

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

Summary

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

Box 2.1: Vision for UK science

By 2014:

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

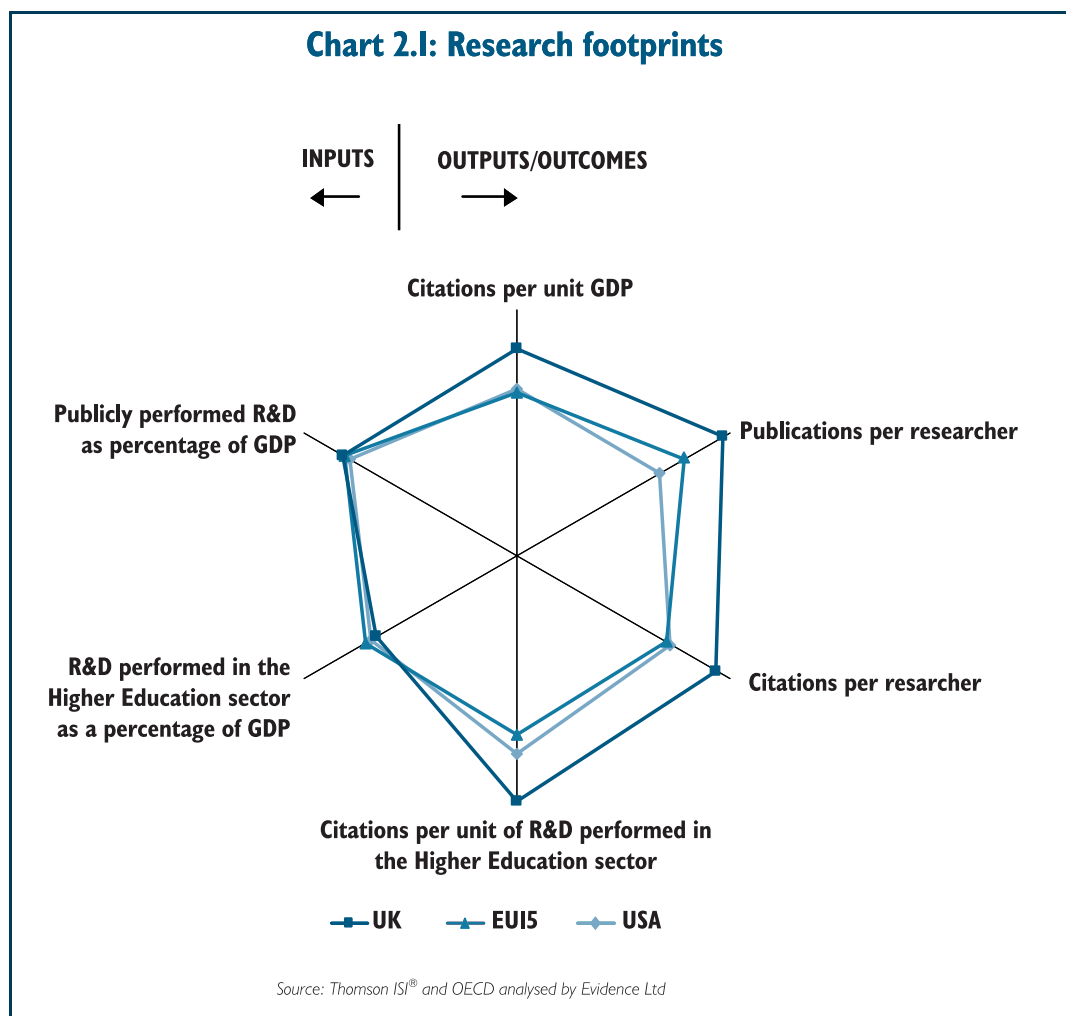
2.2 This chapter sets out some of the key challenges to creating the attributes and operation of the UK science and innovation system that will be necessary to deliver this vision.

