, the UK has recently has been overtaken by Japan. The UK performs well in terms of PhD awards, with the number of PhD awards per head of population behind the US and Germany but similar to Japan.

**2.6** The UK's present strengths must be maintained and enhanced, and action should be taken to significantly enhance capabilities in weaker areas such as physical sciences and engineering. Action is needed to ensure the UK is in a position to seize opportunities from the anticipated new developments in these areas, but also because breakthroughs in the life sciences and new interdisciplinary developments are often instigated in the physical sciences. Attracting talent from abroad will help here, as will the deployment of the Director General of the Research Council's (DGRC) new strategic funding to emerging priorities and to underpin health of disciplines. **As a starting point, the 2004 Spending Review has provided a total of £70 million for this purpose, reflecting the future focus of the Research Councils in ensuring the health of disciplines.**

**2.7** As R&D in the public and private sector increases, and demand for science and related skills increases likewise, the UK will also need to ensure that it has a sufficient supply of skilled people flowing through the education and research system. There are also discipline-specific problems here, for example, the proportion of students gaining any higher-level mathematical science and physical science qualification continues to decline, with accompanying falls in engineering and technology at degree and doctorate level and computer science at doctorate level.

**2.8** Much has been achieved over recent years due to increased investment in science from consecutive spending reviews, some examples are given in Box 2.2 below. There are challenges to sustaining and improving on these achievements, covered in the rest of this chapter.

**Box 2.2: Science base achievements since 1998**

- UK Stem Cell Bank opened in May 2004 - the first of its kind in the world, it will store and supply ethically approved quality controlled stem cell lines for research and, ultimately, treatment
- Renewal of the UK's research infrastructure: by 2006, the Office of Science and Technology along with DfES and the Wellcome Trust will have invested over £2.6 billion in university science research capital
- Investment in Diamond Synchrotron (due to open in 2007): this is the largest UK scientific facility to be built for 30 years, providing facilities for many disciplines and directions of research
- Stronger results on knowledge transfer and commercial exploitation by universities: including growth in contract research, intellectual property licensing and creation of new companied, supported by public funding for knowledge transfer
- Greater support for training and developing the next generation of researchers: including through the launch of 1,000 Academic Fellowships to provide a clear career path for researchers, and increasing PhD stipends from £5,300 in 1997 to £12,000 in 2005-06

## Multidisciplinary working

**2.9** We need to enhance a culture of multidisciplinary research in the UK and provide the underpinning infrastructure and funding mechanisms to support it. This is a critical challenge. Over the next decade many of the grand challenges in research will occupy the interfaces between the separate research disciplines developed in the 19th and 20th centuries. The nations that succeed in producing high-tech economies will be the ones that are best able to adopt a flexible approach to research for the greatest added value. The US, Japan and Germany are already investing in multidisciplinary capability.

**2.10** A change of culture away from viewing university departments as separate entities is needed. Some UK universities are rising to this challenge. Research Councils, too, are promoting cross-Council research programmes and other discipline-hopping activities. However, much more needs to be done, and by more players, if the UK is to achieve a global edge.

**2.11** Key areas for further improvement in the early part of the ten year framework include:

**Improving training;**

- More cross-disciplinary training will be delivered at undergraduate and postgraduate level, particularly cross-disciplinary PhD programmes. More four year PhDs (within a flexible framework) may help, by giving more time for students to experience other research fields as part of their training. More Masters courses should have a cross-disciplinary slant, and more cross-disciplinary Fellowships should give both new and established researchers the opportunity to work across fields.

- Research and Funding Councils will work with universities to establish more translational courses to help bridge the gap between disciplines. A significant barrier to multidisciplinary working is often the failure of the potential partners to speak the same technical language.

**Creating a multidisciplinary research environment;**

- Multidisciplinary research will be embedded in more universities as standard. One favoured model is the centre of excellence which brings together researchers from different disciplines into the same working space with the requisite facilities, infrastructure and support staff. **Over the next five years Research Councils (driven by the needs of their research communities) will work with universities and other funders in the public and private sectors to establish multidisciplinary capabilities in research-intensive universities.**

- Reforms to the Higher Education funding bodies' research assessment exercise, which forms the basis of universities' core research funding, will provide greater recognition and reward for cross-discipline working.

- Multidisciplinary research also presents challenges to Research Council funding and peer review mechanisms. Research Councils UK (RCUK) will consider whether Councils can go further in removing unintentional barriers to multidisciplinary working.

- The Higher Education Research Forum[2] is currently looking at how better to encourage collaboration across institutional boundaries, and also the link between teaching and research.

**2.12** Profiled at the end of this chapter are exemplars of multidisciplinary research themes that are likely to be of international importance over the next ten years – this is not intended to be a comprehensive list but has been included to illustrate the range of opportunities that exist.

## Balance, flexibility and strategic oversight in funding basic research

**2.13** Funding basic research from the Science Budget must achieve a balance between directed ('top-down') and responsive ('bottom-up') research. The latter should continue to form the larger part, and through permissive management and funding of the science base ensure that the world-beating ideas of tomorrow can arise and flourish, generating some of the 'disruptive technologies' of the future for development in the UK. Providing ample scope for cutting-edge research ideas and new knowledge to emerge from the science base has provided huge benefit to business and society – for example, the study of upper atmosphere physics revealed the existence of the ozone hole, and research into the biology of a soil-dwelling nematode worm led to genome sequencing and proof of principle that sparked the human genome project. The UK must continue to make space for the most talented researchers to follow their own initiative in pushing the bounds of knowledge.

**2.14** Against that, a proportion of top-down direction of activity is a necessary and prudent management tool to meet both strategic requirements for business development and public policy goals that cannot be left entirely to the market in research ideas, and to build critical mass in key areas of research. To deliver the best from this balanced model of research funding requires flexibility in modes of funding to seize opportunities or meet new challenges early. This has been highlighted by recent system-wide analysis by the Prime Minister's Strategy Unit.

**2.15** In addition to the top down/bottom up model, research can also be considered along two orthogonal axes, representing consideration of use and the quest for fundamental understanding. This is illustrated in the frontspiece[3]. The UK research funding system will continue to allow space for fundamental basic research, complemented by strategic priority programmes and incentives for researchers to work on projects focused on application. It will also need to find ways of combining these two approaches, to bring together public and private funding and research talent to work on major research challenges with major societal impact.

**2.16** The Research Councils already ensure that funding is, in part, driven by market demand ('stakeholder pull'): Councils consult stakeholders to set priorities in their strategic plans and to develop funding initiatives. Councils also operate a range of funding schemes jointly with industry and government departments, which further align research with needs. Above the Research Councils, though, there should also be additional capability for the Director General of the Research Councils to take the necessary strategic decisions and to shift resources as priorities change.

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[2] www.dfes.gov.uk/hegateway/hereform/index.cfm

[3] *Pasteur's Quadrant: Basic Science and Technological Innovation*, Donald E. Stokes, Brookings Institution Press, 1997

**2.17 This will be achieved through the development of a comprehensive, integrated and efficient performance management system providing a more robust mechanism for translating the overall strategic priorities for the science base into specific aims and objectives for the Research Councils and other delivery agents. The transparent identification of outputs and performance measures will allow a balance of investment to be made across the Science Budget and adjusted in response to a more strategic view of new priorities and identified strengths and weaknesses. The Science Budget allocations in autumn 2004 will be based upon a balance of investment and the methodology for determining this further refined for future years. The Government will further enhance this process in coming years, by providing a central 'strategic fund' for flexible deployment by the Office of Science and Technology (OST) against emerging priorities, for example where it is necessary to focus research effort, build national capacity (including infrastructure) or to seize opportunities from international partnership.**

**2.18** Funding science and research on the basis of excellence is central to a system aimed at assuring world-class research, infrastructure and skilled people. Given finite resources, the allocation of resources needs to reflect the importance of rewarding and building on excellence wherever it is found. Ensuring that access to these excellent outputs is facilitated, for example through building regional capabilities, is important in transferring knowledge.

## Horizon scanning

**2.19** Strategic decisions of the type mentioned above must be embedded in, and driven by, horizon scanning and stakeholder engagement. Building on the work already taking place through the Foresight Directorate (described in Chapter 8, Box 8.3), in Government more widely, and in RCUK, **the Government's Chief Scientific Adviser will work with RCUK, the Prime Minister's Strategy Unit and Departmental Chief Scientific Advisers across Government to build up a single centre of excellence in science and technology horizon scanning**. This will be co-ordinated by OST's Foresight Directorate and will bring together high calibre individuals provided and resourced by other Government Departments, Research Councils and the private sector. This will not replace the requirement for effective horizon scanning in departments, RCUK and elsewhere; rather, it will provide a higher-level strategic context to those other activities, interacting with and informing them. It will feed directly into cross-government priority setting and strategy formation. It will also inform and be informed by the Government's strategy for public engagement with science.

## Public policy and the research base: improving responsiveness

**2.20** The ability to mine effectively into recently developed knowledge from the research base to analyse for opportunities and for risk avoidance for the UK (and the world generally) needs to be fully developed so as to enable the government to make informed policy decisions on the basis of the best available evidence, and to deliver on these decisions. The Government and its research bodies will develop ways to encourage more research, across the spectrum from basic to applied research, to be conducted with a stronger consideration of use built in to the design of the work from the outset.

**2.21** Key policy priorities for government R&D are improvements in healthcare, in security, in the sustainability of our environment and energy and in international development. In many of these areas, R&D could be more effectively targeted by better coordination among funders. Research in government departments forms the basis of Chapter 8, where these areas are explored in more detail.

**2.22** Moving forward, the Government's research priorities will be shaped by the national and international drivers that will define both research needs and the supporting policy framework over the next decade. They will create both threats and opportunities for the UK, and include issues such as demography (ageing population, skills shortages and multiculturalism), globalisation, climate change, sustainability, crime, security, health, EU enlargement/legislation and public trust.

## Information infrastructure

**2.23** The growing UK research base must have ready and efficient access to information of all kinds – such as experimental data sets, journals, theses, conference proceedings and patents. This is the life blood of research and innovation. Much of this type of information is now, and increasingly, in digital form. This is excellent for rapid access but presents a number of potential risks and challenges. For example, the digital information from the last 15 years is in various formats (versions of software and storage media) that are already obsolete or risk being so in the future. Digital information is also often transient in nature, especially when published formally or informally on websites; unless it is collected and archived it will disappear.[4] There are other challenges too, navigating vast online data/information resources determining the providence and quality of the information, and wider issues of security and access.

**2.24** It is clear that the research community needs access to information mechanisms which:

- systematically collect, preserve and make available digital information;
- are easily navigable;
- are quality assured;
- tie into international efforts (e.g. to ensure compatibility); and
- take on board the current debate around the future of scientific publications and open access.

**2.25** **The Government will therefore work with interested funders and stakeholders to consider the national e-infrastructure (hardware, networks, communications technology) necessary to deliver an effective system.** These funders and stakeholders include the British Library, which plays an important role in supporting scientific research and potential, including providing benefits to smaller businesses in the UK through access to science, engineering and technology information sources. Due to the potential importance of a national e-infrastructure to the needs of the research base and its supporting infrastructure in meeting the Government's broader science and innovation goals, as a first step OST will take a lead in taking forward discussion and development of proposals for action and funding, drawing in other funders and stakeholders as necessary.

[4] These issues were part of the evidence and response to the House of Commons Select Committee enquiry on Scientific Publications, see http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/uc39901.htm

## Capital infrastructure

**2.26** Sound supporting infrastructure is an essential underpinning for a strong research base. The Government has over past Spending Reviews addressed the historical under investment in university infrastructure through successive rounds of dedicated capital funding:

- the Joint Infrastructure Fund (JIF) awarded a total of £750 million[5] to science research infrastructure projects at 40 UK universities between 1999 and 2001;
- under the first round of the Science Research Investment Fund (SRIF), announced in 2000, £675 million was allocated to UK High Education Institutions (HEIs) on a formula basis for 2002-04; and
- the second Science Research Infrastructure Fund, announced in 2002, built on SRIF with a dedicated infrastructure scheme worth £500 million a year from 2002 to 2004, again allocated on a formula basis across all the HEIs in the UK engaged in science research.

**2.27** The 2004 Spending Review continues this dedicated capital funding stream at a rate of £500 million a year, and **provides new capital funding for Research Council Institutes of £50 million a year by 2007-08.**

**Box 2.3: Large Facilities**

The UK's priorities for Large Facilities are set out in the Large Facilities Road Map[6]. This takes a 15-year strategic look across all scientific disciplines and sets out those facilities which the Research Councils would like to see available for UK scientists. They include both national and international facilities. The next ten years will see major facilities, both in the UK and abroad, being completed and available for UK scientists. Projects currently underway include:

- the Diamond Synchrotron, a new third generation synchrotron facility due to open in January 2007. By 2013, it will be populated with 22 beamlines;
- the Second Target Station for the ISIS Neutron source and a new instrument suite, due to be completed in 2008;
- the Large Hadron Collider at CERN, Geneva, the world's most powerful particle accelerator for high energy physics, will begin operations in 2007; and
- a replacement marine research vessel to replace the RRS Charles Darwin in 2007.

## Measuring success

**2.28** It is essential that the Government sets out the criteria against which success will be measured. Current evidence gathering and benchmarking activities provide a range of metrics that describe past and present performance of the research base against international comparators. Annex B details measurement metrics for monitoring the effectiveness of the investment framework in delivering science and innovation benefits over the coming decade.

[5] Including £300 million from the Wellcome Trust

[6] http://www.ost.gov.uk/research/funding/lfroadmap/index.htm

**2.29** Performance against these metrics will depend on effective working between the publicly funded science base and its stakeholders in government, business, the wider private sector and internationally. The Government will conduct regular open reviews of progress against targets, in consultation with other funders and users of the UK science base, to diagnose the health of the system and identify in a timely manner actions by public or private sectors to correct emerging shortfalls in performance.

## APPENDIX TO CHAPTER 2

### Multidisciplinary Research Exemplars

**2.30** Described below are some exemplars of multidisciplinary research themes that are likely to be of international importance over the next ten years. The six areas represented here are themes in which the UK has current world-class strengths and could develop a lead, or where there is simply a clear need for more UK relevant research:

i. sustainable Earth systems (Earth systems science);

ii. systems biology (complexity of life);

iii. sustainable energy;

iv. cognitive systems;

v. cyber trust and crime prevention; and

vi. identities and cultures.

**2.31** They are based largely on Research Council assessments and outputs from the Foresight programme. There is also significant connection with the 2003 Cabinet Office Strategic Audit,[7] particularly in the areas of climate change, sustainable energy, systems biology and identities and cultures.

**2.32** Taken together they represent a range of outcomes – wealth creation, public services, healthcare, security, better regulation, policy development and delivery of existing policy commitments, and basic underpinning knowledge and cultural enrichment.

[7] Strategic Audit: Discussion Document. Strategy Unit, Cabinet Office, www.strategy.gov.uk/output/page4953.asp

**i. Sustainable Earth systems (Earth systems science)**

Earth systems science (ESS) seeks to understand and predict the complex interactions between the atmosphere, biosphere, cryosphere, hydrosphere, land and socio-economic systems. Many environmental problems – the supply of water, the yield of crops, the spread of disease, and the vulnerability of ecosystems – require an Earth Systems approach to model, understand and manage them.

The UK is a world leader in ESS modelling and climate change prediction. In many other areas the UK is second only to the USA, and closing the gap. Maintaining this leadership edge will require: innovative mechanisms enabling interdisciplinary work with skilled mathematicians, physicists, engineers and socio-economists; major national and international partnerships; high performance computing and data-handling facilities far in excess of those currently available; comprehensive, 'intelligent' Earth observation and monitoring systems; and world-class laboratories, satellites, ships, autonomous vehicles, aircraft and Antarctic bases.

In the next ten years, key outcomes could be:

- considerably reduced uncertainties in predicted climate change and sea-level rise, both globally and regionally;
- ability to predict environmental hazards with greater clarity, to reduce risks to economic activity, human health and well-being;
- considerably reduce the current uncertainties about the possible rapid collapse of the thermohaline circulation (Gulf stream) which would lead to severe and rapid climate change in north west Europe;
- significantly enhanced understanding of flood risks in the urban environment, including sewage flooding – leading to more effective risk management;
- models that better represent (by orders of magnitude) the microbial biosphere, soil and sedimentary dynamics, and the role of species in maintaining ecosystems;
- complete a global biodiversity inventory, transforming taxonomy into a 21st Century science of information technology driven by molecular biology, and revolutionising evolutionary biology;
- major improvements in understanding the Earth's water cycle, forcing a step-change in the global and regional management of this increasingly scarce resource; and
- understanding the implications of global environmental change for the sustainability of terrestrial and marine ecosystem goods and services.

**ii. Systems biology (complexity of life)**

Systems biology is the future in biology. It aims to understand organisms not as isolated parts but as integrated systems. It will transform understanding of complex living processes such as plant and animal development, immunity, brain function/behaviour, cellular regulation and signalling, and infection-disease. It unites traditionally separate scientific disciplines by combining biological experimentation, mathematics and computer science to investigate and model life processes. Only with the combination of predictive modelling of biological function and experimental testing can research develop true insight into biological complexity.

The UK can become a world centre for systems biology. It is now the European leader in genomics, closely chasing the US. It has considerable strength in biochemistry, glycobiology, structural biology and cell biology and development. Together with access to existing and planned world-class facilities (e.g. the Diamond synchrotron) the UK has an excellent platform to be globally competitive. To maintain this edge the UK must embed systems biology in universities, develop grid-enabled tools and technologies for advanced bio-imaging, interrogation and visualization, have access to high performance computing, and tackle the dearth of students in mathematics and the physical sciences.

In the next ten years, key outcomes could be:

- a greater insight into the function and development of plants, animals and microbes – providing essential underpinning knowledge that advances bioscience in many, and often unpredictable, ways across a broad front;
- a skills base that is fit for the future – a critical mass of highly skilled researchers able to function to a high standard in a multidisciplinary research environment;
- more effective therapeutics that tackle the underlying causes of disease rather than treating the symptoms – pharmaceuticals with fewer side effects;
- the breeding of new and improved crops and livestock that can be farmed more sustainably and are more resistant to diseases;
- a better understanding of the factors necessary to improve animal welfare;
- providing bio-industry with the ability to model and manipulate biological processes better so as to provide novel compounds for the chemical, pharmaceutical and food sectors, thereby improving the competitive edge of these industries;
- a better understanding of healthy ageing and how to maintain a population that remains healthy and productive for longer; and
- the development of predictive (in silico) toxicology models of cells and organs leading to improved drug screens and reduced need for animal testing.

### iii. Sustainable energy

Over the course of this century, fossil fuel reserves will dwindle, whilst world energy demands are likely to increase as a result of increasing population and economic growth. Increasingly, the threat of climate change will stimulate research into sustainable, low-carbon energy generation and its efficient use. Following the Kyoto Protocol, the UK has set itself an ambitious target of reducing carbon dioxide emissions to 60 per cent of 1990 levels by 2050. The challenge will be to find reliable, diverse, affordable, publicly acceptable and safe ways to supply and use energy. Research will generate new ideas about the next generation of energy efficient technologies, vehicles and buildings through the development of knowledge in areas such as fuel cells, the use of hydrogen as a fuel, and solar electricity generation.

Work on sustainable energy will include carbon management, geo-energy, bio-energy derived from plant and microbial systems, wind, wave, solar and tidal energy. New, whole systems approaches will be required to address how people and businesses use energy; the disposal of carbon dioxide produced by fossil fuel burning and of waste generated by nuclear power; and on the economic, social and environmental benefits and impacts of different types of energy generation and use. The UK fusion research community will make a substantial contribution to the development of the International Tokamak Experimental Reactor (ITER), the next generation of fusion device. The outcomes of work by ventures such as the Tyndall Centre for Climate Change Research and the Carbon Vision programme will be key influences on progress.

In the next ten years, key outcomes could include:

- a world-class Energy Research Centre and national research network - promoting a collaborative research environment and stimulating participation in key international programmes;
- the UK as a world leader in basic and strategic research on sustainable energy and its impacts, working with stakeholders to address the research, technical, regulatory, economic and social barriers that currently limit the evolution of the UK sustainable energy system over the period to 2020;
- underpinning research to support economically viable and publicly acceptable renewable energy sources and technologies, helping the UK to meet energy and environmental targets by 2010 and 2020;
- an improved research interface with business which can identify and support the development of new products, processes and services with high commercial potential;
- a cohort of internationally recognised and developing young researchers with the capacity and training to conduct multi-system programmes;
- harnessing the true potential of biological systems for sustainable energy production and carbon sequestration through integrated technologies involving engineering, chemistry, economics and sociology; and
- effective communication and public engagement so that the outcomes of UK research inform public debate about future sustainable energy supply and use and the development of local, regional, national and international energy policies.

**iv. Cognitive systems**

Understanding how the human brain works, in health and disease, is one of the great scientific challenges of our time. The human brain is by far the most complex living system known. It controls every aspect of our lives, mediating thoughts, perceptions, memories, emotions, actions and interactions with the world around us. Computational systems and robotic devices share many of the same objectives and face many of the same challenges as real brains. It is widely acknowledged that the time is ripe for a fresh approach to cognitive systems.

The UK has world-leading expertise in basic neuroscience, developmental neurobiology, the imaging of biological, pathological and behavioural processes in the brain, and cognitive neuroscience. Interchange and active collaboration between neuroscience, cognitive science, informatics, computer science, software engineering, robotics, cognitive psychology and philosophy will be a prerequisite to major advances in the field. If the UK is to maintain its leadership edge, there will be a need for stronger interdisciplinary research networks, high performance computing capacity, the development of new computing architectures and new approaches to neural computing, and investment in neuroscience and research facilities. In parallel, there is the need to explore the sociological and legal issues associated with artificial intelligence and its acceptability.

In the next ten years, key outcomes could be:

- an increased understanding of normal higher brain function, behaviour, psychological illness and cognitive decline, leading to new interventions and new therapies in areas such as addiction, antisocial behaviour and aggression;
- in sociological studies, developing the understanding of the influence of environment and the community on mental health, and to help design and implement community-based interventions;
- significant progress towards implanted chips for the treatment of a wide range of cognitive dysfunctions such as Parkinson's disease, and component level brain enhancement for areas that have been damaged;
- real time monitoring and feedback on brain activity to facilitate and control treatments or speed the learning of new tasks;
- robotic systems that are able to act autonomously, intelligently navigating their environment and capable of substituting in part for some human interactions such as emergency rescue;
- advanced forms of vehicle control and driver assistance that will radically change how we drive;
- internet services that are more resilient and capable, allowing more devices to be wired up and increasing the efficiency and improving the quality and range of private and public services;
- software agents that do our bidding, such as finding out the things we really want to know and negotiating on our behalf; and
- replacement, refinement and reduction of the use of animals (including primates) in cognitive research.

**v. Cyber trust and crime prevention**

Information and communication technology (ICT) has brought, and will continue to bring, massive benefits across society. However, as it reaches further into public and private spaces it raises complicated, uncertain and inter-dependent issues. The complexity and pervasiveness of ICT will require new ways of thinking, particularly about how to continue to deliver the benefits and manage the risks to people and society. There needs to be a better understanding of how risk is perceived and trust is fostered within complex social and technical systems.

The strength of the science base in the UK in key technical areas, as well as with respect to the wider set of problems and issues that are the concerns of the social sciences and the humanities, provides a strong basis for leadership internationally. This is particularly important because cyberspace is global in its reach and many of the solutions require internationally coordinated action to be effective.

In the next ten years, key outcomes could be:

- improved empirical basis for understanding how people place trust in ICTs and what ensures those systems reach appropriate levels of trustworthiness, leading to the rapid evolution and uptake of new applications and services;
- the development of better models for understanding how criminal opportunities are created in virtual environments;
- better methodologies for testing when changes in the human and technical systems are likely to create new vulnerabilities; and
- better ways of managing emergent properties and vulnerabilities in ways that respect changing individual and collective values.

**vi. Identities and cultures**

The UK is one of the most diverse and multi-cultural societies in the world, with a wide level of international engagement and network of interactions. Understanding and managing this diversity is of particular urgency if the UK is to sustain a dynamic and cohesive society, secure both internally and in its relations with the rest of the world. There is a need to know how ethnic identities and cultures develop and are modified, how multiple identities are constructed, and how they interact within the host societies.

Research of value to the UK in this area must take place predominantly in the UK. UK researchers are at the forefront of both theoretical and empirical studies of cultures and identities, have developed cutting-edge approaches, and are effectively networked with leading researchers in the US and the rest of Europe. Achievement has been considerable but piecemeal. There is a need to develop a more sustained and cohesive programme, building research capacity and new intellectual strategies and approaches drawing leading researchers into interdisciplinary programmes.

In the next ten years, key outcomes could be:

- a greater understanding of and insight into how the multiple identities of individuals and groups are created and modified, and how they interact with each other to stimulate senses of both difference and cohesion – providing an underpinning knowledge that supports the development of public policy and the enhancement of civil society;
- the development of a base of researchers who are equipped with the knowledge, understanding and expertise to pursue high-quality empirical and theoretical research across a wide range of relevant subjects and disciplines;
- an enhanced understanding of how cultural policies and the activities of cultural institutions can be developed as instruments of enlightenment, to stimulate engagement to enhance and change the lives of individuals and groups;
- an active engagement of a wide range of community groups and leaders in the work of the research base;
- the development of new paradigms and languages that go beyond the current discourse of multiculturalism, diversity, and inter-generational difference; and
- inputs into the development of public policy in a range of areas including: education and lifelong learning; economic and social regeneration; urban and rural planning; social cohesion and active citizenship; health; crime; national security; and international relations.

# 3 MANAGEMENT OF THE SCIENCE BASE

## Summary

**3.1** The productivity and responsiveness of the UK science base is primarily delivered by the strength of research talent and management within the UK's universities and public research institutes. The Government plays an important role, though, in enabling and encouraging talented people to deliver their best through the structure of research funding and associated governance arrangements.

**3.2** The Government remains committed to developing Dual Support as the organising principle for funding university research, combining growth in core annual funding for institutions through the higher education funding bodies, with growth in project and programme funding from the Research Councils. This chapter describes how the Government will continue to work with the university sector to deliver stronger research outcomes and financial management through reforms aimed at developing the attributes of a successful science and innovation system.

## Basic architecture

**3.3** Central Government funding for science and research activities in universities and research establishments in the UK flows through three main routes:

- the Dual Support system; providing block grant funding for higher education institutions, complemented by project funding for individual academics, research teams and departments;
- dedicated capital funding through the Science Research Investment Fund; and
- knowledge transfer funding, which in England flows through the Higher Education Innovation Fund and the Public Sector Research Establishments Fund; the devolved administrations deploy their own schemes with similar goals.

**3.4** One of the strengths of the UK university system is its ability to secure a diverse range of current and capital funding for research from a variety of public, private and other sources. Chart 3.1 shows how the proportion of university income from different sources has changed over the past decade, with third party funding becoming increasingly important to institutions. This plurality of funding also presents a long-term challenge for government in managing the interaction and balance between funders and universities.

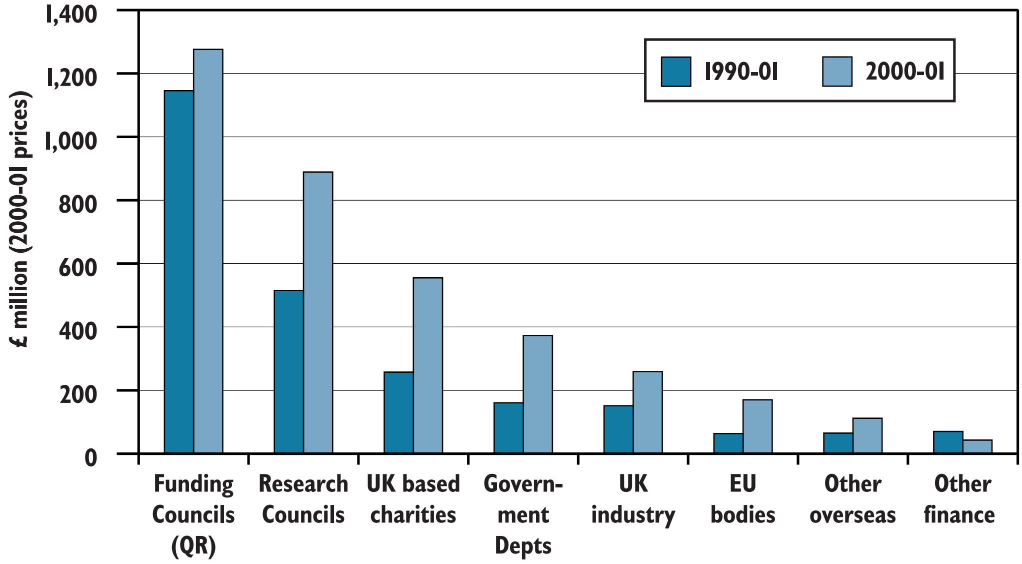
**3.5** The Government has signalled its strong and continuing commitment to the fundamental principle of the Dual Support system for funding science and research in the UK.[1] The two separate streams of funding serve different and complementary purposes. However, concerns have been expressed about both sides of the system, which require policy changes and funding both to safeguard the high quality and sustainability of research in the science base, and to minimise the burdens upon it.

[1] See joint Ministerial letter to English Higher Education Institutions, November 2003 http://www.dfes.gov.uk/hegateway/hereform/index.cfm?cid=33

These changes are being taken forward following consultations and reviews in the last few years.[2]

**3.6** Quality Related (QR) funding - flowing through the DfES and devolved administrations, and distributed by the funding bodies to Higher Education Institutions (HEIs) as part of their block grant - provides a foundation allowing university leaders to take strategic decisions about the research activities of their own institutions. It funds the basic research infrastructure – including the salary costs of permanent academic researchers, support staff, equipment and libraries – that gives institutions the base from which to undertake research commissioned by other funding sources; the flexibility to react quickly to emerging priorities and new fields of enquiry; and the capacity to undertake 'blue skies' research. QR allocations reflect the excellence of individual departments within institutions, using the results of the peer review based Research Assessment Exercise. QR funding will be £1,625 million across the UK in 2004-05.

**Chart 3.1: University research funding sources**




*Source: Office of Science and Technology (2003)*

**3.7** The seven Research Councils[3] – funded through the Office of Science and Technology (OST) – provide a research capability through their own institutes and access to large facilities, as well as funding specific projects and exploratory thinking in HEIs. They are able to take a national strategic view, again ensuring excellence through peer review. Funding through Research Councils was £1,892 million in 2003-4, of which around half was spent in HEIs on research projects.

[2] Including: Review by the UK funding bodies of Research Assessment, 2003; OST consultation on *The Sustainability of University Research*, 2003; Cross-cutting Review of Science & Research, 2002

[3] To become eight on completion of final legislative processes following Royal Assent of the Higher Education Act, when the Arts and Humanities Research Board receives Research Council status. In this context "science" should be read in its broadest sense to encompass all aspects of engineering, technology, design, social sciences and the arts and humanities.

**Box 3.1: Informing policy and understanding: the role of the arts and humanities**

The arts and humanities make a fundamental contribution to key areas of public policy and understanding. Enhancing our understanding of ourselves and our world makes an impact in key areas of public policy as diverse as law and ethics, media and communications, language and language technologies, and creativity and innovation. The imminent transformation of the Arts and Humanities Research Board into a full Research Council will ensure that the impact of this research on informing policy and understanding will be fully exploited. Examples of research priorities are:

- Diasporas, migration and identities - building on work where the UK has been at the forefront in both theoretical and empirical studies of identities based on ethnic, religious, linguistic and historic differences. In an increasingly multicultural society it is essential that we generate new understanding of the way migration affects cultures and identities within the UK and beyond. We need high quality research on religious and language communities, on the complex relationship between diasporas and the societies in which they take shape, on bilingualism and translation, and on the ways in which cultures interact and change.

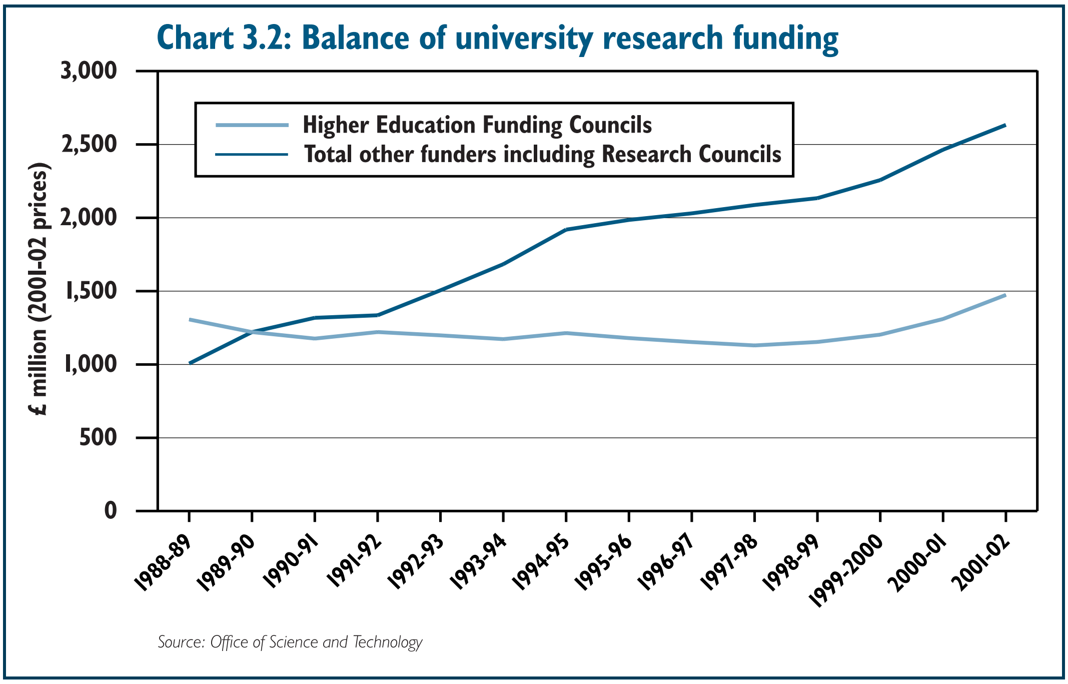
- Landscape and environment, where research in the arts and humanities is fundamental to understanding the changing relations between people and their environment to better understand the changing natural and built environment, the character and history of that environment, and the ways that people relate to the environment, shaped by a number of factors such as culture.

