

Science and innovation investment framework 2004-2014: next steps

March 2006



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department for
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EXECUTIVE SUMMARY

This discussion paper presents the next steps in taking forward the Government's *Science and Innovation Investment Framework 2004-2014*. Against the background of increasing global competition for knowledge intensive business activity, this paper presents next steps on five key policy areas: maximising the impact of public investment in science on the economy through increasing innovation; increasing Research Councils' effectiveness; supporting excellence in university research; supporting world-class health research; and increasing the supply of science, technology, engineering, and mathematics (STEM) skills. The key elements are:

In order to provide a more coherent framework for health research and development (R&D), the Secretaries of State for Health and Trade and Industry will create a single, jointly held health research fund of at least £1 billion per annum. The Government will shortly appoint a leading independent individual to advise on the best institutional arrangements to deliver health R&D under this new structure. A consultation will be launched shortly in order to report on options in time for the 2006 Pre-Budget Report.

In order to maintain the UK's world-class university system, the Government is keen to ensure that excellent research of all types is rewarded, including user-focused and interdisciplinary research. Recognising some of the burdens imposed on universities by the existing Research Assessment Exercise (RAE), **the Government has a firm presumption that after the 2008 RAE the system for assessing research quality and allocating "quality-related" (QR) research funding to universities from the Department for Education and Skills will be mainly metrics-based.** The Government will launch a consultation on its preferred option for a metrics-based system, publishing results in time for the 2006 Pre-Budget Report.

The Government has set new ambitions to improve STEM skills, including to:

- **achieve year on year increases in the number of young people taking A levels in physics, chemistry and mathematics;**
- **continually improve the number of pupils getting at least level 6 at the end of Key Stage 3 (11-14 year olds);**
- **continually improve the number of pupils achieving A*-B and A*-C grades in two science GCSEs; and**
- **step up recruitment, retraining and retention of physics, chemistry and mathematics specialist teachers.**

To meet these ambitions, the Government announces a package of measures to improve the skills of science teachers, the quality of science lessons and increase progression to A level sciences, including new commitments to:

- **make science a priority in schools by including science in the School Accountability Framework;**
- **an entitlement from 2008 for all pupils achieving at least level 6 at Key Stage 3 to study three separate science GCSEs, to increase progression to, and attainment at, A level science;**
- **continue the drive to recruit science graduates into teaching via Employment Based Routes with new incentives to providers of £1,000 per recruit to attract more physics and chemistry teachers; and**

- **develop and pilot a Continuing Professional Development (CPD) programme, leading to an accredited diploma, to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy they need to teach these subjects effectively.**

The Government is consulting on further measures to maximise the impact of public investment in science on innovation, in particular:

- how the UK can best support high-risk, high-impact research in novel fields of scientific enquiry;
- how national and regional policies can work together more effectively to increase innovation and business-university collaboration; and
- building on the work of the Lambert Review, how a wider spectrum of business-university interaction can be encouraged, spreading best practice across different regions and sectors.

The Government is also consulting on how the Research Councils' effectiveness and economic impact can be further improved. In particular, whether the Government should **merge the Council for the Central Laboratory of the Research Councils (CCLRC) with the large facilities operations conducted by the Particle Physics and Astronomy Research Council (PPARC) to create a Large Facilities Research Council**, to improve the management of public investment in large research facilities. The Government is also inviting views on **whether the funding arrangements for the physical sciences should be simplified** in the wake of these changes.

Building on its success to date, the Government expects the Technology Strategy Board to play an increasing role in contributing to the development of the Government's innovation strategy across all important sectors of the UK economy. The Technology Strategy Board will have a wider remit to stimulate innovation in those areas which offer the greatest scope for boosting UK growth and productivity, and plans for it to operate at arms length from central government are being developed.

As part of its new five-year strategy and programme of organisational change, **UK Trade and Investment (UKTI) will have an enhanced role in marketing the UK science base to business, implementing a new £9 million international R&D strategy to attract R&D investment to the UK and to promote Britain's innovative firms abroad.**

Following discussions with business, and in light of the recommendations of Sir George Cox's review of creativity in business, **the Government intends to extend additional support through the R&D tax credit to companies with between 250 and 500 employees, subject to the outcome of state aid discussions with the European Commission.**

Building on the priorities set out in the *Science and Innovation Investment Framework 2004-2014*, the Government's objective is to create the best possible environment for science and innovation in the UK, enabling a world-class science base to connect with business, and creating the right mix of incentives and support mechanisms to grow new knowledge-based firms and take advantage of commercial opportunities arising from research. The measures presented in this document will make further progress towards achieving this objective.

INTRODUCTION

THE GLOBAL CHALLENGE

Global competition is increasing

I.1 The global economy is changing at an unprecedented rate. Advances in technology have dramatically reduced the time and cost involved in conducting economic transactions over long distances. Product cycles are accelerating in response to consumer demand, and have halved every five years over the past two decades, leading to the development of more agile, globally networked value chains.¹ In all countries, economic activity is under pressure to move up the value chain, with developing and emerging economies fast catching up to established players: already, these countries account for one third of global high technology exports.² China and India are investing increasingly in skills and research, and are attracting globally mobile research and development (R&D) investment. For example, US R&D investment in China alone grew from US\$7 million in 1994 to US\$500 million in 2000.³ Chinese investment in R&D doubled between 1996 and 2002. Together, China and India each produce over 2 million university graduates per year, compared to around 250,000 in the UK.⁴ Against this background, established economies such as the UK need to adapt in order to continue to attract and retain high-value economic activities.

I.2 Science and innovation are at the heart of these transformations, not only because technology is itself a key driver of globalisation, but also because countries will increasingly derive their competitive edge from the speed with which they are able to innovate. The link between innovation and increases in productivity and economic growth is well-established.⁵ New ideas drive enterprise, create new products and markets, and improve efficiency, delivering benefits to firms, customers and society. As more countries move up the value chain, the nations that will thrive in the global knowledge economy will be those which are not only able to produce the highest-quality research, but can also translate this most effectively into innovative new products and services.

Creating an “innovation ecosystem”

I.3 This presents both challenges and opportunities for the UK.⁶ On the one hand, the UK is well placed to benefit from the increasingly global nature of R&D and innovation, with a track record of scientific excellence, world-class universities, and leading R&D-intensive businesses in a number of key sectors. On the other hand, the UK has not always been effective at translating the products of excellent research into economic gain, and public and private investment in R&D remains lower than that of many leading competitors. Recognising these challenges and opportunities, the Government published its *Science and Innovation Investment Framework 2004-2014* in July 2004 to set a long-term strategy to improve the UK’s R&D and innovation performance. In order to remain attractive as a location for research and innovation, the UK needs to build on this strategy and create the right “ecosystem” for science and innovation, ensuring that its world-class science base connects with business, and that the right mix of incentives, skills, and support mechanisms are in place to grow new knowledge-based firms and take advantage of commercial opportunities arising from research. This document sets out further proposals for how this objective might be achieved – the next steps in the Government’s *Science and Innovation Investment Framework 2004-2014* – and invites views on some proposals.

¹ European Commission.

² UNIDO.

³ OECD *Science, Technology and Industry Outlook*, December 2004.

⁴ Indian National Association of Software and Service Industries (NASSCOM) and Chinese National Bureau of Statistics.

⁵ A summary of evidence is presented in Annex A of the *Science and Innovation Investment Framework 2004-2014*, HM Treasury/DTI/DfES, July 2004.

⁶ These are set out more fully in *Globalisation and the UK: strength and opportunity to meet the economic challenge*, HM Treasury, December 2005.

THE SCIENCE AND INNOVATION INVESTMENT FRAMEWORK

I.4 The Government has already taken significant steps to sustain the excellence of the UK research base and improve the exploitation of knowledge. The decline in public investment in science during the 1980s and early 1990s has been reversed: the Office of Science and Technology's (OST) Science Budget will rise to £3.4 billion by 2007-08, more than double the level of 1997; and total spending on science through the Department of Trade and Industry (DTI) and Department for Education and Skills (DfES) will reach £5.4 billion by 2007-08. In order to stimulate business investment in R&D, the Government introduced a R&D tax credit scheme in 2000 (extended to large companies in 2002), which has provided nearly £1.5 billion in support to nearly 20,000 businesses to date. In July 2004, the Government published a ten-year strategy for science and innovation, the *Science and Innovation Investment Framework 2004-2014*. This set out a long-term vision for UK science and innovation, with a headline ambition that public and private investment in R&D should reach 2.5 per cent of GDP by 2014. As well as measures to improve the sustainability of the UK science base, the *Science and Innovation Investment Framework 2004-2014* put particular emphasis on stimulating business-university collaboration and making the science base more responsive to the needs of the economy (see Box 1.1).

Box 1.1: The Science and Innovation Investment Framework

The *Science and Innovation Investment Framework 2004-2014* set out a comprehensive vision for UK science and innovation, along six principal themes:

- world-class research at the UK's strongest centres of excellence;
- greater responsiveness of the publicly-funded research base to the needs of the economy and public services;
- increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent;
- a strong supply of scientists, engineers and technologists;
- sustainable and financially robust universities and public laboratories across the UK; and
- confidence and increased awareness across UK society in scientific research and its innovative applications.

Some of the key measures to underpin this vision included:

- additional funding of over £1 billion over 2005-2008 to enhance the sustainability of the science base;
- dedicated funding for knowledge transfer from universities in England through the Higher Education Innovation Fund, rising to £110 million per annum by 2007-08;
- funding for industry-led collaborative research through the DTI Technology Strategy, rising to at least £178 million per annum by 2007-08;
- the Government's response to the Lambert Review of business-university collaboration, including new responsibilities for the Regional Development Agencies (RDAs) in this area; and
- measures to improve the teaching and learning of science, technology, engineering and mathematics (STEM) subjects at all levels.

The Government has since built on these measures, for example by:

- announcing in the 2004 Pre-Budget Report a new mandatory target for Government departments and agencies to place 2.5 per cent of their extra-mural R&D contracts with small- and medium-sized enterprises (SMEs), under the Small Business Research Initiative (SBRI);
- announcing in the 2005 Pre-Budget Report a package of measures to improve the environment for medical R&D in the UK, including a new NHS research strategy, and measures to promote excellence in clinical research and to facilitate the conduct of clinical trials; and
- announcing in the 2005 Pre-Budget Report an independent review of Intellectual Property (IP) in the UK, led by Andrew Gowers, to ensure that the UK's IP framework is appropriate for the digital age.

A strong start, but challenges remain **I.5** The first Annual Report on the *Science and Innovation Investment Framework 2004-2014*, published in July 2005, found that solid progress had been made in implementing the framework during its first year.⁷ The UK remains second only to the US in global scientific excellence as measured by citations, and leads the G7 in the productivity of its research base. Knowledge transfer activity from universities has increased substantially, with spin-out formation, licensing income, and patent applications increasing four-fold since 1998. Over the past two years, 20 university spin-out companies have floated on the stock exchange, with an initial market value of over £1 billion. However, significant challenges also remain. UK business investment in R&D remains low as a proportion of gross domestic product (GDP) in international comparison. While business R&D has increased by 20 per cent in real terms since 1997, real GDP has been growing at a faster rate, and the business R&D to GDP ratio has consequently remained flat at 1.23 per cent of GDP during 2002 and 2003, falling slightly in 2004. UK innovation performance as measured by patenting continues to lag behind the US, Japan, and the EU-15 average. Performance on science, technology, engineering and mathematics (STEM) skills is also mixed, with the number of students taking up STEM subjects at school and university continuing to decline in some areas.

Maximising the economic return on investment **I.6** It will take time for the additional funding and new policy measures introduced in the *Science and Innovation Investment Framework 2004-2014* to have their full impact on key performance indicators, such as levels of business R&D investment and STEM attainment. However, if the impact of additional public investment in science on the economy is to be maximised, it is essential to ensure that the right structures are in place to deliver the benefits of this investment. The Government has made significant progress in this area, for example by creating a business-led Technology Strategy Board to identify technology priorities with market potential, and by giving enhanced responsibilities to new delivery agents such as the RDAs. At the same time, however, the principal structures and processes that have developed to fund research need to be kept under review to ensure that they remain fit for purpose. For example, it is important to consider whether the current division of labour between the Research Councils is optimally effective, or whether the system for allocating “quality-related” funding (QR) to universities can be simplified. Making progress on the supply of high-quality STEM graduates is also essential if the Government’s overall ambitions for UK science and innovation are to be realised.

THE UK’S PERFORMANCE IN INTERNATIONAL COMPARISON

UK science is strong **I.7** Many indicators point to the world-class quality and reach of the UK’s science base. With just 1 per cent of the world’s population, the UK undertakes 5 per cent of the world’s research, publishes over 12 per cent of all cited papers and almost 13 per cent of papers with the highest impact.⁸ UK scientists claim around 10 per cent of internationally recognised scientific prizes every year. In terms of the international profile of UK higher education institutions, a recent survey ranked Oxford and Cambridge universities as 5th and 6th in the world, while London proves itself a global centre for higher education, with four institutions in the top 50 worldwide. The UK dominates the European science base too, with six higher education institutions in Europe’s top ten.⁹

⁷ *Science and Innovation Investment Framework Annual Report 2005*, HM Treasury/DTI/DfES, July 2005, available at: <http://www.ost.gov.uk/policy/sifreview05.pdf>

⁸ Source: *PSA target metrics for the UK research base*, OST 2004, available at: http://www.ost.gov.uk/research/psa_target_metrics.htm

⁹ Times Higher Education Supplement (2004): *World’s Top 50 Universities*

Business R&D and innovation lagging behind

I.8 However, UK investment in R&D has historically been lower than most countries in Europe, with UK overall expenditure on R&D as a percentage of GDP just below the EU-15 average. Low levels of business expenditure on R&D contribute to this. There is also evidence that the UK under-performs in terms of capturing the benefits from the R&D it carries out. For example, on a per capita basis, it lags below the European average in terms of patent applications. The Organisation for Economic Cooperation and Development (OECD) acknowledges that although conventional indicators probably under-state innovation performance, UK performance has not been exceptional by international standards.¹⁰ This assessment is supported by the European Commission, which ranks UK performance as average (along with France, Luxembourg, Ireland, Netherlands, Belgium, Austria, Norway, Italy and Iceland), lagging behind EU leaders: Switzerland, Finland, Sweden, Denmark and Germany.¹¹

STEM skills

I.9 To compete on a global scale requires an internationally competitive supply of STEM graduates. The UK average of 28 per cent of total new degrees in science and engineering compares favourably to the OECD average of 23 per cent.¹² However, comparisons with the emerging economies of China and India demonstrate the challenge faced by the UK. In 2004, China and India produced 125,000 computer science graduates compared to 5,000 produced in the UK.¹³ Additionally, China has a large number of young engineers: 33 per cent of university students study engineering in China compared to 5 per cent in the UK.¹⁴

FURTHER PROPOSALS FOR REFORM

I.10 On the basis of this evidence, and taking into account examples of best practice from other countries, the Government believes that there are three broad areas that need to be addressed if the UK is to create an effective ecosystem for innovation:

- improving the strategic management of investment in science and innovation, to ensure that the UK's science and innovation system is more responsive to economic and public policy priorities, and that different funding mechanisms are coordinated more effectively to deliver the objectives set out in the *Science and Innovation Investment Framework 2004-2014*. This will enhance business confidence in the value of engaging with UK science;
- ensuring that the right skills and brokering mechanisms are in place to encourage greater collaboration between industry and the research base, and enable businesses and the science base to interact in a range of ways to suit their needs; and
- making STEM subjects more attractive to students, to ensure a highly skilled and diverse workforce to drive future innovation and growth.

