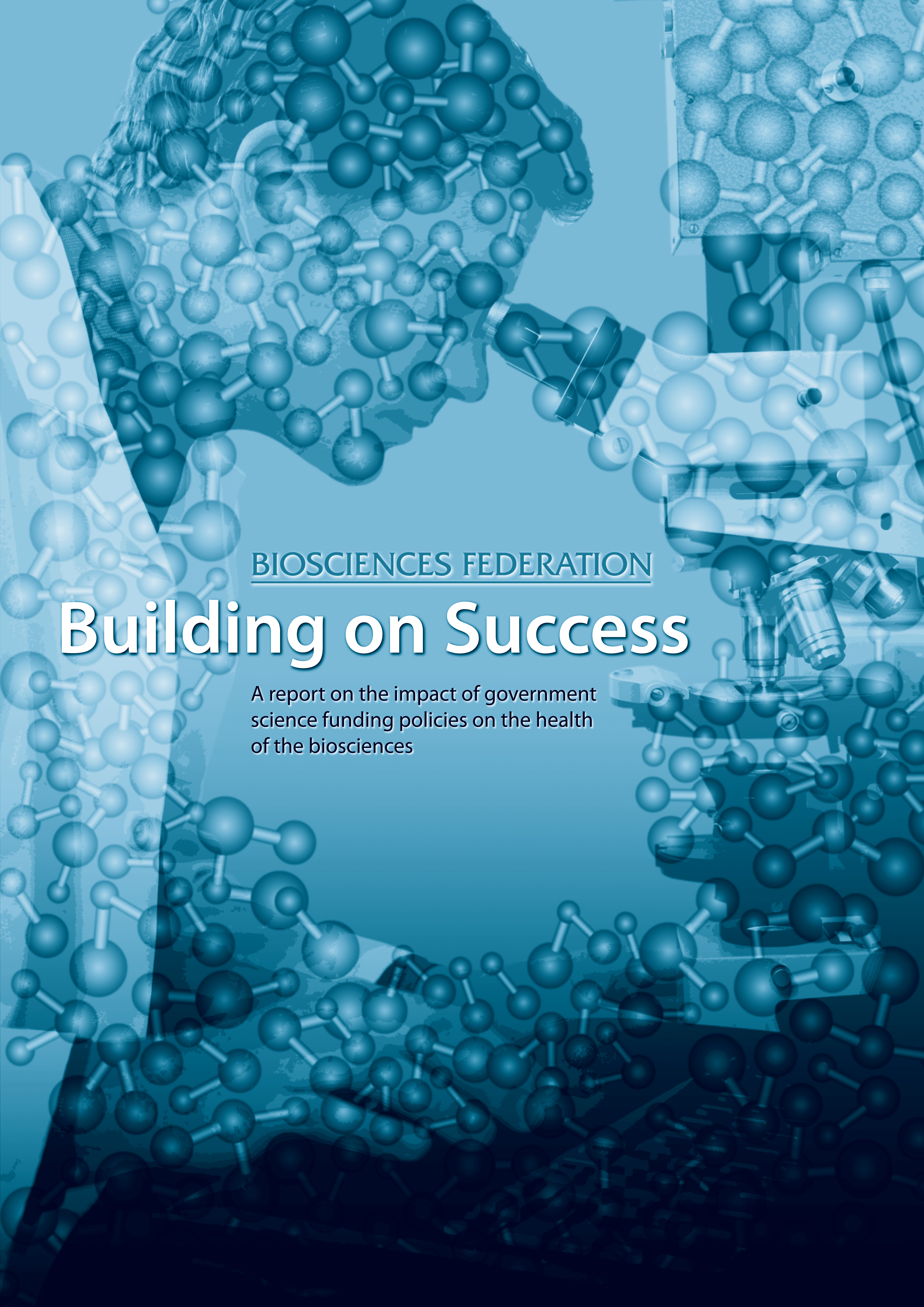

BIOSCIENCES FEDERATION

Building on Success

A report on the impact of government science funding policies on the health of the biosciences

The Biosciences Federation was founded in 2002 in order to create a single authority within the life sciences that science and education decision-makers are able to consult for opinion and information to assist the formulation of public policy. It brings together the strengths of 38 member organisations, including the Institute of Biology, which represents 42 additional affiliated societies. These organisations have a cumulative membership of some 70,000 bioscientists and cover the whole spectrum from physiology and neuroscience, biochemistry and microbiology to ecology and agriculture. The Biosciences Federation is a registered charity (no. 1103894).

This report is also available at
www.bsf.ac.uk/responses/building

Please e-mail your views and comments
on this report to **info@bsf.ac.uk**

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Executive Summary

Since 1998 the government has invested considerable sums in science and innovation with the aim of enabling Britain to remain at the forefront of the growing global knowledge economy. This report assesses the outcome of government science funding policies on the capability and capacity of the bioscience sector and is informed by a survey of university Heads of Biosciences Departments and by consulting two major pharmaceutical companies.

The emphasis of a series of Comprehensive Spending Reviews has been on establishing a strong and sustainable science base; embedding in academic institutions a strong culture of knowledge transfer; fostering an environment in which companies can grow; maintaining a flow of people into science and technology; and improving public acceptance of science and innovation.

Much that is positive for the biosciences has been achieved:

- Greatly improved academic infrastructure in most universities allows work to be undertaken that would otherwise not have been possible;
- Increased funding and better balancing of the two arms of dual support, including the Research Councils moving towards paying full economic costs of the projects commissioned, offer the prospect of sustainability of academic research;
- Research in most areas of the natural sciences continues to be particularly strong and efficient in the UK;
- On a number of criteria, the working relationship between universities and business has continued to improve, and interaction remains strong in the pharmaceutical / biotechnology sectors;
- The UK is the European leader in bioscience industry and second only to the US in world rankings;
- Both the government and scientists have learned the importance of openness in engaging with the public on scientific issues, and a recent poll found increasingly positive attitudes to science among the UK population;
- The government has recognised the serious challenge to bioscience training and research in academia and industry from animal rights extremists, and new legislation appears to be reducing the frequency of incidents of harassment.