**3.8** **As a result of Spending Review 2004, investment in the public science base will be over a billion higher in 2007-08 than in 2004-05. DfES spending will be £1.7 billion in 2007-08, compared with £1.3 billion in 2004-05. OST Science Budget funding will be £3.3 billion in 2007-08, compared with £2.6 billion on 2004-05. This is equivalent to an annual average growth rate in funding, through the DTI and DfES, of 5.8 per cent in real terms over the Spending Review period.**

## Sustainability

**3.9** As demonstrated in chapter 2 and Annex A, the UK has an excellent science base, and one which is highly productive. The last two Spending Reviews have allocated significant funding increases to science spending - with the Science Budget growing by an average 10 per cent year-on-year in real terms from 2002-03 to 2005-06 - to maintain and build on the UK's excellent science and engineering base.

**3.10** The Government has recognised that, without some change, this performance is not sustainable over the long term. The total costs of externally funded research projects and training in universities have risen at an unsustainably faster rate than the rise in core QR funding needed to support this increased volume of activity.




**3.11** The bulk of increased funding from third parties provides only partial coverage of the full economic costs of research sponsored. This causes institutions to draw more heavily on limited QR resources to cover the full costs of a project from a third party funder, or to leave the long term cost impacts of such external projects (in terms of physical and human capital consumption) uncovered.

**3.12** Demands on QR resources to underpin projects from other funders have therefore increased. The effect of this on universities is that the high productivity of the science base has in many cases been achieved by cross-subsidy of research from other areas of the institution's business – such as overseas student fees and internal trading surpluses - and / or at the expense of infrastructure under-investment. In the latter case, this has contributed to the historic under-investment in the asset base of universities and public sector research establishments. This process has been exacerbated by an often poor understanding by institutions themselves of their cost base.

**3.13** The Office of Science and Technology has carried out a 'whole system' analysis to estimate the total deficit of recurrent research funding in Higher Education Institutions. Although most universities report operating surpluses in their accounts, Transparency Review data showed real deficits after adjustments for capital and exceptional items. This data will be robust from 2004-05, but early figures estimate that the annual deficit in the full economic cost of 'public interest' research undertaken by UK HEIs in 2005-06 is likely to fall in the range £0.8- 1 billion. Most of the balance is found by HEIs from other sources but some represents a shortfall in funding against actual volumes of activity and a shortfall in investment against medium term requirements.

**3.14** The Government has begun to address this infrastructure investment backlog through dedicated capital funding, as detailed below. However, sustainability over a longer time frame will only be achieved when institutions are properly aware of, and recover, the full costs of the research they undertake, and avoid running down investment in other parts of the institution's business.

**3.15** This agenda, identified by the 2002 cross-cutting review of science and research and resulting science funding strategy, was taken forward in the Office of Science and Technology's consultation in May 2003[4]. Following this, the OST, Research Councils and HE funding bodies have organised pilots within universities of extensions of the Transparent Approach to Costing (TRAC) methodology to research project costing, through which the full economic cost regime will be implemented.

**3.16** In light of this practical experience, **the Government has decided that**[5]:

- TRAC methodology for costing research project applications by universities to Research Councils will be rolled out by January 2005 in all UK universities;
- proposals to Research Councils must be made on a full economic cost basis, to be funded at a proportion of that cost, from September 2005, with all new awards being made on this basis from April 2006;
- monitoring, development and adjustment will take place during financial year 2006-07; and
- final adjustments to the methodology will be made for financial year 2007-08.

**3.17** **The Government's intention is to reach a situation where universities secure sufficient income from all sources to ensure that they can cover the full economic costs of all the research that they undertake, taking one year with another, without detriment to their other activities or to their long term financial sustainability**. Ultimately, the aim must be for universities to demonstrate that they are achieving medium-term financial sustainability across all of their activities. The further extension of TRAC to provide detailed information on teaching costs, after 2006, will help achieve this.

**3.18** To this end, the Government's aim is, within the context of its funding commitment to the UK science base under the ten-year investment framework, that both strands of Dual Support should rise steadily over this period. By the beginning of the next decade, Research Councils should meet close to 100 per cent of the full economic costs of the research they fund through grants, taking account of capital funding streams.

**3.19** The UK funding bodies and Research Councils are currently developing a light-touch forward-looking regime to monitor universities' implementation of full economic cost methodology. This is intended to assure other funders of the robust costing basis for universities' pricing of their research contracts, in order to identify potential problems, and to monitor the effect of implementing full economic costing, which will be one of the roles of the Funders Forum (see paragraph 3.50)

**3.20** Spending Review 2002 allocated £120m to increase the proportion of costs paid by Research Councils for the projects they fund. From April 2006, Research Councils will use this additional money to add to grants without building volume. The OST and Research Councils are presently analysing data to determine the precise proportion of full economic costs which Research Councils will pay, and details will be given later this year.

[4] The Sustainability of University Research, OST, May 2003

[5] A full Government response to this consultation will be produced by the Office of Science and Technology

**3.21** The Government is mindful of the need to ensure that as Research Councils move towards paying closer to 100 per cent full economic costs, this should not reduce the discipline on universities bidding for grants to maintain cost-effectiveness. While there are also incentives in the opposite direction, it is essential that Research Council assessment processes should be sufficiently robust to guard against unwarranted price inflation from the university sector, for example through guidance for peer-review panels and an ongoing programme of monitoring, benchmarking and dipstick testing. The Government and the Research Councils will actively monitor and manage this risk as the proportion of costs paid increases, while keeping the burden on universities to a minimum.

**3.22** The Government's intention is not to increase either leg of the Dual Support system at the expense of the other, but to achieve balance on both sides of the system against a rising overall investment. Moving closer towards 100 per cent funding of the full economic costs of Research Councils supported projects, and more accurate costing and pricing of other commissioned research, will enable institutions more easily to plan the use of their QR, thus helping them deploy their own resources towards meeting their priorities, from tackling new areas of 'blue skies' research to investing in academic staff recruitment and development.

**3.23** **As a further step on this trajectory to sustainability, the Government has allocated an extra £80m in Spending Review 2004 to further increase the proportion of full economic costs paid by Research Councils by 2007-08.**

**3.24** By the time of the next Spending Review, more precise data will be available on the cost of individual research projects than HEIs are able to provide at present, including from the proposals made to Research Councils from September 2005 using the extensions to TRAC. Therefore, in 2006 the Government will be able to set out a much more precise trajectory of funding, moving towards 100 per cent of full economic costs, with an opportunity to fine-tune if necessary in funding decisions to be taken in 2008.

## Other funders of research

**3.25** Some universities receive as much as half of their research income from sources other than Research Councils and HE funding bodies – the figure for the HE sector as a whole in 2001-02 was 46 per cent. The behaviour of these third party funders is therefore also key in achieving a sustainable funding system. As partners in this system, users of the UK research base should, as a whole, contribute more, through the prices they pay for research and through other partnership programmes with universities, to the resources available to universities to reinvest to achieve a sustainable level of capital infrastructure and research skills, and to maintain the excellence of the research base.

**3.26** Each university, though, has the primary responsibility to ensure that its level of income from external research funding matches the resources required to support this level of activity over time. To help meet this funding and activity balance, universities will be encouraged, through their relationships with and funding from the relevant HE funding bodies, to adhere to the following set of principles to guide the pricing of research projects.[6]

[6] As set out in the 2002 cross-cutting review of science and research and developed further in *The Sustainability of University Research*, OST, May 2003

**Box 3.2: Principles to guide the pricing of research projects**

When undertaking research which is to be externally funded, other than by a Research Council, HEI research departments should have regard to the following points when deciding on the appropriate price to be charged for that research.

Institutions must, taking one year with another, recover the full economic cost (FEC) of their research activities from an appropriate mix of external and internal sources.

To do this, they must have in place systems which enable them to estimate with reasonable accuracy the FEC of research at project level, with particular reference to (i) the method of attributing indirect costs to front-line activities, and (ii) the means of reflecting in prices the long-term research infrastructure needs of the institution.

Funding Council research funding is part of a block grant to institutions for them to use at their discretion. It is mostly distributed according to the quality and volume of research carried out, in order to encourage research of the highest quality. Institutions should consider the resources they wish to use to support research. If they are to undertake Research Council-funded research, they need to allocate appropriate funding to ensure that the full economic costs are met. Following this, to the extent that other resources are available, institutions may wish to support research funded by other external sponsors. Institutions need to consider carefully the level of support within the overall requirement to cover full economic costs. It is recommended that the level of publicly-derived support provided to any particular project should reflect the extent to which the research project in particular and the sponsor in question in general satisfy the following principles:

- Research should demonstrably contribute to the enhancement of the UK research base or in some other way provide a public scientific good. An indicator of this may be that the results will be published openly in academic literature and that the benefits of any intellectual property generated by virtue of the research will accrue to the HEI rather than the funder.
- The sponsor has a published research strategy, which, while recognising the advantages of having a plural funding system, nevertheless takes account of the strategy and priorities of other key funders, most notably the Research Councils and the larger research charities.
- Research supported will be only of the highest quality. Sponsors wishing to benefit from public support will need to be able to demonstrate that they have project appraisal systems in place that ensure that only high quality research is funded.

**3.27** Whatever the cost of the research, the price which is charged will reflect the degree of support for particular research projects at particular universities. It will vary by the nature of the partnership between the university and funder in question and the extent to which the results of the research provide wider public benefits.

**3.28** Universities, knowing the full economic costs of research through TRAC, should charge, and industry funders of contract research primarily for the commercial objectives of the commissioning company should assume that they will pay, prices for research sufficient to cover at least the full economic costs of the work they commission. For collaborative work and longer term partnerships, where joint funding from university and business generates public scientific benefits in the form of published academic results and / or intellectual property which benefits the university, a range of co-funding between university and business is feasible. In this case, universities will need to ensure that they have sufficient QR and / or other sources of

income over the relevant period to meet the costs of supporting collaboration with business without placing an undue strain on their other publicly-funded research activities.

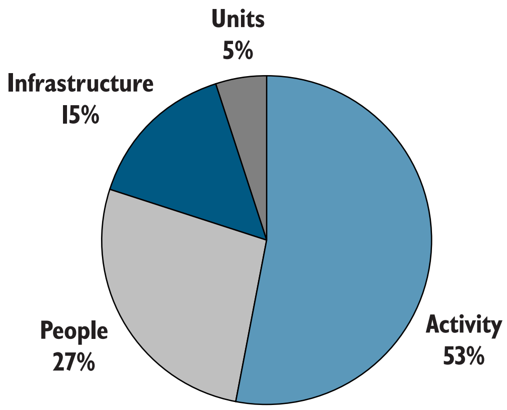
**3.29** Government departments should also be prepared to pay full economic costs unless there are specific reasons for different treatment. An exception is the NHS in recognition of the major investment it already makes to meet the cost to it of research carried out by the Medical Research Council and other sponsors for public scientific benefit. When acting in this mode the NHS is treated similarly to the Research Councils. Charities and the European Union are covered below.

**3.30** It is the responsibility of individual universities to ensure that they achieve the right level of research funding, and the right balance between direct project grants and other funding streams, to achieve a financially sustainable level of research taking one year with another. In doing so, they will be assisted by adherence by business, charities and Government departments to these broad principles of partnership funding for research sustainability. This is key to securing the long-term health of the UK science base; it is in the interests of all funders of the system.

## Charities

**3.31** The Government recognises the vital role that charities play in the UK research environment and the value of the research they sponsor both in HEIs and elsewhere, as well as the teaching and clinical services provided by charity funded researchers. They are a core part of the research landscape, and a key source of project, people and infrastructure funding for universities, much of which satisfies the 'public scientific good' test for the use of public funding (as detailed in box 3.2 above). Chart 3.3 below shows that charity support for university research averaged some £320 million per year in the five years to 2000, with an approximate balance between the direct costs of individual research projects and longer term support for the research infrastructure and ongoing staff costs of university departments.

## Chart 3.3: Charity research funding in UK universities




| | |
|---|---|
| Activity: | £860 million |
| People: | £448 million |
| Infrastructure: | £251 million |
| Units: | £82 million |
| **Total:** | **£1,641 million** |

**Activity** = project grants, programme grants, clinical trials
**People** = studentships, fellowships, professorships, chairs
**Infrastructure** = building, refurbishment, stand alone equipment grants
**Units** = charity-funded centres located within universities

*Source: Association of Medical Research Charities, 1996–2000*

**3.32** Charity funding has grown steadily in recent years, resulting in more pressure on QR funding to support HEIs' share of research funded by the charities. This shortfall is concentrated in medical subjects and (to a lesser extent) in science including biomedical science, but it affects all areas including social sciences and the arts. Data for 2001-02[7] shows that in that year HEIs in England received some £500 million of income from UK based charities of which well over a half (£270 million) was in clinical medical subjects and most of the rest (£140 million) in sciences.

**3.33** In recognition of the important role which charities play in sustaining the health and effectiveness of the UK university research base, and the responsibility of charities and Government to work together to improve the financial sustainability of the research supported in this way, **the Government has worked closely with the Wellcome Trust, involving other leading medical research charities through the Association of Medical Research Charities, to develop a partnership agreement which will provide the basis for working together towards fully funding research in UK universities.**

**3.34** Subject to the continued progress of charity funding towards sustainability, the Government will develop an additional element of QR funding to support charity research funding. This will be allocated through the block grant in relation to the charity income in departments that are above a minimum threshold level of quality (the grant will not be differentiated by quality above this threshold). Only charity income which has been awarded through open competition, excellence and priority using a method of independent external peer review for the allocation of grants will be counted. **The Government will invest, in England through HEFCE, up to £90 million through QR by 2007-08, in combination with the £90 million (in England) currently distributed through the charity volume factor.**

[7] Source: Higher Education Statistics Agency

**3.35** This approach is intended to enable HEIs to achieve a partnership with charity funders of research that will ensure financial sustainability by the end of this decade. To achieve this, as a complement to action by the charities (set out below), the Government would, in support of approximately the current volume of activity, invest further in the charities support element over the period 2008-2010, on a similar scale to the additional investment by 2007-08.

**3.36** Members of the AMRC account for the majority of the charity research funding in the HEI sector. The Government and AMRC have agreed that the following principles should underpin the relationship between charities and HEIs:

- subject to continued needs and trends in overall income levels, major charity research funders will aim to maintain the current proportion of their funding invested in UK universities;
- AMRC member charities will continue to invest explicitly in the research infrastructure in HEIs subject to the investment being within their objectives and strategy;
- there will be a commitment to provide balanced funding across the sector which takes account of (i) the importance of sustainability, (ii) the particular needs and interests of specific research areas, (iii) the proportion of capital and skills infrastructure on which charities' project funding depends, and (iv) the objectives of the charity;
- AMRC will work with HEIs and member charities to develop new models of partnership funding that enable all charities to develop their commitment to research in a sustainable way, supported by financial management decisions in HEIs; and
- the AMRC will work with the HE funding bodies and Government to collect and disseminate robust data on which all parties can rely in assessing progress through the Research Funders Forum, towards financial sustainability of charity-funded research in the UK university sector.

**3.37** The Government hopes that other charities will wish to follow this lead and enter into this partnership approach. This arrangement will be one of the elements reviewed annually as the Government monitors progress along the trajectory of increasing R&D expenditure in the UK.

## European Union

**3.38** The European Union is another significant funder of research in the UK through the R&D Framework Programme. Under the fifth Framework Programme (FP5) from 1998-2002, UK organisations received a total of €2,047m (16 per cent of the total); of that, around half (€1,013m) was directed to universities. The UK won a quarter of all the FP5 funding to European universities.

**3.39** EU funding follows the 'shared cost' principle, recognising that many of the benefits of the research flow to the organisations and countries conducting the research, as well as to the European Union as a whole. Most EU grants are therefore funded at around 50 per cent of full costs, causing another pressure on university income to match this funding, which generally meets the 'public scientific good' test. As the proportion of full economic costs paid by Research Councils rises, the discrepancy

between the EU's level of project funding and that available from UK budgets will both increase and become more evident.

**3.40** The level of EU funding is fixed for the duration of the Sixth Framework Programme, which runs until 2006, with projects continuing for some years after that. The next, seventh, Programme will be launched towards the end of 2006, with projects likely to begin in early 2008. Current outline proposals for FP7 are to increase its funding to around €40 billion euros in total. If this proposed budget were accepted, with an unchanging proportion of costs paid, and UK universities maintained their current success rate in winning research awards, the parallel pressures for extra co-funding from QR and other resources would increase. Conversely, universities will by then be facing greater support and stronger incentives from Research Councils and funding bodies to meet their sustainability goals.

**3.41** In negotiations for the next Framework Programme, the UK will argue for a higher proportion of the total cost of research projects to be paid, based upon a more transparent approach to research costing as has been adopted in the UK. The Government will also press for any new basic research fund (for example, through any new European Research Council) to pay all of the full economic costs of the research it supports. The UK is also raising awareness in Europe of the importance of funding research sustainably, and the need for reducing the bureaucracy which also adds to the overall costs of the research activities.

**3.42** There are, however, differences between accounting and funding systems in the UK and other national systems, which may make it difficult to secure agreement to change funding levels for collaborative research. The Government is aware of this issue, and the possible risk it poses to UK involvement in EU research projects. Whilst in the first instance this agenda must be pursued by negotiation to improve the situation at an EU level, the Government will continue to monitor the situation.

## Research Assessment Exercise

**3.43** The Government is strongly committed to excellent publicly funded science. Excellence has been promoted through the Research Assessment Exercise (RAE), which provides a periodic measure of research quality across the UK university sector through a process of peer review based upon submissions from individual university departments. The resulting quality ratings, combined with the numbers of staff submitted and other factors, are used to allocate the QR element within the funding bodies' block grant to universities.

**3.44** The UK funding bodies carried out a review of the RAE over 2002-04. The consultation carried out as part of this process found overwhelming support for the principle of a peer review-based assessment system, but found concerns about the current system, for example in the incentives for 'game-playing' in the submission of staff, the disincentives to undertake innovative longer term research development, and the bureaucracy involved.

**3.45** There have also been concerns expressed, for example in the Lambert Review of business-university collaboration, about the ability of the RAE to recognise adequately and thus promote the value of interdisciplinary research and research of a more applied or practice-based nature. The funding bodies are working to ensure, through active collaboration with a range of bodies interested in research of these kinds, that the implementation of the new RAE secures the full confidence of a broad range of stakeholders in this regard. Their decision to adopt a two tier assessment panel

structure, and to strengthen the procedures for securing additional specialist advice to supplement the expertise of panel members, will help to ensure that interdisciplinary research is given due recognition in the assessment process. The funding bodies have also already made plain their commitment to ensure that applied and practice based research is assessed on an equal basis as more curiosity driven research.

**3.46** The funding bodies are working to establish the assessment panels for 2008. In appointing members to the panels, the funding bodies will again pay particular attention to securing the involvement of people who have had experience both in conducting research and in commissioning and applying research in public bodies and in business. They will ask panels to which such work may be submitted to produce clear statements as to how it will be assessed against appropriate criteria for excellence. They are also now engaged, in consultation with stakeholder bodies, in preparing guidance to the panels as to how this is to be achieved. Key issues to be covered in this guidance will include approaches to assessing quality in the distinctive forms and types of output typically produced in applied research, and the use of appropriate metrics at the level of the research department. As with all other aspects of the RAE, this will be kept under careful evaluation.

**3.47** The funding bodies published their initial decisions on the timing and broad shape for the next RAE in early 2004[8]. They hope to announce panel membership, and to publish generic guidance to panels on the assessment process, by the end of 2004. Peer review will remain central to the next RAE, which will be held in 2008, but, as indicated above, there will be changes to the system. These include:

- ensuring that applied, practice based and interdisciplinary research excellence are appropriately assessed (as discussed above);
- scope for the greater use of discipline-specific metrics in addition to the core metrics across all disciplines;
- moving to a graded profile for each department instead of the current single rating, to avoid 'cliff-edge' funding and reward pockets of excellence in weaker departments; and
- a two-tier panel system, with cognate subjects grouped together to ensure consistency of assessment between panels and sub-panels. The assessment process will be designed to ensure that joint submissions are not disadvantaged.

**3.48** Metrics collected as part of the next assessment will also be used to undertake an exercise shadowing the 2008 RAE itself, to provide a benchmark on the information value of the metrics as compared to the outcomes of the full peer review process. The aim of any changes following this exercise will be to reduce the administrative burden of peer review, wherever possible, consistent with the overriding aim of assessing excellence.

**3.49** Chapter 5 describes work that will be undertaken to develop metrics to underpin the allocation of an enlarged Higher Education Innovation Fund and to assess the impact of support by RDAs for university-business interaction. These metrics will include indicators of the volume and quality of directly applicable research that universities undertake in collaboration with business and other partners. The aim is to ensure that university departments are given appropriate incentives and rewards for

[8] RAE 12/2004 at www.rae.ac.uk/pubs/

work in these areas, alongside the incentives and rewards provided through the RAE and its associated funding formula.

## Funders Forum

**3.50** The UK Research Base Funders Forum was established in September 2003 to allow the Government and other funders of research to consider the collective impact of their strategies on the health and outputs of the UK research base. The Forum includes representation from business, charities, government departments, Regional Development Agencies and the HE sector, as well as Funding and Research Councils. The Forum's website provides details of its membership and operations. [9]

**3.51** The Government believes that all funders have a responsibility to ensure the continued health of the science base. Sharing plans which might affect other funders, through their representatives at the Funders Forum, is an important element in achieving this. All major funders will therefore be encouraged to discuss proposed changes in the Forum to improve the quality of decision taking.

**3.52** The Forum's membership has recently been extended to enhance this role, enabling other bodies, such as the Science and Engineering Base Consultative Committee, with overlapping membership, to be wound up. This will bring greater transparency to such discussion as well as rationalising the advisory structure.

## Efficiency and effectiveness

**3.53** The Government is keen to bear down on unnecessary costs incurred by universities in interacting with both sides of the Dual Support system.

**3.54** Research Councils' spend on administration as a proportion of their total expenditure compares favourably with that of similar organisations internationally, has been falling steadily and is planned, over the period to 2007-08, to reduce by a further 10 per cent, releasing some £7.5 million per annum to frontline research. Driving down the complexity, and therefore cost, of the Research Council system for grant applicants, for example by the use of joint electronic submission systems, will also secure benefits for users and Councils alike, reducing bureaucracy for individual researchers, and providing additional control and management gains for university administrators.

**3.55** Competition is an essential part of the peer review system and a key driver of excellence. However, it is apparent that the current success rate in grant applications is too low, and that research projects of international quality may go unfunded. Success rates are typically around 30 per cent but are significantly lower in some areas. Even with additional funding, a long tail of unsuccessful applications represents a significant burden for both universities and Research Councils. Councils will work together to ensure best practice in the development of management information systems, and encourage dialogue with HEIs on measures to reduce the proportion of non-competitive applications. An example of good practice here is the Engineering and Physical Sciences Research Council, which deploys University Interface Managers who work directly with universities to improve internal quality assurance and control of proposals prior to submission, and to draw attention to the internal costs incurred by institutions in submitting an application.

[9] http://www.ost.gov.uk/fundersforum

**3.56** The Director General of the Research Councils is responsible for advising on the key outcomes for the Science Budget and the distribution of funding across that budget. Investment over the next ten years will be aimed at making the UK world-class in all areas of basic science, translating knowledge from the science base more effectively into innovation, wealth and quality of life, and enabling the UK to become the best place for R&D and high value-added business. **To this end, the Office of Science and Technology is developing a comprehensive, integrated and efficient performance management system. This will provide a more robust mechanism for translating the overall strategic priorities for the science base into specific aims and objectives for the Research Councils and other delivery agents. The transparent identification of outputs and performance measures will allow a balance of investment to be made across the Science Budget and adjusted in response to a more strategic view of new priorities and identified strengths and weaknesses. The Science Budget allocations in autumn 2004 will be based upon a balance of investment and the methodology for determining this further refined for future years.**

**3.57** For the RAE, the total administrative costs to Funding Councils of the 2001 exercise was £5.6 million, making the RAE a very efficient basis for distributing funds on the basis of outcomes and achievement. Even allowing for further costs in HEIs this is still only just over 1 per cent of the funds distributed by the four UK funding bodies. The measures put in place to reduce 'games playing' in the RAE should also reduce the time spent by HEIs in tactical management, which should reduce the administrative burden. Greater use of metrics would reduce burdens still further. A Regulatory Impact Assessment was published as part of the final proposals for the 2008 RAE.[10]

## Taking stock

**3.58** As this chapter outlines, there are various changes underway to improve the functioning of both sides of the Dual Support system. Whilst there will of course be ongoing monitoring of the effect of the changes, **the Government considers that it would be timely to undertake a stocktake exercise in 2008, when the full economic cost regime will have bedded in and the next RAE carried out, to assess the effect of the changes to both sides of the system in aggregate.**

## Capital

**3.59** The Government has made significant investments in Higher Education research capital in recent years, establishing a dedicated capital funding stream, the Science Research Investment Fund (SRIF). SRIF has increased from £400m a year in 2003-04 to £500m a year in 2004-06, to address the historic backlog of investment. It is the Government's intention that this funding should be maintained, through a SRIF3 programme from 2006-08. As the full economic cost regime develops, account will need to be taken of capital funding in providing closer to 100 per cent Research Council funding of projects.

[10] www.rae.ac.uk/pubs/other/impact

**3.60** Recent study evidence on the impact of SRIF[11] found that:

- SRIF2 funding is being spent on projects addressing infrastructure backlogs, as intended;
- SRIF2 spend is achieving significant benefits including:
  - the maintenance of 'well-found' laboratories to a standard where universities are able to carry out projects from various funding sources, and to compete globally;
  - support for many projects on an inter-disciplinary basis; and
  - better institutional research capital strategies, including specific planning to make estates more flexible and multi-disciplinary, and to improve utilisation of space.
- despite these positive improvements, however, there is still more to be done to 'catch up' following historic underinvestment.

**3.61** The study also found that estates master plans are helping to link research and teaching infrastructure spend, to the benefit of both, improving rationalisation and consolidation of estates. The Government is keen to encourage more holistic capital investment and planning of this sort. To this end, HEFCE will be discussing with institutions the merits of rolling the present research, teaching and IT capital funding streams into one, and Government stands prepared to consider this possibility if it has the potential to improve investment decisions in universities. In return, institutions would be expected to produce comprehensive asset management strategies for the totality of capital funding they receive, and HEFCE would monitor actual capital expenditure against these asset management strategies to demonstrate that universities and colleges are acting to secure the long-term sustainability of their infrastructure.

**3.62** The Government is also keen that investment strategies produced for SRIF funding should fit with the research priorities of other funders. The Funders Forum will advise on the overall shape of the programmes and the fit with the priorities of all funders, and RCUK should continue to play a role in assessing SRIF strategies by commenting on how proposals from individual universities fit with scientific priorities and development.

**3.63** Finally, universities' research equipment and laboratories could become a more valuable resource for business-related applied research, through universities making their expertise and facilities more open to access by business. As the DTI develops its Technology Strategy, through a series of collaborative R&D programmes and knowledge transfer networks focused on particular technology themes, there should be scope for universities to host some of the applied research on their own facilities. Universities would need to charge business an appropriate price for such access, reflecting the costs of the capital utilised and consistent with the principles of charging for research set out in this chapter. The next round of SRIF will continue to enable universities to develop proposals to enhance and maximise the public and private utilisation of university research expertise and equipment.

[11] Study of university infrastructure for science research – 2004 Update, JM Consulting, http://www.ost.gov.uk/research/funding/underinvest/

## Public Sector Research Establishments

**3.64** Public Sector Research Establishments (PSREs), including Research Council Institutes, collectively represent a world-class resource with Government funding of some £1.6 billion per annum. PSREs face some of the same challenges as universities in maintaining their capital base fit for their research missions:

- core funding shared across several sponsor bodies;
- stiff competition for research projects remunerated at less than full cost; and
- science imperatives within each organisation to maintain volume of activity at the expense of medium term investment.

**3.65** A report carried out for OST[12] identified a similar capital investment problem in PSREs as in universities (albeit on a lesser scale), and examined the strategic planning and trading relationships in this part of the UK science base. It found that there is a common need for:

- improved capital investment, linked to better, and forward-looking, science-driven capital investment strategies;
- better recognition and recovery of the full economic cost of the research undertaken for others; and
- greater clarity of responsibilities within and between PSREs and their parent bodies.

**3.66** The Government is supportive of the report's recommendations for joint action by funding stakeholders to ensure long-term fitness-for-purpose and sustainability, greater transparency and discipline in costing and pricing, and more clarity in the allocation of risk/responsibility between PSREs and their owners. Implementation of the recommendations is being taken forward by PSREs themselves, their parent departments or Research Councils, overseen by OST, RCUK and the Chief Scientific Advisor's Committee through a programme of monitoring and discussion. Specific recommendations included that:

- Research Council Chief Executives and Permanent Secretaries of government departments, working through Chief Scientific Advisors, should be jointly accountable for developing joint scientific and investment strategies for their cross-boundary research interests, to be reviewed every five years;
- between a PSRE and its owner/sponsor there should be an unambiguous statement of the allocation of responsibility for adequate capital and recurrent investment in research infrastructure and for bearing risk, and the arrangements for managing that risk;
- PSREs should all have a forward-looking asset management and investment strategy linked to their future scientific strategy, and a plan for financing this (including increasing their level of annual investment towards norms now accepted for the university sector). In most cases, financing will come at least partly from the parent and the strategy should be prepared jointly; and

[12] PSREs and the science base, OST, 2004 http://www.ost.gov.uk/research/psre_sustainability.htm

- all PSREs should demonstrably recover full economic costs over the whole of their activity (taking one year with another). Where funders do not pay full economic costs, the PSRE should make a specific and conscious decision about whether it is justified to subsidise or jointly fund the activity, and whether they have unallocated funds available for this purpose before taking on the work. Public funds should not be used to subsidise work purely of benefit to the private sector.

**3.67** As a first step in addressing the capital infrastructure backlog in PSREs**, the Government has allocated £50 million a year by 2007-08 to provide a dedicated capital funding stream for Research Council Institutes.** This funding will be allocated by Research Councils to their institutes on the basis of need and based on agreed investment strategies between RCI and parent.

# 4 Business R&D and innovation

## Summary

**4.1** Increasing innovation and R&D by business is a key part of the Government's productivity agenda. Innovation is an important determinant of economic growth in an era of market liberalisation, reductions in transport and communications costs and advances in science and technology. There is a clear relationship between R&D and productivity growth: studies show that a significant cause of the UK's productivity gap with the US is lower levels of R&D expenditure[1]. The DTI's Innovation Report identified that other factors were also important for a good innovation performance. These included more outcome-based regulation to encourage innovative compliance, demanding public sector procurement and a strong competition regime.

**4.2** R&D intensity (the ratio of R&D across the economy to national gross domestic product) is a key indicator for measuring innovation performance. UK R&D intensity fell during the 1980s and 1990s as GDP growth outstripped growth in R&D. However, there are now signs that business R&D is rising as a share of national income.

**4.3** As the Government sets out its aspirations for UK science and innovation over the coming decade, and the accompanying public investment to achieve these goals, a key determinant of the success of this strategy will be parallel commitment from the private sector to increase its investment in R&D and its links with the science base. This chapter explains the historic context of UK R&D and the economic rationale for raising R&D intensity in the UK.

## Increasing knowledge-intensity of the UK economy

**4.4** Research clearly shows that investment in business R&D generates substantial returns. A review of the literature reports that estimates of the private return to R&D cluster around 10-15 per cent, although they can be as high as 30 per cent. When one takes into account that benefits from the R&D also accrue to other firms or industries, then rates of return can reach 100 per cent.[2] As part of its goal to improve the competitiveness and innovation performance of the EU economy, the Barcelona European Council in 2002 set an aspirational target that R&D should rise towards three per cent of GDP by 2010 for the European Union as a whole, with business funding two-thirds of this total. France and Germany have adopted this as a national target.[3] A number of smaller Member States, whilst agreeing to the collective target in principle, have set less demanding national targets.

**4.5** The UK faces a major challenge in trying to increase its R&D intensity towards the level of other major developed economies in Europe and beyond. To do this, real R&D expenditures would need to rise at a faster rate than trend economic growth (expected to be around 2½ per cent per annum). In the ten years between 1992 and 2002, annual R&D growth rates only exceeded 2½ per cent by a significant margin on two occasions. Since business R&D accounts for the largest share of total R&D, a

[1] DTI (2003) Competing in the Global Economy – The Innovation Challenge, DTI Economics paper 7.

[2] How important is Business R&D for economic growth and should the Government subsidise it? Griffith R, IFS briefing paper no 12, 2000

[3] Investing in Research: An Action Plan for Europe, European Commission, 2003

substantial increase in R&D intensity can only be achieved by significantly increasing business investment in R&D.

**4.6** The Government agrees with the underlying policy analysis which led to the Barcelona target – the future potential of the UK economy and the rest of Europe to create wealth for the benefit of all must be more firmly rooted in knowledge-intensive activity, operating in a more flexible European economy. To do this, Europe must set more conducive economic framework conditions and supporting innovation policies:

- to capitalise more effectively on its knowledge assets in the science base and companies;
- to connect them more effectively through networks within and across countries in Europe; and
- to provide stronger incentives to invest and grow in Europe, through enabling enterprise by limiting costs of regulation, and opening markets through rigorous application of competition law.