In line with these priorities, this document sets out the next steps in the Government's *Science and Innovation Investment Framework 2004-2014*.

¹⁰ *Economic Survey of the United Kingdom 2005*, OECD, 2005.

¹¹ *European Innovation Scoreboard 2005*. This has been developed by the European Commission to monitor performance under the Lisbon Strategy: <http://www.trendchart.org/index.cfm>

¹² *OECD Science Technology and Industry Scoreboard*, 2005.

¹³ <http://www.demos.co.uk>

¹⁴ Higher Education Statistics Agency and Chinese National Bureau of Statistics.

Maximising the impact of science on innovation

I.11 The Government is keen to create a more effective science and innovation system, which maximises the impact of public investment in science on business innovation, and provides greater incentives for businesses to collaborate with the science base to meet the challenges of globalisation (Chapter 2). **The Government expects the Technology Strategy Board to play an increasing role in contributing to the development of the Government's innovation strategy across all important sectors of the UK economy.** The Technology Strategy Board will have a wider remit to stimulate business innovation in those areas which offer the greatest scope for boosting UK growth and productivity, and plans for it to operate at arms length from central government are being developed. **As part of its new five-year strategy and programme of organisational change, the Government is also announcing an enhanced role for UK Trade and Investment (UKTI) in marketing the UK science base to business and attracting foreign R&D investment, with a new £9 million international R&D strategy.** Following discussions with business, and in light of the recommendations of Sir George Cox's review of creativity in business, **the Government intends to extend additional support through the R&D tax credit to companies with between 250 and 500 employees, subject to the outcome of state aid discussions with the European Commission.** In addition, the Government is consulting on further measures to maximise the impact of public investment in science on innovation, in particular: **how the UK can best support high-risk, high-impact research in novel fields of scientific enquiry; on how national and regional policies can work together more effectively to increase innovation and business-university collaboration in the regions; and on how, building on the Lambert Review, a wider spectrum of business-university interaction can be encouraged, spreading best practice across different regions and sectors.**

Improving Research Councils' effectiveness

I.12 In order to increase the responsiveness of the science base to the needs of the economy and enhance the UK's capacity to conduct internationally excellent science, the Government believes that there is scope for reviewing the effectiveness of the Research Councils' existing structures and operations (Chapter 3). **The Government is consulting on whether the Council for the Central Laboratory of the Research Councils (CCLRC) should be merged with the large facilities operations conducted by the Particle Physics and Astronomy Research Council (PPARC) to create a Large Facilities Research Council,** to improve the management of public investment in large research facilities such as light sources, neutron sources, high power lasers, telescopes, particle accelerators, and space programmes. **The Government is also inviting views on whether the funding arrangements for the physical sciences should be simplified in the wake of these changes, and what further measures could be taken by Research Councils to improve their effectiveness.**

Supporting excellence in university research

I.13 In order to maintain the UK's world-class university system, the Government is keen to ensure that excellent research of all types is rewarded, including user-focused and interdisciplinary research. It also wants to ensure that institutions continue to have the freedom to set strategic priorities for research, undertake "blue skies" research, and respond quickly to emerging priorities and new fields of enquiry. The Government is strongly committed to the dual support system, and to rewarding research excellence, but recognises some of the burdens imposed by the existing Research Assessment Exercise (RAE). The Government's firm presumption is that after the 2008 RAE the system for assessing research quality and allocating QR funding from the DfES will be mainly metrics-based. **The Government will launch a consultation on its preferred option for a metrics-based system for assessing research quality and allocating QR funding, publishing results in time for the 2006 Pre-Budget Report.**

Supporting world-class health research **I.14** Health research is an area of marked UK strength, and the excellence of the health research base is key to attracting and retaining higher levels of business R&D investment. Building on reforms to date, the Government believes that there is scope for creating more effective structures to support world-class health research in the UK, aligning research priorities more closely with wider health objectives, and providing a more coherent approach for translating the results of research into economic benefit. **Research budgets in OST are already ring-fenced. Building on reforms to date, the Government intends similarly to ring-fence the Department of Health's R&D budget and that the Secretaries of State for Health and Trade and Industry will create a single, jointly held health research fund of at least £1 billion per annum.** The Government will shortly invite a leading independent individual to advise on the best institutional arrangements to deliver a more coherent framework for health R&D under this new structure. A consultation will be launched shortly in order to report on options to the Government in time for the 2006 Pre-Budget Report.

Improving the supply of scientists **I.15** A strong supply of highly qualified STEM graduates is essential to underpin the Government's long-term objectives for science and innovation, and a key factor in making the UK an attractive location for business investment in R&D (Chapter 6). *The Science and Innovation Investment Framework 2004-2014* outlined the Government's ambition to create an education and training environment that delivers the best in science teaching and learning at every stage. Despite the progress in taking forward the framework the Government is concerned that progress towards meeting its ambitions is relatively slow in some areas and believes that there is scope for further action to improve the quality of STEM education and increase the supply of STEM skills. **The Government has therefore set new ambitions, including to:**

- **achieve year on year increases in the number of young people taking A levels in physics, chemistry and mathematics so that by 2014 entries to A level physics are 35,000 (currently 24,200); chemistry A level entries are 37,000 (currently 33,300); and mathematics A level entries are 56,000 (currently 46,168);**
- **continually improve the number of pupils getting at least level 6 at the end of Key Stage 3 (11-14 year olds);**
- **continually improve the number of pupils achieving A*-B and A*-C grades in two science GCSEs; and**
- **step up recruitment, retraining and retention of physics, chemistry and mathematics specialist teachers so that by 2014 25 per cent of science teachers have a physics specialism; 31 per cent of science teachers have a chemistry specialism; and the increase in the number of mathematics teachers enables 95 per cent of mathematics lessons in schools to be delivered by a mathematics specialist (compared with 88 per cent currently).**

I.16 To meet these ambitions, the Government announces a package of measures to improve the skills of science teachers, the quality of science lessons and increase progression to A level sciences, including new commitments to:

- **make science a priority in schools by including science in the School Accountability Framework;**
- **an entitlement from 2008 for all pupils achieving at least level 6 at Key Stage 3 to study three separate science GCSEs, to increase progression to, and attainment at, A level science;**

- continue the drive to recruit science graduates into teaching via Employment Based Routes with new incentives to providers of £1,000 per recruit to attract more physics and chemistry teachers; and
- develop and pilot a Continuing Professional Development (CPD) programme leading to an accredited diploma to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy they need to teach these subjects effectively.

I.17 A summary of discussion questions and details of how to submit comments are given in Chapter 7.

2

MAXIMISING THE IMPACT OF SCIENCE ON INNOVATION

In order to meet the challenges of globalisation, the UK needs to develop a more effective science and innovation system, which maximises the impact of public investment in science on business innovation, and provides greater incentives for business to work with the science base.

Building on its success to date, the Government expects the Technology Strategy Board to play an increasing role in contributing to the development of the Government's innovation strategy across all important sectors of the UK economy. The Technology Strategy Board will have a wider remit to stimulate innovation in those areas which offer the greatest scope for boosting UK growth and productivity, and plans for it to operate at arms length from central government are being developed.

The UK's world-class science base has the potential to act as a "magnet" to attract and retain investment from R&D-intensive businesses. **To ensure this potential is fully exploited, the Government is announcing an enhanced role for UK Trade and Investment (UKTI) in marketing the UK science base to business and attracting foreign R&D investment, with a new £9 million international R&D strategy.** This will be part of UKTI's new five-year strategy and programme of organisational change.

In addition, the Government is seeking views on a range of issues which are key to creating a more effective science and innovation system, in particular:

- **how the UK can best support high-risk, high-impact research in novel fields of scientific enquiry;**
- **how national and regional policies can work together more effectively to increase innovation and business-university collaboration in the regions; and**
- **building on the work of the Lambert Review, how a wider spectrum of business-university interaction can be encouraged, spreading best practice across different regions and sectors.**

INTRODUCTION

2.1 The UK is well placed to capitalise on the changing nature of innovation, but it is vital that policy accounts for its increasing diffusion, interdisciplinarity and technological complexity. Acknowledging this, the *Science and Innovation Investment Framework 2004-2014* set the broad direction of travel for UK policy. However, further measures may be required to maximise the productive output of both public and private R&D, so that the UK can rise to the challenges of a global economy.

2.2 This chapter presents new measures and invites comments on a range of areas which are key to an effective innovation system in the UK: creating better links between science and innovation policy; incentivising high-risk, high-impact research; encouraging business investment in R&D; marketing the UK science base more effectively to business; building international links; supporting regional innovation; and facilitating a wider range of business-university interaction.

LINKING SCIENCE AND INNOVATION IN CENTRAL GOVERNMENT

2.3 High-level strategies to improve the commercialisation of UK science are currently being developed by a number of government bodies. The Office of Science and Technology (OST), the Research Councils, and the Technology Strategy Board all have an important role to play. However, in many ways, the science “push” and innovation “pull” have been managed separately within central government. Meanwhile, some countries are increasingly considering science and innovation as an “ecosystem”, and are developing holistic strategies to drive forward a commercialisation agenda. Box 2.1 provides an example.

Box 2.1: Finland’s innovation system

Under the stewardship of a Science and Technology Policy Council, Finland has operationalised an innovation system designed to meet the needs of its high technology knowledge-based economy. This is both an independent advisory body and a strategy-shaping multi-stakeholder institution, where political decision-makers, science and technology administrators, industrial experts and academics jointly design and formulate the development and implementation of national science and innovation policies. Over the past 15 years, their approach has been to develop a consensus-based long-term programme for raising national technological capabilities and increasing domestic R&D. This focus on developing high technology, its effective utilisation, and the determined effort to increase exports has significantly enhanced Finland’s competitive edge. Finland is ranked as one of the leading OECD countries in innovation, measured in terms of growth, technological sophistication and infrastructure.

The Technology Strategy **2.4** The Department of Trade and Industry’s (DTI) Technology Strategy, launched in 2004, is the Government’s flagship policy for funding industry-led research. The Technology Strategy, worth £370 million from 2004-05 to 2007-08, supports collaborative projects in emerging technology areas. Funding priorities are set by an independent, business-led Technology Strategy Board. Take-up to date has been strong, with 262 projects approved for funding under the first three competitions, 86 per cent of which had some participation by universities and 85 per cent some participation by small- and medium-sized enterprises (SMEs). The Technology Strategy published its first annual report in November 2005,¹ which highlighted a number of areas for future development, including:

- exploring the case for funding larger-scale and longer-term projects to ensure that projects achieve critical mass; and
- developing “Innovation Platforms” which link a range of technology areas in response to particular social and economic challenges. Pilots are currently underway in network security and intelligent transport systems and services.

Supporting knowledge transfer **2.5** The Government has also established a number of mechanisms to encourage knowledge transfer from the research base, to ensure that scientific excellence is translated into economic benefit. These mechanisms address both the “supply side”, helping the research base to engage with business and exploit the commercial potential of new discoveries, and the “demand side”, stimulating business demand for research. These include:

¹ *Technology Strategy Annual Report 2005*, available at: <http://www.dti.gov.uk/technologystrategy/>

- the Higher Education Innovation Fund (HEIF), which builds capacity in English universities for knowledge transfer and commercialisation activities. HEIF will rise to £110 million by 2007-08. The allocation of funding for the current round of HEIF has moved to a largely formula-based system to ensure that a wider range of institutions benefit (see paragraph 2.33 below);
- Knowledge Transfer Partnerships (KTPs), which fund highly-qualified researchers to work in a company for one to three years, on a specific project that is important to the strategic development of the business. The DTI estimates that on average, every £1 million invested in KTP results in a £3.3 million rise in business profits before tax, the creation of 77 new jobs, and training for 263 members of staff, as well as giving academics experience of working in a business environment; and
- Knowledge Transfer Networks (KTNs), which form part of the Technology Strategy. KTNs aim to create national networks of stakeholders in particular technology areas to accelerate the knowledge transfer process, bringing together businesses, universities and other research organisations, the finance community, and other intermediaries. There have been 18 KTNs already established, including for aerospace, biosciences, food processing, health technology, and pollution management.²

2.6 From April 2006, a new Office for Science and Innovation will be established within the DTI, bringing together the OST and the DTI Innovation Group (which includes the Technology Strategy Board). This provides an opportunity to consider how policies addressing the science “push” and innovation “pull” can be brought together more effectively.