However, there are also real threats to the continuing success of the biosciences. Some of these have been created or exacerbated by the government's centralising tendency and emphasis on accountability, which introduces burdensome and unproductive bureaucracy, skewed priorities and a loss of flexibility:

- There is a growing problem with recruitment and retention in the biosciences that is exacerbated by education policies. Too few well-qualified students are choosing to study core bioscience disciplines as undergraduates, and too few follow technical courses. The result is that bioscience companies can recruit neither sufficient high quality researchers nor technical staff;
- The unit of resource for teaching science subjects in universities does not cover the cost of courses. Graduates leave most universities with insufficient practical training for R&D careers;
- The work environment in universities has deteriorated as a consequence of the continuing non-competitive pay and uncertain career progression; declining academic freedom; heavy teaching work-load and increasing administrative burden. Departments are finding it increasingly difficult to recruit world-class researchers;
- The lack of clear mechanisms for meeting overheads of charity and European Union research under full economic costing could lead to a decrease in research volume. It is essential not to price-out industrial collaborative research, nor to make Britain's European Union grant applications non-competitive;
- The government has focused too much on university push rather than industry pull for knowledge transfer;
- The tendency for the government to include ring-fenced pots of money in Research Council budgets for priority areas of research is having the undesirable effect of reducing the sums available for responsive mode funding;
- Despite some government success, animal rights extremism remains a potent and expensive threat to biomedical research, and a disincentive for pharmaceutical companies maintaining research facilities in the UK. There is currently a sinister atmosphere of fear.

Recommendations

In order for the government to build on its already successful investment, the Biosciences Federation makes the following recommendations:

- The government should continue in the general direction set out in the 2004 10-year Science and Innovation plan. Funding must not be cut back since the UK is still only 6th among G8 nations in science spending as a proportion of gross domestic product, and the UK is facing mounting competition from Asia – Pacific countries;

- The reasons for recruitment and retention problems are multi-factorial. In addition to what it is already doing the government should seek to improve the science careers advice given to school pupils at key stages of their education. The policy of encouraging 50% participation in higher education must be reconsidered and thought given to how to encourage more students to follow sub-degree technical courses;

- The Higher Education Funding Councils should be invited to determine without delay the real cost of providing a practically-based science course and be given funding to adjust the unit of teaching resource appropriately;

- The government should take action to improve academic pay and conditions (not just for young researchers), which are adversely affecting recruitment. The idealised salary trajectory discussed at a Save British Science colloquium in 2004 provides a suitable model. Government must continue its drive to cut out unnecessary bureaucratic legislation impacting on academics and maximise the positive benefits of high quality researchers with freedom to inquire. It must also address the issue of large class sizes and excessive teaching workload;

- The government must ensure that its research priorities are backed by a majority of the scientific community, and should support its ring-fenced initiatives with fresh funds to the Research Councils and not by diverting money from responsive-mode funding. The Councils must be encouraged to continue to exploit their high quality research by knowledge transfer, but government must not lose sight of the fact that their main function is to fund excellent basic research and train excellent researchers;

- Sufficient funding should be provided through the Research Assessment Exercise and Higher Education Innovation Fund streams to allow departments to make strategic decisions as to which type of research, and knowledge transfer, to pursue. Partnerships with industry must be encouraged, but universities should not be pushed into becoming 'inexperienced companies'. The purposes of RAE and HEIF funding need to be clarified.

- The government must continue to prevent and punish the illegal activities of animal rights extremists and state unequivocally its support for essential animal research. While the Association of the British Pharmaceutical Industry recorded a smaller number of incidents in the first half of 2005, the decision by the owners to close down the Darley Oaks guinea pig breeding facility in August will be seen as a victory by activists. This issue requires urgent attention from the government, universities and bioindustry linked to engaging the public in the need to prevent unlawful harassment.

- The future of the UK bioscience sector depends above all on industry choosing the best technologies on which to focus, and pursuing viable business strategies to achieve profitable growth. The government role is primarily to create a steady and supportive environment. One of the requirements is to establish a favourable, simple taxation regime that is well administered and non-bureaucratic, and in this respect the government needs to look again at the operation of the R&D tax credit system.

1. Introduction

The Labour governments since 1997 have recognised the contribution that a flourishing science base can make to the health and prosperity of the nation, and have been supportive towards science in successive Comprehensive Spending Reviews (CSR). Furthermore, the 3-year spending cycles that the Treasury introduced provide greater stability and continuity to aid research institutions in their medium-term planning. It has been investment with a purpose – to strengthen Britain's economy – and accompanied by increased central control, a drive to bring researchers closer to the users of their research outputs, and for greater accountability by the recipients of funding.

This report outlines the thinking behind the settlements for science in the series of CSR from 1998 to 2004 and assesses the overall outcome from the considerable investment in relation to the capability and capacity of the bioscience sector. The assessment of the outcome is informed by a survey of the opinions of university Heads of Biosciences Departments on certain key issues, and by obtaining the views of two major pharmaceutical companies on the interactions between academia and industry. Finally, the report considers and makes recommendations on how government policy on science and innovation could be modified to be even more successful in creating health and wealth for the nation from the biosciences sector.

2. Science and innovation policies pursued in successive government Comprehensive Spending Reviews

The government's attitude towards science and innovation has been consistent throughout its time in office. The UK economy faces new challenges from increased globalisation and the rapid growth in world trade, which opens up new markets and introduces new opportunities. The government believes that innovative and dynamic companies are essential to national economic success, and these in turn are dependent on a first-class research base and the ability to turn good ideas into marketable products and services. The emphasis in all the CSR has thus been on:

- Establishing a strong and sustainable science base, with mechanisms to ensure that research outputs are translated efficiently into innovative products and services to improve the nation's health and prosperity;
- Linking funding with greater accountability by the recipients;
- Fostering an environment in which companies can grow;
- Maintaining a flow of people into science and technology;
- Improving the public acceptance of science and innovation.

The sequence of major events and reports relating to the funding of science and technology is shown in Table 1 and the key decisions for science and innovation in Table 2.