**4.7** The Government has built a strong platform for future growth in knowledge-intensive sectors in the UK through its successful reforms since 1997 to the macroeconomic framework and a range of microeconomic policies. The stronger growth performance of the UK economy since 1997, in comparison with the rest of the EU, is testimony to the positive impact of this approach to economic management.

**4.8** The Government recognises, though, that continued future growth in output, employment and productivity are likely to depend increasingly on the UK's ability to create and exploit new knowledge. This in turn is reliant on the country's intellectual capital stock and flow. The economic analysis underlying the DTI's Innovation Report set out this analysis, which is being further developed during 2004 by the Prime Minister's Strategy Unit. Against this background, it is apparent that the UK would need to invest a higher proportion of its national income, from public and private sources, in creating productive knowledge assets and the people to exploit them, to secure a sustainable growth rate of the UK economy over the coming decade at or above the current rate.

**4.9** To underpin the required increase in the output of the UK's knowledge-intensive economy, the Government considers that it is now right to set out a target for the UK to increase R&D intensity from the current level of 1.9 per cent to 2.5 per cent of GDP by 2014. Taking account of trends elsewhere in Europe, an increase to 2.5 per cent of GDP would be likely to put the UK among the leading major countries in the EU by the first half of the next decade.

**4.10** To achieve this target requires substantial growth in business R&D in the UK. This in turn requires a similarly significant growth in the underpinning investment in the public science base, both to supply the skills and research results into the economy, and also to attract mobile business R&D investment into the UK. As this framework sets out, it will also require a continued strengthening of the linkages between the public and private sector research bases.

**4.11** On the Government side, this Spending Review represents a further very substantial investment in the public science base, increasing funding, through the DTI and DfES, at an average annual rate of 5.8 per cent in real terms over the Spending Review 2004 period. At the same time, there are encouraging signs that, following decades of decline, private sector R&D in the UK is beginning to grow again. The

Government is committed to driving this partnership with the private sector forward - the central aim of this ten-year framework.

**4.12** The framework sets out the Government's intention to increase investment in the public science base at least in line with the trend growth rate of the economy through the ten-year period, increasing science spending as a proportion of GDP.

**4.13** However, the Government's overall ambition - that overall levels of R&D in the economy should reach 2 ½ per cent of GDP - would require a higher rate of annual growth than this across the aggregate private and public sector research bases - an average annual rate of 5 ¾ per cent from now over the coming decade. Table 4.1 below illustrates a possible scenario for achieving this growth rate, which in this case assumes an equal growth in both public and private sectors.

**4.14** This scenario represents a considerable challenge both for Government and for UK business. It can be achieved only if this commitment from Government to invest substantially in the science base is matched by the private sector and leading charitable funding, and in particular that it is clear that private sector R&D funding is on a new and growing trajectory. This framework, therefore, sets out the Government's plans to monitor the implementation of the policy proposals to support the investment framework, reporting annually, as well as progress towards the 2 ½ per cent target.

**Table 4.1: Indicative scenario towards 2½ per cent R&D/GDP target**

| | R&D investment as percentage of GDP | |
|---|---|---|
| | **2004** | **2014** |
| Science Base | 0.35 | 0.5 |
| Other Government R&D | 0.31 | 0.3 |
| Private sector | 1.24[4] | 1.7 |
| **UK total** | **1.90** | **2.5** |

**4.15** Reaching 2½ per cent of GDP invested in R&D would result in an increase in UK-based R&D of around £16½ billion (in real terms, 2004-05 prices), some 75 per cent higher than the current level of investment of around £22½ billion.

## Context: business R&D in the UK

**4.16** Science, engineering and technology make a significant contribution to the UK economy in terms of GDP, economic growth and labour productivity. A recent report for the Engineering and Technology Board estimated that:[5]

- in 2002, SET-intensive sectors generated £252 billion of value added and accounted for 27 per cent of UK GDP at current prices;
- in the same year, SET skills generated directly £78 billion of value added and accounted for 8 per cent of total UK GDP at current prices;

[4] 2002 estimate (latest available)

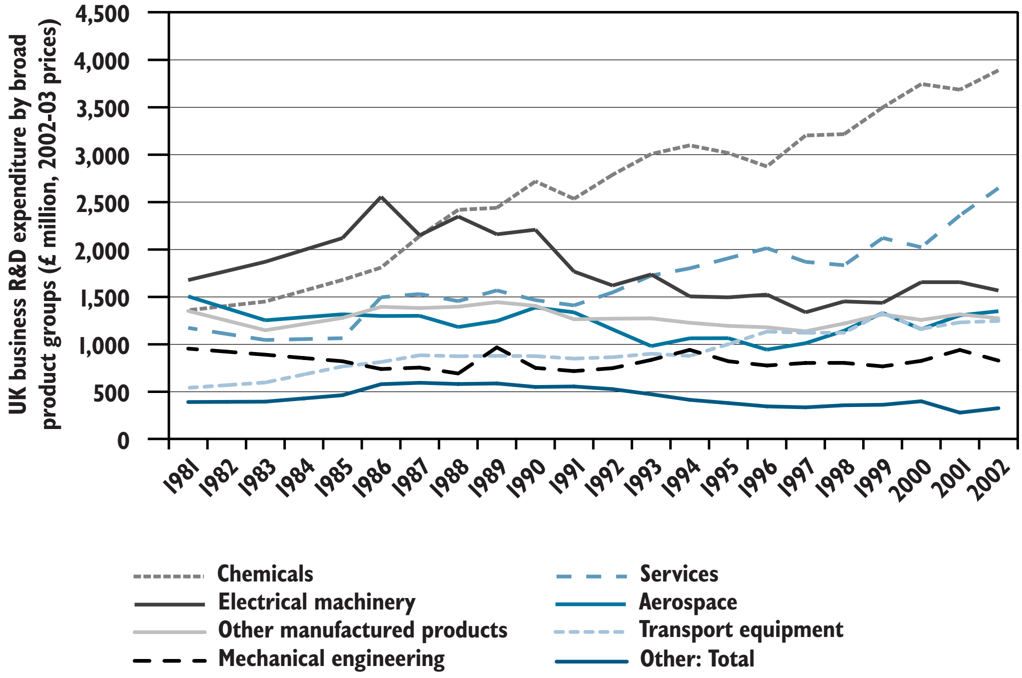
[5] Wealth Creation from Science, Engineering and Technology, 2004

- 61 per cent of the value added generated directly by SET skills was generated outside the SET-intensive sectors; and
- SET-intensive sectors accounted for 17 per cent of total GDP growth in the UK between 1993 and 2000.

**4.17** Business expenditure on R&D (BERD) is the most commonly used economy-wide measure of technological innovation (although studies show that it is a partial measure and biased towards certain sectors[6]). Nevertheless it is widely used as a proxy for performance in an area where fully comprehensive measures of performance are lacking.

**4.18** Since the 1980s, UK BERD in real terms has increased. The largest increases occurred in the chemicals (including pharmaceuticals) and transport equipment sectors. Large increases have also occurred in the service sector. This may reflect growing tendencies to outsource R&D.

**Chart 4.1: UK business R&D expenditure by sector**




Source: Office for National Statistics

**4.19** Although rising in real terms, BERD as a percentage of GDP has fallen steadily and is now below the OECD average. Research suggests that this is largely due to falls in defence expenditure during the 1980s and slow growth in R&D spending within manufacturing, particularly machinery, equipment and transport, during the 1990s.[7]

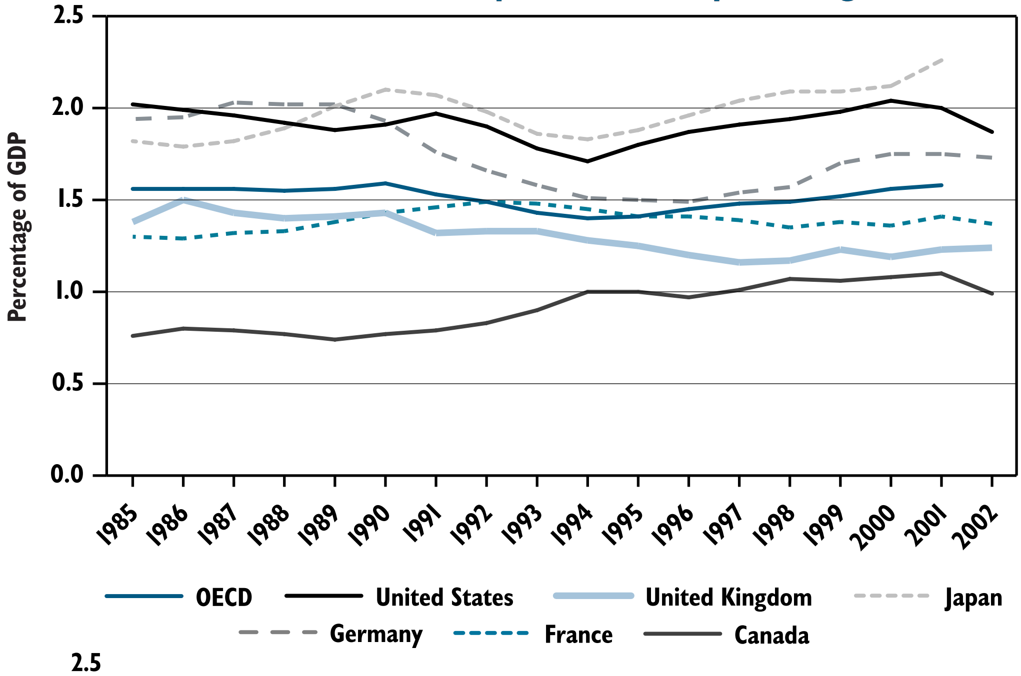
[6] Some of the caveats of R&D measures are set out in *Competing in the Global economy: The Innovation Challenge*, DTI Economics paper 7, 2003

[7] IFS Understanding the UK's poor technological performance, Briefing Note no 37, 2003

**4.20** Compared to its peers (US, France, Germany):

- UK business R&D is heavily dependent on foreign affiliates, attracted to the strength of the UK science base and the relative cheapness of UK researchers (although the latter advantage may be eroding[8]);
- differences in industrial structure explain some of the difference in R&D intensity between the UK and US and the UK and France, but the most significant cause is lower R&D intensities in several leading sectors; and
- business R&D in the UK is heavily dependent on the efforts of a few leading firms, particularly in pharmaceuticals and aerospace, which, by international standards, spend substantial amounts on R&D.

**Chart 4.2: Business R&D expenditure as a percentage of GDP**

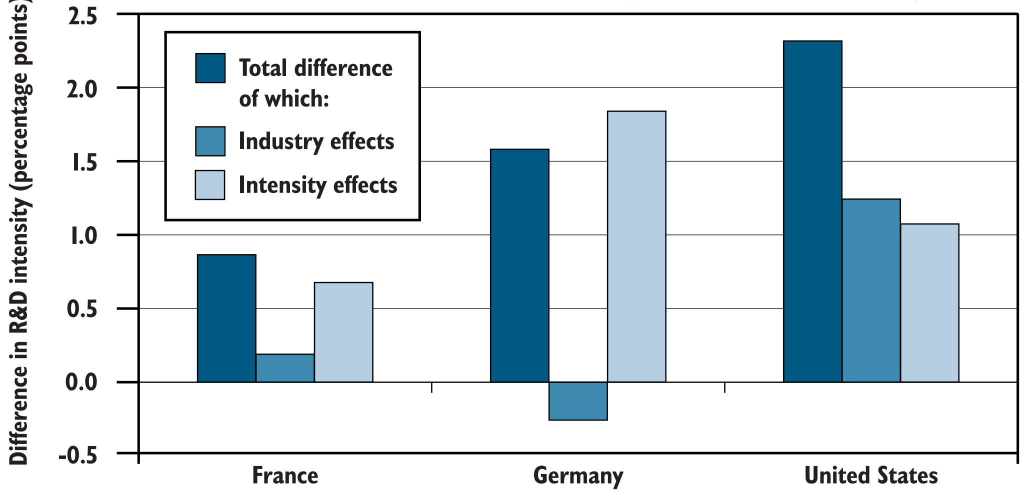



*Source: OECD, Main Science and Technology Indicators (2004)*

**4.21** Differences between countries can be attributed to different shares of output in more R&D intensive sectors (such as pharmaceuticals) or differences in R&D intensity within any sector.

8 Dougherty et al, Performing R&D abroad: international comparisons of value and price, Interim report to the National Science Foundation, 2002

## Chart 4.3: Composition of UK R&D gap in manufacturing



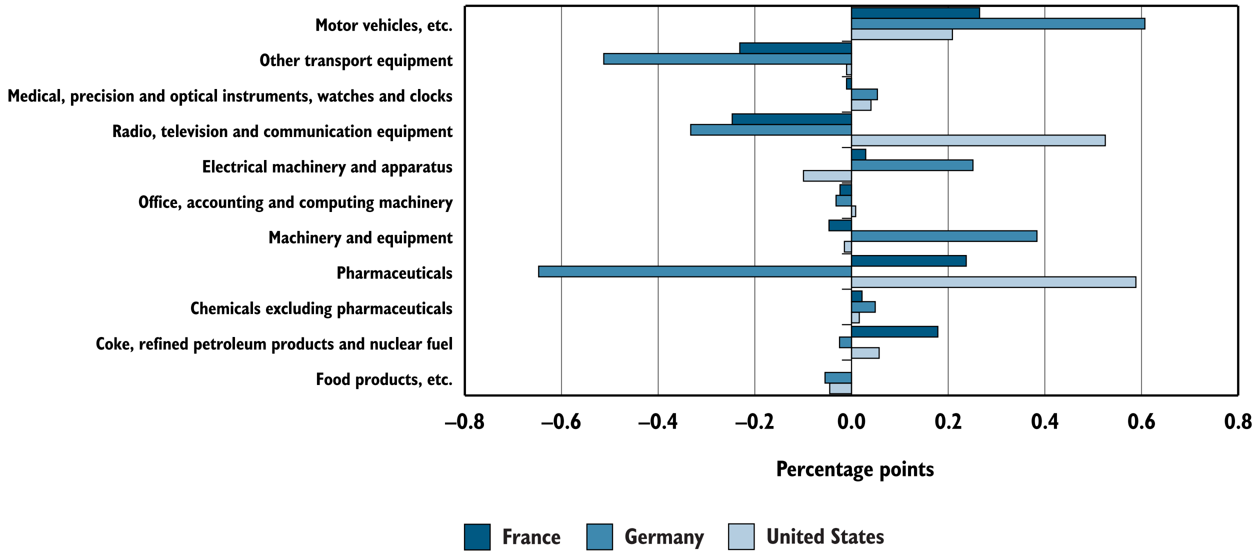

*Source: OECD and DTI calculations (2004); R&D intensity calculated as R&D as a percentage of value added*

**4.22** Looking at UK and US manufacturing[9], differences in industrial mix and differences in R&D intensity within sectors account for roughly similar proportions of the difference in overall R&D intensity. Thus if the UK had the same mix of sectors within manufacturing as the US, manufacturing R&D intensity would rise from around 6 per cent to over 7.2 per cent. Industry mix effects account for a much smaller share of the difference in overall R&D intensities between the UK and France and the UK and Germany.

**4.23** Differences in R&D intensity between the UK and US attributable to industry mix effects are due to three industries: pharmaceuticals; radio, television and communication equipment; and motor vehicles. The share of US manufacturing output in these three industries is much greater than the UK. Comparisons between the UK and Germany show that there are significant industry effects, but these are offsetting: higher German shares in machinery and motor vehicles offset lower German shares in pharmaceuticals, radio, television and communication equipment and other transport equipment. Comparing UK and France, lower French shares in other transport equipment, radio, television and communication equipment are partially offset by higher French shares in pharmaceuticals and energy products.

[9] Manufacturing accounts for the majority, around 80 per cent, of all R&D.

## Chart 4.4: Differences in overall R&D intensity caused by differences in industry structure

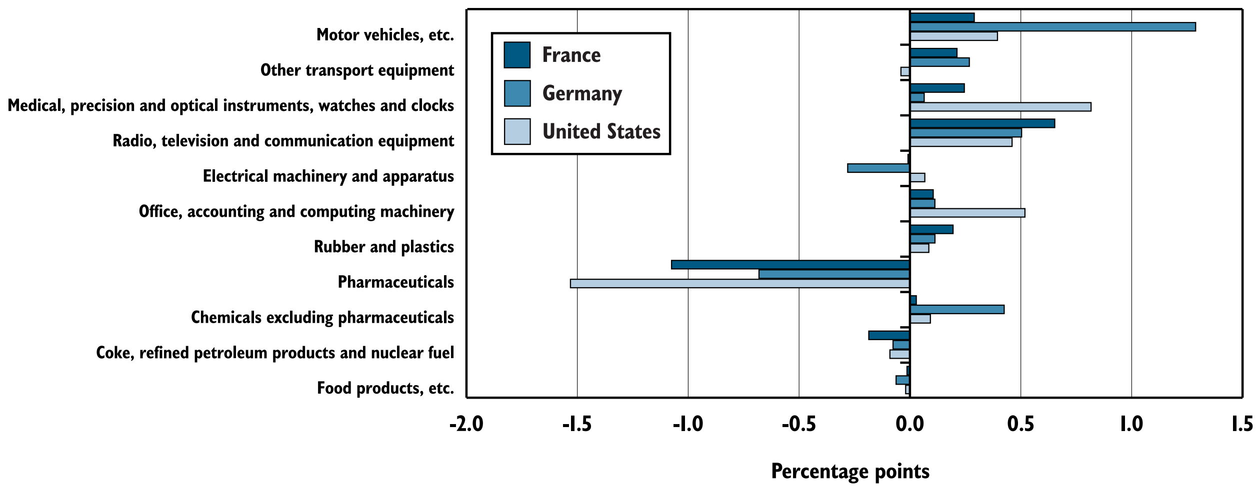



*Source: OECD and DTI calculations (2004)*
*Other sectors not illustrated where differences insignificant: Manufacturing, Fabricated metal products, Basic metals, Other non-metallic mineral products, wood, paper, printing, publishing, textiles, rubber and plastics*

**4.24** Comparing R&D intensities within sectors, the only areas where UK firms consistently spend more as a percentage of value added are pharmaceuticals and energy products. The UK's dependence on pharmaceuticals R&D is also reflected in the R&D scoreboard which shows that the only UK firms to make the top 30 of the international R&D scoreboard are GlaxoSmithKline and AstraZeneca.

**4.25** Across most sectors differences between UK, French, German and US R&D intensities are small. But there are large differences in office accounting and computing machinery; radio, television and communication equipment; instruments; motor vehicles; and other transport, suggesting that these sectors are largely responsible for the UK's lower R&D intensity.

## Chart 4.5: Difference in overall R&D intensity caused by differences in sector intensities

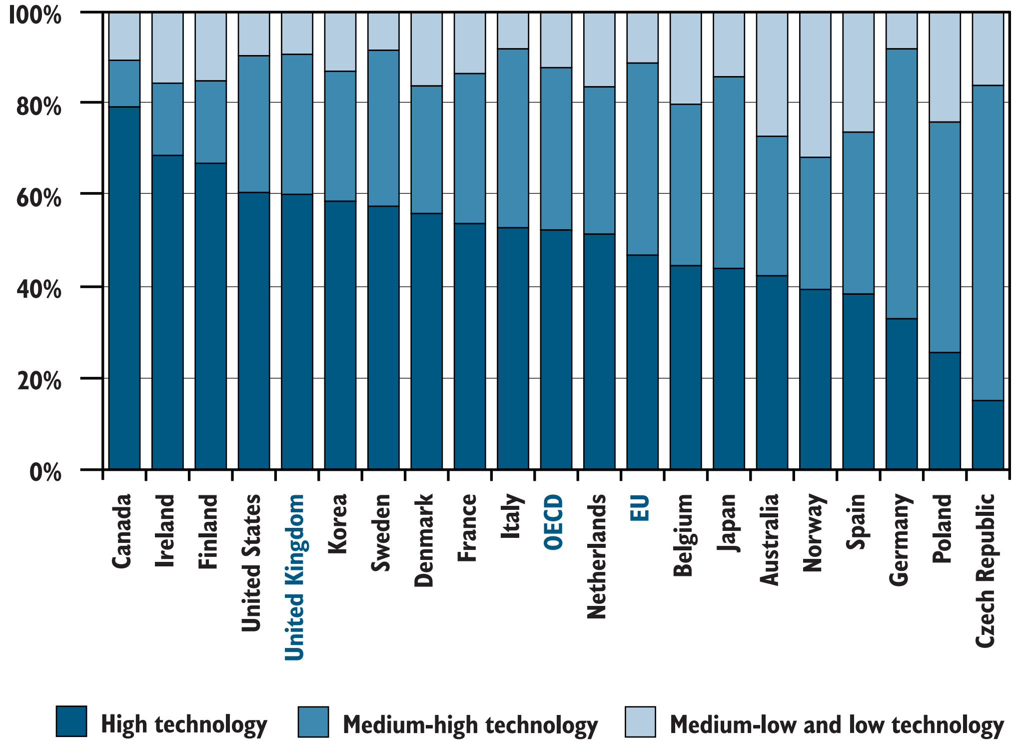



*Source: OECD and DTI calculations (2004)*
*Other sectors not illustrated where differences insignificant: Manufacturing, Fabricated metal products, Basic metals, Other non-metallic mineral products, wood, paper, printing, publishing, textiles, machinery and equipment*

**4.26** The share of business R&D accounted for by small and medium sized enterprises (SMEs) is also high in the UK compared to other major OECD economies. In this regard the UK is similar to those smaller economies that tend to spend less on R&D as a percentage of GDP. Analysis by the OECD suggests that R&D intensity is correlated with the size distribution of R&D performing firms. [10] This suggests that the UK's lower R&D intensity is, at least in part, due to lower levels of R&D amongst larger UK firms besides the top ten or so who are major investors.

**4.27** Manufacturing R&D in the UK is also heavily skewed towards high tech sectors compared to the OECD average.[11] Again this reflects the UK's concentration on pharmaceuticals R&D and the relatively smaller contribution from other sectors.

**Chart 4.6: Share of R&D accounted for by high, medium and low technology sectors**



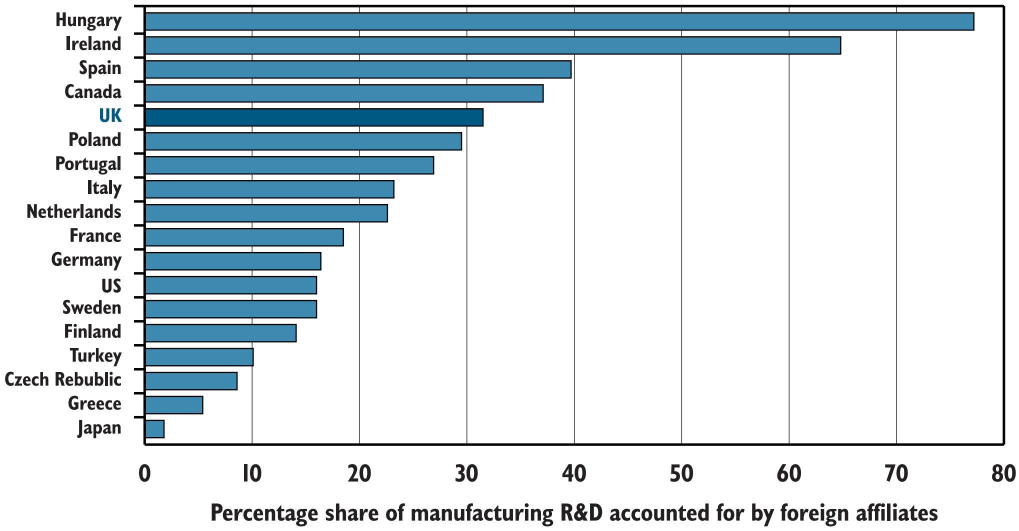

*Source: OECD; data for 2000 except for Ireland, Denmark, France, Netherlands and EU (1999), and Norway, OECD (1998)*

[10] OECD, Targeting R&D: Economic and policy implications of increasing R&D spending, STI Working Paper 2003/8.

[11] High tech sectors include: aircraft and space craft; pharmaceuticals; office, accounting and computing machinery; radio, TV and communications equipment and medical, precision and optical instruments. Low tech sectors are: food, beverages and tobacco; textiles; textile products; leather and footware; wood, pulp, paper, paper products, printing and publishing; manufacturing and recycling. All other sectors are classified as medium technology.

**4.28** UK BERD is heavily dependent on the activities of foreign firms. Research suggests that firms' decisions to locate R&D facilities abroad are mainly driven by the desire to access foreign sources of knowledge or to customise products and services to the needs of foreign markets.[12] The strength of the UK's science base is a source of attraction for foreign firms. In addition, the costs of research in the UK are quite competitive, although there are signs that this advantage has eroded over time. UK firms are also major investors in R&D overseas – for example they are the second largest investors in the US.

## Chart 4.7: Share of manufacturing R&D accounted for by foreign owned firms




*Source: OECD, Activities of Foreign Affiliates Database; data for 1998 or latest available year, S, UK, PL, P, FIN: 1999; HU, IRL, EL: 1997; 1995, I: 1992*
*Third European Report on S&T Indicators, 2003*

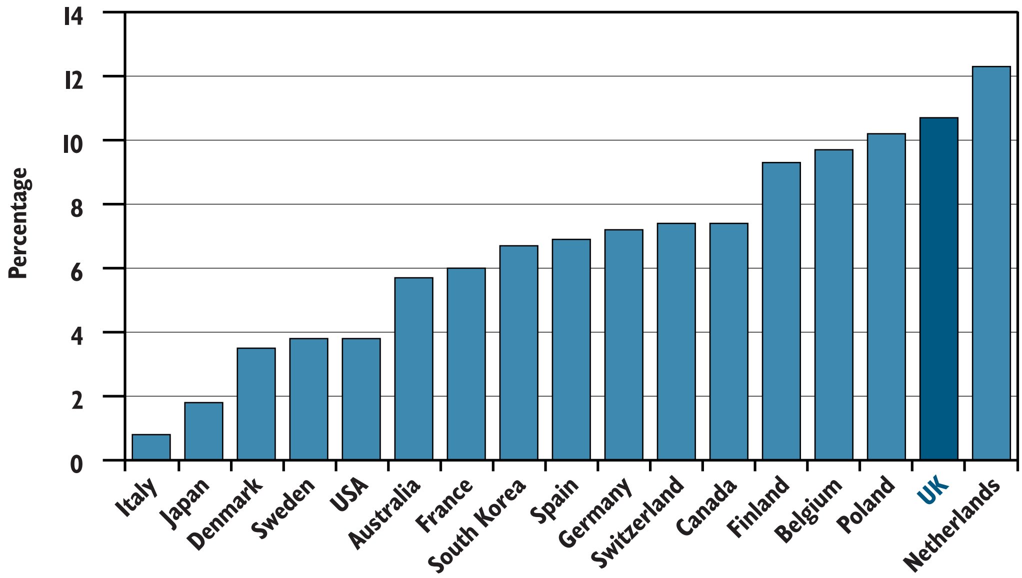
**4.29** Changes in technological and business trends have encouraged UK based firms to extract greater value from their research budgets by engaging in collaborative research with universities[13]. UK firms fund a significant proportion of university research compared to companies in other major OECD countries, as shown in chart 4.8 below.[14]

[12] Edler J, F Meyer-Krahmer and G Reger, *Changes to the Strategic Management of Technology – Results of a Global benchmarking study*, v 32 no 2 pp 149-164, R&D Management Journal, 2002

[13] Coombs R, R Ford and L Georghiou, *Generation and selection of successful research projects: a research study for the UK technology strategy forum,* 2001

[14] Evidence Ltd, *PSA metrics for the UK Research Base*, 2003

## Chart 4.8: Percentage of business R&D investment in publicly performed R&D




*Source: Evidence Ltd; data for 2001*

**Box 4.1: The creative industries**

Beyond manufacturing, the UK is well served by the wealth creation of other innovative sectors whose investment in new knowledge shows up less readily in R&D statistics. The creative industries are amongst the most dynamic and fast-growing sectors of the UK economy, accounting for some 8 per cent of total value-added and growing at an average of 8 per cent per annum between 1997 and 2001.[15] Much of their vitality rests on the bringing together of the creative and performing arts, cutting-edge technologies, and innovative forms of business organisation, often facilitated in regional clusters.

In areas as diverse as design and music, computer games and animation, film and new media, intelligent textiles and fashion, UK business has demonstrated its potential to become a world-class player. Indeed in some – such as computer games and new media – it is already a world leader and major exporter.

The Arts and Humanities Research Board (soon to become a Research Council) is taking the lead in supporting high-quality research to underpin the expansion of the creative industries. It has established a Task Group (working with the Department for Media, Culture and Sport) to identify the forms of knowledge engagement and transfer that are needed for the creative industries, and to ensure that policies are developed to maximise the engagement between researchers and industry in this dynamic area.

[15] *Creative Industries Economic Estimates*, DCMS, 2003

## Prospects for business R&D in the UK

**4.30** The required growth in business R&D - implied by the target to reach 2½ per cent R&D intensity in the UK - will need to be delivered through a range of different business responses across a wide range of sectors. These can be characterised as:

- maintaining or growing R&D in sectors where the UK is strong (e.g. pharmaceuticals);
- attracting investment into the UK from multinationals in an already highly internationalised system;
- increasing R&D intensity in firms or sectors that are lagging behind their peers; and
- developing new R&D intensive sectors and the creation of R&D intensive SMEs.

**4.31** The Government's primary responsibility is to deliver conditions of macroeconomic stability and the right regulatory frameworks for labour, product and capital markets which are conducive to business investment in R&D and the creation of wealth from innovation. Beyond this, the Government has an important role to tailor regulation, tax, procurement, competition and business support policies to help overcome particular barriers which might otherwise inhibit business R&D growth in the UK. Different sets of policies will be relevant to tackling the four different dimensions of raising business R&D highlighted above.

**4.32** A series of connected market failures provide a strong locus for the Government to intervene to help incentivise business R&D and the financing of some technology-based firms. Firms are likely to under invest in R&D, particularly at the earlier stages, compared with an economically-desirable level, because benefits spill over to other companies and cannot be fully captured by the investing firm. The same issue arises with establishing networks, which also exhibit 'free rider' and information market failures. Capital markets may also provide insufficient opportunities for companies to shift risk, owing to the asymmetric information between investor and company, and the difficulty of securing finance on intangible knowledge assets. Government instruments such as R&D tax credits, R&D grants and infrastructure measures such as the patent system are used to narrow the difference between social and private benefits, and to bear risk.

## DTI Innovation Report

**4.33** In December 2003, DTI published the Innovation Report, 'Competing in the global economy: the innovation challenge', which was the result of a joint HMT/DTI-commissioned innovation review. Following wide consultation with stakeholders, the Innovation Report set out an Action Plan containing proposals for Government to take forward in key areas that will have the greatest impact on increasing the levels of innovation in the UK.

**Box 4.2: Innovation Report Action Plan**

A **Technology Strategy** will concentrate Government funding on key technologies identified through consultation with business and other stakeholders. The Technology Strategy aims to support business 'pull through' of new ideas emerging from the UK's world class science and engineering base, will be coordinated by a Technology Strategy Board, comprising mainly senior business leaders, and is underpinned by an initial investment of £150 million over the first three years from 2004. The Technology Strategy and accompanying business support products are covered in more detail in Chapter 5 on knowledge transfer.

New **procurement** guidelines will be designed to make Government a more 'intelligent customer' by using its huge - £109 billion a year – purchasing power to drive innovation through public procurement. The Secretary of State for Trade and Industry and the Chief Secretary to the Treasury have endorsed the new Office of Government Commerce (OGC) guidance, 'Capturing Innovation from Suppliers'. DTI is working closely with OGC, other Government Departments, and with business, to promote and embed innovative procurement practices.

Tailored help for **small businesses** to innovate will be developed, including advice on intellectual property and design; greater access to R&D grants, university and national measurement system research; greater access to public research procurement opportunities, and a programme to develop leadership and management skills at all levels within SMEs.

The **Patent Office**, in conjunction with other partners, will lead the development of a range of measures to increase awareness of the importance of intellectual property (IP) by SMEs and improve confidence in IP protection. It will also develop a new national strategy for dealing with IP crime.

The **Design Council** are leading demonstrator projects on manufacturing and commercialising technology, with the support of RDAs, with the aim of showing how design can help deliver tangible innovation benefits.

Detailed formulation work is now underway on a new programme on **Measurement for Emerging Technologies** to support future technology exploitation. New programmes to increase knowledge transfer commencing in mid 2004 include: 15-25 Joint Industry Projects (involving 50 per cent industry co-funding); up to 250 product development projects for SMEs; and 20 exchange secondments between National Measurement Institutes and industry.

Delivery of the **DfES Skills Strategy** will also be important – the strategy is designed to inject business demand for skills into skills provision, recognising skills as a major contributor to improving levels of innovation and productivity.

There will be a new **regional** focus on innovation. Every English region is to have a Science and Industry Council or equivalent; the new business support product, Selective Finance for Investment in England, has been redesigned to focus on the creation of sustainable, high value added jobs; and regionally-based companies will gain improved access to the national science base, as described more fully in the knowledge transfer Chapter 5.

The Secretary of State for Trade & Industry is leading a Ministerial team to identify and develop further joint actions that will take forward the innovation agenda, including developing in the coming year a forward-looking strategy for supporting innovation and the knowledge economy on a ten year horizon.