Enhanced role for the Technology Strategy Board **2.7** In particular, it is timely to build on the success of the Technology Strategy Board, which has introduced user defined requirements in order to fulfil its mission of stimulating innovation in business. **The Government expects the Technology Strategy Board to play an increasing role in contributing to the development of the Government’s innovation strategy across all important sectors of the UK economy.** This wider remit will require the Board to set priorities for its support on innovation, on areas which offer the greatest scope for boosting growth and productivity, in the context of an increasingly globalised economy. Plans for delivery of the Board’s remit to operate at arms length from central government will now be worked up, to secure improved value for money and better delivery to business. There will be a particular focus on driving up business engagement with universities, so that the UK derives full benefit from the Government’s substantial investment in the UK research base.

INCENTIVISING HIGH-RISK, HIGH-IMPACT RESEARCH

2.8 The increasing convergence of science and technology offers exciting opportunities for innovation. Some of the most interesting scientific advances occur at the intersection of disciplines and on the boundaries between publicly and privately funded R&D. Box 2.2 lists some examples.

²Further information on KTNs is available at: <http://www.dti.gov.uk/ktn/>

Box 2.2: Examples of interdisciplinary research

- Collaboration between cell biologists, engineers and materials scientists has made it possible to grow complex human tissues suitable for repairing the human body. Interdisciplinary research supported by three UK Research Councils has led to the production of injectable tissue scaffolds which are now being commercially exploited by Critical Pharmaceuticals Ltd., a Research Council spin-out company which recently secured £1 million of venture capital investment.
- Advances in information technology and computational sciences are revolutionising other disciplines, from environmental sciences (for example climate change modelling) to bioinformatics and systems biology (using advanced computational techniques to analyse complex biological processes).
- The development of Magnetic Resonance Imaging (MRI), which allows doctors to produce images of living tissue, was the product of high-risk interdisciplinary research at the University of Nottingham, linking physics, medicine and engineering. All major hospitals around the world now have MRI scanners, and these are revolutionising medical diagnosis and brain science.

2.9 The Government cannot, and should not attempt to, predict where and in what form these innovations will occur, and it acknowledges that some of the best future innovations may emerge from proposals that fail to gain widespread support at an early stage. However, the Government can help to support a sufficiently entrepreneurial culture and ensure that innovation is better recognised and exploited. Without a sufficiently forward-looking, open and receptive culture, the best scientific and business talent and investment will be attracted elsewhere, and some innovative ideas may be lost altogether.

Supporting high-risk research

2.10 The UK has mechanisms in place to meet this challenge. For example, Funding Councils' "quality-related" (QR) funds, available to Higher Education Institutions (HEIs), can be used to support research projects that carry high risks, but hold great potential. Equally, longer-term, more strategic partnerships between businesses and universities can facilitate such research. Research Councils are responding by recruiting business representatives onto their assessment panels and boards, promoting more frequent turnover of panel experts, facilitating access to funding for those without a track record, and providing more flexible, long-term programme funding. More broadly, the Government has introduced enterprise education in schools, with the implementation of the Davies Review.³ Nevertheless, the UK is still susceptible to a charge of risk aversion, as classic peer review criteria emphasise tests of scholarship over potential impact. It is not clear that the UK science base has the optimum balance between rewarding recognised excellence and supporting risk. Box 2.3 outlines some US approaches to supporting high-risk, high-impact research.

2.11 The Government would be interested in views about whether the existing framework for supporting science and innovation enables an appropriate level of risk-taking, and if not, suggestions of how any gap might be addressed.

³ A Review of Enterprise and the Economy in Education, DfES 2002, available at: <http://www.dfes.gov.uk/ebnet/DR/DR.cfm>

2.12 The Research Councils keep the peer review process under review to avoid any barriers for funding innovative and interdisciplinary research. There is still some concern that the UK system has traditionally channelled research along specific disciplinary “silos”, which impacts on both Research Council grants and Research Assessment Exercise (RAE) scores. This may unintentionally give preference to work in established fields. There are well-recognised challenges in assessing the quality of interdisciplinary activity, and Research Councils are addressing these. However, further progress may be required to support interdisciplinary research, since many successful new products and processes come not from knowledge at the cutting edge of research, but from the transfer of ideas from one field to another.

2.13 The Government invites views on measures to remove any remaining bias which unfairly favours established research fields over innovative ones. The Government also invites views on how funding mechanisms can be made more responsive to new research challenges.

Box 2.3: The US experience of supporting high-risk research

The US has a strong culture of entrepreneurialism, which is supported by policy and institutional frameworks, for example:

- the proposed US National Innovation Act 2005 aims to enhance the US’s competitive edge by focusing on talent, investment and infrastructure. It proposes to set up a grants programme to encourage high-risk frontier research, whereby federal science and technology agencies would allocate up to 3 per cent of their R&D budgets to this end; and
- the Defense Advanced Research Projects Agency (DARPA), which is an agency of the US Department of Defense responsible for the development of new technology for use by the military. It supports risk-taking and cross-disciplinarity by allocating a relatively small amount of its budget to fund research that is turned down by mainstream routes. In its half century history, its work has resulted in the creation of the Internet, as well as breakthroughs in high-speed microelectronics, stealth and satellite technologies, unmanned vehicles and new materials.

ENCOURAGING BUSINESS INVESTMENT IN R&D

The R&D tax credit **2.14** Despite the potential for growth provided by R&D investment, the existence of wider spillover effects to society means that companies can under-invest in R&D, as the public returns exceed the gains to companies themselves. The R&D tax credit is a key part of the Government’s strategy to tackle this under-investment. Following extensive consultation with business, it was introduced in 2000 for SMEs and extended to large companies in 2002. To date nearly 20,000 claims have been made under the scheme, with nearly £1.5 billion of support provided.

2.15 Following discussions with business, in the 2005 Pre-Budget Report the Government announced the creation of specialist R&D units within HM Revenue and Customs (HMRC) to deal with all SME R&D tax credit claims. These new units, which will help ensure R&D performing companies receive maximum value from the credit, will be in operation by the end of the year. **Furthermore, in light of the discussions, and the recommendations of Sir George Cox’s review of creativity in business, the Government intends to extend additional support to companies with between 250 and 500 employees, subject to the outcome of state aid discussions with the European Commission.**

Gowers Review 2.16 Intellectual Property (IP) is an essential foundation to the UK's success in the knowledge economy. Globalisation and technological change have both raised tensions in the existing system. The Government has launched an independent review, led by Andrew Gowers, to examine the UK's IP framework.⁴ The Review will assess the IP framework to ensure it balances the need to encourage firms and individuals to innovate and invest in new ideas and creative works with the need to ensure that markets remain competitive and that future innovation is not impeded. In incentivising innovation, IP provides a complement to public grants for R&D by enabling firms to benefit from the private returns from innovation for a time-limited period, before the spillovers are released more broadly to the public realm. The Gowers Review launched its consultation phase with a formal call for evidence on 23 February 2006. Submissions to the call for evidence should be submitted by Friday 21 April 2006. The review will report to the Chancellor, the Secretary of State for Trade and Industry and the Secretary of State for Culture, Media and Sport in Autumn 2006.

MARKETING THE UK SCIENCE BASE

UK must be attractive to R&D investment 2.17 R&D is increasingly mobile internationally, with emerging economies such as India and China becoming more attractive as investment locations. In this more competitive environment, the UK needs to find effective ways of retaining and attracting Foreign Direct Investment (FDI) from R&D-intensive companies.

2.18 The UK is well-placed to do this: already, a greater share of UK business R&D is accounted for by foreign firms (over 25 per cent) than in most other G7 nations.⁵ This is partly driven by the world-class reputation of the UK science base, but also relates to the wider investment climate.

2.19 However, if current levels of investment are to be maintained and increased, the UK's capacity to market itself to potential investors must be enhanced, using the quality of UK science as a "magnet" to attract FDI. The UK currently lacks a strong national strategy for attracting FDI from R&D-intensive companies. Investment promotion is undertaken by a range of different agencies, including UK Trade and Investment (UKTI) and the Regional Development Agencies (RDAs).

A new marketing strategy for the UK 2.20 **Before the summer, the Government will publish a new five year strategy for a step-change in the Government's drive to market the strengths of the UK economy internationally, to be delivered by UKTI.** This will have a number of themes, including a particular focus on high-growth countries of strategic importance such as India and China, and a focus on innovative and R&D intensive sectors.

2.21 The UKTI five year strategy will form the basis of a partnership between all Government departments and agencies, RDAs, Devolved Administrations, and numerous private sector bodies active in this field, whose contribution is crucial. It will embrace UKTI's twin roles of trade promotion and inward investment, both of which are vital.

2.22 In order to deliver this new strategy, UKTI will undertake a programme of organisational change, under the leadership of its new chief executive, Andrew Cahn, with the clear aim of a fundamental transformation in its effectiveness in marketing the UK. Details of this programme will be published alongside the strategy.

⁴ The Gowers Review website is at: http://www.hm-treasury.gov.uk/independent_reviews/

⁵ Source: *R&D Intensive Businesses in the UK*, DTI Economics Paper 11, March 2005, available at: http://www.dti.gov.uk/economics/economics_paper11.pdf

2.23 The strategy will build on the UK's strengths in scientific discovery, to attract knowledge intensive businesses to the UK. As a first step, **UKTI will implement an international Research and Development strategy, with £9 million in funding, to attract more business R&D to the UK, and to promote Britain's innovative firms abroad.** UKTI will work in partnership with the academic and business communities, and will spearhead this effort across Government.

BUILDING INTERNATIONAL LINKS

2.24 The UK funds 5 per cent of the world's science, but this means that 95 per cent is funded elsewhere. If the UK is to maintain its science and innovation at a world-class level, it needs to collaborate with other world-class countries. In the last year the Government has provided £6 million across four collaborative projects, which will link world-class British and American universities to increase scientific excellence and innovation. These will include:

- the University of Manchester working with the University of Washington and a wide range of businesses on the development of composite materials for use in aircraft design;
- Imperial College London working with the University of Texas, Oak Ridge National Laboratory and the Georgia Institute of Technology on the treatment of cancer and energy research;
- the University of Cambridge continuing its productive partnership with the Massachusetts Institute of Technology; and
- a consortium of the Universities of Bath, Bristol, Southampton and Surrey working with the University of California, in the areas of wireless technology, life sciences, the environment and advanced materials.

2.25 Over the next three years, the Government plans to support similar links with other pre-eminent universities and high-tech clusters in other parts of the world, and in particular with China and India, including through the next round of HEIF.

SUPPORTING INNOVATION IN THE REGIONS

RDAs and regional innovation

2.26 Supporting science and innovation in the regions is essential if the Government's ambitions for the UK as a whole are to be achieved. The 2003 Lambert Review of business-university collaboration highlighted the key role that the RDAs can play in encouraging stronger links between industry and the research base, and promoting knowledge transfer and business innovation in the regions.⁶ In line with the recommendations of the Lambert Review, the RDAs have been given an enhanced role in promoting business-university links, and have set specific targets for the number of collaborations they facilitate between businesses and the research base. All RDAs have now set up Science and Industry Councils, bringing together business leaders, scientists, and local and regional government, to provide strategic advice on regional science and technology priorities. Collectively, the RDAs are investing around £360 million in promoting science and innovation in 2005-06.

⁶ *Lambert Review of Business-University Collaboration: Final Report*, HM Treasury 2003, available at: <http://www.hm-treasury.gov.uk/>

Regional challenges 2.27 At the same time, there are some significant challenges in promoting regional innovation:

- discrepancies between the science and innovation performance of different regions remain large, with total public and private investment in R&D in the highest-performing region almost 15 times higher than in the lowest-performing region;⁷
- more effective methods for engaging SMEs and businesses with no previous history of university collaboration need to be developed, so that more of them invest in innovation and work with universities in future;
- the RDAs need to work more effectively across regional boundaries, to coordinate development strategies across RDAs where appropriate, and exploit opportunities for collaboration between RDAs.

2.28 There are already some good examples of work underway to address these challenges. For example, the three northern RDAs have developed a joint strategy to promote science and innovation under the Northern Way growth initiative, and will be investing over £100 million in this area up to 2010. More recently, the Government welcomed plans by the RDAs to develop Science Cities, which will provide a focal point for businesses seeking to collaborate with world-class research establishments in the regions. Science Cities are currently being developed in Manchester, Newcastle, York, Birmingham, Nottingham and Bristol.

Next steps 2.29 Looking ahead, the RDAs are taking forward work to develop a more coherent network of national and regional innovation advisors, to ensure that the provision of specialist innovation advice is credible, demand-led, and identifies the best solutions to a business need from available national and regional products. The RDAs will work with the DTI and other Government departments to improve the coordination between existing national and regional schemes, providing a clearer interface for engaging with business (particularly SMEs), and ensuring that consistent advice is given on the full range of innovation support available. The RDAs are also exploring the possibility of establishing regional “innovation hubs”, by improving the coordination between national and regional initiatives to support centres of excellence in industrial collaboration, in order to build critical mass and achieve international excellence.

2.30 **The Government would welcome views on the barriers limiting greater business innovation and business-university collaboration in the regions, and on what more could be done on a national and regional level to tackle these barriers effectively.**

FURTHER SUPPORT FOR BUSINESS-UNIVERSITY INTERACTION

2.31 The 2003 Lambert Review of business-university collaboration highlighted the importance of encouraging closer links between industry and the research base. Firms benefit from this interaction by accessing highly trained students, facilities and faculty. Universities benefit by attracting additional funds, particularly for research; by the exposure to practical problems; and by engaging with new research challenges identified by business. Universities also benefit through employment opportunities for their graduates, and by gaining access to the technological capabilities of business. As a result of the complementary nature of industry-university relationships, some of these collaborative activities have been instrumental in helping firms advance knowledge and propel new technologies in many areas – such as biotechnology, pharmaceuticals, and manufacturing.

⁷ Based on ONS statistics for 2002.