2.1 Comprehensive Spending Review 1998

Sir Robert May and Sir John Cadogan, Chief Scientific Adviser and Director General of the Research Councils at the time, were widely credited with convincing the new Labour government of the need for, and potential return from, investing heavily in science. In 1998 May published an influential paper, *The Scientific Investments of Nations*[1], which concluded that the strong UK science base did more than its share in helping to create wealth around the world, but that this strength was not consistently translated into strong industrial performance within the UK. Cadogan argued that the decline in infrastructure caused by a decade of under-investment by previous governments meant that the strong research performance was unsustainable in the medium term. The 1998 CSR set the tone for succeeding ones by providing substantial new funds to start to restore research infrastructure, together with additional targeted funding for the Research Councils. The infrastructure funding came from a novel collaboration with the Wellcome Trust to create a £600 million Joint Infrastructure Fund (JIF), which was distributed on the basis of competitive bidding. A comparatively small amount (£50 million) was devoted in this CSR to increasing the rate at which scientific discoveries are turned into wealth-creating business successes, through the University Challenge Scheme. There was much discussion at the time about the need for diversity of mission among universities, and of 'third-stream funding' to create a stronger culture of enterprise and innovation and to encourage knowledge transfer. The Higher Education Reach Out to Business and the Community (HEROBC) scheme was introduced in the following year.

[1] May RM (1998) *The Scientific Investments of Nations* Nature **281**, 49-51

2.2 Comprehensive Spending Review 2000

This CSR, and an accompanying Science and Innovation White Paper[2], were informed by a cross-cutting study of science research funding led by the Science Minister, Lord Sainsbury. The study concluded that JIF funding had shifted significantly from its original aim of restoring an investment backlog towards underpinning new or expanded research activity; that dual support of research was broadly meeting its purpose although cross-disciplinary work and applied work needed to be better recognised and rewarded; that university technology transfer work was underfunded; and that government departments needed to increase competence and spending on science and technology. The Science White Paper noted additionally the need to provide better science education for all children and the need for public confidence in the concept of science to be strengthened.

The thrust of these reports was reflected in the Spending Review Settlement for science and research, particularly:

- JIF being replaced by the Science Research Investment Fund (SRIF) that was allocated on the basis of quality and volume rather than on competitive bidding, and required 25% matching funds for any project;
- A £250 million boost to research in key new areas, and funding to increase PhD stipends to £9000 over 3 years;
- A new incentive package to encourage science graduates into school teaching;
- A new Higher Education Innovation Fund (HEIF), incorporating HEROBC, and with an expanded budget that would triple existing funding by 2003/4;
- A commitment for government departments to publish science and innovation strategies, which would make more transparent any attempts to cut back departmental science spending.

Table 1. Sequence of major events relating to the funding of Science and Innovation

1998	**Comprehensive Spending Review**
1998	Joint Infrastructure Funding (JIF) begun
1999	Regional Development Agencies introduced
1999	Higher Education Reach-out to Business and the Community (HEROBC) funding introduced
2000	**Comprehensive Spending Review**
2000	Science and Innovation White Paper *Excellence and Opportunity – a Science and Innovation Strategy for the 21st Century*
2000	Cross-cutting study of science research funding
2000	JIF succeeded by the Science Research Investment Fund (SRIF)
2000	HEROBC incorporated into new Higher Education Innovation Fund (HEIF)
2001	Year of science
2001	Research Assessment Exercise
2002	Roberts Review. *SET for success: the supply of people with science, technology, engineering and mathematics skills*
2002	**Comprehensive Spending Review**
2002	Innovation White Paper *Investing in Innovation – a Strategy for Science, Engineering and Technology*
2002	Cross-cutting review of science and research
2003	*The future of Higher Education* White Paper
2003	Lambert *Review of Business-University Collaboration*
2003	DTI report *Competing in the Global Economy: the Innovation Challenge*
2003	Biosciences Innovation and Growth Team report *Improving National Health, Increasing National Wealth*
2004	**Comprehensive Spending Review**
2004	*Science and Innovation Investment Framework 2004-2014*

2.3 Comprehensive Spending Review 2002

As in 2000, the CSR 2002 and an accompanying White Paper[3] were informed by a cross-cutting review of science and research, and also by Sir Gareth Roberts' review *SET for success – the supply of people with science, technology, engineering and mathematics skills*[4]. The cross-cutting review concluded that JIF and SRIF funding streams had made a real difference, but there was need for a continued and assured capital funding stream; that dual support had become unbalanced as the level of support for project funding from a number of sources outstripped the level of underpinning support from the Funding Councils; that Research Councils should pay an increased contribution to indirect costs of research that they commission, and institutions be required to recover the full costs of research from the various funders in future; that university work with industry still needed to be better recognised and rewarded; and that government Departments should each appoint a Chief Scientific Adviser to help avoid cuts being made to R&D budgets in the face of other spending pressures. The

[2] *Excellence and Opportunity – a Science and Innovation Strategy for the 21st Century* (2000) A White Paper from the Office of Science and Technology (see www.ost.gov.uk/enterprise/excellence.htm)

[3] *Investing in Innovation – a Strategy for Science, Engineering and Technology* (2002) A White Paper from the Department of Trade and Industry, HM Treasury and Department for Education and Skills (see www.ost.gov.uk/policy/invest-innov.htm)

[4] *SET for success – the supply of people with SET and mathematics skills* (2002) A Review for the Treasury chaired by Sir Gareth Roberts

Table 2. Key decisions for science and innovation in successive Comprehensive Spending Reviews

1998
Restoring infrastructure
£600 million from government and Wellcome Trust to new Joint Infrastructure Fund (JIF)
£100 million from the Wellcome Trust for a state of the art high energy Synchrotron for UK genome research
Supporting excellent research
£405 million for Research Councils for "priority areas, particularly life sciences"
£300 million for HEFCE to support research via dual support
Enhancing innovation
£50 million for University Challenge Scheme to increase knowledge transfer