Maintaining and developing world-class excellence and core strengths

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

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

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



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

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

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

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

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

Box 2.2: Science base achievements since 1998

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

Multidisciplinary working

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

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

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

Improving training;

- More cross-disciplinary training will be delivered at undergraduate and postgraduate level, particularly cross-disciplinary PhD programmes. More four year PhDs (within a flexible framework) may help, by giving more time for students to experience other research fields as part of their training. More Masters courses should have a cross-disciplinary slant, and more cross-disciplinary Fellowships should give both new and established researchers the opportunity to work across fields.
- Research and Funding Councils will work with universities to establish more translational courses to help bridge the gap between disciplines. A significant barrier to multidisciplinary working is often the failure of the potential partners to speak the same technical language.

Creating a multidisciplinary research environment;

- Multidisciplinary research will be embedded in more universities as standard. One favoured model is the centre of excellence which brings together researchers from different disciplines into the same working space with the requisite facilities, infrastructure and support staff. **Over the next five years Research Councils (driven by the needs of their research communities) will work with universities and other funders in the public and private sectors to establish multidisciplinary capabilities in research-intensive universities.**
- Reforms to the Higher Education funding bodies' research assessment exercise, which forms the basis of universities' core research funding, will provide greater recognition and reward for cross-discipline working.
- Multidisciplinary research also presents challenges to Research Council funding and peer review mechanisms. Research Councils UK (RCUK) will consider whether Councils can go further in removing unintentional barriers to multidisciplinary working.

- The Higher Education Research Forum² is currently looking at how better to encourage collaboration across institutional boundaries, and also the link between teaching and research.

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

Balance, flexibility and strategic oversight in funding basic research

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

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

2.15 In addition to the top down/bottom up model, research can also be considered along two orthogonal axes, representing consideration of use and the quest for fundamental understanding. This is illustrated in the frontpiece³. The UK research funding system will continue to allow space for fundamental basic research, complemented by strategic priority programmes and incentives for researchers to work on projects focused on application. It will also need to find ways of combining these two approaches, to bring together public and private funding and research talent to work on major research challenges with major societal impact.

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

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

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

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

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

Horizon scanning

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

Public policy and the research base: improving responsiveness

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

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

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

Information infrastructure

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

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

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

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

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

Capital infrastructure

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

- the Joint Infrastructure Fund (JIF) awarded a total of £750 million⁵ to science research infrastructure projects at 40 UK universities between 1999 and 2001;
- under the first round of the Science Research Investment Fund (SRIF), announced in 2000, £675 million was allocated to UK High Education Institutions (HEIs) on a formula basis for 2002-04; and
- the second Science Research Infrastructure Fund, announced in 2002, built on SRIF with a dedicated infrastructure scheme worth £500 million a year from 2002 to 2004, again allocated on a formula basis across all the HEIs in the UK engaged in science research.

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

Box 2.3: Large Facilities

The UK's priorities for Large Facilities are set out in the Large Facilities Road Map⁶. This takes a 15-year strategic look across all scientific disciplines and sets out those facilities which the Research Councils would like to see available for UK scientists. They include both national and international facilities. The next ten years will see major facilities, both in the UK and abroad, being completed and available for UK scientists. Projects currently underway include:

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

Measuring success

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

⁵ Including £300 million from the Wellcome Trust

⁶ <http://www.ost.gov.uk/research/funding/lfradmap/index.htm>

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

APPENDIX TO CHAPTER 2

Multidisciplinary Research Exemplars

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

- i. sustainable Earth systems (Earth systems science);
- ii. systems biology (complexity of life);
- iii. sustainable energy;
- iv. cognitive systems;
- v. cyber trust and crime prevention; and
- vi. identities and cultures.