Lambert Review 2.32 Responding to the Lambert Review recommendations, the Government has introduced a number of measures to facilitate higher levels of business-university collaboration, including giving the RDAs enhanced responsibility for business-university links (see above); providing dedicated funding to support knowledge transfer and commercialisation activities in English universities through HEIF; and publishing a range of model IP agreements (the “Lambert Agreements”) to reduce the time and cost involved for universities and businesses wishing to collaborate on R&D projects.⁸ Survey evidence suggests that the level and quality of business-university interaction continues to improve, with significant increases in university income from contract research and collaborative R&D reported for 2004.⁹

HEIF 2.33 Government support for knowledge transfer has evolved in recent years, with funding for HEIF increasing in size. HEIF supports a wide range of knowledge transfer activity across the whole range of HEIs in England. The third round of HEIF was designed, following extensive consultation, so that the majority (75 per cent) of funding is allocated by a formula to ensure that every HEI receives funding – with the remainder allocated by competition for the most innovative, high-impact ideas. Formulaic allocation of HEIF introduced a predictable funding stream for knowledge transfer, enabling universities to offer long-term careers in that area, rather than confining their knowledge transfer staff to short-term contracts. The new funding model has also reduced the administrative load on universities, thereby releasing staff resources for frontline activities.

2.34 Businesses interact with universities in a number of ways, including through:

- commissioning specific research projects;
- working collaboratively to solve practical problems;
- sponsoring PhD students to undertake a specific project;
- establishing research centres;
- sponsoring research chairs;
- contributing to the development of course curricula;
- employing placement/sandwich students; and
- employing graduates – for many firms this is the only way they interact.

2.35 Looking forward, the Government is keen to ensure that best practice in business-university collaboration is shared more effectively. Business-university engagement remains inconsistent across industries and regions. The Government together with the Higher Education Funding Council for England (HEFCE) is taking steps to promote best practice in business-university interaction. **The Government would welcome views – in particular from outside Higher Education – which can be taken into account in developing best practice models. In addition, the Government would welcome views on how to encourage businesses to work with universities for the first time, perhaps by introducing short-term, low-cost mechanisms for business-university interaction.**

⁸ Details of the Lambert Agreements can be found at: <http://www.innovation.gov.uk/lambertagreements/>

⁹ Higher Education Business and Community Interaction Survey 2005, HEFCE 2005, available at: <http://www.hefce.ac.uk>

Discussion questions: Maximising the impact of science on innovation

1. The Government would be interested in views about whether the existing framework for supporting science and innovation enables an appropriate level of risk-taking, and if not, suggestions of how any gap might be addressed.
2. The Government invites views on measures to remove any remaining bias which unfairly favours established research fields over innovative ones. The Government also invites views on how funding mechanisms can be made more responsive to new research challenges.
3. The Government would welcome views on the barriers limiting greater business innovation and business-university collaboration in the regions, and on what more could be done on a national and regional level to tackle these barriers effectively.
4. The Government would welcome views – in particular from outside Higher Education – which can be taken into account in developing best practice models for business-university collaboration. In addition, the Government would welcome views on how to encourage businesses to work with universities for the first time, perhaps by introducing short-term, low-cost mechanisms for business-university interaction.

3

IMPROVING RESEARCH COUNCILS' EFFECTIVENESS

The UK Research Councils, which account for over 80 per cent of Science Budget expenditure, are widely recognised as a major asset of the UK science and innovation system, driving up scientific excellence through competitive funding. Building on past reforms, the Government believes there is scope to review the effectiveness of the Research Councils' existing structure and operations, to maximise opportunities for knowledge transfer and increase the impact of excellent research on the wider economy.

The Government is inviting views on whether the Council for the Central Laboratory of the Research Councils (CCLRC) should be merged with the large facilities operations conducted by the Particle Physics and Astronomy Research Council (PPARC) to create a Large Facilities Research Council, to improve the strategic management of public investment in large research facilities, such as light sources, neutron sources, high power lasers, telescopes, particle accelerators, and space programmes. This would generate the critical mass to achieve a step change in opportunities for business engagement and commercialising the products of research.

The Government is also inviting views on whether the funding arrangements for the physical sciences should be simplified in the wake of these changes, and what further measures could be taken by Research Councils to improve their effectiveness.

RESEARCH COUNCILS IN THE UK

Role of the Research Councils 3.1 The Research Councils account for over 80 per cent of total Science Budget expenditure, amounting to around £2.8 billion by 2007-08 (Box 3.1). Unlike research funding from the Department for Education and Skills (DfES), which takes the form of a block grant to universities, Research Councils award grants for specific research projects on the basis of scientific excellence, as determined by peer review. This is done either through formal calls for proposals in specific research areas, or in "responsive mode", where researchers are free to submit proposals in any area they choose. In addition, many Research Councils also fund their own specialist research institutes, and subscribe to international science facilities.

Box 3.1: The UK Research Councils

There are currently eight Research Councils, covering a wide range of academic disciplines. These are listed below, together with their budgets:

	£ million, 2007-08
Arts and Humanities Research Council (AHRC)	97
Biotechnology and Biological Sciences Research Council (BBSRC)	382
Council for the Central Laboratory of the Research Councils (CCLRC)	213
Engineering and Physical Sciences Research Council (EPSRC)	721
Economic and Social Research Council (ESRC)	150
Medical Research Council (MRC)	546
Natural Environment Research Council (NERC)	367
Particle Physics and Astronomy Research Council (PPARC)	315
Total expenditure by Research Councils	2,791

Strengths of the current system 3.2 The Research Councils are widely recognised as a major asset of the UK's science and innovation system, driving up the quality of research by awarding funding competitively on the basis of rigorous scientific criteria. The current structure of Research Councils also encourages a balance of investment across a broad range of academic disciplines, promoting breadth as well as depth for the UK science base. In March 2005, a new performance management system was introduced for Research Councils, which will help to align investment with strategic research priorities, and encourage more effective exploitation of research to meet national economic and public service objectives. Research Councils are also increasingly cooperating to promote interdisciplinary research (where many of the most exciting opportunities for future technology development occur), for example by launching joint research programmes in stem cell research and energy research.

Opportunities for improvement 3.3 As well as these recognised strengths, however, there are specific areas where the performance of the Research Councils could be improved, to maximise the impact of public investment. The Research Councils are currently preparing proposals to harmonise further their administrative operations, improve the efficiency of the peer review process, and raise the impact of the science base on innovation and productivity, as part of preparatory work for the 2007 Comprehensive Spending Review. In addition, there is an opportunity to improve the management of large facilities within the Research Councils.

ECONOMIC IMPACT OF THE RESEARCH COUNCILS

3.4 The Research Councils have a key role in nurturing excellent research – indeed, businesses confirm that this is what they value in their interactions with the Research Councils. However, Research Councils are also focusing increasingly on making sure that research results are exploited effectively. As set out in the *Science and Innovation Investment Framework 2004-2014*, each Research Council has developed a strategy setting out explicitly for the first time plans and goals for increasing the rate of knowledge transfer and the level of interaction with business, which have been incorporated into the Research Councils' new performance management framework. This work provides a strong foundation as the Government continues to look for further ways to maximise the economic impact of Research Council spending. Box 3.2 provides some examples of how the work of the Research Councils has had a wider social and economic impact.

Box 3.2: Examples of Research Councils' social and economic impact

- **MRC research first identified the link between high blood pressure and heart disease, and went on to show that aspirin and warfarin reduce the chances of heart attacks and strokes;**
- **PPARC has funded a consortium to develop commercial applications for terahertz imaging, an analytical technique used to monitor planets. It has focused on the security market as the technology can image hidden guns and explosives. The technology is currently being trialled at UK airports; and**
- **NERC researchers provide the data required to inform decisions on when to raise or lower the Thames Barrier. Failing to prevent a flood would cost £30 billion, without counting the loss of human lives.**

RESEARCH COUNCIL EFFICIENCY REVIEW

3.5 In order to increase further the impact of the investment in Research Councils and build the evidence base for policy decisions to be made in the 2007 Comprehensive Spending Review, Research Councils are currently looking at the following key issues:

- *What improvements can be made to the Research Councils' structure and efficiency?* In particular, Research Councils will be exploring the scope for introducing joint administration, and for sharing best practice more effectively among the Councils. In addition, a review of best practice in the peer review process will be conducted, looking at the overall level of resources involved and whether these could be deployed more effectively.
- *How can the impact of the science base on innovation and productivity be increased?* The Director General of Research Councils (DGRC) has asked a group of senior academics and business people to advise him on how Research Councils can deliver – and demonstrate they are delivering – a major increase in the economic impact of their investments. This group has already started to gather views from stakeholders and will finalise its work over the next few months.
- *How will Research Councils work together more closely on promoting public engagement, careers in science, and on the diversity of the science work force?* All Research Councils will work through Research Councils UK (the Research Councils' umbrella organisation) to ensure that the effective coordination and delivery of the Government's science and society priorities are underpinned by clearly agreed strategic objectives and the commitment of agreed resources.¹

3.6 The Research Councils will present the conclusions of this work to the Government by summer 2006.

GETTING THE MOST OUT OF LARGE FACILITIES

What are large facilities?

3.7 Maintaining access to world-class experimental facilities is crucial if UK scientists are to remain internationally competitive at the cutting edge of their fields of research. Large facilities cover a wide range of infrastructure investments, including light sources (such as the new Diamond Synchrotron, the largest scientific facility to be built in the UK for almost thirty years), neutron sources, high power lasers, telescopes, particle accelerators and space programmes. Some of these facilities, for example neutron sources, are of use to a wide variety of researchers in physics, chemistry and biology, whereas others, such as particle accelerators, are of more specialist application.

Large facilities and the Research Councils

3.8 The Science Budget currently invests around £500 million in building and running large scale research facilities, many of which are provided through subscription to international consortia and bodies. The majority of that funding is managed through two Research Councils, PPARC and CCLRC, though smaller amounts are also spent in other Councils. CCLRC owns the UK's two national laboratories, Rutherford Appleton (RAL) in Oxfordshire, on the Harwell site, and Daresbury in Cheshire, where many of these large facilities are located. PPARC is responsible for the UK subscriptions to a number of international organisations such as CERN (the European Centre for Nuclear Research), operates UK-owned telescopes, and also currently provides funding direct to university research groups. CCLRC, with minor exceptions, does not fund universities directly. The OST also manages a separate Large Facilities Capital Fund (LFCF), currently worth £100 million per year, which allows Research Councils to seek additional capital for large scale investments.

¹ See <http://www.rcuk.ac.uk> for more information.

THE CASE FOR CHANGE

3.9 It is not clear that the scientific and wider economic potential of investment in large facilities is being exploited to best effect under the present arrangements.

A strategic approach to investment

3.10 Management of large research facilities is currently rather fragmented. Decisions on investment are frequently taken by different Research Councils without an overall priority-setting process. The exception to this is the sub-set of projects that are supported by the central LFCE, where funding is allocated in line with a “large facilities roadmap”, but these only account for around six to eight projects at any one time. In practice, there are institutional barriers to making investment decisions that reflect strategic choices between different areas of Research Council activity. A more coherent priority-setting process across the spectrum of large facilities investment would improve the quality and value for money of large facilities operations.

Maximising knowledge transfer opportunities

3.11 In addition, PPARC and CCLRC operate two national laboratories and other large facilities. These have considerable potential for greater engagement with business. There is no unified strategy for exploiting commercial opportunities arising from research conducted in large facilities, and no single contact point for businesses interested in accessing these facilities. A more coherent management structure for large facilities could enable a more integrated approach to knowledge transfer from them, making collaboration more attractive to business and maximising the economic impact of public investment in this area.

A new Large Facilities Council

3.12 These arguments suggest that there may be significant synergies and efficiencies to be gained from creating a single management structure for large facilities. In practice, this could be achieved by merging CCLRC with the large facilities operations conducted by PPARC, to create a new Large Facilities Council (LFC) with responsibility for all large facilities investment from the Science Budget. Based on existing CCLRC and PPARC expenditure, the LFC's budget would be of the order £450 – £500 million per annum, and could include a significant proportion of the funds currently allocated to the LFCE. The new LFC would:

- create for the first time a coherent approach to funding and operating large facilities in the Research Councils, aligning investment with strategic research priorities across the spectrum of Research Council activity; and
- generate the critical mass to achieve a step change in knowledge transfer from large facilities, maximising opportunities for business engagement and commercialising the fruits of research.

Creating “Science and Innovation Campuses”

3.13 In support of these objectives, the Government has decided that the Harwell site, which includes RAL, and the Daresbury site should become the Harwell and Daresbury Science and Innovation Campuses respectively. The Government will look to develop these campuses so as to ensure that the facilities located there are internationally competitive, support world-class science, and maximise opportunities for knowledge transfer. Work has been commissioned to explore how this should be delivered in practice.

A new structure for the physical sciences?

3.14 PPARC currently has a role both as a grant-giving Research Council and as an investor in large facilities. This has created different funding arrangements for different parts of the physical sciences, the remainder being the responsibility of EPSRC. If the large facilities operations currently managed by PPARC were to be transferred to a new LFC, this would be an opportunity to integrate PPARC's grant-giving operations with EPSRC. This would effectively mean that a single Research Council (EPSRC) would have responsibility for the full spectrum of physical sciences funding, and would be of particular benefit to physics departments, which have faced difficulties in attaining long-term sustainability. This change would create new synergies and simplify the existing institutional landscape among the Research Councils.

Discussion questions: Improving Research Councils' effectiveness

5. The Government would welcome views on whether all large facilities operations should be integrated under a new Large Facilities Council, or whether there is a case for some facilities to remain under the management of other Research Councils.
6. Furthermore, in the event of a merger, should the grant-giving functions of PPARC be moved to EPSRC?
7. The Government would welcome views on what further measures could be taken by the Research Councils to improve their effectiveness.

4

SUPPORTING EXCELLENCE IN UNIVERSITY RESEARCH

In order to maintain the UK's world-class university system, the Government is keen to ensure that excellent research of all types is rewarded, including user-focused and interdisciplinary research. It also wants to ensure that institutions continue to have the freedom to set strategic priorities for research, undertake "blue skies" research, and respond quickly to emerging priorities and new fields of enquiry.

The Government is strongly committed to the dual support system, and to rewarding research excellence, but recognises some of the burdens imposed by the existing Research Assessment Exercise (RAE). The Government's firm presumption is that after the 2008 RAE the system for assessing research quality and allocating "quality-related" (QR) funding will be mainly metrics-based.

The Government will launch a consultation on its preferred option for a metrics-based system for assessing research quality and allocating QR funding, publishing results in time for the 2006 Pre-Budget Report.