2000
Restoring infrastructure
£1 billion from government and Wellcome Trust to JIF's successor, the Science Research Investment Fund
Supporting excellent research
£250 million for research in "key new areas" including genomics, nanotechnology and bio-engineering
Recruitment and retention in science
Package to encourage science graduates into teaching
PhD stipends increased to £9000 over 3 years
£50 million to attract and retain leading international scientists
Enhancing innovation
New Higher Education Innovation Fund (HEIF) worth £140 million over 3 years introduced as permanent 3rd stream funding, incorporating Higher Education Reach-out fund established in 1999
Tax incentives introduced to encourage small companies to engage in R&D

2002
Restoring infrastructure
Recurrent capital funding stream announced worth £500 million a year by 2005
OST budget for large facilities (eg Diamond synchrotron) doubled to £205 million a year by 2005/6
Up to £70 million announced to improve Research Council Institute infrastructure by 2005/6
Supporting excellent research
£400 million to support "new priority areas" including brain science, regenerative medicine, proteomics, sustainable energy and land use
HEFCE to receive an extra £244 million by 2005/6 to support research in recognition that dual support funding has diverged
Research Councils to receive £120 million from 2005/6 to move towards paying full economic cost (FEC) of commissioned research. Universities to move towards recovering FEC
Recruitment and retention in science (post Roberts Review)
PhD stipends increased to at least £12,000 over 3 years; post-doc starting salary increased to £21,000
Funding to be made available for 1000 new academic fellowships over 5 years
Government to co-fund with Wellcome Trust a National Centre for Excellence in Science Teaching
Enhancing innovation
HEIF funding increased to £90 million a year by 2005/6
Tax incentives extended to all UK-based company R&D

2004
Restoring infrastructure
Dedicated capital funding of £500 million a year to continue
Supporting excellent research
DTI funding over the 3 years of the Spending Review to increase by 5.6% a year, funding for research from HEFCE by 6.0% to narrow the dual support gap
Research Councils to receive an extra £80 million in 2007/8 towards paying FEC, and £35 million in 2006/7 and 2007/8 to enable them to respond quickly to "emerging priorities and opportunities"
£90 million a year to be available by 2007/8 towards overheads of charity-commissioned research
Recruitment and retention in science
PhD stipend to be increased in line with inflation, 'golden hellos' for new teaching staff to continue
Remuneration packages for new school teachers and advanced skills teachers to be improved
Enhancing innovation
DTI Technology Strategy to receive additional £178 million by 2007/8
HEIF to increase to £110 million a year by 2007/8; Regional Development Agencies to have enhanced role in creating links between business and the research base
£200 million UK Clinical Research Collaboration created to bring together the DoH, NHS, MRC, medical charities, industry and the public

Roberts Review assessed what was needed to attract and retain human resources in science and concluded that action was required right across the supply chain from improving science teaching in schools to improving pay and conditions for academics.

These two reports were clearly highly influential in shaping the science settlement in CSR 2002 in terms of:

- A new dedicated capital funding stream being included (this time requiring 10% matching funding by the universities for projects);
- Earmarked funding for the Research Councils to move towards paying full economic costs of their research;
- More for the Funding Councils to help balance the two arms of dual support, and in return a requirement for universities to improve their cost management systems;
- A boost in funding for a remodelled HEIF, and tax incentives for investing in R&D being extended to companies of all sizes;
- PhD stipends and starting salaries for researchers both increased, and a new academic fellowship scheme introduced. In addition, the government announced joint funding with the Wellcome Trust for a National Centre for Excellence in Science teaching.

2.4 Comprehensive Spending Review 2004

This CSR was very much a continuation of the ideas in the 2002 CSR. Both the CSR and the accompanying 10-year Science and Innovation Investment Framework[5] were informed by the Lambert *Review of Business-University Collaboration*[6] for the Treasury, and a Department of Trade and Industry (DTI) report *Competing in the global economy: the innovation challenge*[7]. The Lambert Review recommended that the government should focus more on encouraging industry demand for research rather than increasing the supply of commercial ideas from universities; that more third stream funding should be available for universities performing research of real value to industry, and that Regional Development Agencies (RDAs) should become more effective in catalysing links with industry; and that there should be less focus on university spin-outs, many of which may not be sustainable, and more on licensing discoveries to industry. The DTI report concluded that, despite the emphasis in previous CSR on strengthening innovation, UK innovation performance overall remained average compared to the major competitors. (This excluded certain sectors, including pharmaceuticals and biotechnology, which are world class in innovation). Actions that the DTI proposed to take to raise the rate of innovation included developing a medium to long term Technology Strategy and working closely with businesses to pull through and exploit new technologies; requiring the Research Councils to agree plans and goals to increase their rate of knowledge transfer; and agreeing with RDAs a set of innovation indicators and helping them to set up regional Science and Industry Councils.

The CSR included:

- A commitment to maintain the dedicated capital funding stream at its existing level, and to increase the rate of funding for research through the DTI by 5.6% a year through the Spending Review period;
- A substantial increase in funding for the Higher Education Funding Council for England (HEFCE) intended to narrow the gap in dual support;
- Funding to enable the Research Councils to move towards paying full economic costs for their commissioned research extended to 2007/8, and money also allocated to help meet the overheads of charity-commissioned research;
- An increase in third stream funding, but still distributed through the Funding Councils rather than the RDAs as Lambert recommended;
- A substantial injection of new cash for the Technology Strategy described in the DTI report;
- A new UK Clinical Research Collaboration to facilitate the translation of medical research discoveries into clinical practice.