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

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

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

i. Sustainable Earth systems (Earth systems science)

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

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

In the next ten years, key outcomes could be:

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

ii. Systems biology (complexity of life)

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

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

In the next ten years, key outcomes could be:

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

iii. Sustainable energy

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

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

In the next ten years, key outcomes could include:

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

iv. Cognitive systems

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

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

In the next ten years, key outcomes could be:

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

v. Cyber trust and crime prevention

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

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

In the next ten years, key outcomes could be:

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

vi. Identities and cultures

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

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

In the next ten years, key outcomes could be:

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

Summary

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

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

Basic architecture

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

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

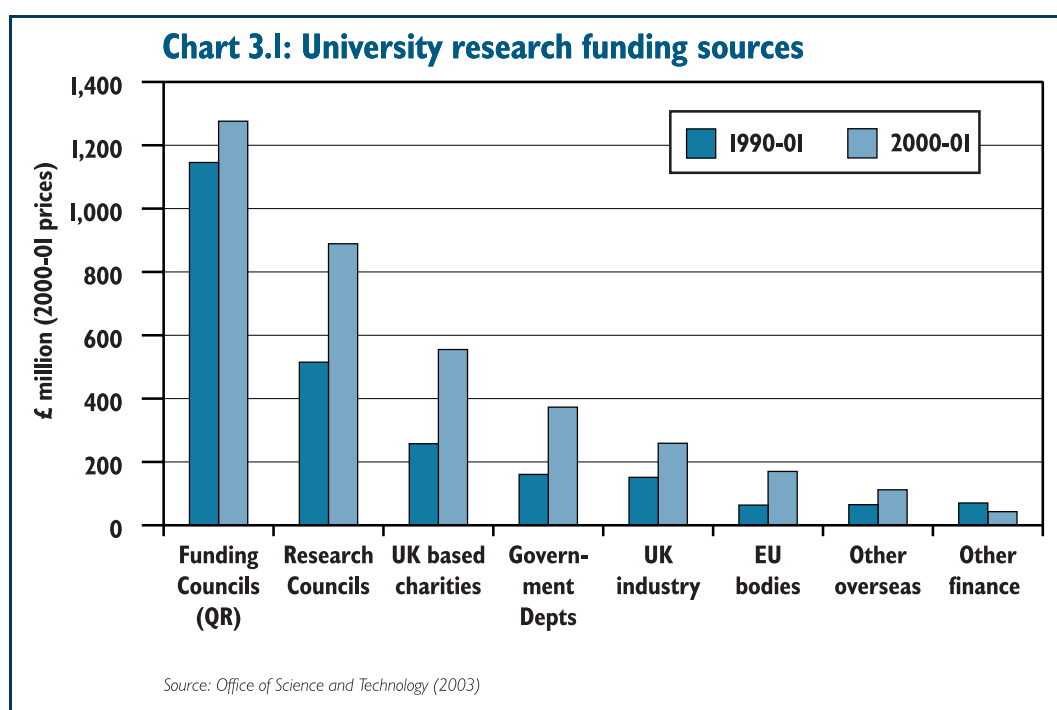
3.4 One of the strengths of the UK university system is its ability to secure a diverse range of current and capital funding for research from a variety of public, private and other sources. Chart 3.1 shows how the proportion of university income from different sources has changed over the past decade,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

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

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

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

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



3.7 The seven Research Councils³ – funded through the Office of Science and Technology (OST) – provide a research capability through their own institutes and access to large facilities, as well as funding specific projects and exploratory thinking in HEIs. They are able to take a national strategic view, again ensuring excellence through peer review. Funding through Research Councils was £1,892 million in 2003-4, of which around half was spent in HEIs on research projects.