INTRODUCTION

The dual support system 4.1 The Government currently funds Higher Education Institutions' (HEI) research through the "dual support system". The logic behind the dual support system is that it provides two distinct, but related sources of income for university research. The Research Councils – funded through the Office of Science and Technology (OST) – fund specific projects and programmes on a competitive basis, as well as funding their own specialist institutes in many cases. They are able to take a national strategic view, ensuring excellence through peer review, and balancing directive and responsive support. By contrast, the funding bodies' allocation of "quality-related" (QR) funding is informed by the results of the Research Assessment Exercise (RAE) as a block grant to institutions. This allows universities to take strategic decisions about their research activities; builds capacity to undertake "blue skies" research and research not supported from other sources; creates flexibility to react quickly to emerging priorities and new fields of enquiry; and provides a base from which to compete for research funding from other sources.

4.2 The dual support system, and the commitment to reward excellence through both sides of the system, are key strengths of the UK's science base and have helped deliver the UK's world class standing in research outputs. The *Science and Innovation Investment Framework 2004-2014* highlighted the Government's commitment to both the dual support system and the importance of rewarding excellent research. This chapter reinforces the commitment to these two tenets and seeks to build on progress to date.

Quality-Related funding 4.3 By 2007-08, £1.45 billion will be allocated to the Department for Education and Skills (DfES) for QR, distributed through the Higher Education Funding Council for England (HEFCE). The Devolved Administrations distribute equivalent funding along similar lines. The Government is committed to maintaining the dual support structure, which has safeguarded the excellence of UK research in the past. The Government is keen to consider what improvements can be made within the dual support system to increase the effectiveness and economic impact of public investment in research. The previous chapters covered measures related to the Research Council side of the dual support system; this chapter focuses on QR. The Government has promised to keep under review the way in which QR funding is allocated. This chapter examines the reasons behind this review and outlines proposed next steps.

The RAE 4.4 At present, QR funding is linked to the Research Assessment Exercise (RAE). The RAE was originally conceived as a mechanism for ensuring that the more limited resources for research available at the time were focused on excellence, as determined by peer review. The RAE has evolved into a wider process that goes beyond informing funding decisions to provide a broader quality assurance. RAEs were held in 1989, 1992, 1996 and 2001. The next RAE is planned for 2008. The RAE is a UK-wide process managed by the four higher education funding bodies.

4.5 The RAE involves assessing the quality of higher education research through peer review led by discipline-based panels (units of assessment) considering written submissions from universities. Universities submit information on research-active staff and their outputs. The results of the RAE consist of a score for each unit of assessment which is subsequently linked to a funding formula so that a total QR income can be established at institutional level.

Impact of the RAE 4.6 Over the years since the RAE was introduced, research quality has risen significantly, as the RAE has acted as a driver of competition, focusing institutions on delivering high quality outputs. Following the 1996 RAE, 32 per cent of staff submitted worked in departments rated as “excellent”. In 2001 the figure was 55 per cent. This improvement was validated by international experts.

4.7 The RAE has played a key role in achieving the UK’s world-class standing in terms of research publications and citations. However, over the years, a number of observations have been made about the RAE. The 2003 review by the UK funding bodies of research assessment highlighted:

- the substantial administrative cost. HEFCE has estimated that the cost to institutions of the 2008 RAE will be at least £45 million;¹
- behavioural impacts on publishing and staff recruitment that have resulted in cyclical patterns that obstruct planning within HEIs;
- the peer review process is silo-driven and has, in the past, failed to capture fully the value of interdisciplinary research; and
- in theory, the RAE is supposed to reward excellent user-focused research in the same way it rewards excellent curiosity-driven research, but it is not at all clear that this has occurred in practice.

4.8 The funding bodies’ response to the 2003 review of research assessment was intended to address some of these problems, and a number of changes to the RAE have been implemented. However, the Government acknowledges the concerns of a number of commentators, including the Council for Science and Technology, the House of Commons Select Committee on Science and Technology and the Royal Society, that the RAE will continue to place a considerable burden on the sector while failing to recognise adequately the full range of high-quality research undertaken in universities.

4.9 The *Science and Innovation Investment Framework 2004-2014* stated that: “metrics collected as part of the next assessment will 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”. The Government’s firm presumption is that after the 2008 RAE, the system for assessing research quality and allocating QR funding will be mainly metrics-based.

¹ HEFCE Circular RAE 01/2004.

Principles for allocating funding 4.10 In considering any new allocation mechanism to replace the RAE, the Government wants to build on the success of the RAE in driving excellent research while addressing some of the shortcomings outlined above. The Government wants to focus debate on how to achieve funding arrangements that continue to reward excellence efficiently. In doing so, the following principles will be adhered to:

- excellent research of all types, from curiosity-driven to user-focused, should be rewarded, maintaining the international standing of the UK's research base, encouraging collaboration and supporting interdisciplinary work;
- the dual support system should be preserved so that QR funds can continue to provide HEIs with the freedom to invest strategically in research, drawing on their own strengths and reflecting local, national and international needs;
- the burden on HEIs should be minimised and only the information necessary to support a fair distribution of funds should be collected; and
- the assessment and allocation processes should:
 - be open to and apply equally to all institutions;
 - be simple, transparent and cost-effective;
 - result in a funding stream to an institution (not an individual or group); and
 - allow HEIs to plan effectively.

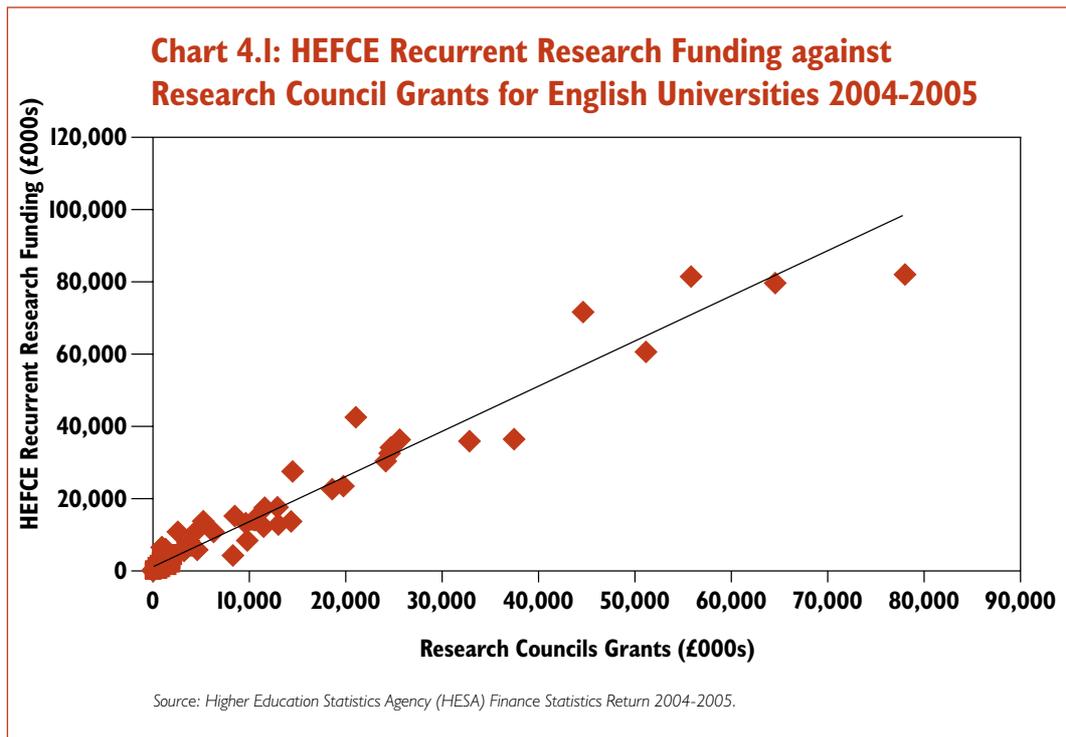
OPTIONS FOR A SIMPLER ALLOCATION SYSTEM

4.11 Over recent years a number of studies have considered options for a radically different allocation system for QR in order to avoid or reduce the need for a peer review process.² The focus in most cases has been on identifying one or more metrics that could be used to assess research quality and allocate funding, for example research income, citations, publications, research student numbers etc. The Government has considered the evidence to date and favours identifying a simpler system that may not precisely replicate the level of detailed analysis of the RAE but would enable an appropriate distribution of QR funding at the institutional level. The possibility of assessing research quality and allocating funding in relation to HEIs' research income is explored below.

Research grant income 4.12 Both elements of the dual support system reward excellent research through rigorous peer review processes: one through the RAE and the other to support Research Councils' decisions on the allocation of grants. The correlation between an HEI's QR and Research Council income streams, when measured at an institutional level, is very strong. Between 2000/01 and 2004/05 the average correlation was 0.98, with no variation across years.³ Chart 4.1 illustrates the relationship. The two separate peer review processes are largely delivering the same outcomes, with any major differences at departmental level balancing out at the institutional level. One of the major objectives behind QR funding is to provide HEIs with the resources and freedom to support their research priorities as they see fit. The Government wants this to continue, but thinks the close correlation between Research Council income and QR income may provide an opportunity for allocating QR using a radically simpler system.

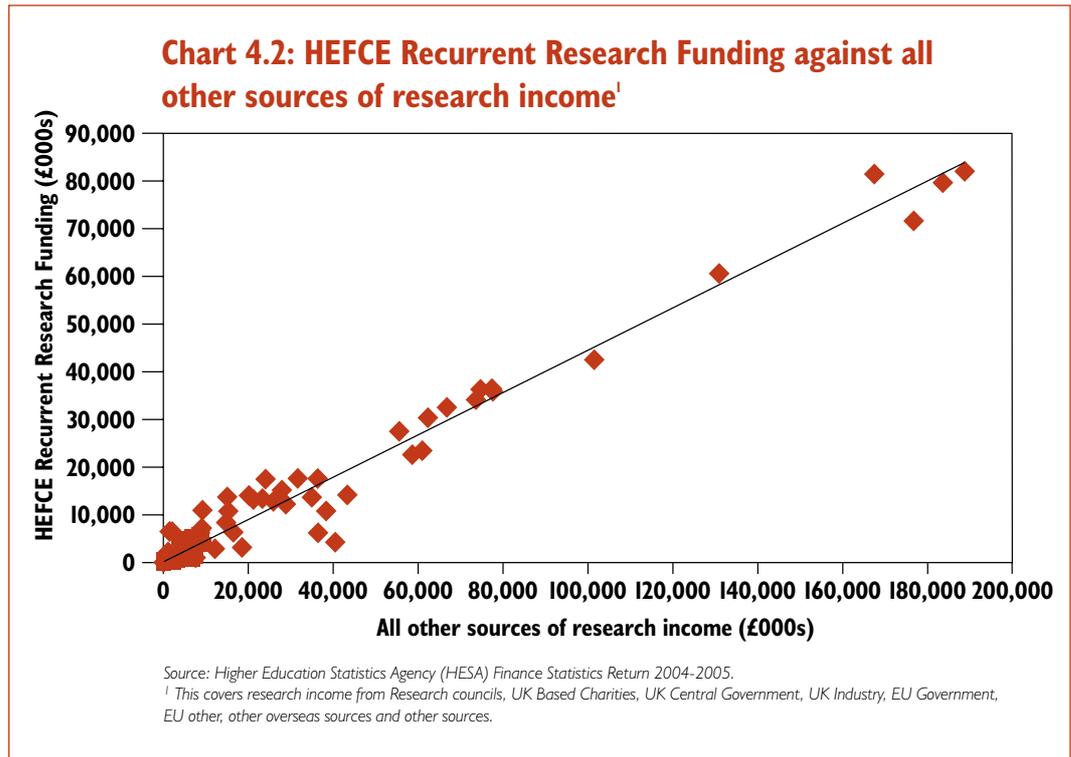
² For example, joint funding bodies' review of research assessment, *Invitation to contribute*, 2002; House of Commons Science and Technology Committee, *Research Assessment Exercise: a re-assessment*, 11th report of Session 2003-04; The Royal Society, *Supporting basic research in science and engineering: a call for a radical review of university research funding in the UK*, policy document 25/03.

³ A correlation coefficient gives a measure of the extent to which variations in one variable are related to variations in another. The closer the correlation is to +1, the stronger the relationship. Data source: Higher Education Statistics Agency (HESA) Finance Statistics Return, 2004-05.



4.13 In addition to rewarding excellent research, the first principle outlined in paragraph 4.10 above highlights the Government's intention to ensure that both curiosity-driven and user-focused research should be rewarded. As outlined in Chapter 1, as more countries move up the value chain, the nations that will thrive in the global knowledge economy will be those which produce the highest-quality research with relevance to the wider economy. Harnessing knowledge to wealth creation is therefore an increasingly important role for HEIs. One way of achieving this would be to relate QR allocations not just to institutions' Research Council income, but to the full range of their research income including charities, industry, the European Union and Government departments. The correlation between institutions' QR income and their total research income from other sources is strong. Between 2000/01 and 2004/05 the average correlation was 0.98, with a variation between 0.97 and 0.99 over the five year period.⁴ Chart 4.2 illustrates the relationship.

⁴ A correlation coefficient gives a measure of the extent to which variations in one variable are related to variations in another. The closer the correlation is to +1, the stronger the relationship. Data source: Higher Education Statistics Agency (HESA) Finance Statistics Return, 2004-05.



4.14 Using research income as a core element of a new allocation system would adhere to the principles outlined above, in particular through rewarding the full range of research conducted in HEIs.

Arts and humanities 4.15 The Government is also aware that while the correlation between research income and QR is close when measured at an institutional level, this is largely driven by science, engineering and medicine. It is therefore not clear that a metric based on research income would fairly support excellent research in the arts and humanities and some other subjects, such as mathematics. It might therefore be the case that other options would need to be explored for these subjects.

Expert panels 4.16 Alongside running a mainly metrics-based system, the Government will also explore the option of continuing to convene expert panels to provide an extra level of verification for the results generated by metrics. The panels would not be expected to hold their own information-gathering exercise. The number and nature of the panels would need to ensure they could cover the full range of pure and applied research activities and promote the fair treatment of all institutions.