The 10-year Science and Innovation Investment Framework

In setting out the government's longer term strategy for British science and technology, the Framework brought together ambitions familiar from previous CSR:

- World class research at the UK's strongest centres of excellence;
- Sustainable and financially robust universities and public labs across the UK;
- 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 and more responsive supply of scientists, engineers and technologists;

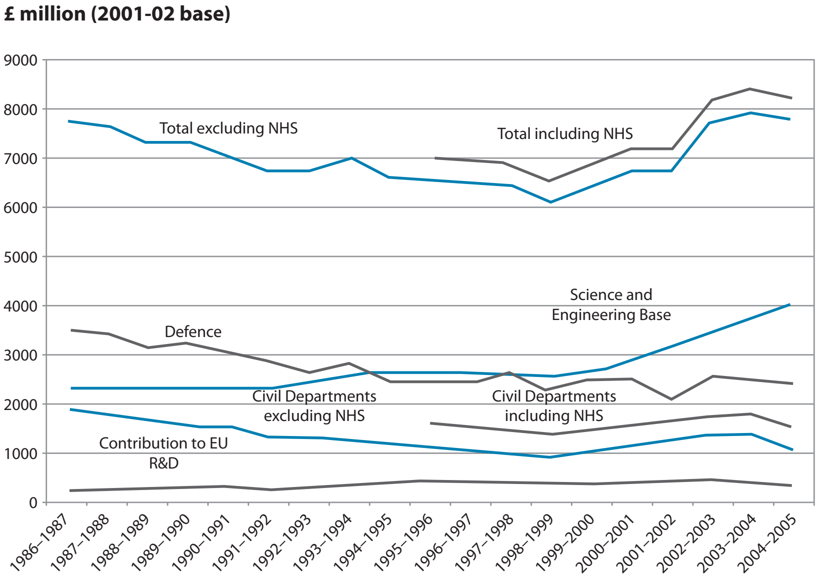
[5] *Science and Innovation Investment Framework 2004-2014* (2004) HM Treasury, Department of Trade and Industry and Department for Education and Skills

[6] *Lambert Review of Business-University Collaboration* (2003) A report for HM Treasury from P Lambert

[7] *Competing in the Global Economy – the Innovation Challenge* (2003) Department of Trade and Industry (see www.dti.gov.uk/innovationreport/innovation-report-full.pdf)

Figure 1. Trends in UK government funded R&D expenditure in real terms

Source: Office of Science and Technology SET statistics, Fig 3.2



- Confidence in and increased awareness across UK society of scientific research and its innovative applications.

To make the UK a world leader in science and innovation and attract substantial inward investment the government has set a target of increasing the total spent on R&D from 1.9 to 2.5% of gross domestic product (GDP) by 2014. This requires substantial growth in business R&D, which the government believes depends in turn on a continuing boost to industry from the research base. The government therefore intends to increase investment in the public science base at least in line with the trend growth rate in the economy through the 10-year period. The dedicated capital funding will continue, balanced dual support over a sustained period will enable the major research-intensive universities to plan and deliver their research strategies more effectively, and institutions will be expected to recover the full economic costs of projects. The DTI will take responsibility for encouraging greater business investment in R&D through the measures recommended in its report.

Mechanisms intended to improve the supply of scientists focus on the recruitment of school science teachers, and on making the salaries of young researchers and university teachers competitive. The framework does not address salaries of established academic staff other than to say that universities are developing a more flexible approach to managing their workforces, and that it is important to adopt a responsive approach to remuneration. The government will work with agencies such as the British Association to promote coherence in the growing range of initiatives for encouraging public engagement. To facilitate this, the Science and Society budget of the Office of Science and Technology (OST) will more than double by 2006/7. Finally, the government has reiterated its determination to protect legitimate research activities from animal rights extremists.

3. Outputs from the investment in science and innovation

The sequence of CSR settlements illustrates well how the government has maintained a clear vision through two parliaments of renewing and sustaining a world-class science base with a view to supporting British industry through the transfer of innovative ideas and knowledge, and the supply of trained scientists. Successive CSRs have refined the policies used to direct the vision, attempting to use evidence-based decision-making where experience demonstrated the need for change. The Biosciences Federation believes strongly that the government has been right to invest so heavily in science, and that the scientific community has already delivered substantial benefits for the money and will continue to do so.

The increase in government funded R&D expenditure from 1998 onwards reversed a disturbing downward trend that had continued for more than a decade (Fig1). By 2003/4 expenditure was restored, in real terms, to what it was in the mid-1980s, and the government predicts that by 2005/6 the OST's science budget will have doubled from the level when it came into office. The investment has been primarily in the science and engineering base. Despite pointed reminders of the importance of government departmental R&D in the cross-cutting reviews of 2000 and 2002, expenditure by Civil Departments has essentially plateaued since 1998.

3.1 Competitiveness of research

The 1998 paper by Sir Robert May[1] showed using a range of metrics that UK research was already excellent in many areas before the government started its programme of infrastructure renewal. But a 2002 study by consultants *Evidence Ltd* for the Higher Education Funding Councils and Universities UK[8] confirmed that this performance had been achieved by drawing heavily on the reserves of research institutions, and by staff commitment involving workloads above reasonable long-term levels. It would not have been sustainable without increased investment.

[8] *Maintaining Research Excellence and Volume* (2002) A report by Evidence Ltd to the Higher Education Funding Councils and Universities UK

The DTI commissioned *Evidence Ltd* to develop additional metrics for the science base and to use these to rank the UK annually in the international community. The company's 2004 report[9] concluded that *"the UK research base has a strong relative international performance in terms of achievement, productivity and efficiency. It is strongest overall in the natural sciences, and on many indicators is second only to the US. Although the UK has been overtaken by other nations in some areas, it sustains a more consistent performance across fields than those countries. The strong international performance has been achieved with lower average investment compared to its competitors, and with a relatively lower availability of people with research training and skills"* (see Table 3). UK research is thus accepted to be highly efficient. In its most recent review of the performance of the OST, the Commons Science and Technology Committee noted that the UK still spends less than its competitors on research as a proportion of total economic activity[10]. It stressed the need for continued investment in the science base, and particularly on R&D by government departments. The weakness of the UK in the availability of skilled people with research training is an indication of the relative unattractiveness of research careers.

It would be expected that the increased investment in the science base since 1998 would improve these metrics, but it is too soon, as yet, for the investment to be reflected in a clear change in the UK's performance. A study commissioned by the OST estimated that it takes 6 years for public expenditure on science to impact fully on scientific publications, and 7 years on citations[11].