## Knowledge transfer funding

**4.34** As set out in Chapter 5, these mechanisms for increasing business demand for and investment in science and technology are complemented by funding for knowledge transfer out of the science base and into business. The Higher Education Innovation Fund will provide £187 million over 2004-06 for knowledge transfer activities in universities, with the Public Sector Research Establishment Fund doing the same for PSREs, with funding of £15 million over two years. The 2004 Spending Review provides increases to these funds, as set out in chapter 5.

## Working with business sectors on innovation

**4.35** Innovation and Growth Teams (IGTs) are brought together by the DTI to look strategically at a specific sector, with the top-level commitment of industry and drawing on the expertise of the major stakeholders. The aim is to identify the key issues which will shape the future of a particular industry and how the UK can best respond to the competitive challenges which it will face.

**4.36** To date nine IGTs have been created[16], making recommendations on the future strategic issues for their sector. Many have highlighted the need to focus more on innovation for the future success of business in the UK. For example, the Bioscience IGT identified the need for a National Clinical Trials Agency to permit effective, early trialling of new diagnostics and drugs. Following this, in the 2004 Budget, the Chancellor announced the creation of the UK Clinical Research Collaboration (UKCRC), underpinned by new funding of £100m by 2007-08. The DTI Technology Strategy complemented this approach by giving a focus to bioprocessing when it launched the Technology Programme in April 2004.

## Fiscal measures

**4.37** As a complement to other forms of business support and regulatory intervention, the Government will continue to deploy fiscal measures, where appropriate, to help businesses overcome barriers which inhibit innovation and growth.

**4.38** There is strong academic evidence that tax incentives can increase R&D spending by an amount equal to the loss in tax revenues – every pound spent in tax support is invested by companies in additional R&D.[17] Like many other leading economies, the UK has introduced fiscal incentives to support companies' R&D and incentivise them to do more. **R&D tax credits** were introduced for SMEs in 2000, including a payable element which allows the credit to benefit loss-making early stage companies, that are most in need of the cash-flow boost the credit provides. In 2002 the credits were extended to large companies and subsequent Budgets have announced further improvements to the schemes, resulting from Government's continuing dialogue with business.

[16] Automotive, Software and Digital Content, Chemicals, Environmental Goods and Services, Aerospace, Retail, Construction, Biosciences and Electronics.

[17] Bloom, Griffith and Van Reenen *'Do R&D Tax Credits Work?' IFS Working Paper*, 2001

**4.39** Over 10,000 tax credit claims were received from SMEs up to 6 May 2004, with £570 million of support provided since the inception of the credit. For the year 2002-03, 95 per cent of eligible SMEs made a claim.[18] Early indications show significant interest in the credit by larger companies, making the UK an attractive base for multinationals to base their R&D.

**4.40** The Government has also reformed **the taxation of intangible assets** – including patents, trademarks and copyrights – to encourage UK companies to take advantage of new opportunities in the knowledge-driven economy and compete internationally.

**4.41** For those smaller companies seeking to exploit scientific and technological advances, lack of **access to finance** is often a key factor that holds back their growth. The Government has introduced several measures to promote equity investment, including the Capital Gains Tax business asset taper relief and enhancements to the Enterprise Investment Scheme (EIS) and Venture Capital Trusts (VCT). Since the inception of EIS, over 9,000 companies have raised £3.5 billion of venture capital and VCTs have raised over £1.6 billion, investing in more than 850 companies.

**4.42** To enable smaller high-tech companies to recruit and retain talented employees, the Government has also introduced the **Enterprise Management Incentive** share option – rewarding employees for investing their time and skills in helping small companies achieve their potential. Employees can receive options of up to £100,000 that benefit from tax and National Insurance advantages. Early evidence suggests that SMEs have found this to be a valuable help in securing the personnel they need to develop, with around 1,900 companies granting EMI options each year since 2001-02.

**4.43** In 2003 the Government brought in new rules to clarify the **tax treatment of shares** issued to employees (primarily designed to protect income tax and National Insurance revenues against aggressive tax planning). Concerns have since been raised by the university sector on the potential adverse effects of these rules on university spin-out companies. UNICO (the University Companies Association) and the Inland Revenue have worked closely together and have identified a ‘safe harbour’ which will allow university academics to become shareholders in start up companies, now knowing with certainty that tax on share gains will be payable only when they cash-in their shares.[19] The Government will actively review, with universities and their tax advisers, the impact of the new ‘safe harbour’ arrangements on the ability of universities to create spin-out companies where there are commercial opportunities to do so.

## Regulation and innovation

**4.44** The Government and sectoral regulators and are becoming increasingly aware of the incentive effects of regulation on R&D activity. In sectors where regulators directly control the prices of monopoly service providers – for example in water and energy distribution – companies do not have the normal competitive incentives to improve their products and services in order to gain market share. Instead, incentives have to be provided through the regulatory settlement between the firm and the regulator. There is some concern that the five-year price control periods typically used by the economic regulators do not give efficient incentives to undertake R&D that will reduce costs beyond the five-year price horizon.

[18] http://www.inlandrevenue.gov.uk/stats/corporate_tax/menu.htm

[19] The April 2004 Memorandum of Understanding between the Inland Revenue and UNICO can be found at www.inlandrevenue.gov.uk/shareschemes/agreement-with-unico.pdf

**4.45** Regulators have sought to encourage R&D firstly by introducing competition in previously regulated parts of their markets. For example, energy supply competition was introduced during the late 1990s, and telecoms services have been progressively liberalised over time since the privatisation of British Telecom in 1984. The Government and regulators are continuing to pursue opportunities to open up markets to competition. For example, Ofcom is currently consulting on the scope for introducing tradable spectrum rights, and the Water Industry Act 2003 introduced a framework for competition to supply large water users.

**4.46** Regulators have also sought to ensure that the remaining regulated monopoly businesses have efficient incentives to engage in R&D activity. Generally within the price control framework there have been moves to reduce distortions in investment incentives. Regulators have also considered specific measures to encourage R&D; for example Ofgem is currently considering two incentive schemes for electricity distribution companies:[20]

- Innovation Funding Incentive – a mechanism to encourage distribution companies to invest in appropriate R&D activities, focusing on the technical aspects of network design, operation and maintenance. The principal objective is to deliver benefits to consumers by enhancing efficiency in operating costs and capital expenditure.

- Registered Power Zones – intended to develop a mechanism to encourage distribution companies to develop and demonstrate new, more cost effective ways of connecting and operating generation that will deliver specific benefits to new distributed generators and broader benefits to consumers generally.

**4.47** Aside from direct economic regulation, environmental regulation also provides an opportunity to encourage R&D and innovation in addressing environmental problems. For example, under the Government's Renewables Obligation, electricity suppliers have to source at least ten per cent of their electricity from renewable power sources by 2010. This is having a direct impact in stimulating innovation and research into new energy sources such as offshore wind turbines.

**4.48** The Government has also used fiscal measures in a way that encourages innovation in the environmental field. In particular the use of enhanced capital allowances through the Green Technology Challenge process has encouraged the uptake of new and emerging technologies which aim to save energy and water. These incentives send strong signals to encourage the market to invest in the latest environmental technology and will consequently drive a degree of innovation as the market develops faster than it might have done.

**4.49** As highlighted by the DTI Innovation Report, there is also an opportunity to increase innovation through increased use of outcome-based regulations. DTI are leading a cross-Government project team including DEFRA, DfT, Cabinet Office and the Environment Agency, and working in consultation with business and other stakeholders, to look at three areas of environmental policy to assess how the regulations are designed and whether there are effective alternatives to regulation.

[20] Ofgem (2004), 'Electricity Distribution Price Control Review: Regulatory Impact Assessment for Registered Power Zones and the Innovation Funding Incentive', March 2004

## Inward investment and R&D

**4.50** The UK has for some decades been viewed as an attractive location for overseas companies seeking to establish an R&D facility in the EU. The UK has one of the highest shares of foreign affiliated R&D in manufacturing across Europe. To raise the R&D intensity of the UK in the coming decade, it is vital that the economy continues to attract substantial inward investment in R&D, both on its own and linked to other manufacturing and service activities. The strengthening of the UK's science base through the Government's medium term commitment to substantial growth in funding will help underpin continued excellence in UK science which is itself a major attractor for many high technology companies.

**4.51** The Government will continue to develop its approach to inward investment, through UK Trade & Investment, the Regional Development Agencies, and devolved administrations acting in partnership to raise the profile of the UK as an attractive location for globally mobile R&D investments. This is a focus of the recent White Paper on trade and investment.[21] Chapter 9 on UK science in the global context sets out how the Government will work to make the UK a stronger partner of choice for inward investment by technology businesses into the UK.

[21] *Making Globalisation a force for good*, DTI, 2004

# 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 tem 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 schemes[5] 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');

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[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 Review[1], 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.

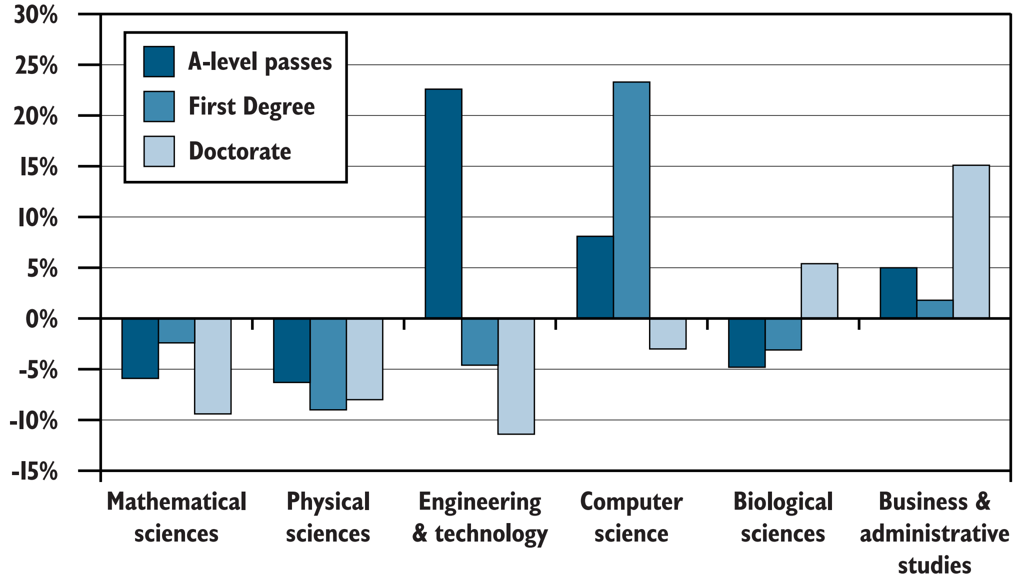
**6.3** Whilst implementation of Roberts' recommendations has not yet had time to make a full impact, Chart 6.1 shows that data collected since publication of the review points to a continued trend of decline in the take up of physical and mathematical sciences and engineering, relative to other subjects. For example, the proportion of students gaining first degrees in physical sciences has fallen by 8 per cent from 1999/2000 to 2001/02[3].

[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

**Chart 6.1: Change in proportion of students gaining scientific or technical qualifications, 1999/2000 to 2001/2002**




*Source: DfES, HESA. A-level data for England only; higher education data is UK-wide*

**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 economy[4] 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 mathematics[5] that the Government also addresses the problems in mathematics. The DfES's response[6] 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 economy[7].

**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 Greenfield[8]. 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 chemistry[9]. 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 technicians[10].

**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 Industry[12] 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 respondents[13] 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 survey[14] 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 Equality[15], 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.

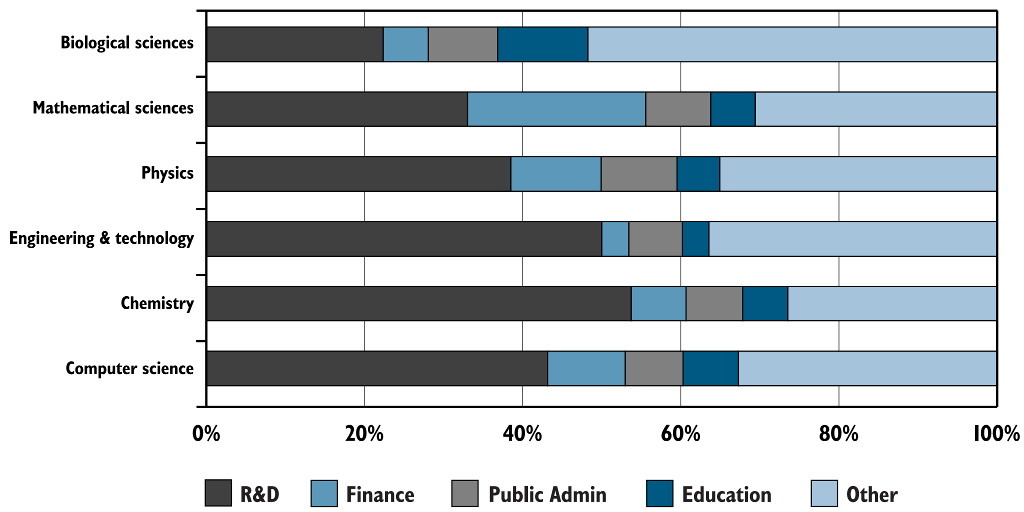
## Responsiveness to Employers and Skills needs of the Workforce

**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.

**Chart 6.2: First destination of science and engineering graduates**




*Source: DfES, HESA; data for 2001-02*

**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 Report[16] 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.

# 7 SCIENCE AND SOCIETY

## 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 2000[1] 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 2000[3], 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.

# 8 Science and innovation across Government

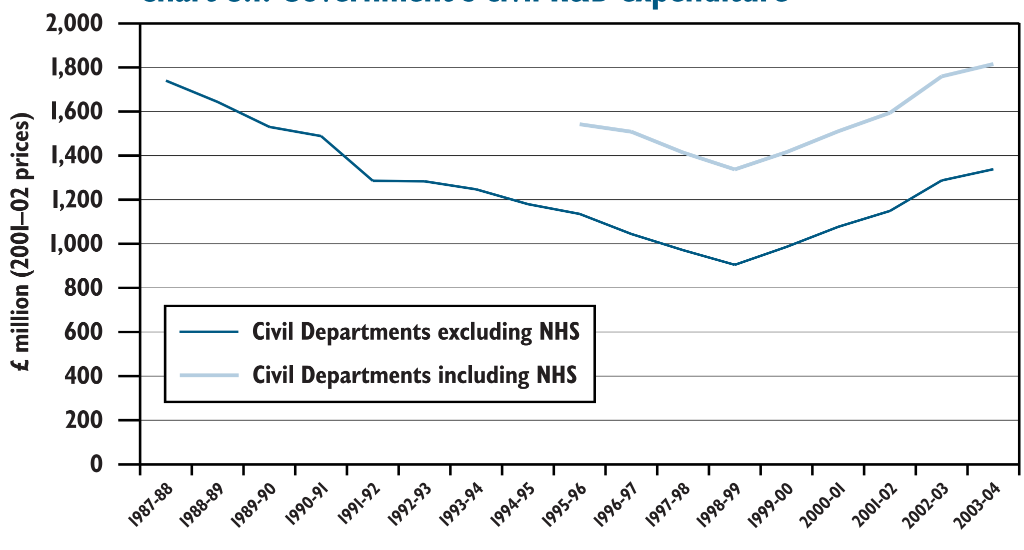
## Summary

**8.1** Science and innovation are not only key drivers of wealth creation, but also underpin evidence-based policy development and improved service delivery. Government therefore needs to use – and be seen to use – the highest quality science and research, as well as expert and independent advice as an input to policy formation and delivery. Government departments spent over £4 billion on R&D in 2002-03, significantly more than the total funding for the Research and Funding Councils. This chapter sets out how the Government will work, increasingly across departmental and public-private sector boundaries, to ensure that Government's own R&D programmes deliver their public service goals and support the translation of research into economic benefits.

## The Government's record to date

**8.2** In recent years, the Government has made firm commitments to evidence-based policy making and to improving the use of science and research by departments. This commitment has required a shift in the level of public investment. The historic decline in civil R&D expenditure that took place throughout the 1980s and 1990s has been reversed.

**Chart 8.1: Government's civil R&D expenditure**




*Source: DTI, The Forward Look (2003)*

**8.3** The Government has put in place measures to improve the way departments manage their own research and use expert advice. Drawing on key principles enunciated by Lord Phillips in his BSE Inquiry Report in 2000, the Guidelines 2000 and the 2001 Code of Practice for Scientific Advisory Committees provide guidance on how departments should obtain and use scientific advice in policy making, including the presentation of that advice and decisions based on it.

**8.4** The Guidelines 2000 cover the processes of identifying issues requiring scientific advice, obtaining the best possible advice from a wide variety of sources and the handling of advice by departments. The 2001 Code of Practice provides a framework to ensure that high levels of openness and transparency are maintained throughout the network of relationships between Scientific Advisory Committees and Government. This guidance is currently being supplemented by more recent work by the Cabinet Office and others. Findings from the 2002 report *Risk: improving government's capability to handle risk and uncertainty*[1] by the Prime Minister's Strategy Unit have led to a cross-government programme to improve risk management. The *Principles of managing risk to the public*[2] currently being implemented within departments include recommendations for increased openness and transparency to improve communication with the public where there is scientific uncertainty, taking into account public perceptions in decision-making, and promoting the use of independent experts.

**8.5** The Government is also taking steps to ensure that departments have the capability to manage properly the science and research they conduct or commission. A key milestone here was the 2002 Cross-Cutting Review of Science and Research. The Review recommended that all departments that rely on significant amounts of science have Departmental Chief Scientific Advisers (DCSAs), Science and Innovation (S&I) strategies that are properly costed and subject to external scrutiny, and appropriate arrangements in place to better manage their in-house expertise.

**8.6** There has been good progress in implementing the Review's recommendations: most departments now have costed S&I strategies and many have appointed DCSAs. Some departments have also introduced review processes that evaluate the delivery, impact and value of research, and examples of good practice have been collated by the Government's Chief Scientific Adviser (GCSA). For example, MoD's move to outcome-based justification for research is an important development from which other departments may learn. Similarly DEFRA's processes for identifying priorities, managed by their DCSA and involving the OST, the department's finance team, stakeholders and Ministers, represent a good practice benchmark.

**8.7** Government departments are encouraged to commercialise their research outputs, where appropriate. The 1999 Baker report[3], on the economic potential of public-sector research, the Government response to this and subsequent guidance, for example from the Patent Office, set out a framework for promoting more effective exploitation of research from Public Sector Research Establishments (PSREs). Chapter 5 describes measures to stimulate knowledge transfer from the PSRE base, **including an increase in funding available through the PSRE Fund to around £20 million a year by 2007-08.**

## Improving the use and management of research

**8.8** There are a number of challenges remaining. The first is to ensure that all S&I strategies link the science that departments plan to commission to departmental objectives, set priorities, explain how the work will be commissioned, managed and used, be open to wide consultation, and be reviewed regularly.

[1] Strategy Unit Report, November 2002. http://www.number-10.gov.uk/su/risk/risk/home.html

[2] HMT/Cabinet Office Principles, September 2003. http://www.hm-treasury.gov.uk/media//8B2AE/risk_principles_220903.pdf

[3] *Creating knowledge, creating wealth: realising the economic potential of public sector research establishments* – a report to DTI/HMT (1999)

**8.9** The 2003 DTI Innovation Report highlighted the potential of Government departments to stimulate innovation and wealth creation in the wider economy, for example, by using best-practice procurement techniques to provide incentives for companies to develop new products, processes and services, or by increasing the proportion of R&D purchased from SMEs. S&I strategies need to take better account of the potential of innovation and wealth creation in departments' internal policy delivery work.

**8.10** To address these issues, the Chief Secretary to the Treasury has asked the GCSA to review departments' S&I strategies following the 2004 Spending Review. **During the coming months, the OST will work together with the Prime Minister's Strategy Unit and the Ministerial Group on Innovation in the Knowledge Economy to assess strategies in respect of the following criteria**:

**Strategies' input to policymaking and service delivery:**

- whether spending plans are consistent with the strategy;
- the extent to which these plans and the strategy have been subject to appropriate peer review;
- whether the value added for new work is clear and credible;
- whether relevant proposals are in place to sunset programmes which have run their course;
- whether clear mechanisms are in place for setting objectives, evaluating results and ensuring accountability for performance; and
- whether sufficient mechanisms are in place to ensure investment in R&D is sustained throughout the economic cycle.

**Strategies' contribution to innovation and wealth creation:**

- whether they encourage the pull through of new technologies and techniques to industry and the wider economy;
- whether they facilitate the use of Government procurement to encourage innovation in the suppliers of research;
- whether they contribute to a regulatory framework which encourages innovative approaches to adherence;
- whether they contribute to delivery of the skills strategy; and
- the degree to which they involve the active participation of industry and in particular SMEs, including the share of externally-commissioned R&D funding awarded to SMEs, as part of departments' contributions to the government-wide Small Business Research Initiative.

**Strategies' contribution to government-wide knowledge and cross-government challenges:**

- the degree to which they take account of work in other Government departments;
- the degree to which they coordinate their work with that underway in the wider science base;

- whether there is potential to improve the Government's capacity to set clear government-wide objectives based on assessment of future strengths, weaknesses, opportunities and threats; and
- whether there is potential to improve the Government's capacity to deal with cross-departmental and multi-disciplinary challenges.

## A vision for the management of science and research across Government

**8.11** Completing the implementation of the recommendations of the 2002 Cross-Cutting Review and achieving further progress through review procedures on the issues identified above will enable and encourage departments to become increasingly sophisticated in their management of science and research, and their use of expert knowledge.

**8.12** Looking beyond this, over the coming decade the Government aims to achieve the attributes described in Box 8.1 for managing science and research across Government. Many departments have already made substantial progress towards them. Going forwards, concerted and sustained effort will ensure that all departments build on recent progress in order to achieve these objectives.

**Box 8.1: Attributes for the effective management of science and research across Government**

1. The Government as a whole, and all Government departments, will have adopted a culture of using sound scientific advice to inform policy development, delivery and departmental decision-making. This should involve DCSAs in all major departments with direct access to Ministers and departmental managers, and with departmental managers involving DCSAs on all major policy issues, not just those with obvious scientific aspects.
2. All scientific work commissioned and used by Government will be of appropriately high quality, drawn from the best possible sources (including the science base and the private sector), commanding the confidence of Government Ministers and officials. Government departments will be paying the full economic costs of the research they commission from universities.
3. Priorities for research will be set at the strategic level, not just within departments as they are now, but also across government as a whole, taking account, for example, of the 2003 Strategic Audit from the Cabinet Office. CSAs – acting as a group – along with other bodies, such as the Council for Science and Technology, will provide advice on the prioritisation of strategic issues. The use of science in policymaking will be applied consistently across the board where an issue affects more than one department.

**Box 8.1 continued: Attributes for the effective management of science and research across Government**

4. All Government departments will be using sophisticated scientific horizon-scanning techniques, linked both to their own policy horizon scanning, that of other departments, and to the OST horizon-scanning centre (described in paragraph 8.18). This should involve departments drawing upon the science base to ensure they are informed about future risks and opportunities. Cross-departmental science initiatives, such as the Foresight programme and Prime Minister's Strategy Unit work, should develop and disseminate best practice guidelines and should provide capacity to deal with selected issues, working closely with other departments.

5. Scientific expertise will be used to the maximum effect possible, allowing greater use of Research Council, charity and private sector input to Government advice, and giving Government scientists greater opportunities to contribute to the work of the science base and the exploitation of their work in the wider community, industry and commerce. Analysts, including scientists, will be able to network more effectively – within their own department, across departments, Research Councils, the private sector and internationally – to ensure awareness not just of research results already generated but also active research underway elsewhere.

6. Knowledge transfer objectives will be fully incorporated into departments' S&I strategies, and scientific advice on procurement in Government departments will be seen as a natural and logical means of pulling through the development of new technologies.

7. The use of scientific knowledge will have been fully integrated into Government analytical and risk assessment processes, and risk assessment guidance will be consistent with the advice in Guidelines 2000. Science will be regarded as one of the key analytical inputs to decisions along with specialisms like economics, law and statistics, with policy staff at all levels aware of the need to seek scientific advice – in the same way as they incorporate economic and legal advice.

8. Scientific advice for the Government will be generated in a fully inclusive manner and command the support of the public and other stakeholders. Scientists, including Government scientists, will have the training and willingness to communicate openly with the public, including through the media. Politicians and the public will understand what science and research can and cannot deliver, in particular that science and analysis will provide information and knowledge to those who must take decisions, but that it is for politicians and for the public to take the decisions themselves.

**8.13** Work on these objectives will be taken forwards through a variety of methods. Some fall within the remit of the ongoing work of the OST in scrutinising departments' S&I strategies, while others fit into existing work-streams elsewhere, such as the implementation of the DTI Innovation Report, the public engagement agenda, or the current cross-government programme on improving risk management. Others will require new interventions, such as additional training for scientists and policymakers, the formulation of best practice guidelines, or the creation of appropriate networks. **As part of the review of departments' S&I strategies later in 2004, the OST and Prime Minister's Strategy Unit will work together to assess what more needs to be done to achieve these goals.**

## Departments' research programmes and future priorities

**8.14** In examining departments' priorities for science and research over the next decade, a number of cross-cutting issues are apparent:

- the identification of policy objectives supported by research commissioned or conducted by several departments, for example, climate change and energy research (see Box 8.4) and security and anti-terrorism research;
- a common interest in research into future technologies and techniques that are required for progress with different policy challenges, for example: research into new sensors and imaging technologies using developments in materials technology for military, civil security, commercial and health applications; research into the methods that might be used in new supercomputing facilities for the analysis of huge volumes of data; and research to inform departments better as to the potential risks attached to policy options; and
- the increasing demand for social and humanities research to inform policymaking (see Box 8.2), for example on the way behaviour might influence health; the building of safe and sustainable communities and urban regeneration; and a better understanding of the factors that need to be taken into account by physical scientists and engineers in promoting public acceptance of new technological developments.

**Box 8.2: Social research in Government**

The Government's Chief Social Researcher, in consultation with departments, other stakeholders in Government and the wider research community, has developed a strategy for Government Social Research to enhance its impact and contribution to Government policy making and delivery.

Government social research uses the methods of social scientific enquiry – surveys, qualitative research, analysis of administrative and statistical data, case studies, controlled trials – to measure, describe, explain and predict social and economic phenomena, and subsequently uses this data to inform policy debate.

The Government Social Research Service provides objective, reliable, relevant and timely social research to support the development, implementation, review and evaluation of policy and delivery, and to ensure that policy debate is informed by the best research evidence and thinking from the social sciences.

**8.15** In order to deal effectively with cross-governmental policy challenges, it is essential to ensure the coherence and strategic relevance of science and research across government, both across departments and across disciplines. Taking full account of the current and potential contributions of existing fora for coordinating science and research across government, such as the Cabinet Ministerial Committee on Science Policy (SCI) and the Chief Scientific Adviser's Committee (CSAC), the Cabinet Office is currently examining options for strengthening the determination of cross-cutting analytical and research priorities and ensuring the coordination of research and analysis to support policy development.

**8.16** Complementarity between departments' own research programmes and those funded through the Research Councils is also crucial, not only to avoid potential gaps and overlaps in publicly funded research, but also to maximise the contribution of the UK science base to public service priorities. A number of departments already have research concordats in place with Research Councils, outlining areas for strategic cooperation or joint working, for example:

- the Medical Research Council has concordats with the Welsh Assembly, the Department for Environment, Food and Rural Affairs (DEFRA), the Department for International Development (DfID) and the Ministry of Defence (MoD), and bilateral links with the DTI, Food Standards Agency (FSA) and individual charities; and
- the Particle Physics and Astronomy Research Council has concordats with the MoD and Department of Health (DH) covering agreements to work together on technologies of common interest and promote effective interaction on these.

**8.17** Excellent horizon-scanning of current science and technology, looking at opportunities and threats at least five to ten years ahead, and often considerably beyond that, is essential to the effective governance and direction of Government policy, publicly funded research and many of the activities of the private sector, and to the interactions between them. Horizon scanning currently takes place both within individual departments and the Office of Science and Technology's Foresight Directorate (see Box 8.3), as well as within the Research Councils (RCUK).

**Box 8.3: Foresight**

The Office of Science and Technology's Foresight programme carries out in-depth projects on issues where science and technology may create major future opportunities and challenges. Each project reviews the relevant science and creates visions of the future to help frame choices and debate. Foresight works with a wide range of stakeholders to identify areas for further action.

Recent projects are now contributing to wider engagement on the implications of potential developments in flood risk and climate change, human and artificial cognitive systems, and next generation information and communication technologies. Future projects will continue to explore selected areas with relevance for public engagement, longer-term regulatory environments and investment.

**8.18** **Building on the work already taking place in the Foresight Directorate, in Government more widely, and in RCUK, the Government's Chief Scientific Adviser will work with RCUK, the Prime Minister's Strategy Unit and Departmental Chief Scientific Advisers across Government to build up a single centre of excellence in science and technology horizon scanning.** This will be co-ordinated by OST's Foresight Directorate and will bring together high calibre individuals provided and resourced by other Government Departments, Research Councils and the private sector. This will not replace the requirement for effective horizon scanning in departments, RCUK and elsewhere; rather, it will provide a higher-level strategic context to those other activities, interacting with and informing them. It will feed directly into cross-government priority setting and strategy formation, improving Government's capacity to deal with cross-departmental and multi-disciplinary challenges. It will also inform and be informed by the Government's strategy for public engagement with science.

## Research in Government departments

**8.19** In the following section, the research activities and future priorities of some of those departments with the highest levels of investment in science and research are highlighted.

## Department of Health

**8.20** The Department of Health (DH) invests in research to support Government objectives for health services, public health and social care, as well as contributing to the Government's overall science strategy. The DH spent approximately £540 million in 2002-03 through the NHS R&D programme and Policy Research Programme. The NHS R&D programme (around £500 million) provides two main streams of support:

- NHS Support for Science: used mainly to support clinical research, this budget meets the NHS costs of supporting R&D under agreed standards of strategic direction and quality assurance by the Research Councils and by other eligible funding partners.[4] It includes an element for the costs of developing R&D proposals and for building work around research supported by the external funder; and
- NHS Priorities and Needs R&D Funding: this supports R&D required to underpin modernisation and quality improvement in the NHS. Among the NHS responsibilities that are supported are: clinical R&D; R&D to develop and apply new technology in the NHS; health services R&D, including work on service delivery; and public health R&D, including epidemiology. This support is given to those best able to undertake the research and achieve the results required. These include collaborations between the NHS, universities, local authorities and other bodies, and groupings outside institutional boundaries, across clinical specialisms, health communities and care pathways.

**8.21** Additionally, some NHS R&D funds are used to help improve capacity to undertake research; for example, the Research Capacity Development Programme is a national programme that provides personal awards and funds academic infrastructure to support research capacity development within the NHS. The purpose of the programme is to build and support a skilled workforce capable of advancing high quality research with the aim of maintaining and improving health within a knowledge-based, patient-centred health service.

**8.22** The Policy Research Programme (around £32 million per year) undertakes development and evaluation in public health, health services and social care in order to ensure that policy is based on reliable evidence of needs. The research portfolio covers healthy living and social wellbeing, disease prevention, the role of the environment in health, social care for adults and children, the organisation of the NHS, and strategies for treating particular diseases or conditions. The Department directly commissions research on major areas of public health, including lifestyle and inequalities.

**8.23** The Government committed, in Budget 2004, to increase NHS R&D funding by £25 million per annum over each of the next four years, an additional £100 million by 2007-08 compared with 2003-04 levels. This new investment will underpin the creation

[4] Including the Wellcome Trust, Association of Medical Research Charities (AMRC), EU, US National Institutes of Health (NIH) etc.

of a new UK Clinical Research Collaboration (UKCRC) for the effective and efficient translation of scientific advances into patient care. The UKCRC is a medical research partnership involving the Departments of Health in England and the devolved administrations, the Medical Research Council (MRC), the Wellcome Trust, the Association of Medical Research Charities, related industry sectors, the medical academies, the NHS and patients and carers. It will create and fund research networks, based on the successful model developed by the cancer research networks, to increase the number of patients involved in clinical trials in important disease areas. This will start with mental health, medicines for children, Alzheimer's, stroke and diabetes. It will develop and implement proposals to enhance research careers and streamline the regulatory framework governing research.

**8.24** The UKCRC will work to transform the clinical research environment in the UK by:

- taking strategic oversight of clinical research;
- identifying gaps in clinical research capability and programmes and identifying opportunities for action;
- planning and co-ordinating approaches between funding bodies to fill gaps and take advantage of opportunities;
- monitoring progress in implementing agreed plans and in achieving agreed objectives; and
- giving leadership to develop the profile of clinical research and enhance the research culture of the NHS.

**8.25** The creation of the UKCRC was strongly welcomed in responses to the consultation on this science and innovation investment framework as a major step forward. At the same time, a number of respondents identified further issues that needed to be tackled, particularly with regard to the strategic coordination of medical research between public sector funders: whilst it is clear that the MRC and the Health Departments already work well together across a range of areas, it was felt that this could be taken further.

**8.26** **The Government has therefore tasked the MRC and the Department of Health (DH) in England to create, together with the Health Departments in the devolved administrations if they wish to participate, a new joint body, the Joint MRC/DH Health Research Delivery Group.** The Group, which will report to both MRC and DH through their normal reporting channels, will have a remit to:

- develop agreed positions on research issues to be discussed and developed into proposals at UKCRC;
- agree delivery timetables and performance indicators for the proposals to be taken forward by Government funders;
- pool funds for specific activities where appropriate (e.g. fellowships, clinical trials);
- organise delivery on a joint basis where required (rationalising the present position, and so improving operational efficiency);
- achieve greater cohesion in knowledge management and exploitation of research outputs from publicly funded medical research; and

- develop coordinated bids for medical research funding for future Spending Reviews for submission through the Health Departments and OST.