CONCLUSION

4.17 The Government strongly supports the dual support system and the allocation of QR funds according to excellence. However, after 20 years of relying on the RAE to allocate these funds the Government thinks there is now sufficient evidence to support moving towards a simpler and less burdensome system of allocation. In order to prepare for a new system to be implemented after the RAE in 2008 the Government will run a shadow metrics exercise alongside the RAE 2008 and would look to implement changes post-RAE 2008. **The Government will launch a consultation on its preferred option for a metrics-based system for assessing research quality and allocating QR funding. The consultation will be launched in May with results published in time for the 2006 Pre-Budget Report.** This will involve all the higher education funding bodies.

4.18 The Government is aware that preparations for the 2008 RAE are well underway. It is therefore the Government's presumption that the 2008 RAE should go ahead, incorporating a shadow metrics exercise alongside the traditional panel-based peer review system. However, if an alternative system is agreed and widely supported, and a clear majority of UK universities were to favour an earlier move to a simpler system, the Government would be willing to consider that.

Health Research and Development (R&D) is an area of UK strength, promoting health and economic gains. The excellence of the health research base is key to attracting and retaining higher levels of business R&D investment. Currently public funding for health R&D is split between the Medical Research Council and the Department of Health. The Government is keen to ensure that the contribution of these funding streams is maximised. In recent years a number of initiatives have sought to address this, including the creation of a Joint MRC/NHS Health Research Delivery Group.

The Government's vision is of a holistic health R&D system that will maximise the value of the UK's health research base. Building on the reforms to date, the Government wants to ensure the UK's health research is more closely aligned with wider health objectives, builds on scientific progress to date, and translates the results of research into economic benefit.

Research budgets in the Office of Science and Technology are already ring-fenced. The Government intends similarly to ring-fence the Department of Health's R&D budget and that the Secretaries of State for Health and Trade and Industry will create a single, jointly held health research fund of at least £1 billion per annum, for which they will agree strategic priorities.

The Government will shortly invite a leading independent individual to advise on this and to launch a consultation in order to report on options to the Government in time for the 2006 Pre-Budget Report.

THE IMPORTANCE OF HEALTH RESEARCH

Health research and the UK economy

5.1 Health R&D is an area of marked UK strength. In addition to the obvious public health benefits, the quality of the UK's health research base, including medical research, is an important factor in retaining and growing R&D investment from the pharmaceutical industry – already the UK's largest contributor of private R&D, with over £3.3 billion of investment per year. The industry employs around 73,000 employees, 29,000 of which are employed in R&D-related activities, with a further 250,000 jobs in the supply chain. It has a growth rate of 4 to 5 per cent a year – exports in 2004 were over £12.3 billion, creating a trade surplus of £3.75 billion.¹ The UK's biotechnology sector is the largest in Europe and second globally only to the US. There are approximately 455 dedicated biotechnology businesses in the UK employing around 22,400 staff, with revenues of around £3.6 billion in 2003. UK biotechnology companies spent £1.23 billion on R&D in 2003. The UK accounts for around half of public biotech companies in Europe.²

5.2 In addition to these economic benefits, health research has the potential to make an important contribution to health outcomes. Few, if any, other countries have a health service that provides researchers with the potential to access virtually the entire population, through an integrated system of primary, secondary and tertiary care. This is a unique selling point for public sector researchers, charities and private sector organisations.

Role of DH and MRC

5.3 Currently, public funding for health R&D is split between the Medical Research Council (MRC – £546 million by 2007-08), and the Department of Health (DH – £753 million³ in 2006-07). The MRC covers the full spectrum of health research from basic research through

¹ Association of the British Pharmaceutical Industry (ABPI).

² *Comparative statistics for the UK, European and the US biotechnology sectors*, analysis year 2003, DTI February 2005.

³ This is the sum of £703 million resource and £50 million capital.

to clinical and public health, although the focus on the latter two has been more recent. The NHS R&D function is focused on the clinical and public health end, as well as applied research (health technology assessment and health services delivery). In common with other Research Councils, MRC funding is allocated to specific research activities on a competitive basis, either individual projects, larger programmes, or research centres in universities or in the MRC's own institutes. By contrast, the vast bulk of DH funding is allocated as an institutional grant to NHS Trusts, until now on a formulaic basis. In future, under the new NHS R&D Strategy,⁴ DH funding will be firmly targeted towards supporting outstanding individuals, working in world-class facilities, conducting leading-edge research focused on the needs of patients and the public.

Coordinating health R&D 5.4 The Government is keen to ensure that the contribution of these funding streams is maximised. In recent years a number of initiatives have sought to address this concern, including:

- the creation of the UK Clinical Research Collaboration (UKCRC) in 2004, bringing together the NHS, research funders, industry and other stakeholders to develop joint actions to support clinical research in the UK, and exploit the potential of the NHS more effectively. The UKCRC is widely acknowledged in the health research community to have been an important step forward in providing coordination of strategy and funding between public, private and voluntary funders of clinical research;
- the creation of a Joint MRC/NHS Health Research Delivery Group in 2004, to improve the strategic management and delivery of health R&D. The Joint Delivery Group has been successful in sharing research portfolios across the two organisations and in taking forward joint working, for example in health economics and informatics;
- the announcement of a new R&D strategy for the NHS in the 2005 Pre-Budget Report, *Best Research for Best Health*, including the creation of a National Institute for Health Research (NIHR) to coordinate research in the NHS, and an increased focus on promoting excellence in clinical trials and facilitating clinical trials. Implementation of the strategy begins in April 2006;
- establishing Medical Research Council Technology (MRC Technology) in 2000, bringing together a range of existing technology transfer functions to create a critical mass of patenting and licensing functions with laboratories and scientists; and
- a stronger focus, within the Research Councils' performance management framework introduced in 2005, on the dual importance of excellent science and knowledge transfer, and the requirement on all Research Councils to produce knowledge transfer plans.

⁴ *Best research for best health: a new national health research strategy*. Department of Health, January 2006, available at: <http://www.dh.gov.uk/>

5.5 In addition, the 2005 Pre-Budget Report announced a range of measures building on *Best Research for Best Health*, including: a commitment to ensure the national NHS IT network facilitates the recruitment of patients for clinical trials; creating a “one-stop shop” for industry to make informed decisions about the feasibility and suitability of a trial site; and further streamlining of the regulatory and governance processes for clinical trials. In response to these initiatives, the pharmaceutical industry made it clear that a step-change in their clinical research investment in the UK is very achievable if the right environment is established. They believe it would be likely to rise by as much as £500 million a year in the short to medium term and around £1 billion a year in the medium to long term. Box 5.1 outlines some of the key achievements delivered by the MRC and DH R&D.

Box 5.1: MRC and Department of Health achievements in health R&D

- **The pioneering MRC-supported work of Sir Richard Doll on the link between smoking and cancer, cardiovascular disease and many other disorders, has led to the dramatic reduction in smoking rates in Britain over the past 50 years, especially among men.**
- **MRC researchers were the first to identify the human flu virus – a discovery that has helped to save millions of lives.**
- **MRC patents cover a series of inventions from the MRC Laboratory of Molecular Biology during the late 1980s and early 1990s for making “humanised” or fully human monoclonal antibodies. These technologies have had a major impact on health and the economy in the last decade with 114 therapeutic antibodies already marketed. Examples include the drug HUMIRA®, which is used to treat rheumatoid arthritis, early rheumatoid arthritis and psoriatic arthritis.**
- **Since it was founded, 22 Nobel Laureates have worked for, been supported by, or had associations with the MRC. In particular, MRC Laboratory of Molecular Biology scientists have been awarded 12 Nobel Prizes.**
- **The NHS R&D Programme has established research networks in the NHS in areas of key importance to health and health care. For example, the National Cancer Research Network has more than doubled the number of cancer patients in research studies. As a result, a greater percentage of cancer patients in the UK are participating in research studies of the latest advances in cancer diagnosis, treatment and care than anywhere else in the world.**
- **The world-renowned NHS Health Technology Assessment programme has provided crucial evidence to underpin guidance from the National Institute for Health and Clinical Excellence and is undertaking new research that only the NHS can do such as the PROTECT trial to determine the most effective treatment for prostate cancer and the EVAR study of endovascular stents for abdominal aneurysms.**
- **The Department of Health has ensured that funding and support is available in the NHS to enable landmark research studies to be delivered. These studies – such as the Heart Protection Study on statins and the CRASH trial on corticosteroids in head injury – have led to paradigm shifts in the way that care is delivered across the world.**

CREATING A WORLD-CLASS ENVIRONMENT FOR HEALTH R&D

The Government's vision **5.6** The Government's vision is of a holistic health R&D system that will maximise the value of the UK's health research base, delivering additional health and economic benefits. Building on reforms to date, the Government wants to ensure the UK's health research supports three inter-linked objectives:

- health objectives – ensuring research priorities are firmly grounded in the Government's wider health objectives, national and international, and that health research is rooted in, and a key priority for, the NHS;
- science objectives – ensuring the continued delivery of world-class basic science, according to the long-standing Haldane principle which states that day-to-day decisions on Research Council scientific funding must be taken at arms-length from ministers. Funding would continue to be awarded on the basis of excellence across the full spectrum of health research, from basic to clinical and public health. This will include continued support for investigator-led research; and
- economic objectives – ensuring the delivery of high-quality translational health research to deliver real economic, as well as health, benefits, from the UK's excellent science base.

5.7 **Research budgets in OST are already ring-fenced. Building on the reforms introduced to date, the Government intends similarly to ring-fence the Department of Health's R&D budget and that the Secretaries of State for Health and Trade and Industry will create a single, jointly held health research fund of at least £1 billion per annum, for which they will agree strategic priorities in line with the health, science and economic objectives above.**

5.8 The Government is aware of the complexities involved and wants to ensure stakeholders have an opportunity to comment on the institutional arrangements that would be required to deliver the objectives outlined above. This includes the involvement of the Devolved Administrations. **The Government will shortly invite a leading independent individual to advise on this and to launch a consultation in order to report on options to the Government in time for the 2006 Pre-Budget Report.**

The *Science and Innovation Investment Framework 2004-2014* highlighted the importance of a strong supply of scientists, engineers and technologists to support the UK's ambition to move to a higher level of research and development (R&D) intensity. The Government's ambition is to create an education and training environment that delivers the best in science teaching and learning at every stage. Despite the progress in taking forward the *Science and Innovation Investment Framework 2004-2014*, the Government is concerned that progress towards meeting its ambitions is relatively slow in some areas, and that there is scope for further action to improve the quality of science, technology, engineering and mathematics (STEM) education and increase the supply of STEM skills. **The Government has therefore set new ambitions, including to:**

- **achieve year on year increases in the number of young people taking A levels in physics, chemistry and mathematics so that by 2014 entries to A level physics are 35,000 (currently 24,200); chemistry A level entries are 37,000 (currently 33,300); and mathematics A level entries are 56,000 (currently 46,168);**
- **continually improve the number of pupils getting at least level 6 at the end of Key Stage 3 (11-14 year olds);**
- **continually improve the number of pupils achieving A*-B and A*-C grades in two science GCSEs; and**
- **step up recruitment, retraining and retention of physics, chemistry and mathematics specialist teachers, so that by 2014 25 per cent of science teachers have a physics specialism; 31 per cent of science teachers have a chemistry specialism; and the increase in the number of mathematics teachers enables 95 per cent of mathematics lessons in schools to be delivered by a mathematics specialist (compared with 88 per cent currently).**

To meet these ambitions, the Government announces a package of measures to improve the skills of science teachers, the quality of science lessons and increase progression to A level sciences, including new commitments to:

- **make science a priority in schools by including science in the School Accountability Framework;**
- **an entitlement from 2008 for all pupils achieving at least level 6 at Key Stage 3 to study three separate science GCSEs, to increase progression to, and attainment at, A level science;**
- **continue the drive to recruit science graduates into teaching via Employment Based Routes with new incentives to providers of £1,000 per recruit to attract more physics and chemistry teachers; and**
- **develop and pilot a Continuing Professional Development (CPD) programme leading to an accredited diploma to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy they need to teach these subjects effectively.**

THE IMPORTANCE OF THE STOCK AND FLOW OF SKILLED SCIENTISTS

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. A highly skilled and diverse workforce will drive innovation and growth. A strong supply of science, technology, engineering and mathematics (STEM) skills will enable UK businesses to exploit new technologies and scientific discoveries, achieve world-class standards and compete globally.

6.2 In March 2001, Sir Gareth Roberts was asked to undertake a review into the supply of science and engineering skills in the UK. The Roberts Review,¹ published in 2002, identified a number of problems in the supply of STEM skills, including significant falls in the numbers taking physics, mathematics, chemistry and engineering qualifications. The review concluded that these downward trends could undermine the Government's attempts to improve the UK's productivity and competitiveness.

6.3 The Government's response to the recommendations of the Roberts Review was outlined in *Investing in Innovation*,² and expanded upon in the *Science and Innovation Investment Framework 2004-2014*. These documents set out the Government's commitment to achieving a step change in the quality of science education and increasing the supply of graduates with STEM skills. Additionally, in the 2004 Pre-Budget Report, Lord Leitch was asked by the Government to consider what the UK's long-term ambition should be for developing skills in order to maximise economic prosperity and productivity and improve social justice. The Leitch Review will conclude later in 2006.

THE TEN-YEAR SCIENCE AND INNOVATION INVESTMENT FRAMEWORK

Commitments and ambitions

6.4 The *Science and Innovation Investment Framework 2004-2014* set out the Government's approach towards achieving a step change in the level of science skills in the UK economy. It outlined the Government's ambition to create an education and training environment that delivers the best in science teaching and learning at every stage, and is responsive to the needs of learners, employees, employers and the wider economy.

6.5 More specifically, the Government's 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 science, engineering and technology subjects in post-16 education and in higher education; and
- the proportion of better qualified students pursuing R&D careers.