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

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

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

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

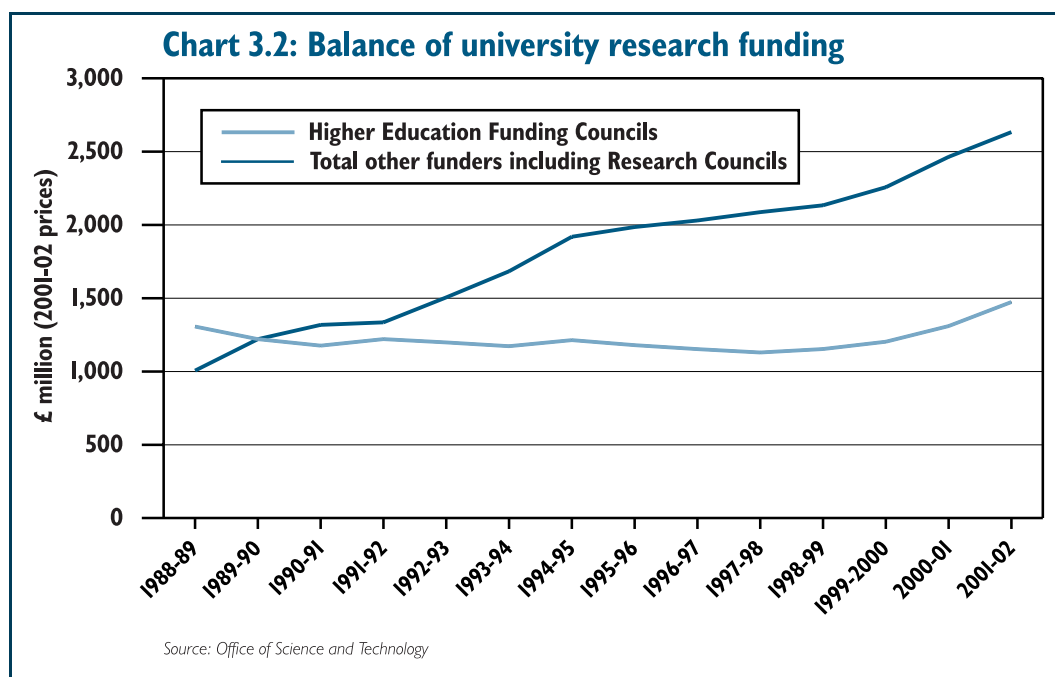
- Diasporas, migration and identities - building on work where the UK has been at the forefront in both theoretical and empirical studies of identities based on ethnic, religious, linguistic and historic differences. In an increasingly multicultural society it is essential that we generate new understanding of the way migration affects cultures and identities within the UK and beyond. We need high quality research on religious and language communities, on the complex relationship between diasporas and the societies in which they take shape, on bilingualism and translation, and on the ways in which cultures interact and change.
- Landscape and environment, where research in the arts and humanities is fundamental to understanding the changing relations between people and their environment to better understand the changing natural and built environment, the character and history of that environment, and the ways that people relate to the environment, shaped by a number of factors such as culture.

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

Sustainability

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

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



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

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

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

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

3.15 This agenda, identified by the 2002 cross-cutting review of science and research and resulting science funding strategy, was taken forward in the Office of Science and Technology's consultation in May 2003⁴. Following this, the OST, Research Councils and HE funding bodies have organised pilots within universities of extensions of the Transparent Approach to Costing (TRAC) methodology to research project costing, through which the full economic cost regime will be implemented.