3.1.1 Impact of the recent investment in infrastructure

There is abundant evidence that the investment is having a profound indirect effect on research competitiveness by improving morale and the ability to carry out excellent work. An early survey by Save British Science[12] of those who won funding in the two rounds of JIF found that nearly all grants supported interdisciplinary work, and they were almost exclusively supporting research that would otherwise not have been possible[13]. A more detailed evaluation of the impact of JIF[14] found that it was widely welcomed and had created a sense of opportunity and excitement, particularly in respect of becoming internationally competitive. JIF was considered to have kick-started a period of sustained investment in UK scientific infrastructure. There was also evidence that the status of a JIF award helped departments attract funding from other sources.

Save British Science followed up its earlier survey with a 2004 snapshot[15], based on a few specific examples, of what is being achieved with the new investment and concluded: *"The message is clear: look at what the scientific community can achieve on current levels of funding, and imagine what will be achieved as investment in our schools and laboratories reaches world-class levels in the coming years"*

Table 3. Summary of the 2004 *Evidence Ltd* report on the performance of the UK Science Base

Theme	Conclusions
Inputs (including expenditure on research)	The UK is spending less on research as a proportion of GDP (1.8%) than its competitors. It is sixth in the G8.
Outputs (including people and publications)	The UK's share of PhD awards is broadly the same as other countries but much less than Germany. It has slipped to third behind the US and Japan in its share of global journal article publications.
Outcomes (research recognition, citations, training and research quality)	The UK gets 12% of global citations, behind the US but Germany is a close third. It has second place behind the US in 7 of the 9 main research fields (3rd in maths and 4th in physical sciences)
Productivity - financial (outcomes and outputs relative to inputs)	The UK is highly productive in terms of PhDs and citations per unit input.
Productivity - labour	Second in PhDs awarded per researcher in the G8 and leads in publications and citations per researcher.
People	The UK is weak in producing highly skilled people with research training, one of the lowest in the G8 whether relative to population or workforce.
Business expenditure	The UK performs well in business investment in the HE research base, comparable to the US. The most significant increases for the UK have been in the natural sciences.

The Biosciences Federation recently conducted its own survey to learn the views of university Heads of Biological Sciences departments on the various outcomes of government science funding policy (Box 1). Nearly all of the 38 departments that responded had received JIF or SFIF funding, and valued the benefits that it had brought about. Most considered that further funding was needed to complete the updating of facilities (as the government recognises in its continuation of the SRIF scheme) (Q2). A few respondents could say that the funding had led already to an increase in publication output, but more echoed earlier comments about indirect benefits, particularly improved staff morale and the ability to recruit and retain excellent staff (Q3): *"Whilst it is early days, the injection of new equipment has helped staff morale, has helped in further bidding based on the new equipment and allowed work to be undertaken that would not otherwise have been possible"*

It is disturbing, however, that two-thirds of the Department Heads said that they are experiencing financial difficulty in meeting the running costs of the new facilities, particularly in regard to technical support and maintenance contracts on major equipment (Q4). This points to the need for greater openness by departments applying for funding to improve infrastructure; and for more coherent and integrated thinking between departments, the administrators of infrastructure funding schemes, and research funding bodies from whose grants running costs are met.

[9] *PSA Target Metrics for the UK Research Base* (2004) A report by Evidence Ltd to the Office of Science and Technology

[10] *The Office of Science and Technology: Scrutiny Report 2003* (2004) Commons Science and Technology Committee report HC316

[11] *The Productivity of Science: an International Analysis* (2004) A report by the Science Policy Research Unit (Sussex) for the Office of Science and Technology

[12] Now known as the Campaign for Science and Engineering

[13] *The Benefits of Recent Investment in Scientific Research* (2000) Save British Science report SBS 00/15

[14] *The Joint Infrastructure Fund: Preliminary Evaluation* (2003) A report by Evaluation UK for the Wellcome Trust, the Department of Trade and Industry and HEFCE

[15] *Delivering a Return on Scientific Investment* (2004) Supplement to Save British Science Newsletter 40

Box 1 The impact of government science funding policies on the health of the biosciences

Results of a Biosciences Federation questionnaire survey of 38 university Heads of Biosciences Departments – 29 pre-1992 institutions and 9 post-1992

1. Has your Department received infrastructure funding in recent years from the JIF, SRIF or other government streams?

Yes = 35
No = 3

2. Has the government investment largely solved the problem of antiquated, ill-equipped research laboratories?

Yes = 7
No, or only partially = 27
Not relevant = 3
No response = 1

While valuing the improvements that JIF and SRIF funding have brought about, and the improved competitive position, most respondents considered that significant further investment is required to bring all infrastructure to the same standard.

3. What have been the greatest effects on your research output, whether direct or indirect?

Times mentioned:
Improved morale = 12
Improved recruitment / retention of quality staff = 9
Ability to perform work otherwise not possible = 7
Help with other grant bids = 6
Positive effects counteracted by worsening work environment = 4

While one or two mentioned improved publication output, more referred to indirect benefits such as those above as being what can be measured at this early stage. A few noted that the positive effect on team morale has been counter-balanced by a worsening work environment, including larger student:staff ratios and increased administrative burden.

4. Do you have adequate funding to actually equip and run the improved facilities?

Yes = 10
No = 24
Don't know yet = 1
Not relevant = 3

10 institutions referred specifically to difficulty in paying for technical support from grant income, and 6 to difficulty in meeting the maintenance contracts on major equipment. Those agreeing the notion tended to be larger institutions having more staff flexibility, and they often qualified their comments by reference to "coping at the moment" or "facing extreme pressure on cost recovery".

5. How do you anticipate that the continuing funding for science infrastructure that is proposed in the 10-year science and innovation framework will enhance research in the UK?

Times mentioned:
Will concentrate research in a smaller number of large institutions = 8
Will allow some departments to be internationally competitive = 5
Will lead to a slow improvement in infrastructure = 4
Will maintain the present position = 4

Most thought that research infrastructure will improve further, but the benefits will be skewed. The leading research universities will benefit most and should be able to remain globally competitive. The overall effect may be to concentrate research in a smaller number of large institutions, and there is some concern that this will reduce the breadth and diversity of research. Continuity of investment needs to be assured in order to allow forward planning. There will be no immediate change in terms of the climate for research and the attractiveness of research as a career.