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

² *Investing in Innovation: a strategy for Science, Engineering and Technology*, July 2002, available at www.hm-treasury.gov.uk

6.6 The *Science and Innovation Investment Framework 2004-2014* set out measures to improve the teaching and learning of STEM subjects and help the Government meet the above ambitions. This included measures to:

- improve the recruitment and retention of science teachers, for example by increased “Golden Hellos”;
- build on the roles of Higher Education Institutes (HEIs) and other stakeholders to better inform students about the choices they have on entering higher education;
- improve the under-representation of women in STEM education and the workforce; and
- bring coherence and coordination to the many STEM initiatives across the education system and review success.

Progress to date

6.7 The first Annual Report on the *Science and Innovation Investment Framework 2004-2014*, published in July 2005, raised concerns that progress towards meeting the ambitions above was relatively slow. The Annual Report noted some improvement in GCSE attainment for science and mathematics in 2004, but a continued decline in the number of A level entries in some sciences. It also noted a mixed picture for take-up of science subjects at university level.

6.8 Significant progress has been made in implementing the measures outlined in the *Science and Innovation Investment Framework 2004-2014*. Key achievements between 2004 and 2005 include:

- implementation of training bursaries and Golden Hellos to attract more science teachers into the profession;
- support for the Continuing Professional Development (CPD) of science teachers, for example through the establishment of Science Learning Centres in each region;
- the launch of a cross-cutting programme to rationalise and increase the effectiveness of the range of initiatives supported by Government and its partner organisations to promote interest in STEM subjects at all levels; and
- the creation of a Women’s Resource Centre to work in partnership with businesses to increase the opportunities for professional women in science, technology and engineering.

GCSE science curriculum 6.9 The GCSE science curriculum has also been reviewed and amended with the aim of making science more interesting to young people. This was in response to a Nuffield Foundation report, *Beyond 2000*,³ indicating that science in schools was neither encouraging sufficient numbers of students to study science further, nor adequately addressing the science needs of future citizens. The main thrust of the revision is to reduce prescription, thus allowing schools greater flexibility to design a curriculum tailored to their needs. The new science programme is based on ‘how science works’ and includes scientific methods and the way scientific knowledge develops. The new Key Stage 4 (14-16 year olds) programme of study was published in 2004, and the new GCSE specifications will be taught from September 2006.

THE REMAINING CHALLENGES

6.10 Despite the progress in taking forward the measures contained in the *Science and Innovation Investment Framework 2004-2014*, the Government cannot be complacent, as significant challenges remain. The Government is concerned that progress towards meeting its ambitions is relatively slow in some areas, and that there is scope for further action to improve the quality of STEM education and increase the supply of STEM skills.

Pupil attainment 6.11 Pupil attainment for science in primary school is good. At age 11 the number of pupils achieving level 4 (the expected level for their age) has risen from 78 per cent in 1999 to 86 per cent in 2005. Additionally, the numbers achieving level 5 (the above average level) have risen from 27 per cent in 1999 to 47 per cent in 2005. The situation at GCSE level, however, is less encouraging, with only 50 per cent of students getting a good grade (A*-C) at GCSE. This compares to 57.2 per cent of 15 year olds achieving grade A*-C in GCSE English and 51.5 per cent in GCSE mathematics.

6.12 Between 1994 and 2004, the number of 16-18 year olds taking biology A level increased by 6.6 per cent, but fell for chemistry by 7.5 per cent, and by 20 per cent for physics entries. Declining science A level entries have repercussions on the numbers studying science at HE. For example, those graduating with an undergraduate degree in chemistry fell by 27 per cent between 1994/95 and 2001/02, and by a further 7 per cent between 2002/03 and 2004/05.

6.13 Reversing the above trends is critical to achieving the ambitions of the *Science and Innovation Investment Framework 2004-2014*. To achieve this, Budget 2006 announces new commitments to:

- **work with schools and other partners, with the aim of achieving year on year increases in the numbers of young people taking A levels in physics, chemistry and mathematics so that by 2014 entries to A level physics are 35,000 (currently 24,200); chemistry A level entries are 37,000 (currently 33,300); and mathematics A level entries are 56,000 (currently 46,168);**
- **work with schools and others to continually improve the number of pupils getting at least level 6 at the end of Key Stage 3 (11-14 year olds);**
- **continually improve the number of pupils achieving A*-B and A*-C grades in two science GCSEs;**

³ *Beyond 2000: Science Education for The Future*, Nuffield Foundation 1998.

- step up recruitment, retraining and retention of physics, chemistry and mathematics specialist teachers so that by 2014, 25 per cent of science teachers have a physics specialism (compared to 19 per cent currently); 31 per cent of science teachers have a chemistry specialism (compared to 25 per cent currently); and the increase in the number of mathematics teachers enables 95 per cent of mathematics lessons in schools to be delivered by a mathematics specialist (compared with an estimated 88 per cent currently); and
- work with schools to further improve our world class position in international comparisons of school science.

6.14 If the Government is to meet the goals outlined above, a number of significant challenges must be overcome. The following sections explain these challenges in more detail and highlight the policy priorities in each area.

Making science a priority in schools

6.15 The renewed focus on English and mathematics in schools has meant that in some schools this has been to the detriment of science. Evidence from the Office for Standards in Education in England (Ofsted) suggests that in too many primary schools science has ceased to be regarded as a core subject, and little energy has been put into planning and teaching an exciting and engaging programme of science. Ofsted find that in less well-managed schools attention has been diverted to focus solely on literacy and numeracy to the detriment of other subjects, especially in Year 6.

6.16 Public Sector Agreement (PSA) targets exist for attainment at Key Stages 2 (7-11 year olds), 3 (11-14 year olds) and 4 (14-16 year olds). Of these, science is specifically identified only at Key Stage 3. Attainment is not, however, the only measure of success, increasing the number of pupils progressing from GCSE science to A level science is also important. **A key policy priority is to make science a priority in schools at all levels through formal accountability mechanisms which monitor student attainment in science and the number of pupils progressing to study science at A level.**

Box 6.1: Making science a priority: commitments

To make science a priority in schools using formal accountability mechanisms the Government will:

- **from 2007, include the percentage of pupils who achieve two or more good (A*-C) GCSEs in science in or alongside school performance tables;**
- **build monitoring of pupil attainment in science into every school's self evaluation and the dialogue with the school's school improvement partner; and**
- **work with schools to consider ways of getting more transparency around post 16 progression rates, so that schools are aware of the importance of students progressing to study A level sciences.**

Improving the skills of the workforce

Teacher recruitment 6.17 A good supply of high-quality science teachers is crucial to achieving results in the classroom. Ofsted has found that the quality of science teaching is related to teachers' initial qualifications. Where the match between the teachers' qualifications and the subjects they taught was thought to be excellent/good by Ofsted, the quality of teaching was excellent/very good or good in 94 per cent of schools. This compares to schools with an unsatisfactory match of teacher qualifications to subjects, which resulted in the quality of teaching being good in 22 per cent of schools, satisfactory in 26 per cent and unsatisfactory in 12 per cent of schools.

6.18 Currently, however, there is an imbalance of teacher specialisms: 44 per cent of science teachers have a biology specialism, 25 per cent are specialised in chemistry and 19 per cent in physics. This has resulted in a quarter of maintained 11-16 secondary schools lacking a physics specialist. According to the National Foundation for Educational Research (NFER),⁴ less than one third of those teaching the physics element of double award science have a degree in physics or are qualified to teach it through Initial Teacher Training (ITT). The Government recognises that there have been improvements in the overall recruitment of science teachers but notes that the balance between specialisms is of concern.

The quality of teaching 6.19 CPD is key to keeping teachers up to date and helping teachers teach outside their subject specialisms. Overall, there is now a good supply of relevant science CPD focused on both local and national priorities. The Annual Report on the *Science and Innovation Investment Framework 2004-2014* noted that regional Science Learning Centres have now been established in each region delivering CPD courses, but that take up on these courses has been slow with limited results so far.

6.20 **The policy priority is to improve the quality of teaching and learning through further recruitment and retention of science teachers with specialisms in physics and chemistry and increased take up of subject-specific CPD.**

⁴ *Mathematics and Science in Secondary Schools: The Deployment of Teachers and Support Staff to Deliver the Curriculum*, NFER Research Report 708, January 2006.

Box 6.2 Improving the quality of teaching and learning: commitments

To improve the quality of teaching and learning the Government will:

- remit the School Teachers' Review Body (STRB) to advise on improving the use of current pay incentives and flexibilities to improve the recruitment, retention and quality of science and mathematics teachers;
- from 2006, continue the drive to recruit science graduates into teaching via Employment Based Routes, with new incentives for providers of £1,000 per recruit to attract more physics and chemistry teachers;
- from 2006, offer additional courses to enhance physics, chemistry and mathematics subject skills for those entering teaching who do not have a recent degree in the subject;
- develop and pilot a CPD programme leading to an accredited diploma to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy they need to teach these subjects effectively;
- remit the STRB to advise on whether science teachers who are not physics and chemistry specialists should receive an incentive to encourage them to complete physics and chemistry enhancement CPD, leading to an accredited qualification;
- expand the student associates scheme to give science and mathematics students at university a taste of teaching with a view to encouraging them to pursue teaching as their career; and
- from 2006, produce a range of case studies which evidence the school level factors associated with high levels of progression to post 16 science and maths study and disseminate these through the Secondary National Strategy.

Collaboration and partnership 6.21 The *Science and Innovation Investment Framework 2004-2014* recognised the importance of working in partnership with key stakeholders, including employers, universities, science centres, learned societies and Research Councils, to demonstrate to young people some of the exciting and inspiring opportunities that studying science can lead to. One such initiative is the Science and Engineering Ambassadors Scheme, which places role models from businesses in schools. There are over 12,000 Science and Engineering Ambassadors across the UK, representing over 700 different employers from a large range of multinationals and other organisations such as the NHS and the Environment Agency. On average, each ambassador works with schools on two to three occasions per year. The Government fully supports industry's efforts in this area. Additionally, sharing best practice and working in partnership with schools that have high attainment and progression rates is an important tool to develop teacher quality. **The policy priority is therefore to improve collaboration between schools but also between schools and industry and the science base.**

Box 6.3 Collaboration and Partnership: commitments

To support collaboration and partnership the Government will:

- produce guidance and consider the use of financial incentives to encourage schools and Higher Education Institutes to share resources and expertise with other schools in the area, including expanding on existing partnership schemes such as the 'Building Bridges Scheme';
- from 2006, the Secondary Strategy and Specialist Schools and Academies Trust (SSAT) to identify and systemise models of effective collaborative working and distribute among schools;
- engage more effectively with employers and universities on how they can help support attainment and progression in science to higher education and science careers through a model of best practice;
- significantly expand the Science and Engineering Ambassadors scheme to support teachers and engage and enthuse pupils to continue studying science; so that by 2007-08 the total number of ambassadors will be 18,000, an increase of 50 per cent; and
- from 2006, pilot 250 after school science clubs to offer an engaging and stretching programme of activities to Key Stage 3 pupils with interest and potential in science.

Improving the quality of science lessons

The quality of science lessons 6.22 Ofsted have reported that pupils' attitudes to science are affected by how actively involved they are through scientific enquiry, making decisions and expressing views. Despite the importance of practical experiments, the Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS) in 2005 reported that, "There are significant misunderstandings on the part of teachers and technicians about the chemicals and scientific activities which are banned in secondary schools and some teaching is inhibited by unjustified concerns about health and safety."⁵

6.23 The Roberts Review found that science and design and technology laboratories and equipment are vital to pupils' education in these subjects, both in directly educating pupils about areas of science and technology, and in interesting them and enthusing them to study these subjects further. Modern well-equipped laboratories are more likely to influence students' perceptions of science and post-16 choices. Research commissioned by the Royal Society of Chemistry in 2004, however, showed that 35 per cent of the 26,340 secondary school science laboratories in England were graded good or excellent. Of the remainder, 25 per cent were considered either unsafe or unsatisfactory for the teaching of science. The Government is committed to improving school accommodation: by 2007-08, capital investment in schools will have reached £6.3 billion a year. **The policy priority is to improve the state of school science accommodation by making school science labs a priority.**

⁵ 'Surely that's banned?' A report for the Royal Society of Chemistry on Chemicals and Procedures thought to be Banned from use in Schools, October 2005.

Box 6.4 Improving the quality of science lessons: commitments

To improve the quality of practical experiments and school science accommodation, the Government will:

- review the Building Schools for the Future (BSF) exemplar designs for school labs to ensure they reflect the latest thinking on what is required to ensure effective interactive teaching; and
- ask the Secondary National Strategy to identify and promote effective practice in interactive teaching including imaginative use of practical work.

Increasing progression to A level sciences

The curriculum 6.24 A science curriculum that is relevant to the modern world and imparts key knowledge and skills is critical to the future supply of STEM skills. The curriculum should not only provide all pupils with a sufficient understanding of science for their role as scientifically literate citizens, but should also excite young people to study science further. The new Key Stage 4 (14-16 year olds) curriculum and the new science GCSEs have these principles in mind. **The policy priority is to review and evaluate the effectiveness of these changes and ensure that science enthuses and inspires pupils – particularly the most able pupils – whilst providing a sound basis for further study.**

Box 6.5 The curriculum: commitments

The Government will:

- ask the Qualifications and Curriculum Authority (QCA) to design and implement monitoring arrangements for the new Key Stage 4 programme of study which will include consulting a group of independent scientists;
- ask QCA to consider and seek advice from independent scientists on how the new Key Stage 3 programme of study can stretch the most able pupils;
- develop a new strand of the Secondary National Strategy focused on support to increase the numbers achieving level 6+ at Key Stage 3; and
- provide additional training and guidance for teachers delivering the new science Key Stage 4 programme of study and GCSEs.

6.25 At GCSE, students have a choice of taking a single science, a double science or three separate sciences. The type of science GCSE taken has an impact upon the likelihood of pupils to progress to A level study in science and their attainment. The odds of getting an A or B at A level chemistry in the maintained sector are increased by 76 per cent for pupils who take three separate science GCSEs compared to those who took double science. Double science equips pupils with the necessary skills for A level but the three separate sciences appear to be an important determinant of progression. It is also crucial to have mechanisms in place to stretch the most able pupils as much as possible. **The policy priority is to increase provision of the three separate science GCSEs.**

Box 6.6 GCSE options: commitment

The Government will:

- by September 2008, all pupils achieving at least level 6 at Key Stage 3 to be entitled to study triple science GCSE, for example through collaborative arrangements with other schools, FE colleges and universities;
- by September 2008, ensure that all specialist science schools offer triple science at least to all pupils achieving level 6+ at the end of Key Stage 3; and
- encourage all schools to make triple science available to all pupils who could benefit.