**8.27 A review of progress will be carried out in advance of the 2006 Spending Review, in order to help inform decision-making on medical research funding. Its remit will include advising on the best way to use both existing and new resources to maximise the benefits of clinical research in the NHS and the wider economy.**

**8.28** Looking forward, the DH has identified a number of priorities that it intends to address over the next five years, subject to funding allocations:

- increased capacity, infrastructure and funding of clinical research in order to strengthen the effective and efficient translation of scientific advances into patient care;
- taking maximum advantage of new genetic advances and technologies, drawing on funding partners, for example in the DTI and the Welsh Assembly Government;
- public health research to support the identification and implementation of cost-effective approaches to improving population health, prevention and reducing health inequalities;
- work to implement the recommendations of the Healthcare Industries Task Force to maximise the benefit to patients from healthcare products, building on public procurement elements of the DTI Innovation Report; and
- moving to full transparency of the use of R&D funds allocated to NHS Trusts and achieving full sustainability for clinical research in the NHS.

**8.29** Improving public health research capacity and links between public health academics and practitioners was identified as essential to delivery of the Government's long-term health policy aims in the February 2004 report by Derek Wanless, *Securing Good Health for the Whole Population*. A Wellcome Trust report, *Public Health Sciences: Challenges and Opportunities*, published in March 2004 also made a number of recommendations in this area. Responses to the consultation on this framework identified these and other wider issues in public health as priorities.

**8.30** The Government will take these ideas and recommendations forward in a White Paper on improving health, which will be published later in 2004 and will address the Wanless and Wellcome recommendations on public health research capacity and infrastructure.

## Department for Environment, Food and Rural Affairs

**8.31** The Department for Environment, Food and Rural Affairs (DEFRA) spends some £325 million per year on science activities, including research, covering policy priorities such as climate change and energy, natural resource protection and animal health and welfare. DEFRA has developed its own ten-year perspective on its science needs in the form of its *Science Forward Look*[5], to be published in July 2004, so that it can plan for appropriate investment in science and research up to 2013. This will be the subject of consultation and inform the development of DEFRA's next Science and Innovation Strategy (2005-08).

[5] *Evidence & Innovation: Defra's Next 10 Years*, DEFRA, in press.

**8.32** DEFRA plans to alter the balance of its current science programme towards its environmental priorities. Top priority will be strengthening science and innovation in support of policy on climate change and energy. Targets here include: the development of improved warning systems for severe weather, improved mitigation strategies and continued science support for DEFRA's leading international role in this area; improved understanding of factors influencing energy consumption leading to reduced CO2 emissions; and increased investment in the Renewable Energy and Energy Efficiency Partnership (REEEP), a unique programme for building capacity for renewable energy and energy efficiency market growth and innovation.

**8.33** Furthermore, **the Carbon Trust will continue its support for developers and co-investors to tackle climate change through the discovery and development of low carbon technologies and business**. Its mission is to work with various communities (academic, early-stage, pre-commercial, corporate research and investors) to identify innovative technologies, test concepts, provide viability and define future markets that create real wealth. Expansion of the Carbon Trust's programmes in the business sector will introduce significant improvement in delivery of carbon savings, both in the short term and over a longer period, helping to meet targets in 2020 and beyond.

**8.34** DEFRA will place increased emphasis over the next ten years on partnerships and strategic alliances, both with other Government Departments and with the UK science base, especially in environmental science, bioscience and the social sciences. The next S & I Strategy will also set out how DEFRA will promote innovation to support environmental and other policy priorities. Key components of DEFRA's approach include:

- technology foresight and horizon scanning to identify emerging technologies and the drivers for innovation and policy support;
- support for technology transfer and innovation by business, especially the development of sustainable technologies;
- direct funding for innovation to support policy needs and to develop new approaches to regulation that encourage innovative solutions; and
- policy on ownership of intellectual property to encourage the results of DEFRA-funded research to be brought to the market.

**Box 8.4: Cross-cutting research: climate change and energy**

Energy research, development and demonstration (RD&D) is diverse and fragmented, with a wide range of departments and other public bodies responsible for different aspects. This diversity brings benefits, but at the same time risks complexity in coherence and leadership. Currently the Sustainable Energy Policy Network (SEPN) network, the Chief Scientific Adviser's High Level Energy Group on R&D, and The Carbon Trust are the main vehicles active in coordinating efforts, with the High Level Group linking additionally with the Research Councils. Another relevant strategic body is the UK Environment Research Funders' Forum (ERFF), established by DEFRA, the Environment Agency and the Natural Environment Research Council in 2002 to coordinate national activities in environmental research and training.

**Box 8.4 continued: Cross-cutting research: climate change and energy**

Overall expenditure on energy research in the UK lies behind that of France and Germany. The gap with the US, scaled for relative size of the economies, is even more pronounced. The level of private sector funding for energy R&D has fallen significantly since the 1980s and privatisation of the utilities. Equally, the value of research into renewables by the major oil companies is a small fraction of that into fossil fuel-related research.

The combined expenditure by the UK Research Councils on energy research, including the two main programmes – SUPERGEN and Towards a Sustainable Energy Economy – currently amounts to around £14 million per annum, including the current provision for the establishment of the new UK Energy Research Centre. In the DTI, renewables research has amounted to around £20 million per annum, although larger sums have been allocated, for example, to support the development of offshore wind farms.

Over the coming decade, the Government will work with partners in the private sector to improve the effectiveness of UK energy R&D investments overall, and the scale of these investments relative to the economic and environmental challenge facing the UK. Better dialogue between key funders of energy RD&D – industry, Government and other public bodies, and academia – will be central to our future approach. The Energy Research Centre is a step forward in this respect, providing greater leadership and coherence to energy research, including a focus for wider international engagement. Energy innovation will remain of the highest priority and strategic importance for the UK, and globally, for many decades to come.

Three areas of activity the UK needs to engage in over the next ten years include:

- promoting collaboration between public and private sectors on energy RD&D, and transferring knowledge effectively into business;
- greater pull-through of innovative technologies to demonstration and commercialisation; and
- playing a stronger role in the large-scale technical research projects being undertaken in EU and other international collaborations.

## Department for International Development

**8.35** DfID has a specific remit to reduce global poverty. New science, technologies and ideas are crucial for the achievement of this aim, but global research investments are currently insufficient. DfID commissions research to help fill this gap, aiming to ensure effective outcomes for the world's poorest people. There has been notable success in these areas since the creation of DfID in 1997, and the Department is now recognised as an international front-runner in terms of development science, particularly on HIV/AIDS.

**8.36** DfID also works with governments through projects and budget support programmes to help establish sustainable research and knowledge capacity. Capacity is on the increase in some regions, notably China and India, but remains weak across Africa. The advantages of building domestic capacity are twofold: country- or region-specific research has greater value for developing countries (for example in agricultural research); and a sustainable research base in a developing country increases the chances that research results will be taken up by policy-makers and entrepreneurs.

**8.37** In response to the Government's 2002 Cross-Cutting Review of Science and Research and an independent review of DfID's research programmes[6], DfID has prepared a long-term research strategy to establish a focus on areas where DfID and the UK can make a significant contribution to development science.

**8.38** The strategy will serve to link DfID research to wider Governmental science priorities, and will include building research and knowledge capacity in developing countries to ensure that findings can be communicated effectively to those in need. The strategy will also seek to:

- link in with DfID's wider work with developing countries;
- increase the coherence of all UK Government departments' research spending on development issues;
- build closer working relationships with international bilateral and multilateral agencies; and
- identify a longer-term research and policy agenda.

**8.39** Since 1997, DfID has increased its bilateral spending on HIV/AIDS from £38 million to more than £270 million in 2002-03. **Over the next three years, DfID will continue to increase funding for HIV/AIDS. In addition, DfID research spending will increase from £80m per year to at least £100m per year from 2006-07, demonstrating the commitment to making progress in this area.** Spending will focus on four key themes: African agricultural productivity; killer diseases such as HIV/AIDS, malaria and TB; states that work in the interests of the poor; and climate change.

**8.40** To build on this additional investment, **DfID will set up a UK Funders' Forum that will for the first time bring together Government departments, Research Councils and the private sector to pool knowledge on the application of science and research to development goals**.

**8.41** DfID is playing a leading role internationally in supporting the development of Public-Private Partnerships (PPPs) for the development of vaccines, drugs and microbicides. These include the Medicines for Malaria Venture (£1 million per year), the International AIDS Vaccine Initiative (£14 million over the period 2000-2004), and the Microbicides Development Programme of the Medical Research Council (£16 million over the period 2000-2005). A PPP on livestock vaccines is under development.

**8.42** The Wellcome Trust is an important partner with DfID in meeting their shared public health goals to bring lasting benefits to the world's poor. **Working in partnership with DfID to combat malaria through research, the Wellcome Trust expects to commit around £10 million over the next five years, matched by DfID investment. The Trust are also exploring with DfID the joint development over the same period of capacity building for health research in sub-Saharan Africa.**

**8.43** DfID also works with the Bill and Melinda Gates Foundation, which has provided over $1.1 billion of grants for work on HIV, TB and reproductive health. The Foundation places particular emphasis on innovative approaches and greater coordination in research into new technologies for HIV/AIDS, including vaccines and microbicides. In particular, DfID is engaging with the Foundation on the establishment

[6] Research for Poverty Reduction: DfID Research Policy Paper. http://62.189.42.51/DFIDstage/Pubs/files/pov_red_pol_paper.pdf

of the New Global HIV Vaccine Enterprise announced at the Sea Island G8 summit in June 2004.

## Ministry of Defence

**8.44** The Ministry of Defence (MoD) spends around £12 billion per annum on the procurement of fighting equipment for the UK's Armed Forces. Of this, around £2 billion is spent on the development of new equipment and a further £450 million on research for future capabilities and to provide wider technical advice across the Department. The vital role that science and technology can play in transforming the UK armed forces to meet the security challenges of the 21st Century was highlighted in the New Chapter to the 2002 Strategic Defence Review[7] and reinforced in the recent Defence White Paper.[8] Defence technology has also contributed to wealth creation in the wider economy through spin-off into the commercial sector; examples include thermal imagers, foetal monitors and liquid crystal displays.

**8.45** The 2004 Spending Review will enable the MoD to drive through a series of reforms, including the establishment of a new Top Level Budget holder responsible for science and technology, to ensure that these resources are used in the most efficient way. The MoD is also working to widen its research supplier base with the part-privatisation of the Defence Evaluation and Research Agency (now trading as the private company QinetiQ), and an increased move towards the use of competition in contracting for research services. It is planned that by 2007-08 the entire research programme will be subject to open competition, with the exception of that which, for national security and other reasons, has to be undertaken within Government.

**8.46** The combination of this move to expand the defence research base that the MoD has access to, whilst at the same time enhancing direct investment in technology and innovation in that supplier base, has necessitated the establishment of new partnerships between industry, public-sector research institutions and the academic sector. The Defence Technology Centre (DTC) initiative, which creates partnerships between Government, academia and business around specific technology themes, is the key action supporting this. **The 2004 Spending Review reaffirms the MoD's commitment to the DTC initiative, under which the MoD provides 50 per cent of the funding for a six-year competitively let contract, the remainder being provided by other consortium partners**. Innovative intellectual property rights (IPR) arrangements have also been negotiated that will secure those rights required for Government use while at the same time giving maximum freedom for industrial exploitation.

**8.47** An initial tranche of three DTCs was successfully established in 2003 in the areas of Data and Information Fusion (£30 million over six years), Human Factors Integration (£7.6 million over three years) and Electromagnetic Remote Sensing (£15 million over three years, with options to extend to six years). A further DTC in the field of Systems Engineering is due to be launched by the MoD later in 2004, and soundings within industry indicate strong further demand for DTCs.

7 *Strategic Defence Review: A New Chapter*, MoD, July 2002.

8 *Delivering Security in a Changing World*, MoD, December 2003.

**8.48** Looking further ahead, the MoD has identified seven priority areas for investment in underpinning technologies over the period to 2007-08:

- network-enabled capability for the armed forces;
- technologies for national security and to counter chemical, biological, radiological and nuclear (CBRN) threats;
- the development of unmanned aircraft;
- the production of non-lethal weapons and personnel protection;
- novel power sources;
- enhanced capabilities in the development of open computer architecture in new equipment; and
- technologies to ensure enhanced sustainability and affordability of complex defence equipment.

One of the challenges in the coming years will be to link, through joint programmes and co-funding arrangements, these emerging defence technology priorities and those applied science and business technology opportunities identified through the Research Councils' forward planning and the DTI's new Technology Strategy Board.

## Home Office

**8.49** The Home Office has a wide variety of research interests, from technologies for reducing crime to research on the economic consequences of migration, and currently spends some £50 million per annum on science and research. The fruits of this research are apparent in numerous areas, such as identification techniques, where the exploitation of DNA techniques through the National DNA Database has led to an increase from 24 per cent to 38 per cent in detection rates where DNA is used. In many cases such technologies are making direct contributions to efforts to achieve Home Office Public Service Agreement targets: for example, crime reduction best practice and toolkits based on authenticated evidence covering CCTV, and the application of problem-oriented policing techniques, have contributed to real reductions in burglary (down 40 per cent since 1997) and vehicle crime (down 34 per cent since 1997).

**8.50** The Home Office's key science and technology priorities over the period to 2007-08 include:

- the creation of a new central intelligence hub;
- the development of a coordinated cross-departmental programme to develop the evidence base to deal with CBRN risks and other aspects of terrorism;
- the coordinated deployment of biometrics;
- the greater use of effective technologies for policing, such as tracking and surveillance technologies, and non-lethal technologies for police protection;
- targeted higher quality evaluations and modelling work to enhance and assess the efficiency and effectiveness of various Criminal Justice System agencies and interventions;
- the evaluation of effective drug treatments; and

- strategic research looking at crime, offenders brought to justice, longitudinal analysis of refugees and other recent migrants, and research to support civil renewal and increasing volunteering.

**8.51** Building on significant recent developments in the way in which science and research are managed in the Home Office, such as the appointment of a Chief Scientific Advisor and the creation of a Home Office Science and Technology Reference Group of eminent independent scientists, **the Home Office will, over the years through to 2007-08, be putting in place an integrated approach to managing investment in science and research by creating an overarching science and technology strategy for the Home Office**. This will include: establishing a central mechanism for science planning, strategy, quality assurance and horizon scanning; restructuring and strengthening the Police Scientific Development Branch to become the Home Office Scientific Development Branch; a department-wide science and technology unit; and strengthening cross-departmental science links to ensure high standards and appropriate cross-departmental working on delivery issues such as CBRN, drugs and youth justice.

**8.52** Looking forward over the next ten years, the Home Office has identified key areas of science and technology that will support its strategic aims: horizon and intelligence scanning, identification technologies, cross-disciplinary uses of science and technology, sensor technology, material technology, ICT, data analysis and mining, location technologies and intelligent imaging.

# 9 GLOBAL PARTNERSHIPS, DEVOLVED ADMINISTRATIONS AND THE REGIONS

## Summary

**9.1** The Government's aim is that the UK should be a 'partner of choice' for global businesses looking to locate their research and development (R&D), and for foreign universities seeking collaboration with the science base or business. In a global economy, with healthy competition from both developed and rapidly emerging developing nations, and with the costs of 'big science' increasing, the UK needs to maximise the value of collaborations at an international level and in European fora, as well as maintaining a healthy competition with our European neighbours.

**9.2** Given the devolved nature of a significant proportion of research funding and industrial policy, the Government also needs to connect international and national R&D networks efficiently with the economic plans of the UK's countries and regions. This chapter illustrates the science and innovation strategies adopted by the UK's devolved administrations. At a regional level, the importance of science and innovation in improving regional economic performance is increasing, highlighting the need for regional and national bodies to coordinate funding and strategies.

## Effective international engagement

**9.3** Science is an international enterprise, and increasingly so, both in its scale – for example, the human genome project or high-energy physics – and in addressing global challenges – for example, climate change, terrorism and infectious disease. Many areas that have been dominated by national networks and facilities will be replaced by international ones, and global competition to attract private sector R&D investment is rising strongly. Because of the UK's strengths, scientists here should increasingly be seen as the partners of choice and involved in international networks and collaborations. To develop further the UK as one of the world leaders in R&D, the nation needs to capitalise on international collaborations, working with major players such as the USA, European partners, Japan, Canada, China and Russia.

**9.4** A survey of international opinion, canvassed in 2004 by the Foreign and Commonwealth Office's Science and Technology (S&T) network, found that the UK has a strong reputation for science, particularly for excellent basic science capabilities. These were generally seen as being on a par with France and Germany, and delivered through a more efficient and effective research management system. However, the breadth of UK strengths, across disciplines and in centres of excellence throughout the UK, is not fully appreciated in key markets such as the USA. The UK could further improve the attraction for inward investors of its world-class researchers and universities which are now more actively engaged in collaborations with business R&D.

**9.5** Ninety per cent of the world's R&D takes place outside the UK. The UK can benefit from this by linking into international networks or building international collaborations. Providing UK researchers and businesses with access to the world's best science, scientists and facilities, wherever they are located, is key. This is essential if the UK is to stay at the forefront of leading fields and to provide access to large EU or global-scale facilities (such as telescopes, particle colliders and large datasets) that are too expensive to develop alone. Collaboration and engagement at an international level also has the potential to increase the UK's global influence and reputation in R&D and

attract more inward investment, visiting workers, and students to UK higher education. Box 9.1 illustrates two current examples of fruitful international collaboration.

**Box 9.1: International science partnerships**

The benefits of partnership between world-class researchers are already being demonstrated, for example:

- in the UK and the US, the initial phase of the UK/Texas Bioscience Collaboration Initiative, launched in 2002, focuses on key areas of bioscience, medicine and bio-nanotechnology, where there are complementary strengths in the UK and Texas, and potential for commercialisation. Texas was chosen because of the strength of its bioscience and medical research centres, the openness of its research community and a readiness to partner with the UK. This initiative could prove a useful model for developing collaborations with other parts of the US, which offer complementary scientific excellence and eagerness to work with the UK; and
- the development in Japan of the world's most powerful super computer – the Earth Simulator – which allows the global climate to be modelled at much higher resolution. UK and Japanese scientists were brought together by the FCO, resulting in UK experts in climate prediction modelling gaining unprecedented access to the Earth Simulator, to support the further groundbreaking insights by UK scientists into the complex interactions of climate change.

**9.6** The Government already facilitates these aims in a number of ways:

- The FCO's network of science and technology (S&T) attachés in key countries around the world, working closely with the DTI, UK Trade and Investment, British Council, Research Councils and others, helps inform policy making on science and innovation, and uses science in support of foreign policy objectives, for example on climate change. The network promotes the UK as a partner of choice and facilitates collaboration to enhance the UK science base, helps companies access overseas innovation and technology, facilitates technology-based trade and inward investment, and uses science and technology as a vehicle to maximise the UK's influence and impact abroad.
- The DTI's GlobalWatch service offers a range of practical help to UK-based firms, which wish to acquire knowledge of technological developments, advanced skills and scientific advances in other countries, to help develop their businesses. This includes facilitated technology partnering through the International Technology Promoters (ITPs).
- UK Trade and Investment (UKTI) provides support for companies across the range of international business activities, encompassing inward investment and export promotion. Through its Global Partnerships Service, UKTI enables potential inward investors to identify technologically-advanced UK firms with which they may wish to build strategic collaborations.
- The British Council promotes UK culture and creativity, and has a unique role to play in sustaining communications for and about the UK system of innovation as a whole, acting to support both wealth creation and social well being. The Council has two main science programmes worldwide: to engage

and influence scientific communities, and to spread awareness and appreciation of the UK with wider international audiences.

**9.7** The Government recognises the need for an overarching national strategy for international engagement in R&D and access to large facilities, to bring together the main UK players in international R&D, including Government departments, the FCO network of S&T attachés, scientific societies and the Research Councils. The strategy should develop a more evidence-based approach to international engagement, in line with the approach to performance metrics developed for UK-funded research that will monitor UK strengths and weaknesses compared with the rest of the world, examine barriers to progress and identify appropriate actions. This should ensure that UK actions take account of the changing international economic and research environment, that key initiatives and opportunities are identified, and that UK priorities are agreed to ensure that international research structures meet our needs.

**9.8** **A cross-government group – the Global Science and Innovation Forum – led by the Government's Chief Scientific Adviser, will develop this strategy**. The strategy will include:

- the FCO, DTI and UKTI pro-actively promoting the UK as the partner of choice for international R&D and facilitating inward investment and outward trade;
- coordinating cross-government work on the S&T aspects of major global issues, such as climate change and S&T capacity building in developing countries;
- identifying main strategic partners for international facilities and collaboration and using networking and other programmes more strategically to make these partnerships happen;
- presenting an interface between UK activities and individual researchers and businesses that is coherent and simple to access;
- identifying and prioritising EU and global large facilities which the UK will want to contribute to or host; and
- using EU R&D programmes to the best advantage, particularly taking into account EU enlargement to 25 Member States.

## Facilitating global links

**9.9** To help deliver its broader goal of raising the UK's R&D and innovation performance, the Government will develop a higher impact approach (delivered through the bodies described above) to raising the UK's reputation as a leading partner for science and business R&D collaboration and inward investment. Based on clearer targeted information to scientific and business audiences in key markets, and monitored regularly for effectiveness, the Government will aim to raise the reputation of the UK over the next two years as a partner of choice in Europe and the rest of the world.

**9.10** The UK Government – through key stakeholders (Office of Science and Technology (OST), International Technology Service of the DTI, the FCO's Science and Technology network, the British Council and the Research Councils) – will also need to continue to make an important contribution to the Government's wealth creation

agenda by coordinating cross-departmental approaches to key overseas markets (e.g. China, India and the USA); coordinating cross-departmental initiatives on important international issues (e.g. climate change); and ensuring that national science and technology initiatives contain an international component, reflecting the full business potential – and influence - of UK science and technology.

**9.11** The UK will need to build on international agreements with both developed (e.g. US / Japan) and emerging (e.g. China / India) economies through international networking agreements that identify research partnership opportunities, develop areas of mutual interest, and optimise synergies. Through promotional activities, the UK can showcase what it has to offer in science and technology: global campaigns presently running include an FCO and British Council sponsored North American campaign 'UK Science and Technology for a New World', which focuses on biotechnology, energy and the environment - areas where British science, innovation and policy lead the world. In 2005, a 'Year of Science' campaign is planned in China.

**9.12** The UK needs to ensure that the right opportunities exist, and are taken up, for collaboration with leading states both bilaterally and through EU programmes, that there is the right balance between EU and non-EU collaboration and that there are effective links with leading US regions, expanding the approach which is working so well in Texas (see Box 9.1). In this context, the Research Councils should look to build on existing support for international collaborations.

**9.13** The UK will also need to influence international policy in critical areas of global concern. UK researchers and businesses are well positioned to lead on finding solutions to global problems, which in turn will provide business opportunities, better security and an improved quality of life. Two important examples of areas where international efforts will be necessary are climate change and sustainable energy, and capacity building in developing countries. On the former, the UK has provided international leadership on climate change and is well placed, including through the forthcoming G8 and EU Presidencies, to promote further international research and technology cooperation and information sharing. On the latter, the UK scientific community has strong technical experience and research leadership in critical disciplines, and the UK can work, through the G8 Presidency, towards a more coordinated and sustainable international effort in tackling development issues. These policy areas are covered in more detail in Chapter 8. Through knowledge transfer and capacity building, the UK can make a significant contribution to addressing global issues of sustainable development, poverty and poor education, killer diseases, lack of clean water provision and access, and the consequences of global warming.

## Large research facilities

**9.14** Maintaining access to leading edge experimental facilities is a key element of keeping UK scientists competitive and at the forefront of their fields of research. In many cases the responsibility for the investment needed to maintain this access should properly fall to the universities and institutes in which the scientists are employed. However, there are a range of facilities that may, for a number of reasons (e.g. size, cost, interdisciplinary scope), fall outside the funding remit, or capability, of any individual authority.

**9.15** The UK currently spends about £230 million per annum on the capital expenditure of large facilities projects, through Research Council baseline expenditure, international subscriptions, and from the Large Facilities Capital Fund held centrally by the OST. Funding is allocated on the basis of excellence, scientific need based on

prioritisation, and best value, using whichever of these funding mechanisms best suits the project.

**9.16** The breadth and quality of science possible in large facilities is rising as new technologies emerge. New facilities are more technologically complex and hence more expensive than the facilities they are replacing. Hence, many areas which have up until now been dominated by national facilities will be replaced in the next generation by international facilities. New technologies such as grid computing will have a major impact on the nature of the facilities which are needed and generate major new challenges, such as exponentially increasing amounts of data to store and curate. At the same time, new potential funding partners for investment in large facilities are emerging (for example, research charities, Regional Development Agencies, and the EU).

**9.17** In such an environment, the UK needs to take a strategic position as to the best way to maintain access for researchers and to manage and fund new investment. The Large Facilities Road Map[1] sets out the key facilities of the future, both in the UK and overseas, which the Government and Research Councils see as potentially strategically important for UK researchers to be involved with. It gives a 15-year forward look of priorities, and helps with periodic prioritisation exercises to ensure that the funding available is focussed on the highest priorities, based on the following criteria:

- the scientific excellence of the research delivered from the facility and the importance of that facility in delivering that science;
- the timeliness of the investment and the impact on the UK of potential delay;
- the extent to which the project would meet other national and international needs, and hence the interest and possible leverage from other potential funders;
- the strength of the potential research user group in the UK and its breadth across subject areas and Research Councils; and
- the overall financial scale of the project.

**9.18** These criteria apply to investments in both national and international large facilities, located in the UK and elsewhere. There are additional factors to be considered if the UK wishes to host an international scientific facility on UK soil. There is the potential for the UK to secure further benefits from hosting an international large facility, through gaining scientific leadership and leverage, and attracting international research talent. There may also be secondary industrial benefits, from winning a greater proportion of technology contracts for the facility itself, and the development of clusters around the site. However, there are obviously additional costs to the UK of hosting such a facility; typically the host country pays a premium.

**9.19** In many cases, UK interests will be well served by participating in a facility overseas, for example through international subscriptions or bilateral arrangements with the host country. In a few cases there may be a strong case for the UK to host such a facility, and where this is the case the UK Government will be actively involved in the international discussions to maximise the chances of a potential UK bid. The UK also

[1] http://www.ost.gov.uk/research/funding/lfroadmap/index.htm

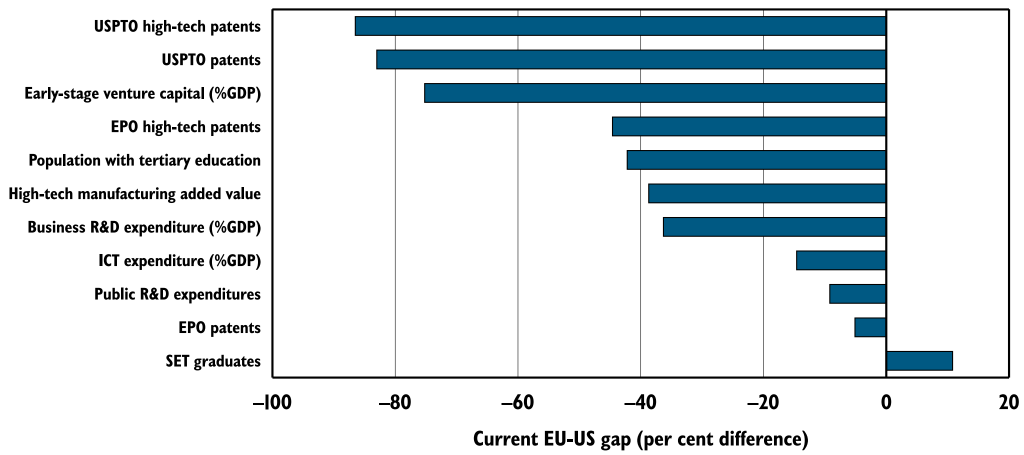
needs to become more strategic in negotiating access for UK scientists to overseas facilities. Research Councils will work together through Research Councils UK to ensure that needs and opportunities are identified across the spectrum of large-scale facilities. Where substantial UK investment is required for this, priorities will be guided by the Large Facilities Road Map, and funding committed only where there is a good value for money case for investment, as balanced against other research priorities.

## European Union research and innovation

**9.20** At the Lisbon European Council in 2000, Europe's leaders set the strategic goal for Europe 'to become the most competitive and dynamic knowledge-based economy in the world by 2010'. To achieve this goal, Europe must improve its R&D and innovation performance.

**9.21** Despite the importance of R&D to growth and productivity, the performance of the European Union lags that of major competitors such as the US or Japan. Furthermore, EU expenditure on R&D amounts to just 2 per cent of GDP, compared with 2.7 per cent in the US and 3.1 per cent in Japan. Many European countries also fail to translate promising research into innovation. The most recent (2003) European Innovation Scoreboard shows the EU trailing the US on 10 out of the 11 indicators available for both, particularly in patenting, tertiary education, and the provision of early-stage venture capital (see chart 9.1). The Scoreboard also suggests that, on current trends, none of the gaps will be closed by 2010 without additional effort.

**Chart 9.1: EU-US innovation gap**




*Source: European Innovation Scoreboard, 2003*
*USPTO: United States Patent and Trademark Office*
*EPO: European Patent Office*

**9.22** The 2002 report to EU Economic and Finance Ministers on research and development emphasised the importance of ensuring supportive framework conditions for innovation to thrive. It also identified several key barriers to innovation in the EU – many chiming with the UK's national policy priorities – including: ineffective intellectual property regimes; weak science-industry links and insufficient exploitation of public research; a lack of risk capital, particularly at the early stage; the regulatory burden for start ups; and punitive bankruptcy laws.

**9.23** A combination of measures – at the regional, national and Community levels and including partnerships with the private sector – are required to address these problems and improve Europe's innovation performance. National-specific policies can be directed at tackling national/regional problems. To enable this to happen, EU

frameworks need to be sufficiently flexible to allow Member States to develop policy that is tailored to their own economic and social circumstances. In this respect, application of the Open Method of Coordination offers the opportunity for Member States to develop policies that are, at the same time, consistent with common European economic goals and tailored to domestic economic environments. This approach, consisting of mutual learning and peer review, has been recently applied to the shared political commitment of increasing investment in R&D in Europe. Box 9.2 gives an overview of recent innovation policy in France, Germany and the Netherlands.

**Box 9.2: Innovation policies in other EU Member States**

In **France** a new innovation plan was announced in March 2003 for implementation in 2004. The action plan addresses four specific issues:

- creating an attractive legal and fiscal status for business angel investors;
- support to innovative start-ups, including exempting young research-intensive firms from some social security charges and taxes;
- a new R&D tax credit, from which all firms can benefit; and
- strengthening the partnership between the public research and the industrial research community, for example, through incentives to increase the recruitment of graduates.

In **Germany**, innovation policy includes a range of targeted support programmes to tackle market failures; due to Germany's federal system, such programmes exist both at the national and state level, with coordination between the two. Some examples of current initiatives include:

- Information Society Germany 2006, a plan to support different activities in business, research, government and society to further improve ICT penetration and use;
- a strategy for high-tech start-ups and SMEs, introducing new measures to support such firms and improving existing measures to facilitate cooperation between innovative SMEs and research institutions; and
- developing a new, comprehensive innovation strategy to push innovation in all areas of business, research, government and society.

In the **Netherlands**, the Government launched an 'Innovation Platform' – a council of experts chaired by the Dutch Prime Minister – in September 2003, with a budget of €185 million. This was followed in October 2003 by a government policy commitment to three main goals:

- to promote innovation by expanding the tax incentive for private sector R & D (with a proportion aimed specifically at SMEs), introducing a new mechanism to stimulate collaborative R&D projects, and tackling the shortage of knowledge workers;
- to increase the number of innovative companies by improving the climate for technology-based start-ups, focussing assistance on SMEs which are motivated to innovate, and attracting knowledge-intensive entrepreneurs to the Netherlands; and
- to ensure better exploitation of opportunities to innovate, for example through policies for exploiting university knowledge and changes to university financing.

**9.24** EU interventions can be valuable in helping create framework conditions that provide firms with both the incentives to invest in R&D and the ability to reap the rewards of their investment. These conditions include a stable macroeconomic

environment, open and competitive product, labour and capital markets, sensitively designed regulation, a favourable tax climate, and a responsive intellectual property regime.

**9.25** The European Commission is working towards an Innovation Action Plan, currently under consultation, which will provide strategic direction and specific recommendations for improving the innovation performance across Europe. The Action Plan will include actions both at Member State and at European Community level. The Government believes that any Action Plan must consider the steps that can be taken at the Community level to promote innovation. They are:

- a review of the State Aid Framework. The Commission has said it will draw up, by 2005, a Communication on state aid for innovation, and produce by the end of 2004 a users' guide to the state aid rules applicable in the field of innovation. These welcome announcements provide a valuable opportunity for reform to ensure that Member States have sufficient flexibility to use state aid to promote innovation. It will be important to ensure that the state aid rules allow support to be given to tackle market failures in all phases of the innovation process;
- improvements in the regulatory process to reduce the burdens on innovative firms. Regulation can both provide incentives for and inhibit innovation. Improving the regulatory framework is therefore a key element of efforts to boost innovation in the EU;
- steps to build better cross-border university-business networks, such as international partnerships, and to improve the mobility of researchers, including, as described below, through the use of Framework Programmes;
- rapid progress on improving the patenting system in Europe, alongside relevant directives, to ensure that the outcomes strike the right balance between the needs of businesses and consumers; and
- an examination of the prospects for more specialised financing instruments to support particular modes of research exploitation, utilising opportunities within the European Investment Bank's (EIB) *Innovation 2010 Initiative* funding stream.

**9.26** The forthcoming UK Presidencies of the EU and G8 in 2005 will provide further opportunities to promote this agenda.