6. Is the balance between directed funding for initiatives and non-earmarked responsive- mode funding for individual projects about right in your area? If not, comment on how the distribution of Research Council funding should be changed.

Yes = 10
No = 27
No response = 1

A large majority considered the balance is not right. The need for more responsive mode funding was stated by 18 respondents, and four of these added that responsive mode grants are generally acknowledged to fund better science overall. This was rationalised in terms of directed initiatives often effectively shutting out smaller departments from applying, causing researchers to chase after initiatives because of the extra funding rather than from a deep commitment to the project, and the peer-review process often being perceived to be less rigorous. It was argued that directed initiatives are not efficient – the smartest researchers will always use the best approaches to address the most pertinent issues – but recognised that Research Councils run them in order to leverage money from the government.

7. Do you consider that the government is placing too much emphasis on research funded by the Research Councils becoming more closely aligned with the needs of the economy?

Yes = 28
No = 10

It was acknowledged that in return for its investment in the science base the government has a right to expect an economic return, but argued that there is too much emphasis on short-term rather than long-term benefit. Universities are most effective in performing fundamental research whose economic value may only become apparent in the longer term. There should be a separate pool of funding for more applied research, as indeed is the case with the HEIF fund.

8. Are there sufficient opportunities for young investigators to obtain Research Council grants in your area?

Yes = 5
No = 32
Don't know = 1

A large majority considered that there are still too few schemes for young researchers, and/or too small funding pots in such schemes, resulting in competition being "horribly fierce". A very strong track record is needed to win Research Council funding, and the adverse situation for young researchers is exacerbated by the relative decline in responsive mode funding.

9. Do you expect that the introduction of full and economic costing (FEC) will enable your department to meet properly the costs of research projects?

Yes or qualified yes = 8
No = 20
Too early to tell = 10

Some respondents were strongly negative, but the majority expected some improvement, depending on the balance of funding sources used and the proportion of FEC that Research Councils, charities, government departments, the EC and industry end up paying. Seven expressed direct concern that it could result in fewer research grants being available, partly through applications to charities and the EC being disadvantaged. This would be disastrous for the biosciences in view of the growing competition from countries like the US, Japan and Asia-Pacific nations.

10. How concerned are you that government demands for accountability in the use of research funding, or in the recovery of FEC, will place a heavy bureaucratic burden on researchers?

Very concerned = 21
Concerned, quite concerned = 11
Not too concerned, not concerned = 5
Too early to tell = 1

There was almost unanimous agreement that the administrative burden on academic staff is already high, and continually growing. Any disproportionate increase could further drive researchers out of academic life, act as a disincentive to applying for grants, or reduce the precious time available for other key activities. Those who were not unduly concerned considered that their universities would provide appropriate software or algorithms to ease the task of calculating FEC. It is essential that university administrators communicate effectively with RCUK and HEFCE to ensure that they do not exceed the appropriate level of detail.

11. Is the current unit of resource for teaching biosciences adequate? If not, please indicate how this has affected biosciences teaching in your institution.

Yes = 4
No = 33
No response = 1

It was agreed almost unanimously that the unit of teaching resource is inadequate. The consequences noted most frequently were an inability to provide an appropriate level of practical teaching, field work or project work; an unacceptably high student:staff ratio adversely affecting the student experience; and an inability to renew and maintain high-cost lab equipment. Bioscience courses have to be cross-subsidised by various means, which makes them an attractive target for closure in order to reduce institutional costs.

12. Has the limited resource for teaching science caused your institution management to consider decreasing the class sizes and the diversity of science subjects taught?

Yes = 8
No = 29
No reply = 1

The biosciences have not been affected by course closures to the same extent as the physical sciences. The loss of chemistry provision, which is an integral part of many bioscience disciplines, hinders bioscience teaching. Rather than class sizes being reduced, the norm is for them to have increased. Some of the less research-intensive universities have adopted a strategy of maintaining teaching numbers at all cost and have added new 'popular science' courses such as forensics or lifestyle biology, often without increasing staff numbers. Others reported that modules have been streamlined to cut out the less popular ones, and courses designed to share modules where possible in order to maximise teaching efficiency.

13. Is your Department able to attract a cohort of undergraduate entrants of as high a calibre as 10 years ago? If not, what differences do you note?

Yes, or qualified yes = 18
No = 18
Not relevant = 2

There was a very mixed experience, with the leading universities and those perceived as up and coming tending to be still able to attract as strong cohorts as 10 years ago despite the increase in student numbers. Several observed that their best students tend to be from abroad. The expansion of medical school intakes has reduced the pool of the most able students available to the biosciences. Some noted that students are less able on entry despite having stronger paper qualifications, others that there is a longer tail of less able students. The most frequent criticisms of students were poor numeracy, followed by a lack of chemistry knowledge, then poor written English. It was suggested that the expansion of modular A-levels has resulted in students being less able to synthesise information from across modules and subjects. Students often need more initial support than former cohorts, but can achieve well eventually. On the other hand, some noted that other skills such as IT and verbal communication are better developed in today's students.

14. Has the increased PhD stipend in recent years led to the recruitment of higher quality PhD students?

Yes, or in some areas = 9
No = 27
Too early to tell = 1
Not relevant = 1

Most respondents reported no noticeable change. A minority commented that PhD students are driven by the science and that stipend is not that critical; the reputation of the department is also likely to have an influence. A larger number commented that the increase in PhD stipends coincides with an increase in graduate indebtedness and since the PhD stipend is still less than can be earned elsewhere it is not an attractive proposition. The Research Council stipend is still significantly lower than that offered by the Wellcome Trust, which has a record of attracting excellent students. Some respondents commented that undergraduate courses do not prepare students as well for lab work as they used to. Finally, postgraduate students need to be able to see a longer-term, well-paid career route in science, which is currently lacking.

15. Are the additional funds made available for PhD training and career development of young scientists following the recommendations in the Roberts Review sufficient to enable you to enact the improvements called for in the Review?