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

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

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

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

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

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

⁴ The Sustainability of University Research, OST, May 2003

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

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

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

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

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

Other funders of research

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

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

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

Box 3.2: Principles to guide the pricing of research projects

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

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

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

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

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

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

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

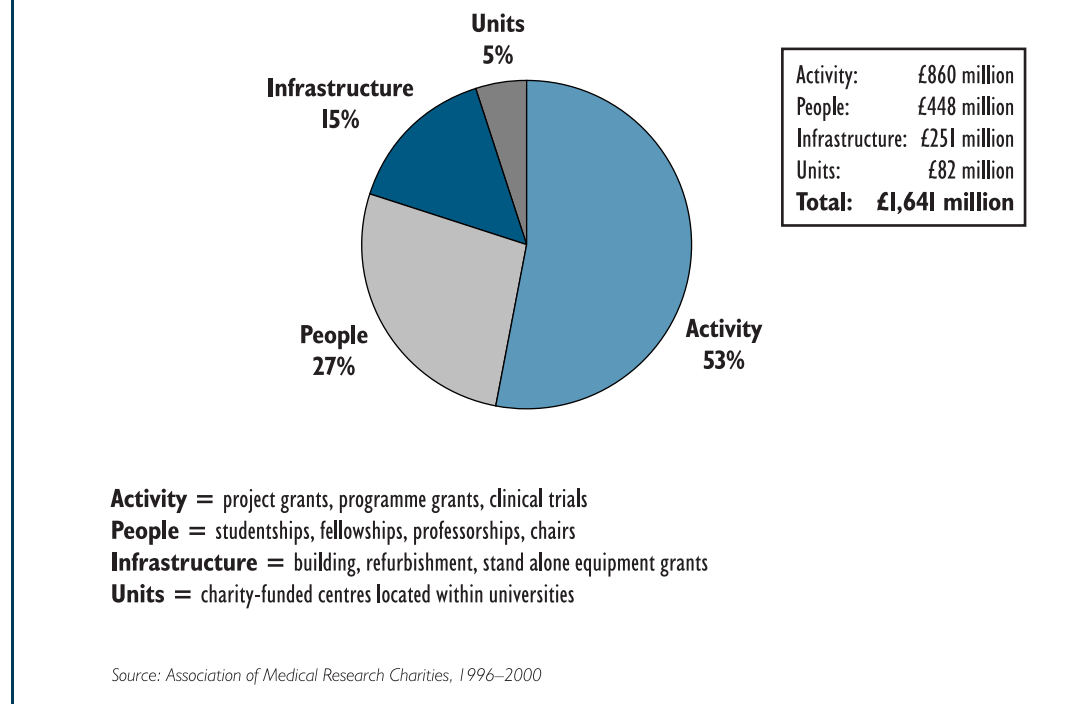
income over the relevant period to meet the costs of supporting collaboration with business without placing an undue strain on their other publicly-funded research activities.

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

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

Charities

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

Chart 3.3: Charity research funding in UK universities

3.32 Charity funding has grown steadily in recent years, resulting in more pressure on QR funding to support HEIs' share of research funded by the charities. This shortfall is concentrated in medical subjects and (to a lesser extent) in science including biomedical science, but it affects all areas including social sciences and the arts. Data for 2001-02⁷ shows that in that year HEIs in England received some £500 million of income from UK based charities of which well over a half (£270 million) was in clinical medical subjects and most of the rest (£140 million) in sciences.

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

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

⁷ Source: Higher Education Statistics Agency

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

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

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

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

European Union

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

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

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

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

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

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

Research Assessment Exercise

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

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

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

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

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

3.47 The funding bodies published their initial decisions on the timing and broad shape for the next RAE in early 2004⁸. They hope to announce panel membership, and to publish generic guidance to panels on the assessment process, by the end of 2004. Peer review will remain central to the next RAE, which will be held in 2008, but, as indicated above, there will be changes to the system. These include:

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

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

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

⁸ RAE 12/2004 at www.rae.ac.uk/pubs/

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

Funders Forum

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

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

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

Efficiency and effectiveness

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

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

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

⁹ <http://www.ost.gov.uk/fundersforum>

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

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

Taking stock

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

Capital

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

¹⁰ www.rae.ac.uk/pubs/other/impact

3.60 Recent study evidence on the impact of SRIF¹¹ found that:

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

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

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

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

¹¹ Study of university infrastructure for science research – 2004 Update, JM Consulting,

<http://www.ost.gov.uk/research/funding/underinvest/>

Public Sector Research Establishments

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

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

3.65 A report carried out for OST¹² identified a similar capital investment problem in PSREs as in universities (albeit on a lesser scale), and examined the strategic planning and trading relationships in this part of the UK science base. It found that there is a common need for:

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

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

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

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

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

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