## EU expenditure: the 2007-2013 financial perspective

**9.27** Although these innovation challenges must primarily be addressed through national policies or the improvement of the European framework conditions, there is also scope for using the EU budget to help improve the R&D and innovation performance of the EU as a whole.

**9.28** The Agenda 2000 negotiations in Berlin in March 1999 determined the expenditure ceilings for the EU budget for the period from 2000 to 2006. The next financial perspective will be the first one decided by an enlarged Union of 25 Member States. Although the challenges faced in negotiating the next financial perspective will be considerable, it represents a unique opportunity to increase both the effectiveness and transparency of expenditure and to consider how allocations within a limited EU budget, stabilised at around one per cent of EU gross national income, can best be

refocused in support of the Union's priorities, including economic reform and the Lisbon agenda, rather than simply increased.

**9.29** A principled budgetary framework would be based on the best of the current strategic planning arrangements, but would also draw lessons from the Lisbon process. A more developed policy framework for EU expenditure should:

- be **objectives-focussed** with the emphasis on outcomes not inputs; there should not be an automatic assumption that a certain level of spending is needed to meet the Union's objectives;
- be **evidence-based** by evaluating the impact of budgetary policy; strategic planning should be based on what works, and poorly performing programmes should be displaced or redirected;
- examine, particularly where a new area of spending is proposed, whether the Union Budget is the best instrument for **adding value** or whether action would be better addressed at Member-State level or through other, non-spending, policy measures;
- ensure sound financial management and budgetary discipline; and
- ensure an equitable distribution of spending across the EU, consistent with value-added principles.

**9.30** A key criterion for determining the appropriateness of EU spending is value added. For EU level spending to be justified, there has to be tangible added value from giving the competence to the supranational level.

**9.31** R&D is the third largest area of expenditure in the European budget. Current negotiations provide a real opportunity to ensure setting of strategic goals, achievement of value added and improved evaluation and handling of funds. On the basis of the Commission's proposals and previous levels of participation, EU Programmes have the potential to increase the levels and effectiveness of UK R&D investment, with consequent increases in annual UK industrial output of the order of several billion pounds.

## R&D Framework Programmes

**9.32** EU R&D expenditure is channelled through the multi-annual Framework Programmes provided for in the Treaty and implemented by the European Commission. The EU R&D programme is just 5 per cent of European public sector civil R&D spend, so funding needs to be targeted, consistent with overall budget ceilings, towards those areas where the case for European action is strongest:

- the Programme should demonstrate its impact against clear **strategic objectives**, addressing EU weaknesses and challenges. These should promote the key outcomes of improving competitiveness and high-technology inward investment, raising the quality and scale of public and private research capacity and supporting EU policy objectives;
- it should provide clear **European added value**, in accordance with the subsidiarity principle. International collaboration brings an additional overhead, and the UK may already have a 'critical mass' of research efforts in many areas. The EU must focus on where this level of action is really needed;

- the Programme needs **effective delivery mechanisms**, based on evaluation evidence and addressing the drivers of the intended participants. Bilateral programmes or intergovernmental collaborations may provide a more effective route to the same goal.

**9.33** The Framework Programme is the EU's third biggest funding mechanism: the Sixth European Framework Programme, running from 2002-06, has a budget of €19 billion. However, the Programme currently lacks an effective system of performance measurement. Progress is being made to improve the monitoring and assessment of the programme's delivery processes, but there is a bigger challenge of tracking the longer-term impact of the programme as a whole. It can take many years before projects have quantifiable outputs, and often the contribution of a project to a new product or service is lost due to the complex evolution of a project and the timescales involved. It is important, nonetheless, to increase efforts to perform strategic evaluations and assess the long-term impact of the programme on European science and technology.

**9.34** It is vital that the UK makes best use of the opportunities offered by the programme and influences the priority areas for support. However, many participants, in particular SMEs, have difficulties engaging in it. The UK is a major player in this area, with more participation in the recently completed Fifth Framework Programme than any other Member State. So the Government has an important role to play in ensuring there is effective promotion of the programme and appropriate support for organisations looking to participate. The current system has evolved over a number of years and has several different components and points of delivery. While a good level of service is offered in many areas, the Government will work to raise the visibility of the support available, ensure that the service is easy to navigate and that an appropriate level of support is provided across all areas, in addition to national programmes for collaborative research.

**9.35** The accession of the new Member States brings a number of opportunities such as access to well-educated scientists, exposure to fresh ideas and new markets, as well as the lower costs associated with working in these countries. The UK is well placed to make the most of these opportunities due to our excellent S&T reputation and the widespread knowledge of the English language in the new Member States, and is already developing a stronger S&T presence in these countries through a wide range of activity. It is, however, important that the development of good S&T working relationships between organisations in the new Member States and the UK is based on mutual benefit.

**9.36** The Seventh Framework Programme (FP7) will cover the period 2006 to 2010-11. In April 2004, the Government launched a public consultation, which will help to develop a UK position paper in autumn 2004. This will be used to influence the Commission's formal FP7 proposals, expected in the first half of 2005.

**9.37** The Commission's early thinking suggested that the budget be doubled to around €40bn.[2] The UK initial view is:

- a higher proportion of the EU budget should be allocated to research, within overall budget constraints, recognising the added value of appropriate international public funding of research;

[2] Commission Communication: *Science and technology, the key to Europe's future – Guidelines for future European Union policy to support research*, COM (2004) 353, http://europa.eu.int/comm/research/future/pdf/com-2004-353_en.pdf

- the priorities should be to promote cooperation between business and research and boost future technologies. The key challenge is to increase private sector investment in and exploitation of R&D;
- the programme has to be simplified to make it more user-friendly for industry and science;
- the programme needs clearer, more outcome-focused objectives and delivery mechanisms focused on raising research excellence and quantity to global standards, translating research into high value products and services, and increasing industrial R&D investment, with any increased support for basic research based solely on excellence; and
- the EU should pay an increased proportion of costs of the research it funds in the science base, to support financial sustainability.

**Box 9.3: A European Research Council?**

A key driver of research excellence is competition – competing for funding, for recognition and for the best researchers in an open system drives up the quality of the research undertaken. The European Commission, in its June 2004 Communication on guidelines for future EU policy to support research[3], has recognised that the limited scope for competition within Member States could have a negative impact upon research excellence when compared with major global competitors.

The Commission's main proposal for action at this stage is the establishment of a new European support mechanism modelled on the US National Science Foundation's Individual Grants Scheme, that is, comprising grants to individual teams chosen through competition on the basis of scientific excellence, without any cross-border or mobility requirements. Substantial new EU funding is proposed for this scheme, which could be administered by a new delivery agency or a 'European Research Council'.

The UK Government has welcomed this new proposal, making clear that research funding must be awarded on the sole basis of scientific excellence as judged by rigorous international peer review, and that such funding would need to be awarded through a delivery mechanism that minimises bureaucracy, encourages the very best to apply and meets the full cost of the research undertaken.

## European Investment Bank

**9.38** The European Investment Bank (EIB) is playing a growing role in financing applied R&D and other measures to support business innovation. The EIB's actions under the *Innovation 2010 Initiative* concentrate on three areas: education and training; R&D and downstream investment; and, creation and dissemination of information and communication technologies. The EIB will also give priority to projects involving synergies between the public and private sectors. In particular, the EIB looks to support facilities such as science parks and business incubators; and the development of micro credit. The European Investment Fund (EIF), the risk capital arm of the EIB group, is working to develop further venture capital markets in the EU, focussing on providing support for new technologies.

[3] *Science and technology, the key to Europe's future- Guidelines for future European Union policy to support research*, COM(2004) 353, June 2004.

**9.39** The UK is encouraging the EIB to: consider the additionality of the finance it provides; to take more risk than the market is willing to, providing finance to new innovative businesses which would otherwise not have received financing; and to develop instruments to leverage in greater amounts of private sector capital, as well as creating funding mechanisms to provide additional finance to innovative businesses in disadvantaged areas.

## Science and innovation in the devolved administrations

**9.40** Whilst this framework sets out a vision for the UK as a whole, supported by significant UK-wide funding, such as that flowing through the Research Councils, the devolved administrations have lead responsibility in their own countries for funding a number of key areas in relation to the science base, such as research and knowledge transfer funding at universities. The devolved administrations have their own economic development bodies, with remits similar to those of the English Regional Development Agencies. This section highlights the contributions of the Scottish, Welsh and Northern Irish administrations to UK science and innovation.

**Box 9.4: Scotland**

The Scottish Executive is committed to enhancing the role of the science base in Scotland and to playing a full part in the UK's ten year investment framework for science and innovation. Scotland has an excellent science base in its universities, Research Institutes and Centres, and in the NHS with many leading in UK wide programmes and objectives. Scotland's HEIs in recent years have won around 12 per cent of UK Research Council awards and, in the last Research Assessment Exercise nearly 50 per cent of submissions were rated as internationally competitive. The need to maintain a fully competitive HE research base in Scotland is emphasized strongly in the Executive's Review of Higher Education in Scotland[4] and in subsequent policy statements. A current initiative is examining proposals from the HE sector to pool the research strengths in certain subject areas across several institutions and so form critical masses of internationally competitive research.

The 2001 Science Strategy for Scotland[5] sets the framework which informs the detailed development of policy for the support and use of science to achieve the Executive's objectives, including development of the science base, increasing the effective exploitation of scientific discovery, science education, public understanding of science and use of science by government.

Scotland's research base continues to provide a lead for the UK in several areas, including the work at the Roslin Institute on cloning, the UK's National e-Science Centre at the University of Edinburgh in partnership with Glasgow University; the Wellcome Trust Biocentre at Dundee University; and Mineral and Mining Engineering at Heriot-Watt University. The planned £200 million biomedical research centre in Edinburgh will create the UK's largest research site in this field. A major international collaboration, the Edinburgh and Stanford Link project, aims to establish Scotland as a global leader in the commercial development of language technology.

[4] http://www.scotland.gov.uk/library5/education/fhes-00.asp

[5] http://www.scotland.gov.uk/library3/education/ssfs-00.asp

**Box 9.4: Scotland continued…**

Research in the biological sciences in Scotland is internationally recognised, and the Scottish Agricultural and Biological Research Institutes, funded by the Scottish Executive, contribute to this. The strategic work in these organisations will increasingly focus on the needs of the Scottish population, and they will also pursue closer collaborative links with universities and other research providers in Scotland in order to tackle bigger and more complex questions.

On human health, the Scottish Longitudinal Study, a collaborative venture involving four Scottish universities, will pioneer new ways of making data accessible for both scientific and policy-related research. Collaboration with European science is also high on the Scottish agenda with a strong participation in Framework Programme 5 projects. Scotland is now well placed to take advantage of the Genomics and Biotechnology for Health funding stream presented by the EU Sixth Framework Programme.

Harnessing the benefits of research through commercialisation and knowledge transfer is a key part of the Scottish Executive's science and enterprise strategies. Scotland does relatively well in UK terms on measures of business-university interaction, but levels of business R&D and innovation are relatively low. A range of measures have been put in place in to help boost this, including proof of concept funding; support for commercialisation of research from the NHS in Scotland; and the £450 million investment over ten years in three Intermediary Technology Institutes to support new market-driven R&D opportunities in life sciences, energy and communications technology/digital media.

The Scottish Executive has taken a strategic approach to address some of the challenges facing science education, providing specific funding to Local Authorities to raise teachers' science skills and modernise science laboratories. It recognises that science teaching has to be more innovative, that science equipment and the curriculum must be kept up-to-date and continued effort is required to ensure that young people are enthused by science. The Executive has recently provided financial support to four of the science centres in Scotland to ensure that these valuable assets are secured for the future.

**Box 9.5: Wales**

In Wales, the Welsh Assembly Government – in conjunction with its agencies, notably the Welsh Development Agency and Higher Education Funding Council for Wales (HEFCW) - is strongly driving the knowledge exploitation agenda forward as part of 'Wales: A Better Country', the strategic agenda of the Welsh Assembly Government.[6]

The Welsh higher education sector has a key role to play in promoting knowledge exploitation and the development of a skilled workforce. The latest UK-wide higher education business interaction survey shows that Wales is punching above its UK economic weight in a number of key knowledge transfer activities. For example, in 2001-02 Wales accounted for: over 10 per cent of all spinout activity from UK HEIs; 19 per cent of all graduate business start-ups; 11.6 per cent of all HEI contracts signed with SMEs; and 6.9 per cent of all UK Research Council grants involving business co-funding.

In addition, the quality of research undertaken by the higher education sector in Wales has improved markedly over the past decade. The results of the 2001 RAE demonstrated that the quality of research in Welsh institutions now stands comparative with the rest of the UK.

In response to relative weaknesses in some science areas, HEFCW established a research capacity development fund to provide some £8.5 million over three years to build research capacity in key topics, including nanotechnology and biosciences. Further, the Assembly Government aims to strengthen the research base in the Welsh HE sector by selective funding to build world-class capacity, and in particular to encourage collaborative bids and collaborative effort. The Wales Cancer Bank, the Cardiff Gene Park, the Brain and Repair Imaging Centre and the merger of Cardiff University with the University of Wales College of Medicine are all notable examples of what can be achieved through collaboration and partnership funding.

High impact innovation initiatives from the Welsh Assembly Government and its agencies (summarised in the Wales for Innovation Action Plan[7]) include: making full use of available European Structural Funds on a wide range of innovation related projects; the unique Welsh Centres of Excellence; and Technium programmes and the Knowledge Exploitation Fund.

Looking forward, the Welsh Assembly Government's recent policy review in this area, 'Knowledge Economy Nexus'[8], has concluded that the bonds between excellence in higher education and high added-value companies could be strengthened, by ensuring that:

- good companies around the world are more aware of Welsh research excellence;
- companies in Wales readily access excellence within both HEIs in Wales and those further afield;
- collaborative research opportunities are identified which are in line with marketplace drivers and which will significantly enhance the excellence of the Welsh research base;
- all parts of the national innovation system in Wales are more involved in its future, holistic development;

[6] http://www.wales.gov.uk/themesbettercountry/strategic-e.pdf

[7] http://193.113.180.44/resources/action-e.pdf

[8] http://wales.gov.uk/subitradeindustry/content/know-econ-nexus-e.pdf

**Box 9.5: Wales continued…**

- within Welsh higher education and the Welsh NHS, opportunities for direct knowledge transfer and commercialisation are maximised;
- success from generating and implementing new ideas is increasingly celebrated in all walks of life; and
- the performance of the knowledge economy in Wales is measured objectively.

Underpinning all this, the value of public understanding of the importance of science and technology has long been recognised in Wales and Techniquest, headquartered in Cardiff, is now of world renown in this field.

**Box 9.6: Northern Ireland**

In Northern Ireland science, technology, R&D and innovation are recognised as vital contributors to economic prosperity. Over the last ten years both the public and private sectors have invested heavily in key technology areas, including biotechnology, communications engineering, polymer processing and nanotechnologies. In that period, Government support for industrially relevant R&D was £182 million, in a total investment of £565 million. In June 2003 The Department of Enterprise Trade & Investment (DETI) launched 'think|create|innovate: The Regional Innovation Strategy for Northern Ireland', marking a step change in Northern Ireland's commitment to R&D, innovation, and the wider science and technology agenda. It sets out the blueprint for a coherent regional R&D and innovation infrastructure involving government, academia and the private sector, with an action plan designed to make Northern Ireland an internationally competitive innovating region.

A major addition to the R&D infrastructure is the Northern Ireland Science Park (NISP), established in March 1999 by DETI and its economic development agency Invest NI. Based in Belfast, with linked facilities in Coleraine and Londonderry, it should create over 3000 high-quality jobs. NISP embodies the view that leading-edge centres for research have a critical role to play in establishing the region's reputation for technological excellence. In addition to the NISP, there are more than 40 research centres of excellence, across a number of key technologies, established with support from regional industry and higher education since 1995. Further to this, Invest NI has developed the Research and Technological Development (RTD) Programme to add value to Northern Ireland's R&D infrastructure and capability, with a focus on commercial and industrial research. DETI and Invest NI have also developed a £3 million pilot Proof of Concept Fund, aimed at academics, to provide pre-seed funding to prove commercial potential of a product of research.

At the heart of Northern Ireland's science, technology and R&D base are its two universities. Between 2001-03, 34 high-technology based companies were spun out from university initiatives. Queen's University Belfast (QUB) and the University of Ulster (UU) have established international reputations as centres of research excellence. The Department for Employment & Learning (DEL) is the principal funder of university research (£35 million for 2003-04). DEL also operates the Support Programme for University Research (SPUR), a public-private partnership to develop a high quality research capability in Northern Ireland, investing up to £44 million in the universities' research infrastructure between 2000-04, with a second round of £50 million investment between 2004-07. Additionally, under the UK wide Science Research Investment Fund (SRIF), between 2004-06 Northern Ireland will secure a total investment in the universities in excess of £21 million.

DETI, DEL and Invest NI have also jointly established the Northern Ireland Higher Education Innovation Fund (HEIF), a £9 million initiative which will run from 2004-07, and will provide financial incentives to the universities to transfer their knowledge to industry. Also working closely with the universities, the R&D Office for the Northern Ireland Health and Personal Social Services supports £12 million of R&D each year. Northern Ireland's Department of Agriculture & Rural Development (DARD) also invests approximately £6 million per annum to support the sustainable development of the region's agri-food industry through excellence in analytical and diagnostic services, education, research and technology transfer.

## Science and innovation at a regional level

**9.41** Science and innovation have the potential to play an important role in achieving the Government's objectives of increased prosperity and reducing the current disparities between regional economic performances. The English Regional Development Agencies have seized on this role as a key part of their economic development mission in response to the aims of UK Government science and innovation policy (following a pattern set by the Scottish, Welsh and Northern Irish development bodies and administrations). The RDAs' Regional Economic Strategies outline measures designed to increase the level of innovation in their regions, and many are now backing this up with significant investments in science and innovation. Collectively, RDAs invested some £240million in science, engineering and technology-related activities in 2002-03, some 15 per cent of their total budgets. Following the lead of the North West Development Agency and One NorthEast, which established Science and Industry Councils to provide high-level advice from businesses and universities on regional science priorities, by the end of 2004 all RDAs will have established their own models of Science and Industry Councils.

**9.42** The process of knowledge transfer to business and the encouragement of innovation in business requires a combination of national and regional input to ensure that business has ready access to the expertise it requires, and is encouraged to seek it out. Partnership working between regional and national bodies is key to maximising the value and complementarities of strategies and funding at both levels. The RDAs themselves have identified three modes of partnership between national and regional bodies to deliver Government policy in this area:

- regional delivery with national advice and direction, for example, grants for R&D for SMEs; improving the capacity of universities to collaborate productively with business, as recommended by the Lambert Review on business-university links;
- national delivery, but which depends on regional advice and input, for example, in the Higher Education Innovation Fund, where RDAs played a role in assessing submissions for HEIF2, and the roles of HEFCE regional advisors; and
- inter-regional partnership, in which the RDAs work together.

**9.43** The Research Councils, devolved administrations and the RDAs are currently working together to explore how the funding of research on a predominantly national basis can be better aligned with the development and delivery of Regional Economic Strategies. At a strategic level, activities are underway to build on the existing work initiated via the Research Council and RDA Chief Executives. For example, Research Councils worked with the RDAs on the development of research priorities and proposals during the current and previous Spending Reviews. At an institutional level, there is increasing cross membership of the decision-making bodies.

**9.44** There is also extensive interaction at operational level, particularly with regionally-based Research Council Institutes (RCIs), which have a working partnership on a range of regional initiatives, collaborations and facilities. In total, there are some 77 RCIs across the UK, of which 50 are outside London and the South. Some of the several examples of recent collaborations between Research Councils and RDAs include:

- the creation of the North West Science and Innovation Park alongside the Daresbury Laboratory of the Council for the Central Laboratory of the Research Council (CCLRC);
- a £1 million investment by the East of England Development Agency (EEDA) to establish a bioincubator at the Biotechnology and Biological Sciences Research Council's (BBSRC) John Innes Centre;
- a BBSRC collaboration with Yorkshire Forward to promote entrepreneurship training for postgraduate and postdoctoral bioscientists in the region; and
- the establishment of the Centre for Integrated Genomic Medical Research as part of the North-West Science Initiative, with £3 million of Medical Research Council (MRC) funding over three years.

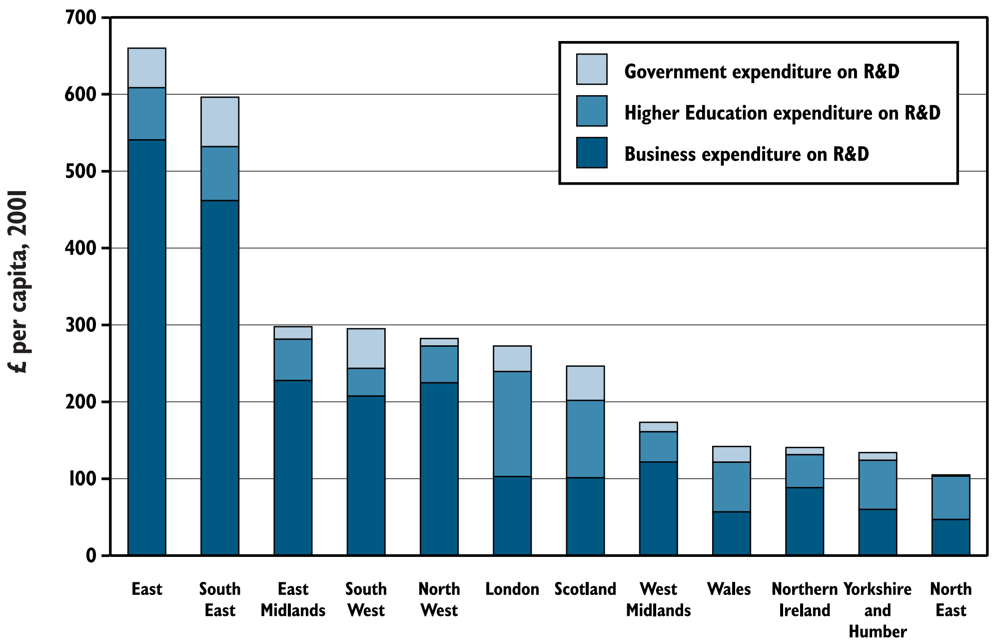
**9.45** To help strengthen further the regional contribution to broader UK-wide science and innovation policy and delivery over the next three years, **the Research Councils will enhance the scale of their support for developing the RDAs' professional capabilities in science and technology issues, including through secondments of experienced staff into the RDAs and through representation on the advisory boards of the newly-established Regional Science and Industry Councils**.

**9.46** The RDAs have expressed strong support for the Government's ambition for the better exploitation of national funding of research into economic advantage. All Regional Economic Strategies highlight the importance of innovation to wealth creation, and make a commitment to raising skill levels and exploiting the science base. The RDAs concur with Government's view that a strong, user-facing and responsive UK science, engineering and technology base working effectively with business is vital to the future well-being of the regions and the UK as a whole.

**9.47** The Government and the RDAs are working towards a practical partnership to ensure that the aim of reducing regional disparities in prosperity is compatible with the pursuit of scientific excellence on a UK-wide basis.

**9.48** Technology-based innovation by business holds out the prospect of contributing significantly to the challenge of narrowing gaps in regional economic performance, by enabling regions to renew their industrial base over time. Indeed, the key challenge for regions in improving the level of R&D expenditure in each region – as with the UK as a whole – lies in raising the level of business R&D expenditure. Differences in R&D expenditure in each region are mainly a result of business investment, as illustrated in Chart 9.2 below. Every region has a number of universities containing truly world-class departments and disciplines. Facilitating collaboration of these world-class departments within and across regions can promote networks of real excellence.

## Chart 9.2: Regional investment in R&D across the UK



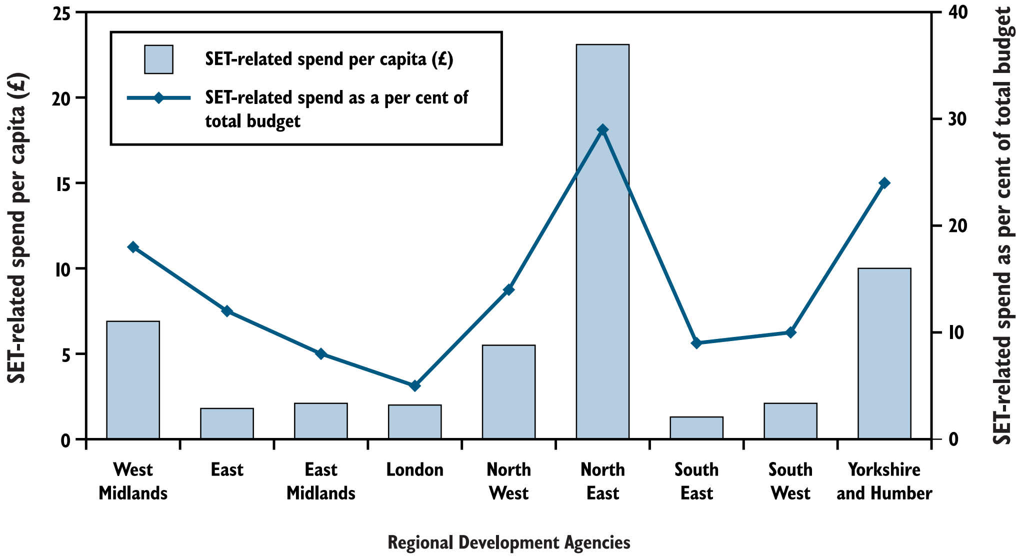

*Source: Office for National Statistics; data for 2001*

**9.49** As Chart 9.3 below illustrates, those regions with low levels of business R&D expenditure are making particularly sizeable investments in SET-related activity. Examples include:

- Advantage West Midlands' investment of £40 million in the International Automotive Research Centre; launched in 2003, the Centre is a £70 million initiative that aims to support 50,000 jobs by helping companies in the automotive sector improve product development through skills training and R&D; and

- One NorthEast's investment of £200 million over five years to develop five sector-based research centres of excellence to capitalise on strengths of the existing research base and current levels of business demand.

**Chart 9.3: Science, engineering and technology related expenditure across the English Regional Development Agencies**




*Source: RDA's submission to House of Lords Science and Technology Committee Report: Science and the RDAs, 2003*

**9.50** Chapter 5 on knowledge transfer sets out the Government's overall approach towards encouraging a stronger business innovation performance through strengthening links with the research base. This sets out, in response to the 2003 Lambert Review on business-university collaboration, the Government's positive response to the proposal that the English RDAs be given a greater remit and more strongly focused targets in order to strengthen productive links between business and the universities within a given region, with consequent implications for the RDAs' resource allocations and performance measurement.

**9.51** In developing their roles in knowledge transfer in support of regional growth, it will be important for the RDAs and DTI to develop a cross-regional, national and international perspective, and prioritise accordingly. Facilitating inter-regional knowledge transfer can help reduce regional disparities: geographical variations in the creation of knowledge will matter less if knowledge can be transferred effectively to firms in other regions. The RDAs have also emphasised the need to encourage and assist regional businesses to engage with the nationally-funded research base, wherever the research is done. There are already some successful examples of schemes that facilitate cross-regional knowledge transfer and collaboration. The DTI, through the Technology Strategy, will work to strengthen the national gains from synthesising capabilities across the country, to create UK-wide collaborative R&D programmes linking business and the science base across the UK.

## Regional distribution of national research funding

**9.52** Public funding of research at a national level, through the Research Councils and funding bodies, is dedicated to supporting excellent research, irrespective of its UK location. The 'excellence principle' is fundamental to safeguarding the international standing and scientific credibility of UK science and research and supporting an excellent, diverse, expanding and dynamic science base, providing value for money for public investment.

**9.53** There is at least one leading university in each region of the UK, and every region has a number of universities containing world-class departments. Regional Development Agencies (RDAs) are increasingly focussing on the role these departments can have as centres of excellence, and the contribution they can make to regional economic growth, not simply through their own direct contribution as employers, but also through their roles in stimulating innovation through links with business and attracting industry and commerce.

**9.54** Given the location of the UK's major research universities (which owes much to history, over centuries in several cases), this principle of funding research by excellence, irrespective of its location, results in geographical disparities in research funding. On the surface, for example, the DTI's Science Budget spend is heavily skewed towards London, the South East and East of England, although when rebalanced for the number of higher education institutions (HEIs) in each region which are eligible to apply for RC grants, the picture is somewhat more evenly balanced across the country.

**9.55** However, looking at regional benefit from the Science Budget shows a much wider distribution of resources than would be suggested simply by examining the regional spend by location of the host institution. For example, some funding goes to collaborative projects, such as collaboration between HEIs in one RDA region and businesses in another. Approximately 40 per cent of all projects funded by the Engineering and Physical Sciences Research Council (EPSRC) are in collaboration with industry and, depending on the English region in question, between 60 per cent and 85 per cent of the collaborative projects are with industries in a region other than the HEI 'host' region. In Scotland, Wales and Northern Ireland, the equivalent figures are between 25 and 60 per cent. Recent research[9] has highlighted the important role that inter-regional knowledge transfer (of which collaboration is one example) can play in reducing regional economic disparities.

**9.56** National funding streams also exist that can help universities improve their capacity to compete on the basis of excellence. The second round of the Science Research Investment Fund (SRIF2), for example, included a capital stream to support strategic rationalisation and restructuring of the university science base. This is currently supporting mergers between UMIST and the University of Manchester, and between Cardiff University and the University of Wales College of Medicine. Furthermore, HEFCE provides strategic funding each year (£217 million in 2003-04) to support HE institutions' priorities in, for example, developing learning and teaching, widening participation, and developing capabilities to respond to the needs of business and the community.

**9.57** Restructuring processes such as the mergers described above can produce a critical mass of research excellence that cannot be achieved by individual institutions using their individual funding allocations, thus enabling the universities in question to make a more significant contribution to economic growth in their regions. The University of Manchester-UMIST merger, for example, is also being supported by a significant investment from the North West Development Agency, reflecting their view that it has the potential to deliver real economic benefits to the region.

**9.58** The Government believes that sharp falls in science teaching capacity may adversely affect student access to provision in particular regions, and may reduce the responsiveness of the overall HE teaching base in meeting future changes in student

[9] Frontier Economics (forthcoming), commissioned to inform evaluation of policies addressed at closing regional economic performance gaps.

demand over the longer-term. As outlined in Chapter 6, HEFCE will therefore take a more active role working with RDAs and other stakeholders to evaluate the implications that falling science provision may have for student access at the regional level, and HEFCE will consider providing additional funding to particular departments if there is a powerful case for doing so.

## Future directions

**9.59** Science and innovation policy is increasingly a priority at regional level, as Government and regional bodies seek to drive up regional economic performance. The RDAs fund a significant and increasing amount of SET-related activity. Their new role in funding business-relevant research, as recommended by the Lambert Review of business-university collaboration and endorsed by the Government, builds on this developing capacity.

**9.60** The Government has successfully fostered business-university collaboration at national and international levels, but agrees with the Lambert Review's analysis that a greater engagement of business could be achieved by building up a regional knowledge transfer agenda to complement the national one. The Government recognises the value that RDAs can add to national decisions on funding and strategies. The Government will work with the RDAs to continue to build their capacity in knowledge transfer and business/HEI interaction, both within and across regions. This will make a direct and important contribution to the delivery of regional economic strategies.

# A THE ECONOMIC CASE FOR INVESTMENT IN SCIENCE AND RESEARCH

## Summary

**A.1** This chapter summarises the economic evidence supporting public investment in the science base. It highlights the need to embed this science core within a broader well-functioning national innovation system, involving the investments and actions of many other public and private sector actors. Finally, it presents evidence on the internationally measured quality and impact of UK science.

## Economic Benefits

**A.2** Modern economies recognise the importance of a strong public science base to support improvements in welfare. The outputs we get from the science base, which include new knowledge, skilled people, new methodologies, and new networks, have contributed to improvements in the things that matter to us, such as our wealth, education, health, environment, and culture. They have also improved decision-making about the governance of these things, including better public policy.

**A.3** It is difficult to quantify the contribution of science to advances in these areas, but a wide range of economic studies over a long period have recorded a range of direct benefits to the economy as a whole and to firms individually. Surveys of the views of R&D managers suggest that academic research has led to innovation accounting for up to 5 per cent of industry sales.[1] [2] [3] Patent data has also been used to identify the importance of public research for innovation.[4] Evidence from Australia, for instance, found that 90 per cent of research papers cited in Australian-invented US patents were publicly-funded. There have been fewer studies of individual industries but those of the pharmaceuticals industry highlight the importance of public investment in science, with one study recording a 30 per cent return.[5] [6]

**A.4** Research confirms that engagement between innovators and the science base creates real welfare benefit. An important recent study by the OECD found that 1 per cent growth in public R&D leads to a 0.17 per cent increase in total factor productivity in the long run.[7] Moreover, this effect increases with the share of public science conducted in universities. Other studies confirm the positive contribution of academic research to economic growth.[8] [9]

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[1] *Academic research and Industrial innovation*, Mansfield, Research Policy, 1991

[2] *Academic research and Industrial innovation: an update of empirical findings*, Mansfield, Research Policy, 1998

[3] *Public research and industrial innovations in Germany,* Beise and Stahl, Research Policy, 1999

[4] *The linkages between US technology and public science*, Narin, Hamilton and Olivastro, Research Policy, 1997

[5] *Publicly Funded Science and the Productivity of the Pharmaceutical industry*, Cockburn and Henderson, NBER Conference on Science and Public Policy, 2000

[6] *The impact of public research on industrial innovation: evidence from the pharmaceutical industry,* Toole, SIEPR Discussion Paper, Stanford CA, 2000

[7] *R&D and Productivity Growth: Panel data analysis of 16 OECD countries,* Guellec and van Pottelsberghe de la Potterie, 2001

[8] *The economic impact of industry funded university R&D*, Bergman, Research Policy, 1990

[9] *The economic impact of Canadian university R&D*, Martin, Research Policy, 1998

## Delivering benefits through open innovation systems

**A.5** Studies show that R&D delivers benefits by allowing an economy to do two things: understand and appreciate the value of others' findings and results; and make new discoveries.[10] [11] Drawing on the concept of the dual roles for R&D, Griffith, Redding and Van Reenen (2000) found that to assimilate R&D information that 'spills over' from other countries, an economy does need to be doing R&D itself.[12] The same logic applies to the membership of networks. If a country, company or university does not have anything to contribute then it is unlikely to be a valued part of the network.