Careers advice 6.26 For young people to make informed decisions about learning and career choices it is crucial to ensure they have access to good quality careers education and guidance. The Government recognises the range of work that R&D-intensive industries undertake in partnership with schools and universities to encourage pupils to engage in science. The Government fully supports these activities and encourages further participation. **The policy priority is to work with the science base and industry to improve young people's and their parents' awareness of the benefits of studying science and the career opportunities available.**

Box 6.7 Careers advice: commitment

The Government will work with key stakeholders to develop ways to improve the awareness of young people and their parents and teachers of the benefits of studying science and the career opportunities available to those with science, engineering and maths degrees and other qualifications.

International benchmarking

6.27 The above sections have outlined a comprehensive package to help achieve a number of ambitions. The real test for success, however, is how the UK performs in relation to other countries. There have been a number of such comparisons: for example, the Programme for International Student Assessment (PISA)⁶ is an internationally standardised assessment that was jointly developed by participating countries and administered to 15 year-olds. Unfortunately, the two most recent studies (PISA 2003 and TIMSS 2003) do not include the UK due to problems with the sample size in England. **The policy priority is to continue to monitor UK performance in international benchmarks.**

Box 6.8 International benchmarking: commitment

As part of the annual reporting on the *Science and Innovation Investment Framework 2004-2014*, the Government will continue to monitor performance in international benchmarks, and will encourage all schools to take part in international assessments.

⁶ <http://nces.ed.gov>.

Conclusion

6.28 In summary, the Government recognises the progress made in moving towards the vision set out in the *Science and Innovation Investment Framework 2004-2014* and in improving the provision of science education, but believes that further steps are necessary to meet its targets. The package of measures outlined in this chapter reflects this concern, and will: raise the profile of science in schools; improve the quality of science teachers; and increase progression rates to A level sciences.

INVITATION FOR COMMENTS

7.1 This document sets out the Government's thoughts on the long-term challenges facing UK science and innovation and next steps to build on the *Science and Innovation Investment Framework 2004-2014*. Views are invited on proposals outlined in Chapter 2 "Maximising the impact of science on innovation" and Chapter 3 "Improving Research Councils' effectiveness".

Summary of discussion questions

1. The Government would be interested in views about whether the existing framework for supporting science and innovation enables an appropriate level of risk-taking, and if not, suggestions of how any gap might be addressed.
2. The Government invites views on measures to remove any remaining bias which unfairly favours established research fields over innovative ones. The Government also invites views on how funding mechanisms can be made more responsive to new research challenges.
3. The Government would welcome views on the barriers limiting greater business innovation and business-university collaboration in the regions, and on what more could be done on a national and regional level to tackle these barriers effectively.
4. The Government would welcome views – in particular from outside Higher Education - which can be taken into account in developing best practice models for business-university collaboration. In addition, the Government would welcome views on how to encourage businesses to work with universities for the first time, perhaps by introducing short-term, low-cost mechanisms for business-university interaction.
5. The Government would welcome views on whether all large facilities operations should be integrated under a new Large Facilities Council, or whether there is a case for some facilities to remain under the management of other Research Councils.
6. Furthermore, in the event of a merger, should the grant-giving functions of PPARC be moved to EPSRC?
7. The Government would welcome views on what further measures could be taken by the Research Councils to improve their effectiveness.

HOW TO RESPOND

7.2 The consultation period will begin on 22 March 2006 and run for 12 weeks until **16 June 2006**. Please ensure that your response reaches us by that date. Please send responses to this consultation document to:

Science Consultation
 c/o Fiona Mackay
 Bay 365
 Office of Science and Technology
 1 Victoria Street
 London SW1H 0ET

Tel. (+44) (0) 207 215 5689
 Fax (+44) (0) 207 251 3830

Email: scienceconsultation@dti.gsi.gov.uk

7.3 When responding please state whether you are responding as an individual or representing the views of an organisation. If responding on behalf of a larger organisation please make it clear who the organisation represents, and where applicable, how the views of members were assembled.

7.4 The Government has sought to provide numerous opportunities to comment on policy in this area as it has developed. Respondents should therefore not feel the need to reiterate their previous substantive observations in response to earlier reviews. This consultation welcomes responses from every part of the UK.

7.5 All written responses will be made public unless the author specifically requests otherwise. Responses will be published within three months of the closing date at http://www.ost.gov.uk/policy/science_consult.htm. In the case of electronic responses, general confidentiality disclaimers that often appear at the bottom of e-mails will be disregarded unless an explicit request for confidentiality is made in the body of the response. If you wish part, but not all, of your response to remain confidential please supply two versions - one for publication, and a second, confidential version.

PARTIAL REGULATORY IMPACT ASSESSMENT

7.6 A partial Regulatory Impact Assessment (RIA) on the proposals covered in this document follows at Annex A, and should be read in conjunction with this document.

THE CONSULTATION CRITERIA

7.7 The consultation is being conducted in line with the Code of Practice on Consultation. The criteria are listed below (a full version of the criteria can be found at <http://www.cabinet-office.gov.uk/regulation/Consultation/Code.htm>).

The six consultation criteria

- 1 Consult widely throughout the process, allowing a minimum of 12 weeks for written consultation at least once during the development of the policy.
- 2 Be clear about who may be affected, what questions are being asked, and the timescale for responses.
- 3 Ensure that your consultation is clear, concise and widely accessible.
- 4 Give feedback regarding the responses received and how the consultation process influenced the policy.
- 5 Monitor your department's effectiveness at consultation, including through the use of a designated consultation co-ordinator.
- 6 Ensure your consultation follows better regulation best practice, including carrying out a Regulatory Impact Assessment if appropriate.

If you feel that this consultation does not fulfil these criteria please contact:

Julie Humphreys
HM Treasury
1 Horse Guards Road
London SW1A 2HQ

Tel: (+44) (0) 207 270 5543

Email: Julie.Humphreys@hm-treasury.x.gis.gov.uk

TITLE OF THE DISCUSSION PAPER

A.1 *Science and Innovation Investment Framework 2004-2014: Next Steps*

PURPOSE AND INTENDED EFFECT

Objective of the paper

A.2 The discussion paper presents the next steps in taking forward the Government's *Science and Innovation Investment Framework 2004-2014*. It announces further measures to create a more effective science and innovation system in the UK, and invites views on a range of issues which are relevant to the Government's ambition to improve the UK's science and innovation performance and maximise the impact of public investment in research on the economy.

Background to the paper

A.3 Science and innovation are key drivers of productivity, and raising the UK's science and innovation performance has been a priority for the Government. In July 2004, the Government published the *Science and Innovation Investment Framework 2004-2014*, to set a long-term strategy to improve the UK's R&D and innovation performance. This included a headline ambition to raise public and private investment in R&D to 2.5 per cent of GDP by 2014, and measures to improve the sustainability of the UK science base and make it more responsive to the needs of the economy and society.

A.4 The first Annual Report on the *Science and Innovation Investment Framework 2004-2014*, published in July 2005, found that solid progress had been made in implementing the framework, but that key challenges remain in encouraging greater business investment in R&D and raising science, technology, engineering, and mathematics (STEM) skills. The Government believes the time is right to consider whether the UK has the right "ecosystem" in place to increase levels of innovation and deliver the maximum impact from public investment in the science base on the wider economy and society. The paper takes forward policy in five key areas: maximising the impact of public investment in science on innovation; increasing Research Councils' effectiveness; supporting excellence in university research; supporting world-class health research; and increasing the supply of STEM skills.

CONSULTATION

A.5 This Partial Regulatory Impact Assessment accompanies the discussion paper *Science and Innovation Investment Framework 2004-2014: Next Steps*. The deadline for responses to the discussion paper is **16 June 2006**. Responses are invited in two areas: maximising the impact of science on innovation; and increasing Research Councils' effectiveness. A separate consultation will be launched on the Government's preferred option for developing a metrics-based system for assessing research quality and allocating "quality-related" funding, which will report in time for the 2006 Pre-Budget Report. A separate consultation will also be launched on the best institutional arrangements to deliver a more coherent framework for health R&D in the UK, reporting back in time for the 2006 Pre-Budget Report. The Government will take a decision on how to implement any of the options on which views are invited once the relevant consultation period is complete.

OPTIONS

Maximising the impact of science on innovation

A.6 This section of the document presents new measures to maximise the impact of public investment in science on business innovation, and provide greater incentives for business to work with the science base. These include an enhanced role for the Technology Strategy Board in promoting business innovation in those areas which offer the greatest scope for boosting UK growth and productivity; and an enhanced role for UK Trade and Investment (UKTI) in marketing the UK science base to business and attracting foreign R&D investment. In addition, the Government is inviting views on a range of issues which are key to creating a more effective science and innovation system, in particular:

- how the UK can best support high-risk, high-impact research in novel fields of scientific enquiry;
- how national and regional policies can work together more effectively to increase innovation and business-university collaboration in the regions; and
- building on the Lambert Review, how a wider spectrum of business-university interaction can be encouraged, spreading best practice across different regions and sectors.

A.7 Responses on these issues will inform the future development of policy.

Improving Research Councils' effectiveness

A.8 This section of the discussion paper sets out options for improving the effectiveness of the Research Councils and raising their impact on the economy. In particular, the document invites views on the creation of a new Large Facilities Council, and subsequent changes to the management of funding for the physical sciences.

The case for change **A.9** It is not clear that the scientific and wider economic potential of investment in large facilities is being exploited to best effect under the present arrangements. Management of large research facilities is currently rather fragmented, and decisions on investment are frequently taken by different Research Councils without an overall priority-setting process. A more coherent priority-setting process across the spectrum of large facilities investment would improve the quality and value for money of large facilities operations.

Option 1: a new Large Facilities Council **A.10** The main option put forward in the consultation document is to merge the Council for the Central Laboratory of the Research Councils (CCLRC) with the large facilities operations conducted by the Particle Physics and Astronomy Research Council (PPARC), to create a new Large Facilities Research Council (LFC) with responsibility for all large facilities investment from the Science Budget. This would create for the first time a coherent approach to funding and operating large facilities in the Research Councils, aligning investment with strategic research priorities across the spectrum of Research Council activity. It would also generate the critical mass to achieve a step change in knowledge transfer from large facilities, maximising opportunities for business engagement and commercialising the fruits of research.

Option 2: a new structure for physical sciences **A.11** If the large facilities operations currently managed by PPARC were to be transferred to a new LFC, a further option would be to integrate PPARC's grant-giving operations with those of the Engineering and Physical Sciences Research Council (EPSRC). This would effectively mean that a single Research Council (EPSRC) would have responsibility for the full spectrum of physical sciences funding.

Costs and benefits **A.12** The Government expects both options to improve the effectiveness of Research Council operations, by facilitating a more coherent strategy for investment in research facilities, and exploiting more fully the synergies between complementary areas of research.

Supporting excellence in university research

A.13 In order to maintain the UK's world-class university system, the Government is keen to ensure that excellent research of all types is rewarded, including user-focused and interdisciplinary research. It also wants to ensure that institutions continue to have the freedom to set strategic priorities for research, undertake "blue skies" research, and respond quickly to emerging priorities and changing fields of enquiry.

A.14 The Government is strongly committed to the dual support system, and to rewarding research excellence, but recognises some of the burdens imposed by the existing Research Assessment Exercise (RAE). The Government's firm presumption is that after the 2008 RAE the system for assessing research quality and allocating "quality-related" (QR) funding will be mainly metrics-based.

A.15 The Government will launch a consultation on its preferred option for a metrics-based system for assessing research quality and allocating QR funding. The consultation will be launched in May with results published in time for the 2006 Pre-Budget Report.

Supporting world-class health research

A.16 The Government's vision is of a holistic health R&D system that will maximise the value of the UK's health research base. Building on the reforms to date, the Government wants to ensure the UK's health research is more closely aligned with wider health objectives, builds on scientific progress to date and translates results of research into economic benefit.

A.17 Research budgets in the Office of Science and Technology are already ring-fenced. The Government intends similarly to ring-fence the Department of Health's R&D budget and that the Secretaries of State for Health and Trade and Industry will create a single, jointly held health research fund of at least £1 billion per annum, for which they will agree strategic priorities.

A.18 The Government will shortly invite a leading independent individual to advise on this and to launch a consultation in order to report on options to the Government in time for the 2006 Pre-Budget Report.

Improving the supply of scientists

A.19 The Government is concerned that progress towards meeting the ambitions of the *Science and Innovation Investment Framework 2004-2014* in raising STEM skills is relatively slow, as reflected in recent evidence on school attainment. The Government believes that there is scope for further action to improve the quality of STEM education and increase the supply of STEM skills. The Government is announcing new measures to make science a priority in schools, improve the skills of the teaching workforce, improve the quality of science lessons, and increase student progression to A Level sciences.

SECTORS AND GROUPS AFFECTED

A.20 The issues on which views are invited would potentially affect a wide range of stakeholders active in the UK's science and innovation system, including:

Private sector

- R&D-active businesses
- Higher Education Institutions

Public sector

- Central Government
- Research Councils and higher education funding bodies
- NHS
- Schools
- Regional Development Agencies
- Other Government agencies

COSTS AND BENEFITS

A.21 A more detailed analysis of costs and benefits will be undertaken for any policy options which are developed further as a result of public consultation.

SMALL FIRMS IMPACT TEST

A.22 A more detailed analysis of the impact on small firms will be undertaken for any policy options which are developed further as a result of public consultation. The Small Business Service will be consulted once the results of the consultation have been analysed.

COMPETITION ASSESSMENT

A.23 A more detailed analysis of the impact on competition will be undertaken for any policy options which are developed further as a result of public consultation.

ENFORCEMENT, SANCTIONS AND MONITORING

A.24 The Government will monitor the impact of the measures presented in this discussion paper, and future measures taken forward as the result of public consultation, as part of its annual reporting on the *Science and Innovation Investment Framework 2004-2014*.

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