**A.6** The ability to engage and work in partnership with other R&D performers is likely to become increasingly important as commentators suggest that national innovation systems are moving to an 'open model'. The OECD has described this model succinctly: '… innovation systems … become less centred on the individual firm and more based on markets and knowledge networks'.[13] The innovation system is the set of interrelated organisations joined together by the opportunities and incentives that exist to bring something new and better to the market.

**A.7** Companies commercialise their most promising ideas in the pursuit of higher profits or to fend off threats from their competitors. Past investment in the skills of their workforce and R&D put them in the position to seize these opportunities.

**A.8** Companies may not, however, invest sufficiently in R&D, particularly in more long-term research, because the benefit of their efforts may spill over on to other companies. They may also find it difficult to find sources of financing that give them the means to hedge against the risk inherent in these activities. Government can help companies to overcome these difficulties through instruments such as R&D tax credits, the patent system and a number of DTI innovation programmes, which include R&D Grants, Collaborative R&D and Grants for Investigating an Innovative Idea. Chapter 4 explains the Government's approach to supporting business R&D.

**A.9** At earlier stages of the innovation process, companies may work with other organisations that offer them the opportunity to monitor a wider portfolio of research and to gain access to specialist skills. Doing this helps them to innovate more efficiently and to avoid the risk of a narrowly-defined research portfolio. Some emphasise that this is the key part of the 'open model', which innovation systems are moving towards, where working in partnership with other innovators and the science base is important for germinating the most promising ideas. This is different to pure outsourcing of research, which has an earlier tradition, where there is less opportunity for the cross fertilisation of ideas and a narrower range of research avenues – see chart A.1.

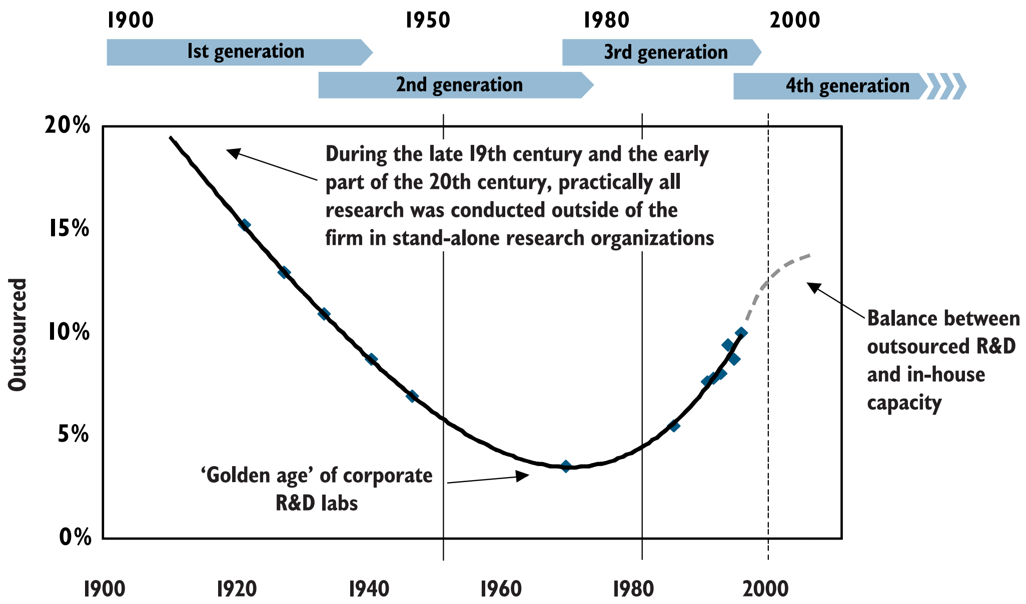
[10] Zucker and Danby (1995) report that "as with the 1973 Cohen - Boyer discovery – then any scientist wishing to make use of the knowledge must first acquire hands on experience". The Cohen-Boyer discovery allowed scientists to isolate genes from any organism and to make large amounts of that gene for analysis, which is essential for genetic engineering, and hence biotechnology. Zucker and Danby (1995) Virtuous Circles of Productivity: Star Bioscientists and the Institutional Transformation of Industry, NBER Working Paper

[11] *Innovation and Learning: the two faces of R&D – implications for the analysis of R&D investment,* Cohen and Levinthal, Economic Journal, 1989

[12] *Mapping the two faces of R&D: productivity growth in a panel of OECD industries*, Centre for Economic Policy Research Discussion Paper, Griffith, Redding and Van Reenen, 2000

[13] OECD (2003) Patents and Innovation: Trends and Policy Challenges

## Chart A.1: An historical perspective on outsourcing R&D




*Source: European Industrial Research Management Association*

(chart A.1)[14]

**A.10** Universities have an important partnership role to play in the innovation system. Gibbons et. al. (1994) have characterised this role as follows:

"…it is no longer like a relay race, in which the baton is passed cleanly and quickly from one runner to the next. Technology transfer looks more like a soccer game in which the university is a member of a team. To score, it [the innovation system] needs the aid of all its team mates. The ball is passed back and forth among the players who may include business people, venture capitalists…".[15]

**A.11** Swann (2002) identified that enterprises are more likely be a part of this "soccer team", and work with the science base, if they:

- are doing R&D, and so have the capacity to value information;
- employ qualified scientists and engineers, who have the capability to understand new information; and
- lack key personnel, that is, they recognise where they need to bring in outside expertise.[16]

**A.12** The science base can gain additional income and insights into applications of their field of research when they work with companies. Government has supported the development of the science base's capacity and capability to engage business through the Higher Education Innovation Fund (HEIF) and the Public Sector Research Establishment (PSRE) Fund. It did this because private sector finance may not have

[14] Based on an presentation by TNO to EIRMA, using source material from: *Research and technology outsourcing and innovation systems: an exploratory analysis Industry and Innovation and Research and Technology Outsourcing Technology Analysis & Strategic Management; and analysis*, Roland Berger Consultants, Howells, 1999

[15] *The New Production of Knowledge*, Gibbons, Limoges, Nowotny, Schwartzman, Scott, and Trow, 1994)

[16] *Innovative Business and the Science and Technology Base: An analysis using CIS 3 data*, A report for DTI, Swann, 2002

been forthcoming as a consequence of the uncertain nature of research and the form of the science base's assets – largely people, who are free to move around employers.

**A.13** As a consequence of increased support, the UK science base has been widening and strengthening its capability to engage users in recent years. This capability includes the management of intellectual property (IP), through formal IP rights and spin-out companies. It includes broadening the skills of staff and students through enterprise training. Complementary assets, such as seed-corn funding, incubator facilities and sources of business advice are also a vital part of this capability.

**A.14** With the capability in place to engage users, there are a number of channels through which knowledge can be exchanged, as identified by recent research[17]. They include: the sale of intellectual property rights and spin-out companies; research under contract with business as well as in collaboration with it; and bespoke services such as advisory and consultancy work, training and hiring out facilities. Universities also exchange knowledge rather than sell it, and this happens through the exchange of people and active participation in networks. Who initiates this engagement does not matter. What is important is that people make use of the information that the science base generates.

**A.15** HEIF, the PSRE Fund and Collaborative R&D Grants, Knowledge Transfer Networks and Knowledge Transfer Partnership schemes provide a package of support for these activities because a number of factors may stop business, the science base, and, ultimately, the UK enjoying the full benefit of them. One set of hampering factors include a difference in the benefit to the individual organisation and to the partners from organising and conducting innovative work. Others include differences in incentives and culture between differing types of partner. Public infrastructure measures such as standards, measurement and the intellectual property rights system help define property rights and the characteristics of information, which are vital for any type of technology transfer.

**A.16** Business and the science base have increasingly worked together for the past 20 years, and, as the Lambert Review highlighted, there is benefit in increasing this further. The Government's approach to knowledge transfer is set out in chapter 5 of this document.

## Relative international performance of the science base

**A.17** For companies seeking to develop technological advantage it is natural that they want to work with the best quality university departments. The most highly cited 1 per cent of scientific papers are nine times as likely to be cited in a patent as a randomly chosen US paper.[18] The UK is well placed to benefit from the trend towards the 'open model' of innovation as companies are able to find excellent research resources in the UK, as an international benchmarking study commissioned by the Office of Science and Technology (OST) shows.[19] The report concluded that the UK research base retained its:

"….strong relative international performance in terms of achievement, productivity and efficiency. We are probably strongest overall in the natural sciences, and on many indicators are second only to the USA. Where the UK has been overtaken by other nations, we still have a more consistent performance across fields than those countries.

[17] *Measuring Third Stream Activities, A report to the Russell Group of Universities* SPRU, 2002

[18] Periodic Newsletter, Vol VIII, No 1, July 2000, CHI Research

[19] *PSA Target Metrics for the UK Research Base*, Evidence Ltd, www.ost.gov.uk/research/psa_target_metrics2.pdf

Our strong international performance has been achieved with lower average investment compared to our competitors and with relatively lower availability of people with research training and skills".

**A.18** Publications are a readily measurable output from the public expenditure on science. The UK's share of world publications (around 8.5 per cent) has long ranked second to the USA but it has declined recently, with the UK being overtaken by Japan. The UK also performs well in terms of PhD awards, another important output of expenditure. The UK's number of PhD awards per head of population is behind the US and Germany, but it is similar to Japan.

**A.19** The quality of the UK's outputs is also high. The UK's 11 per cent share of citations – the generally accepted measure of research excellence – ranks second only to the USA, though Germany is now a close third and increasing its share at a faster rate than the UK. The UK has generally fewer (and a declining share of) lower quality papers than its competitors; it also has the second highest share of the world's most highly cited papers.

**A.20** This quality is mirrored in all of the nine main research fields except mathematics, where the UK is third, and the physical sciences and engineering (fourth in each case). These results are also broadly borne out by the Research Assessment Exercise (RAE), which also grades, by peer review, research of international excellence. The improvement of the quality of research assessed by the RAE has been dramatic. In 1992, 23 per cent of researchers were in a 5 or 5* rated department, rising to 31 per cent in 1996 and 55 per cent in 2001. Nearly two-thirds of all universities now have at least one 5 or 5* department.

**A.21** The UK's excellent research performance compared to its relatively low use of inputs suggests that UK science generates high output per unit of input, and this is the case. Whether based on Gross Expenditure on R&D (GERD), Higher Education R&D spend (HERD), or total public expenditure on R&D, the UK is the best performer in the G7 per unit of R&D spend. The UK also produces relatively more PhDs per unit spend than most of our competitors.

**A.22** A recent study by the Science and Technology Policy Unit (SPRU), also commissioned by the OST, sheds more light on the way that public expenditure on science leads to outputs[20]. The combined impact of UK and other countries' spending on Higher Education R&D means that a 1 per cent increase in each of these sources of funding leads to a 1 per cent increase in publications and a 1.1 per cent increase in citations.

**A.23** These effects do not happen immediately. It takes six years for the full effect to impact on papers and seven years for citations. SPRU also found that public funding of Higher Education R&D neither encourages nor discourages business and other sources of funding for this type of R&D, the latter including charity and foreign funding bodies.

**A.24** SPRU also compared the productivity of a group of OECD countries. The measure they used captures the efficiency with which a country uses all of its resources devoted to R&D to produce publications and citations. Hence, it takes into account differences in the distribution of R&D between higher education and the private sector, the amount of spillover benefits and the effects of past spending on higher education

[20] *The productivity of science: an international analysis*, SPRU, 2004

R&D. SPRU found the US to be the most productive country, followed by the UK. However, other countries are catching up.

## Role for government to support public research

**A.25** Investment in public science supports a successful innovation system by providing knowledge assets, infrastructure and trained people that help organisations, whether public or private, seize opportunities. The private sector generally does not have the incentive to invest in knowledge made publicly available because it could not earn a return. The Government therefore funds this type of research, particularly the more fundamental, long-term research that is unlikely to have immediate application but has the potential for greatest spillover benefit. A recent review of economic, statistical studies tentatively concluded that public R&D is a complement to private R&D.[21] Hence, public sector R&D does not substitute for private sector effort.

**A.26** Skilled people are the lifeblood of any successful innovation system. Companies and individuals often face difficulties financing training that leads to skills that are transferable amongst employers. The Government therefore supports undergraduate and postgraduate training, as well as other types of education and training. Chapter 7 explains what the Government is doing to support the development of higher level skills.

**A.27** In addition to funding, the government also has an important role to play in managing the national research system to deliver effectively and sustainably over the medium term. The key actors in the science base are universities who are charities and are free to make their own decisions about how they use institutional funding. Other important players include the Public Sector Research Establishments (PSREs) which have varying degrees of institutional autonomy. The individual decisions of these organisations may not work to the benefit of the system as a whole, though may well be a response to the incentives they face. The Government response to this system-management challenge is covered in chapter 3 on the management of the science base.

[21] *Is public R&D a complement or substitute for private R&D? A review of econometric evidence.* David, Hall and Toole Research Policy, 2000

# B SETTING TARGETS AND MEASURING PROGRESS

## Summary

**B.1** The Government has set out in this ten-year investment framework a challenging goal for the UK economy which will require concerted public and private effort across a range of actions over a sustained period. To shape future planning across government and business, the Government will set out clear high-level goals for the targeted outcomes from the UK science and innovation system, linked to inputs and intermediate indicators. It will monitor and publish a range of input, output and outcome data on a regular basis. This progress reporting will both inform policy development within the public sector, and provide the basis for a continuing dialogue with business, the science base and other stakeholders about the impact of collective investment in UK science and innovation. Future public spending decisions will be made in the context of demonstrable progress and engagement with private sector stakeholders in business, and the charity sector.

## Attributes of the UK science and innovation system

**B.2** The Government set out, in the consultation paper issued in March 2004 on the investment framework, a series of high-level attributes which it sought to achieve from concerted public and private investment in the UK science base, knowledge transfer and the supply of relevant skills.[1] The consultation revealed strong support from across universities, scientific organisations and business for these attributes, set out below with proposed qualitative goals:

**Box B.1: World class research at the UK's strongest centres of excellence**

The UK's leading research remains among the world's best, and can act both as a magnet for globally mobile corporate and private R&D investments and personnel, and as an inspiration to the next generation of researchers and educators. We must ensure that the institutions which foster the most excellent research can continue to compete at the highest level, and that the benefits of this global leadership can be leveraged across the UK economy.

**Sustainable and financially robust universities and public labs across the UK**

The high quality research and personnel in the UK science base must be maintained. High levels of productivity are to be welcomed, but not where this means that research is subsidised at the expense of under-investment in other areas. Increased funding for Research Councils project costs, and a significant level of dedicated capital funding, as allocated in previous spending reviews, provides a sound underpinning for sustainability. However, action is also needed from other funders, in order to properly recognise the worth of the research they are commissioning from the science base. Universities themselves also need to ensure that their corporate governance and financial management continue to develop to enable effective and sustainable management and delivery of their teaching, research and knowledge transfer. Public Sector Research Establishments and their parent departments similarly need to clarify their long-term approaches to sustaining their research activities and supporting infrastructure.

[1] http://www.hm-treasury.gov.uk/consultations_and_legislation/science_innov/consult_sciinnov_index.cfm

**Box B.1 continued:**

**Greater responsiveness of the research base to the needs of the economy and public services**

Better translation of the wealth of knowledge in the science base into innovation by business and the improvement of public services will bring benefits to the science base, government, business and the economy as a whole. Universities and public laboratories must continue to develop a stronger programme of engagement with users on knowledge exchange, to create conduits for productive flows of ideas and people between research and its practical application. Government funding for the science base must fully recognise applied and business-relevant research as it does basic research. Businesses need to improve their links to and engagement with the science base to access the raw materials needed to improve their innovative potential. Government's own R&D needs to be of high quality, and focused on improvements in public services. Synergies between different funders and the science base should be recognised and the complementarities maximised to improve the impact of research and funding.

**Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent**

Leveraging up the levels of business investment in R&D in the UK is crucial to increasing the innovation performance of the UK economy. More businesses need to engage with the science base, either directly or through intermediary bodies. More businesses need to adopt the practices of the best UK-based companies in creating and sustaining partnerships with a network of research teams, providing a productive means for companies to access the creativity and expertise of the science base. More businesses should become engaged in shaping school and university curricula to inspire and attract the next generation of trained personnel.

**A more responsive supply of science, engineering and technology skills to the economy and greater flexibility within schools and universities to attract the skills they need**

The UK education and training system needs to become far more attuned to the evolving needs of UK-based businesses and public services in shaping the quality and quantity of students produced by schools and universities. To do so effectively, schools, colleges and universities themselves will need to be able to compete effectively with other employers to secure the right quality and quantity of teachers and researchers.

**Confidence across UK society in scientific research and innovative applications**

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 which supports and protects research operating within boundaries set by society through Government. Researchers and policy makers must earn public confidence and trust in science through addressing public priorities and concerns. In this way the scientific community, working with Government and other partners, can ensure that society's understanding and acceptance of scientific advances moves forward, and does not become a brake on social and economic development in the UK.

## Managing the science base to deliver knowledge and innovation

**B.3** The Department of Trade and Industry (DTI) manages a significant proportion of the UK Government's funding for science and innovation, with expenditure on science, engineering and technology is set to total over £3 billion in 2004-05, accounting for 34 per cent of total public sector expenditure on SET, or 48 percent of civil SET.[2] Its aim is to ensure that it manages this expenditure well and helps the UK to improve its innovation performance.

**B.4** Managing science and innovation expenditure is, however, challenging due to the inherent uncertainty about the creative and experimental nature of the work, and the long timescales over which performance becomes evident. To meet this challenge DTI has designed a robust management system around the Public Service Agreement it has agreed with HM Treasury for the present 2004 Spending Review, namely to:

**Box B.2: Science and innovation PSA target**

Improve the relative international performance of the UK research base and increase the overall innovation performance of the UK economy making continued progress to 2008, including through effective knowledge transfer amongst universities, research institutions and business.

**B.5** This is a major task and so DTI has broken it down into a number of smaller, mutually reinforcing ones. This is set within the framework of the UK's National Innovation System, a conceptual model which highlights the rationale for DTI policy interventions, providing the first steps in managing funding – identifying rationale and the objectives for action. The subsequent steps define measures to check progress against objectives and how this information is to be collected and used in a forward-looking manner.

**Box B.3: The UK Innovation System**

DTI's expenditure is designed to improve incentives to innovate and to provide assets that support and enable innovation. It uses programmes that affect all roles needed for a successful innovation system, including:

- the 'innovation dynamo', where in response to market signals and technological opportunities innovators work to commercialise the most promising ideas;
- 'transfer factors', to identify and promote the sharing of promising ideas that innovators are likely to need and to provide cooperation opportunities with partners who share a common understanding and can bring specialist skills to applied problems. National innovation assets form key linking and supporting factors – including the National Measurement System, the standards infrastructure and the Design Council; and
- the 'science and engineering base', which has the assets to solve applied problems and the infrastructure to help the exchange of ideas.

[2] OST/ONS (2003) *The Forward Look, Government Funded Science, Engineering and Technology*

**Box B.3 continued:**

**The Innovation Dynamo**

Companies commercialise their most promising ideas in the pursuit of higher profits or to stave off threats from their competitors. The opportunities they have to do this depend on what they know about the likely success of commercialisation strategies to meet consumers' demand, and how they can overcome any remaining technical challenges. These opportunities will, therefore, depend on the company's past investments in knowledge creation, including R&D, the skills of their staff, and the ability to combine and develop these capabilities in conjunction with external sources of knowledge.

Companies may under-invest in R&D (compared with an economically desirable level) because the benefit of their efforts may spill over on to other companies. They may also have insufficient opportunities to cover risk because capital markets offer limited financial instruments to hedge against the uncertainty inherent in R&D projects. The instruments the Government uses to narrow the difference between the benefits to the economy and to the company of R&D, and to spread risk, include R&D tax credits, the Patent System and a number of DTI programmes to co-fund applied R&D.

At earlier stages of the innovation dynamo a company may need to work with other organisations to help mitigate the risk of having a narrowly defined R&D portfolio. This is also likely to raise the research productivity of the company since it can concentrate on research areas it knows well, integrating the knowledge and expertise of others and keeping abreast of promising results in other fields.

**Transfer factors**

Increasing profitability through learning about the likely success of R&D strategies give companies good reason to work with other companies and the science and engineering base. Working with other players in the National Innovation System requires the capacity to absorb new knowledge and the capability to value and use it. Hence a company's past investment in R&D and training will hold it in good stead to work with others on innovative projects.

Partners, such as the science and engineering base, gain from working with other innovators through the income they earn as well as the knowledge they learn from the other parties. Specialist knowledge, skills and infrastructure give these organisations opportunities to play a full part in the National Innovation System. Past government investment in science and innovation creates a valuable stock of intellectual capital which can be drawn down over decades, enhanced by additional investment, and applied to a series of evolving business challenges which require technology inputs.

To take advantage of these opportunities the science and engineering base needs the capability and the capacity to work with partners, developed with government support. Private sector support for knowledge transfer activities of universities and Public Sector Research Establishments (PSRE) may not have been forthcoming because of the uncertain nature of research, the diffuse nature of the benefits, and the form of these organisations' assets – largely their staff, who are free to move to other employers.

**Box B.3 continued**

There are clear benefits to all from working collaboratively and past investments in R&D, training and infrastructure give these players the opportunity to enjoy these benefits. What may stop companies and the science and engineering base enjoying the full benefits of working together, however, are differences between the benefit they get individually and the benefit for the partnerships as a whole. These differences can stem from the benefits that spill over to other partners (and those outside the project or network) when knowledge is exchanged and from the cost to the individual innovator of organising a network. There may also be other difficulties, such as describing the characteristics of information, necessary to exchange it, and differences in the culture and incentives faced by different players. These problems give the Government reason to take action beyond its funding of the research base.

**The science and engineering base**

The science and engineering base has a clear role to play in the National Innovation System, by acting as a source of knowledge, skills and infrastructure. Innovators may work with it to solve applied problems and to explore potential research strategies.

The two key outputs of the science and engineering base are trained people and freely available research results. Both of these outputs exhibit strong spillover effects across the economy, creating the rationale for financing by government. The final outputs of the research base are academic results, practice-based research in collaboration with users, and a supply into the economy of highly trained people. These depend crucially on a healthy infrastructure and flow through of the supply of young people educated and trained in science, technology, engineering and maths. This flow is in turn dependent on a complex mix of supply factors, regarding the quality and attraction of STEM education, training and research, and demand factors shaping individuals' perceived rewards from undertaking STEM-based learning and professional development.

**B.6** In addition to the DTI's role in leading the management of the UK science base and translation of research into wealth creation, the DfES[3] provide underpinning support through their maintenance and development of the education system. Increasingly, the DfES are working in partnership with DTI and employers to ensure that the supply of skills, educated young people, and lifelong learning for adults meets more closely the evolving needs of the UK economy and society. Science, technology, engineering and maths have a core role in the future health of sustainable higher value-added activity in the UK. As such, the DfES will play a more strategic role in the coming years towards monitoring the quality and quantity of outputs from the education system, at all levels, in STEM subjects, and acting decisively to redress emerging mismatches between supply and demand for skills.

## Setting targets and measuring progress

**B.7** The following section identifies, for each of the broad attributes of the UK science and innovation system, the Government's overall goals for the coming decade and the measures which will be used to track progress and influence policy. These build out from the core set of metrics for the DTI's science and innovation PSA target for the SR2004 period (see box B.2 above), taking a broader view of desirable progress over the ten year framework. Progress towards each of the attributes will be measured annually, against a basket of indicators as set out in this Annex.

[3] And counterparts in Devolved Administrations

## World class research at the UK's strongest centres of excellence

**B.8** The UK already performs at or close to the world's leading edge in quality and impact of research. The challenge over the coming decade will be to maintain this performance as established industrial economies renew their research endeavour and the more successful developing nations move rapidly to compete with the UK for world class science.

**B.9** Delivering world class research and effective university engagement with major businesses increasingly require a cross-disciplinary approach. The market for top talent and multinational investment is becoming ever more globally competitive. These factors point towards the UK needing to ensure, for the achievement of its research and innovation goals, the sustained health and global competitiveness of a small core of leading universities and other centres of excellence which perform a national role in making the UK a partner of choice for mobile investment and talent.

**B.10** At the same time, the Government will continue to promote competition within and across research fields and institutions, to foster excellence wherever found in the UK and maintain competitive pressure for funding as a strong performance stimulus. No leading institution should be without credible competition for funding from the next tier down, and the funding system should enable promotion to and relegation from the top tier over time.

**B.11** Wherever research is conducted, the Government will continue to aim for world class quality, impact and productivity overall and balanced strength across research disciplines. In particular, the Government will focus on improving areas of emerging relative weakness which are of strategic significance for the broader research base, business innovation and public services.

### Table B.1: Indicators of progress: world class excellence

| Indicator | Goal |
|---|---|
| Share of world citations, overall and in each of the broad nine science disciplines | Maintain overall ranking as second to the USA, and current lead against rest of OECD.<br><br>Close gap with leading two nations where current UK performance is third or lower |
| Citations per unit GDP<br><br>Citations per researcher<br><br>Citations per unit of research spend in higher education | Maintain UK lead in impact and research productivity across these indicators |
| Benchmark research strength and impact of top ten UK universities against international peers<br><br>Benchmark research strength and impact of top ten UK public research centres against international peers within the relevant subject area | UK to retain sufficient world class centres of research excellence to continue to attract internationally mobile R&D investment and highly skilled people, to support delivery of overall goal of higher R&D intensity and innovation impact |
| Benchmark research strength and impact of top ten UK universities against second tier of next twenty institutions<br><br>Benchmark research strength and impact of top ten research departments/centres in each broad discipline against second tier of next twenty departments/centres | Ensure that leading UK centres are complemented by a broader network of strong institutions, departments and centres, to create a dynamic and competitive market for research funding and people |

## Sustainable and financially robust universities and public laboratories across the UK

**B.12** The Government is concerned to ensure that the excellent performance of UK science in efficiently delivering high quality and high impact outcomes is underpinned by robust financial management across the research base. The Government will work with universities and research establishments to improve financial sustainability through balancing direct and infrastructure funding, and creating stronger incentives for universities and private and not-for-profit sector funders to work towards the same goal.

### Table B.2: Indicators of progress: financial sustainability

| Indicator | Goal |
|---|---|
| Research costs versus revenues (public and private) across higher education sector | Ensure a financially sustainable level of activity across UK higher education sector by early in 2010 decade, avoiding over-reliance on non-research incomes and under-investment in research infrastructure |
| Share of full economic costs paid by Research Councils for projects conducted in universities | Research Councils to provide close to full economic cost of university projects (taking account of capital funding streams) |
| Research costs versus revenues (public and private) across public sector research establishments | Ensure a financially sustainable level of activity across UK public sector research establishments by early in 2010 decade, avoiding over-reliance on non-research incomes and under-investment in research infrastructure |

## Greater responsiveness of the research base to the needs of the economy and public services

**B.13** The major challenge for the UK science base in the coming decade is to translate investment effectively into economic and public service impact, through stronger synergies with other investment from a range of public and private sources, and increased engagement with business.

### Table B.3: Indicators of progress: responsiveness

| Indicator | Goal |
|---|---|
| Research Councils' engagement with business and public service R&D users in design, co-funding and delivery of R&D programmes | Research Councils' programmes more strongly influenced by and delivered in partnership with end users of research |
| The quantity of patent applications and grants from higher education institutions and public sector research establishments, relative to total research activity | Overall improvement in performance against these metrics, towards world-leading benchmarks |
| The quantity and value of HEI and PSRE intellectual property licences, relative to total research activity | |
| HEI and PSRE income from business for contract research, relative to total research activity | |
| Research publications jointly authored between science base and industry, relative to total research activity | |
| Quantity and economic value of spin-outs companies from HEIs and PSREs, relative to total research activity | |
| Level of business confidence in university knowledge transfer activities | Continued improvement |

## Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent

**B.14** Delivering the Government's overall ambition for wealth creation and productivity growth from innovation will require sustained business investment and engagement in UK science, to translate research ideas and deploy trained personnel effectively. The Government will support the translation of R&D into commercial innovation through a range of framework conditions and specific measures, and will track progress on innovation performance against a range of outcome indicators. Regional Development Agencies (RDAs) will also develop their own indicators to measure business-university collaboration as part of their tasking framework.

**Table B.4: Indicators of progress: business investment and engagement**

| Indicator | Goal |
|---|---|
| Business investment in R&D as a share of GDP | Increase from 1¼ per cent towards goal of 1.7 per cent over the decade |
| Business R&D intensity by sector<br><br>Investment in innovation-directed activities, including R&D, as a percentage of business turnover | Narrow the gap in performance between the UK and leading international competitors in each sector, reflecting the size distribution of companies in the UK |
| Proportion of businesses that collaborate with HEIs and PSREs | Increase to reach leading position in Europe and close gap with the US |
| Patents granted per capita | Narrow the gap in performance between the UK and leading international competitors in each sector |
| Business innovation performance, as measured by basket of indicators (share of firms which had introduced new product, service or process improvement; average turnover in firms accounted for by new or significantly improved products and services; share of firms which are 'innovation active' | Narrow the gap in performance between the UK and leading international competitors in each sector |

## A more responsive supply of science, technology, engineering and mathematics skills to the economy

**B.15** The Government will actively monitor and target improvement in the supply of science, technology and engineering (SET) skills across the education and training system. It will relate evidence on supply trends with that on evolving patterns of demand for SET skills, and use the monitoring data to inform policy development over the coming decade. Its overall aim is to ensure a stronger and higher quality supply at every stage of the transition from school into the workforce.

### Table B.5: Indicators of progress: skills

| Indicator | Goal |
|---|---|
| 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 targets 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 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 in the post 16 sector | To reduce shortages |
| Graduates in SET subjects | To increase the numbers qualifying |
| PhDs per head of population | To maintain international rank and remain above the average for the G8 countries over ten years |
| Quality of researchers | To increase the UK ranking of citation share in nine research fields to top three in G8 in 7-9 super units of assessment by 2006 |
| Proportion of minority ethnic and women participants 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 |

## Public engagement and confidence in science and research

**B.16** 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. 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, set out in the table below.

### Table B.6: Indicators of progress: public engagement

| Indicator | Goal |
|---|---|
| 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 improvement |
| Acknowledgement and responsiveness to public concerns by policy-makers and scientists | |
| Trends in media coverage of science and technology issues | |

## Conclusion

**B.17** The Government will publish an annual stocktake on progress against the attributes of the science and innovation system as set out in the framework, reaching a judgement on progress informed by a range of indicators. It will conduct every two years, to inform periodic reviews of public spending, a detailed assessment of the progress towards the goals for each attribute. In drawing up this assessment, it will consult widely across Government, and with other stakeholders including the Funders Forum, to reach a balanced judgement about the UK-wide progress on science and innovation, and the implications for future policy.

# C THE GOVERNMENT'S RESPONSE TO THE LAMBERT REVIEW

**C.1** The Lambert Review of Business-University Collaboration was commissioned by the Chancellor in the 2002 Pre-Budget report, with a remit to examine whether the links between universities and businesses in the UK could be improved. The Review was led by Richard Lambert, member of the Bank of England's Monetary Policy Committee and former editor of the Financial Times. The final report was published in December 2003.[1] This Annex sets out the Government's response to the recommendations of the Review.

## Recommendation 2.1

**C.2** UK business should establish a high-level forum to enhance the effectiveness of technical innovation in the UK.

**C.3** Chief Executives of R&D-intensive businesses in the UK should agree its remit: it should be business-led and focused on the key issues for retaining and expanding high value-added business in the UK.

**C.4** **The Government agrees with the Lambert Review's finding that more needs to be done to stimulate demand from business for research and development (R&D) activities. The Government also agrees that business leaders of research-intensive companies are the people best placed to tackle this challenge. The Government therefore welcomes the establishment of a business-led group of top R&D-intensive companies under the chairmanship of Sir Tom McKillop of AstraZeneca. The group held its first meeting in May 2004, to explore how leading businesses can work more effectively with Government to improve the UK's R&D and business innovation performance.**

## Recommendation 2.2

**C.5** The Government should seek ways of directing a higher proportion of its support for business R&D towards SMEs.

**C.6** **In the DTI Innovation Report[2] the Government noted that, "While the public sector purchases significant amounts of R&D, it has proved difficult for small and medium-sized enterprises (SMEs) to get access to research funding". A major cause of this is the high concentration of government R&D directed towards defence, an industry dominated by large companies. However, the Government recognises that more can be done to direct government R&D towards the SME community. The Small Business Research Initiative (SBRI) was established in 2001 to increase the success of smaller businesses in obtaining contracts from government bodies to conduct research and development. Those government departments involved have a target of purchasing 2.5 per cent of their R&D from SMEs this year. The Innovation Report set out a number of initiatives to improve the effectiveness of the SBRI by strengthening the DTI's role in coordinating and monitoring the programme, extending the collection of SBRI data across departments, publishing the results on an annual basis, and looking to broaden the scope of SBRI to encompass a wider range of R&D**

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[1] *Lambert Review of business-university collaboration: final report,* December 2003

[2] *DTI Innovation Report: Competing in the global economy: the innovation challenge* December 2003

**opportunities from, for example, Regional Development Agencies (RDAs) and local authorities. The DTI is taking forward these actions.**

## Recommendation 2.3

**C.7** The Review recommends an enhanced role for the development agencies in facilitating business-university links. A priority should be to identify non-collaborating SMEs that have the potential to gain significant benefits from working with universities.

**C.8** **The Government agrees that RDAs have a very important role to play in helping promote demand from business for research activities and in facilitating business-university links. The Government has set out proposals to give the RDAs new responsibilities for promoting innovation in their regions. (See Recommendations 6.2 and 6.3 for details.)**

## Recommendation 2.4

**C.9** The Government should continue to support Knowledge Transfer Partnerships (formerly TCS) but the programme should be better marketed to business. Increasing the regional focus of the scheme would allow it to be tailored more closely to the needs of local businesses.

**C.10** **Knowledge Transfer Partnerships (KTPs) are a key element in the DTI's suite of new business support products and it is a strategic priority to raise awareness of their full potential to businesses and the knowledge base. KTPs, by their "local partnerships" nature, have a strong "regional" element built in to them and have been particularly successful in the devolved administrations. The RDAs in England are now being encouraged to use some of their resource to support projects tailored to the needs and capabilities of regional business clusters and knowledge-base partners.**

## Recommendation 2.5

**C.11** The Government should market the R&D tax credits better in order to increase their take-up by business.

**C.12** **The R&D tax credits have been taken up by business as a valuable source of co-funding for R&D in the UK. Over 10,000 tax credit claims were received from SMEs up to 6 May 2004, with £570 million of support provided since the inception of the credit. For the year 2002-03, 95 per cent of eligible SMEs made a claim. Early indications show significant interest in the credit by larger companies. DTI will be working with HM Treasury and Inland Revenue to further promote the R&D tax credits to business in 2004, building on the enhancements to the tax credits and simplification of the R&D definition introduced in Budget 2004. During 2004, the Inland Revenue will be producing and disseminating more comprehensive guidance material to help companies, their advisers and tax inspectors to understand and claim the R&D tax credit.**

## Recommendation 3.1

**C.13** Universities UK (UUK) and the Standing Conference of Principals (SCOP) should establish a list of academics with relevant qualifications who are interested in becoming non-executive directors on company boards, and should arrange training for them in this role.

**C.14 The Government supports the view that more companies need to have research and development issues represented at the board level and that appropriately qualified and skilled academics, sitting as non-executive directors, would be one way to achieve this goal. The Government therefore welcomes UUK's decision to proceed with this recommendation and to develop a database of academics interested in becoming non-executive directors.**

## Recommendation 3.2

**C.15** The Department for Education and Skills should exempt business people from the requirement to undertake training to lecture in universities.

**C.16 Higher education is enriched by other professional groups who contribute their expertise and knowledge of practice and the business world to teaching and learning as visiting lecturers and professors. As well as supporting teaching, these interactions between business people and the sector can provide a valuable source of future business-university collaboration activity and, as such, should be encouraged by Higher Education Institutions (HEIs) wherever possible.**

**C.17 The Higher Education Funding Council for England (HEFCE), UUK and SCOP are working together to develop a national professional standards framework for teaching. HEFCE is also providing funding for institutions to enable them to expand training, continuing professional development and career development provision to prepare for the agreed professional training standards, linked to accredited qualifications for all new staff, from 2006.**

**C.18 Within this framework, individual HEIs will be expected to define the precise training arrangements for business people engaged in part-time or visiting lecturing. The Government supports the Lambert Review's recommendation that such arrangements should be applied proportionately, ensuring that they do not impose unnecessary demands on professional people and that they encourage more professional people to contribute to teaching and learning in universities. The HE Academy will be asked to build into their evaluation of the implementation of the new standards a specific focus on their impact on the participation of business people in teaching.**

## Recommendation 3.3

**C.19** Universities, departments and faculties should develop their alumni networks in order to build closer relationships with their graduates working in the business community.

**C.20 The Government supports this recommendation. Departments that regularly interact with their alumni are able to develop more leads for possible business-university collaborations. Not only can alumni bring and effectively articulate business demand to departments and the institution as a whole, but more developed alumni interaction would also bring wider benefits to the alumnus and the HEI concerned. The Higher Education Endowment Task Force has reviewed the importance of alumni relations as a cornerstone to effective fundraising and the Government supports the view that alumni interactions at all levels of the university should be aggressively encouraged.**

## Recommendation 3.4

**C.21** Where they do not exist, clear codes of conduct to avoid conflicts of interest in carrying out research with business should be developed by universities.

**C.22 As HEIs engage in more commercial activity, so the complexity of their relationships with both internal and external stakeholders increases, and the potential for conflicts of interest emerges. The Government agrees that HEIs should develop and publish policies and codes of conduct governing the work they undertake with business, and supports the Committee of University Chairmen's plan to include guidance on conflicts of interest codes in its revised *Guide To Members of Governing Councils*, due to be published in autumn 2004.**

## Recommendation 3.5

**C.23** The Association for University Research and Industry Links (AURIL), the Confederation of British Industry (CBI) and the Small Business Service (SBS) should produce a small set of model research collaboration contracts, for voluntary use by industry and universities.

- Develop a range of model agreements, setting out various approaches to IP ownership, management and exploitation rights including, but not limited to, ownership of the IP by the university with non-exclusive licensing or exclusive licensing to industry.
- Agree model contracts by the main representative bodies, distributed to universities through AURIL and UUK and to industry through CBI and SBS.

**C.24 The Government welcomes 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 (see recommendation 4.1). 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.**

## Recommendation 3.6

**C.25** The Government should continue to invest in a permanent and substantial third stream of funding, while simultaneously monitoring and evaluating the outputs from its investment.

**C.26** Third stream funding should be increased to around £150m per annum in England in the future, in order to increase the flow of knowledge and ideas from the science base into business and the wider community.

**C.27 The Government is committed to build the Higher Education Innovation Fund (HEIF) as a dedicated third stream of funding for universities in England to further build capacity in the university sector for knowledge transfer. To reflect this, Spending Review 2004 allocates funding to increase HEIF to £110 million a year by 2007-08.**

## Recommendation 3.7

**C.28** Third stream funding should be allocated for three years on the basis of universities' business plans for their third stream activities. Universities that meet their third stream benchmarks in year one would automatically receive their second and third year allocations.

**C.29** Simultaneously, work should be undertaken by Funding Councils to develop a basket of metrics that might in the future provide the basis for a predictable way of allocating funds on a formulaic basis.

**C.30** In summary, if knowledge transfer is to achieve its full potential in the UK, the Review recommends that third stream funding should be substantial, permanent and allocated in a way that enables universities to make long-term plans for these activities.

**C.31** **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 the DfES will work with the universities, PSREs, and business to create a long-term career path for academics and knowledge transfer professionals who wish to focus on interacting with business and external partners.**

**C.32** **With these aims in mind, the Government will move towards a predictable funding allocation on the basis of research, commercialisation and other knowledge transfer metrics. This new allocations process will be introduced for a substantial part of HEIF in 2006-7. OST and HEFCE will take this forward working with stakeholders through a series of formal and informal consultations. As part of this work, a robust basket of measures will be developed, building on the Higher Education Business and Community Interaction Survey, that focus 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 also reflect 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.**

## Recommendation 4.1

**C.33** The Funding Councils and Research Councils, in consultation with universities, the CBI and other industry groups, should agree a protocol for the ownership of IP in research collaborations.

**See recommendation 3.5**

## Recommendation 4.2

**C.34** The Government should use third stream funding to support regional shared services in technology transfer.

**C.35** **The Government agrees that universities with greater experience of technology transfer should help other universities move forward and develop their own capacity. It is also recognised that sometimes shared services in technology transfer can be**

**beneficial, in order to achieve a minimum efficient scale, particularly where specialist technical skills are needed. The Government therefore welcomes the increased amount of collaboration between institutions demonstrated in the bids for the second round of the Higher Education Innovation Fund (HEIF2). HEIF2 funding will include support for more than 40 collaborative projects involving around 100 institutions.**

## Recommendation 4.3

**C.36** The Government should increase the level of funding for technology transfer and knowledge transfer training to stimulate the development of new training courses.

**C.37 The Government agrees that there is a need to stimulate increased levels of training for knowledge transfer practitioners and has already invested £1 million to support training for knowledge transfer practitioners which will be delivered by a consortium of AURIL, Praxis (the UK university technology transfer training programme) and the University Companies Association (UNICO). Training is also a fundable activity under both HEIF and the PSRE Fund.**

## Recommendation 4.4

**C.38** As third stream funding increases, university technology transfer offices should actively seek to attract individuals with industry background and experience.

**C.39 The Government agrees that developing industry experience among technology transfer offices is important and therefore welcomes the commitment by AURIL and UNICO, to take forward this recommendation. It is also essential that new staff are brought in and trained to professional standards, which will allow them to move between industry and academia with ease. This is the rationale for the co-ordinated £1 million knowledge transfer training programme supported by the DTI and initiated earlier this year by AURIL, UNICO and Praxis. AURIL will develop a Continuing Professional Development programme and an Institute for Knowledge Transfer; UNICO will produce a series of printed and electronic guides for technology transfer professionals; and Praxis will increase the number and range of its short courses and develop an online information resource.**

## Recommendation 4.5

**C.40** UK organisations representing technology transfer should look to the US Association of University Technology Managers to see what lessons can be learnt in terms of providing quality training, increasing industry involvement and sharing best practice.

**C.41 One important means of strengthening the quality and capacity of technology transfer offices is by providing universities with opportunities to increase their skills and experience. Involvement of business is important to improve understanding of the needs of business (and vice versa) and to build productive networks. The Praxis courses were designed for the UK after studying the AUTM courses in the US and taking account of the different regulatory, legal and funding frameworks, as well as the different cultural attitudes to risk.**

**C.42 Recognising the need for more formal support for technology transfer staff, AURIL have developed a continuing professional development programme, which alongside complementary provision from Praxis, is funded by the DTI. AURIL–CPD provides flexible opportunities to gain accredited qualifications. It is designed to**

**benefit individuals and organisations, employers and clients. It forms the first step in the establishment of the proposed Institute of Knowledge Transfer. The Government welcomes the commitment of AURIL, Praxis and UNICO to taking forward this recommendation.**

## Recommendation 4.6

**C.43** Government should set clear guidelines for third stream funding to rebalance commercialisation activities towards licensing. In particular, it should:

1. increase the availability of proof of concept funding; and
2. reduce the availability of seed funding, and use public seed funds to draw in private finance wherever possible.

**C.44 The Government agrees with the Lambert Review that commercialisation activities need to be balanced and that quality of spin-outs may be more important than quantity. The measurement framework for the DTI's science and innovation Public Service Agreement, set out in Annex B, places spin-outs as one of a broader set of options for commercialisation of university research. The bids for HEIF2 funding reflected strong demand for proof-of-concept funding. For example Cambridge, Imperial College, Oxford, and University College London have been awarded funding to establish 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.**

## Recommendation 5.1

**C.45** Regional Development Agencies should have targets that promote business-university collaboration.

- Their core outcome target for innovation should reflect the long time lag between R&D and economic impact.
- All RDAs should set a specific milestone for building business-university links.

**C.46 DTI's science and innovation Public Service Agreement is to, "improve the relative international performance of the UK research base and increase the overall innovation performance of the UK economy, making continued progress to 2008, including through effective knowledge transfer amongst universities, research institutions and business". The Regional Development Agencies in England recognise the important role that they can play in promoting knowledge transfer and business-university interaction within their regions. The RDAs have welcomed the opportunity to expand this role and agree that it should be reflected in their tasking framework, to be finalised in autumn 2004. The RDAs have agreed that they will deliver specific outputs in relation to business-university collaboration and this will be reflected in their Regional Economic Strategies. All of the outputs to be delivered by each RDA will be set out in their Corporate Plans, early in 2005.**

## Recommendation 5.2

**C.47** The Government should change Regional Selective Assistance so that it can support more knowledge-intensive clusters and businesses, and be used to help build a region's infrastructure for collaborative R&D projects with universities.

**C.48 The DTI's new business support product, Selective Finance for Investment in England, which replaced Regional Selective Assistance in April 2004, is aimed at attracting high productivity and high skills investments to the Assisted Areas in England. The new product will help to deliver the RDA Regional Economic Strategies, including facilitating the development of clusters. More generally, high quality, innovative projects which meet the criteria will rank highly for support.**

## Recommendation 6.1

**C.49** The Government should now take stock of the proposals in the review of research assessment and in the review of the sustainability of university research. It should consider the conclusions of these two reviews together when deciding on the future direction of research funding and policy in the UK.

**C.50 The ten-year investment framework for science and innovation takes stock of reforms to both sides of the Dual Support system. In particular, the Government welcomes the Funding Councils' commitment that:**

- **the next Research Assessment Exercise will be designed to recognise excellence in applied research, in new disciplines and in fields crossing traditional discipline boundaries; and**
- **membership of panels and sub-panels will include people with experience of commissioning and using research, including industry and commerce.**

## Recommendation 6.2

**C.51** The Government should create a significant new stream of business-relevant research funding, which would be available to support university departments that can demonstrate strong support from business.

**C.52** Demand for the funding from business would need to be assessed but funding in the region of £100m-£200m could be an appropriate starting point.

## Recommendation 6.3

**C.53** There are a number of possible ways to allocate the new business-relevant research funding stream including an expansion in the scope of Higher Education Innovation Fund, an expansion of existing schemes such as LINK, or allocation through the Regional Development Agencies and their equivalent bodies in Scotland, Wales and Northern Ireland.

**C.54** The Review's preferred approach is to allocate the new funding stream to the RDAs through their single pot allocation, and to provide them with targets on promoting business-university collaboration.

**C.55 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 SMEs. RDAs will also have a strong role to play in facilitating cross-regional activity – a responsibility shared with the higher education sector. Universities are already one of the drivers of regional economic development and this role can be developed further. RDAs, as part of their strategies for improving regional economic performance and reducing regional disparities, recognise the importance of innovation and R&D to their long-term competitiveness. Many RDAs are already making a significant investment in science and innovation and are taking an active role in making links between business and universities, for example through Science and Industry Councils.**

**C.56** **The Government wishes to enhance the role of the Regional Development Agencies in England in supporting business-university collaboration. As indicated in the second report on the review of devolving decision making,[3] the Government is working to ensure that the tasking framework for RDAs is more closely aligned to the priorities identified in their Regional Economic Strategies as well as the Government's high-level PSA targets. The new approach will come into effect from April 2005, with the outputs to be delivered by each RDA set out in their Corporate Plans. As part of this framework, the Government will task the Regional Development Agencies to help a broader spectrum of businesses develop more productive links with the university base in each region, including through support for business-focused research. This will complement national third-stream funding, which builds up HEI capacity for knowledge transfer and interaction with business.**

**C.57** **The Government is investing substantial amounts of funding to build up capacity in universities and Public Sector Research Establishments to interact with business. The Government is also investing in new science infrastructure (see Chapter 3 for details). The RDAs are exceptionally well placed to stimulate demand in the business community for this new enhanced capability in the science base. We have already seen early examples of success in this area. For example, Yorkshire Forward has created six centres of industrial collaboration that act as intermediaries between the science base and businesses in the region.[4] The effectiveness of business-university interaction can be further enhanced by the deployment of regional technology advisors to build networks within and between regions, signposting business to the best sources of advice wherever they are located. The Government will work with the RDAs to further develop their capabilities in this area.**

**C.58** **The Regional Development Agencies recognise the important role that they can play in promoting knowledge transfer and business-university interaction within their regions. The RDAs welcome the opportunity to expand this role and are responding to Lambert in different ways – see the example of the three RDAs in the North of England below. The first steps towards this will be assessed in their tasking framework, to be finalised in autumn 2004. The RDAs have agreed that business-university collaboration will be one of the measures of RDA performance and the importance of knowledge transfer and encouraging business-university collaboration will be reflected in their regional economic strategies. RDAs output targets are due to be finalised in the autumn and will include measures of business-university activities.**

[3] Devolving decision making: 2 – Meeting the regional economic challenge: Increasing regional and local flexibility, HMT/ODPM/DTI, March 2004

[4] Details at http://www.yorkshire-forward.com/view.asp?id=2147&pw

**C.59 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 of which are 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.**

**C.60 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 them to fund.**

**C.61 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.**

## Recommendation 6.4

**C.62** The Russell Group of universities should encourage the development of a league table of the world's best research-intensive universities. This could well be produced by the private sector: the Sutton Trust is one group which is already considering the possibility.

**C.63 The UK needs a significant number of research-based institutions that are able to compete with the best in the world and the Government supports the recommendation that a league table of world class universities is necessary to measure performance against this objective. The Financial Times and the Sutton Trust are actively investigating ways of developing a league table of the world's best universities which will assess their performance in a number of fields. Meanwhile, the Government supports the recommendation and encourages the Russell Group to actively benchmark university performance internationally.**

## Recommendation 7.1

**C.64** The Review recommends that the Committee of University Chairmen, in consultation with the sector and Government, develops a concise code of governance, representing best practice across the sector. The draft (Appendix II of the Lambert Review), should be seen as the starting point for drawing up the code.

**C.65** While the code should remain voluntary, all institutions should disclose in their annual report when their governance arrangements do not conform to the code, and explain why their particular governance arrangements are more effective.

**C.66 The Government welcomes the work the Committee of University Chairmen is undertaking to revise its guidance on good governance and to develop a code to be published in autumn 2004.**

**C.67 The Government fully supports a code that challenges the sector to meet best practice. The Government also recognises, however, that good practice exists in structures or processes outside that of the proposed code. The code should not become a national prescription. Where an institution's practices are not consistent with particular provisions of the code, an explanatory note should be published in the corporate governance section of the audited financial statements.**

**C.68 The Government would recommend that the code be revised regularly by the sector to ensure it remains at the forefront of best practice.**

## Recommendation 7.2

**C.69** Each governing body should systematically review its effectiveness in carrying out its obligations to all stakeholders every two or three years.

**C.70** These reviews should take into account the stated objectives of the governing body, the performance of the institution against key performance indicators, evaluations of senior management and the results of effectiveness reviews of senate and committees.

**C.71** To ensure transparency, the methodology and results should be published in the university's annual report and on the internet.

**C.72 The Government recognises that the sector has made significant and positive steps since the first wave of effectiveness reviews were conducted following the Dearing report and is encouraged that the CUC intends to recommend to members a more regular and thorough approach to effectiveness reviews when it publishes its new Guide to Members and its Code of Governance in autumn 2004. The Government fully supports the view that more regular reviews are essential and that these reviews should focus on the performance of the governing body in carrying out its duties.**

## Recommendation 7.3

**C.73** The Review supports the Leadership Foundation as an initiative to address the sector's need for high-quality leadership and senior management.

- The Foundation should focus its efforts as much on future vice-chancellors as current ones.
- Development programmes and training should be implemented with third parties rather than created and supplied internally.
- The Foundation should develop programmes to support council chairs in their increasingly challenging roles.

**C.74 The Leadership Foundation was launched in spring 2004 by the Chancellor of the Exchequer. The Chief Executive and Chair for the Foundation have been appointed. The 12 Board members for the Foundation include representatives from**

**the HE representative bodies. In its first strategy paper, the Board outlined how, among other objectives, it will carry out these recommendations.**

## Recommendation 7.4

**C.75** The Review recommends that the Government and all funders should minimise the use of hypothecated funding streams.

- Funders should continue to consolidate individual funding into larger streams, more proportionate to the necessary level of bureaucracy and regulation.
- Smaller hypothecated funding streams should, where possible, be allocated on a metrics or formulaic basis, rather than by bidding.
- Funders should minimise audit requirements on hypothecated funding streams.
- "Top sliced" funding streams should have a limited life of no more than three years, after which they should be rolled back into core funding, unless policy is explicitly renewed.

**C.76** **Hypothecated funding can provide a very powerful stimulus to the sector and achieve positive outcomes, but the Government acknowledges the burden that can arise from too many streams existing at one time. The DTI has in recent years rationalised its support for knowledge transfer from university research from three schemes to one, and has also reduced the range of business support products which foster business R&D and networking with the UK research base. DfES and HEFCE have recently reduced the total amount of money diverted to hypothecated funding streams from the core grant from £303 million in 2003-04 to £269 million in 2005-06. As part of this process, the HEROBAC scheme was absorbed in the first round of the HEIF, which subsequently evolved into HEIF2. Within HEIF2, previous separate funding for the University Challenge Fund and Science Enterprise Centres has been combined to provide a single stream of funding, and earmarked human resources funds are being consolidated as part of the mainstream teaching grant. In addition, commitments from the 2003 HE White Paper relating to new schemes such as Promising Researcher Fellowships and additional capital have been mainstreamed.**

**C.77** **HEFCE is also to undertake in 2004 an audit of all hypothecated funding streams to identify ways to reduce this figure still further. Where these streams continue to exist, HEFCE is committed to reducing the associated burden on institutions, for example by adopting two-stage bidding processes or moving to formulaic allocations.**

## Recommendation 7.5

**C.78** The Review recommends that funders and agencies should apply a significantly lighter-touch regulatory and accountability regime to well-run universities.

**C.79** One agency should be responsible for risk assessments on behalf of all funders and regulators. In time, assessments should be published. Risk should be assessed on:

- adherence to the sector's code of governance;

- quality of Management;
- financial soundness; and
- institutional performance measured against key performance indicators set by the governing body, as well as other broad policy goals (as set by Government).

**C.80** In the longer term, well-run universities should receive greater financial freedoms, such as the freedom to move funding across budget lines and longer, multi-year funding cycles.

**C.81** **The Government accepts that advances made by the sector on issues of governance, management and leadership should be matched by a corresponding step-change in the approach taken to regulate the sector and hold it to account. An accountability regime predicated on the principle of risk would significantly lighten the burden of accountability for the vast majority of institutions.**

**C.82** **HEFCE is already demonstrating a commitment to risk-based approaches both through the implementation of the QAA's new quality assurance arrangements and with their proposals for revising the Audit Code of Practice. Work is also being undertaken by HEFCE to extend risk-based approaches to earmarked capital allocations and to Rewarding and Developing Staff.**

**C.83** **Work is continuing to reduce the overall accountability burden on the sector, including the recent formation of the HE Gatekeeper Body to replace and build on the work of the Better Regulation Review Group. Any new approach to accountability, therefore, should also deal with the recurring problems of stakeholder coordination and duplication.**

**C.84** **The Government recognises that the accountability regime should better reflect the low level of risks in well run universities and has received input from Universities UK, among others, on how best to proceed with this recommendation. The Government will continue to work with the sector in defining a new way forward and will report on progress at the end of 2004.**

## Recommendation 7.6

**C.85** In three years time, the vice-chancellors of Oxford and Cambridge should take stock of the progress of reform, and agree with the Government what further steps will be necessary for the two universities to sustain their global position.

**C.86** **The Government supports the view that Oxford and Cambridge, each with a new Vice-Chancellor, should be allowed time to implement reforms. The Government will revisit the situation in three years.**

## Recommendation 8.1

**C.87** Funding Councils should require universities to publish information in their prospectuses on graduate and postgraduate employability for each department (or faculty, if datasets are too small) by 2006.

**C.88** This information should include:

- employability statistics and first destination data – to allow students to see whether particular courses are likely to be useful for specific careers;

- starting salary data – to give students an indication of the value that employers place on graduates from particular courses; and
- other information relevant to specific disciplines.

**C.89 The Government welcomes the development of the new Teaching Quality Information (TQI) website 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.**

**C.90 The Government welcomes the recommendation of the Lambert Review and 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 website and HEIs publishing it in their prospectuses, and will report by the end of 2004.**

## Recommendation 8.2

**C.91** The Government should ensure that Sector Skills Councils have real influence over university courses and curricula. Otherwise, they will fail to have an impact on addressing employers' needs for undergraduates and postgraduates.

**C.92 The Government welcomes this recommendation to bring universities and business closer together to contribute towards improved employability. Over the past six months, Sector Skills Councils (SSCs) and the Sector Skills Development Agency (SSDA) have taken considerable steps with the sector towards greater interaction and debate. The Government warmly welcomes the forthcoming publication of the Concordat between SSDA, UUK, HEFCE, HE Academy, AoC and SCOP which aims to address further the concerns regarding HE courses and curricula failing to meet the needs of business. The Government will support the concordat and continue to develop close working relationships with its partners to further this agenda.**

**C.93 Evidence from recent initiatives between individual Sector Skills Councils and HEIs suggests that there are many models for improving the relationships between SSCs and the sector. The Government will, in summer 2005, review the impact of these and other initiatives on university courses and curricula, and will consider a further response to this recommendation should certain models of interaction prove particularly effective.**

## Recommendation 8.3

**C.94** The Higher Education Funding Council for England should ensure that its forthcoming review of the teaching funding method for universities:

- takes account of the views of employer-led bodies and representatives from the public and voluntary sector rather than funding courses solely on the basis of historic cost; and
- considers whether the UK university system is producing the right balance of graduates in the disciplines that the economy needs.

**C.95** The other Funding Councils should also consider these issues.

**C.96** **The Funding Council 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. The Funding Council 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 (such as through student bursary support) in certain subjects that they deem crucial to the development of their region.**

**The Funding Council 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 Funding Council 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.**

# D CONSULTATION

## Summary

**D.1** In drawing up this ten-year framework, the Government consulted widely with key stakeholders – including the scientific community, businesses, charities and regional bodies – and has received invaluable contributions from a wide range of individuals and organisations.

## Consultation responses

**D.2** The Government published a consultation document *science and innovation: working towards a ten-year investment framework*[1] as part of Budget 2004. Around 200 consultation responses were received from organisations and individuals. Responses can be requested from scienceframework@hm-treasury.gov.uk.

**D.3** The following organisations submitted responses and consented to their publication. Names of individual respondents are available on request.

1994 Group

ABB
Association of the British Pharmaceutical Industry
Academy of Medical Sciences
Applied Industrial Research Trading Organisations
Architects & Engineers for Social Responsibility
Arthur D Little
Association for Science Education
Association of Clinical Biochemists
Association of Medical Research Charities
Aston University
Athena Project
Association for University Research & Industry Links
Avon Longitudinal Study Parents and Children, Institute of Child Health

BAE Systems
Belfast e-Science Centre, Queen's University Belfast
BioIndustry Association
Biosciences Federation
British Nuclear Fuels
Bolton Technical Innovation Centre Limited
British Academy
British Association for the Advancement of Science
British Council

[1] *Science and innovation: working towards a ten-year investment framework*, DfES / DTI / HMT, March 2004. http://www.hm-treasury.gov.uk/media//F1761/science_406.pdf

British Library
British Lung Foundation & the British Thoracic Society
British Psychological Society

Cambridge University Graduate Union
Cambridge-MIT Institute
Cancer Research UK
Confederation of British Industry
Council for the Central Laboratory of the Research Councils
Central Manchester and Manchester Children's University Hospitals NHS Trust
City University
Corus
Council for Higher Education in Art & Design

Department for Environment Food and Rural Affairs & Natural Environment Research Council (Joint Submission)
Department of Medical Physics & Bioengineering, University College London
Design Council

ECSITE-UK
EEF/SEMTA
Eli Lilly & Co Ltd
Engineering Council
Engineering Professors Council

Field Studies Council
Foresight Globe Network
Friends of the Earth

GE Healthcare
GeneWatch UK
GlaxoSmithKline
Greenpeace

Heriot-Watt University
Hewlett-Packard
Higher Education Research Forum

IBM Hursley
Institution of Electrical Engineers
Imperial College London
Institute of Cancer Research
Institute of Directors

Institute of Physics

King's Fund

Lancaster University
Lawson Software
Linear Collider UK Collaboration
LGC Ltd
Lloyd's Register
London Development Agency
London Mathematical Society
London Metropolitan University
London School of Economics and Political Science
Loughborough University

Macaulay Institute
Manchester Chamber
Manchester: Knowledge Capital
Medical Sciences Division, University of Oxford
Mercia Institute of Enterprise, University of Warwick
Morgan Crucible Company plc
MRC researchers at Kings College London

Napier University
National Addiction Research Consortium
National Grid Transco
National Museum of Science & Industry
National Postgraduate Committee
National Endowment for Science, Technology and the Arts
Nirex
North East Science and Industry Council
Northwest Development Agency
Novartis
Nuffield Council on Bioethics
Nuffield Foundation

Open University
Oxford Innovation Ltd

Partnerships UK
Peninsula Medical School
PERA
Pfizer Global R & D

Prospect

Queen Mary University of London
Queen's University, Belfast
QinetiQ

Regional Development Agencies collective response
Research Councils collective response
Royal Academy of Engineering
Royal Astronomical Society
Royal College of Art
Royal College of Physicians & Surgeons of Glasgow
Royal Holloway, University of London
Royal Society
Royal Society of Chemistry
Royal Society of Edinburgh
Russell Group of Universities

Save British Science
Society of British Aerospace Companies
Science Council
Scientific Alliance
Scientists for Global Responsibility
Scientists for Labour
Scottish Science Advisory Committee to the Science and Innovation
Science, Engineering, Technology and Mathematics Network
SETPOINT Devon and Cornwall
SETPOINT Wales
SETPOINT West Yorkshire
Sheffield Hallam University
Society for Academic Primary Care
Stroke Association

Technology Innovation Centre, Birmingham

UK Computing Research Committee
UK Neutrino Factory
UK Science Enterprise Centres
United Kingdom Atomic Energy Authority
UMIST/Victoria University of Manchester
United Nations Millennium Project, Harvard University
Universities UK
University College Chester

University of Birmingham
University of Bristol
University of Cambridge
University of Central Lancashire
University of Durham
University of East Anglia
University of Glasgow
University of Hertfordshire
University of Huddersfield
University of Hull
University of Leeds
University of Nottingham
University of Oxford
University of Plymouth
University of Salford
University of Southampton
University of Stirling
University of Sunderland
University of Surrey
University of Wales College of Medicine
University of Wales, Bangor
University of Wales, Swansea
University of Warwick
University of York

Wellcome Trust

Yorkshire Forward and Yorkshire Universities (joint response)

## Meetings

Ministers and officials conducting the consultation met with the numerous individuals and organisations in the period January to June 2004, including the selection below:

| Institution | Contact |
|---|---|
| Advent Venture Partners | Sir David Cooksey, Chairman |
| Amersham | Sir William Castell, Chief Executive |
| Association of Medical Research Charities | Diana Garnham, Chief Executive |
| AstraZeneca | Sir Tom McKillop, Chief Executive |
| Confederation of British Industry | John Cridland, Deputy Director-General |
| Engineering & Technology Board | Sir Peter Williams, Chair |
| Engineering Council | Sir Colin Terry, Chairman |
| GlaxoSmithKline | Sir Christopher Hogg, Chairman |
| Institute of Biology | Professor Alan Malcolm, Chief Executive |
| Institute of Physics | Professor David J Wallace, President |
| Lambert Review | Richard Lambert, Review Leader |
| Microsoft UK | Professor Stephen Emmott, Director |
| National Museum of Science and Industry | Dr Lindsay Sharp, Director |
| Post-14 Maths Review | Professor Adrian Smith, Review Leader |
| Regional Development Agencies | various |
| Royal Academy of Engineering | Philip Greenish, Director |
| Royal Institution | Baroness Susan Greenfield, Director |
| Royal Society | Professor Lord May, President |
| Royal Society of Chemistry | Professor Sir Harry Kroto, President |
| Save British Science | Dr Peter Cotgreave, Director |
| Science Council | Sir Gareth Roberts, President |
| Shell UK | Mark Phillips, External Affairs Manager |
| Surrey University | Professor Patrick Dowling, Vice Chancellor |
| The Sanger Institute | Sir John Sulston, Director |
| Universities UK | Baroness Diana Warwick, Chief Executive |
| University of Oxford | Sir Colin Lucas, Vice Chancellor |
| Wellcome Trust | Dr Mark Walport, Director |

**D.4** Beyond this, the Government is indebted to Sir Tom McKillop, Chief Executive of AstraZeneca, for convening a group of leading executives from major businesses with substantial R&D investment and employment in the UK, to provide senior business input into Government policy making. The group, who also took part in meetings with Ministers and officials prior to Budget 2004, includes:

ARM
AstraZeneca
BAe Systems
BP
BT
Ford UK
GE Healthcare
GlaxoSmithKline
IBM UK
Invensys
Johnson Matthey
Marconi
Microsoft UK
Motorola
Pfizer
Philips UK
Reuters
Rolls-Royce
Shell UK
Unilever
Vodafone

## US organisations

**D.5** The policy review team is also grateful to Professor Edward Crawley (MIT) and Professor Michael Kelly (Cambridge University), Executive Directors of the Cambridge-MIT Institute, for consulting the following US organisations on the Government's behalf:

Booz Allen Hamilton
Boston University
Council on Competitiveness
DuPont
Ford Motor Company
General Electric
Globalstar
Loral Space & Communications
Massachusetts Institute of Technology (MIT)
Motorola
National Academy of Engineering

National Aeronautics and Space Administration (NASA)
National Institute of Standards and Technology
National Review Online
National Science Foundation
Orbital Sciences Corporation
Purdue University
Science Applications International Corporation
Small Business Administration
United Technologies
University of Michigan
University of Virginia
University of Wisconsin
University of Connecticut
University of Tennessee
University of Arkansas
University of Pennsylvania
US Department of Commerce
US Department of Defense
US Department of Education
US Office of Science and Technology Policy
US Senate

## Overseas perspectives

**D.6** The policy review team is also grateful to the Foreign and Commonwealth Office's Science & Technology Unit, and in particular to their network of Science & Technology Officers, who provided valuable information from the following countries on overseas perceptions of the UK science base and its attractiveness for scientific collaboration and R&D investment:

Australia
Czech Republic
France
Germany
India
Israel
Italy
Netherlands
Poland
Russia
Singapore
USA

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