Yes = 10
No = 19
Partly = 3
Too early to tell = 1
Don't know = 3
No response = 2

Mixed views, but a majority find the new money alone insufficient to satisfy the intended purpose. Several noted that the money has not filtered down to department level. Those responding positively tended to be already heavily engaged in providing broader generic skills training and not dependent on the new money as a primary source of funding

16. Do you experience difficulties in recruiting and retaining high calibre teaching and research staff? If yes, what do you consider to be the chief contributing factors?

Yes = 27
No = 9
No response = 2

A large majority experiences difficulty, due to a complex mixture of factors that varies between institutions. This includes: the level of remuneration (stated particularly in relation to the high cost of living in London), job insecurity and poor career structure, difficulty in obtaining funding for a newcomer to establish a lab, competition between universities to recruit the best researchers, location of institution and size, and the perceived worsening in job environment (reduced academic freedom, greatly increased administrative bureaucracy, the tendency to separate research and teaching functions, perceived lower status of academics).The RAE is seen to have driven the competition to acquire star researchers and the change in research /teaching balance.

17. Do you see a clear differentiation between applied research that could be funded through the RAE and that more appropriate for 'third-stream' funding?

Yes = 13
No = 19
Don't know = 5
No response = 1

Most respondents had a definite view on this question, but opinions were fairly evenly divided. Some stated that the functions of the two funding streams are particularly blurred for biosciences because of the strength of the biotech sector and strong encouragement to commercialise research discoveries.

18. Does your Department seek 'third-stream' Higher Education Innovation Funding? If so, how easy is it to access?

Yes = 16
No = 15
Don't know = 5
No response = 2

Evenly divided. Those that have obtained such funding have often done so as part of a broader university initiative. The funding was considered to be no more difficult to access than Research Council funding, but the process is radically different and it is valuable to have experienced staff with specific responsibility for facilitating this route.

19. Do you believe that there is good engagement between your department and industry?

Yes, or reasonable = 26
No = 12

A large proportion of heads consider that they have good engagement with industry. Many of those who said the links were only reasonable or poor indicated an intention to improve them, but in some instances were unsure how to make the right contacts (see question 20)

20. What could be done to improve further the collaboration between your department and industry?

Times mentioned:
Better communication, better appreciation of each other's capabilities and requirements = 10
Improved working practices to give academics more time to look for industry collaborations = 7
More collaborative training schemes such as CASE and ROPA = 4
Stronger industry pull = 3

Mechanisms to improve communication and aid an understanding of each sector's capabilities and requirements were highlighted. This could be achieved by increasing the number of collaborative training awards, and by incentives to increase the industry pull for collaboration. At the same time the work load on academics needs to be decreased, whether by decreasing the student: staff ratio, reducing the amount of bureaucracy, or by other means, to give them time to pursue industrial interactions.

3.1.2 Effect of research concentration

A common opinion among Department Heads was that the continuation of the SRIF scheme, which allocates funding on the basis of quality and volume of existing research, would skew the benefits to a small number of large universities and result in further concentration of research (Q5). Save British Science has referred to "*a tension between existing excellence and new potential*" in government science funding policy in recent years[16]. By attempting to enhance existing strengths (in the 10-year Science and Innovation plan in pursuit of *"world class research at the UK's strongest centres of excellence"*) funding decisions are already placing insufficient emphasis on future potential and plans. This is manifest in choosing to cut funding for departments rated 4 in the 2001 RAE and in the criteria set for RAE 2008. The Biosciences Federation and its forerunner the UK Life Sciences Committee have argued consistently that the selectivity of research funding was appropriate at the time of the 2001 RAE and should not have been tightened.

Reports commissioned from *Evidence Ltd* by the Higher Education Funding Councils and Universities UK in 2002[17] and by Universities UK in 2003[18] argued against further research concentration. They concluded that UK research performance is highly competitive and has improved measurably against world baselines over the last 15 years. The 2003 report pointed out that there is no evidence of a current problem with the performance of the research base that needs to be addressed, either overall or at the level of the units most likely to see a funding loss. It added that if there were an emerging problem, then there is no clear evidence that the UK's research performance would benefit from further concentration of research funding. On the contrary, innovative research of disciplinary, economic and social benefit could be at risk from a diminution of research funding for RAE grade 4 units. Finally, there was evidence that research concentration would seriously exacerbate existing regional differences in research capacity and performance. This is ironic in view of the government's strong commitment to science and innovation being driven on a regional basis.

[16] *An Opportunity to Save British Science* (2004) Save British Science response to the consultation on a 10-year Investment Framework for Science and Innovation. Report SBS 04/06

[17] *Maintaining Research Excellence and Volume* (2002) A report by Evidence Ltd for the Higher Education Funding Councils and Universities UK

[18] *Funding Research Diversity* (2003) A report by Evidence Ltd for Universities UK

3.1.3 Dual support

The Biosciences Federation supports the concept of dual support for the funding of higher education research, and peer review as the basis for the RAE. The Federation therefore welcomes the government commitment to dual support, and the recognition in CSR 2002 that action had to be taken to rebalance the funding of the two arms. The combination of a continued dedicated funding stream to maintain infrastructure, increased research council budgets to enable them to move towards paying the full cost of research that they commission, and increased research funding support through the funding councils, promises to restore the balance, but this will need to be monitored. These funding streams, together with the requirement for universities to accept responsibility for recovering the full costs of research that they perform, should have a major impact on ensuring the sustainability and competitiveness of research. Universities have complained for a number of years that the block grant for research administered through the funding councils has been insufficient to cover one of its intended purposes:- that of funding a small volume of highly speculative research to develop new ideas or approaches. It is hoped that the position will be substantially improved by the budget increases for the funding councils.

While the implementation of full economic costing will have many benefits, its potential effect on the maintenance of animal facilities needs to be addressed. Academic institutions have, in effect, been cross-subsidising the costs of animal work. Now that the full cost will be transparent there is a real possibility that some institutions will seek to close the animal facilities if they cannot pay their way. This will have an adverse impact on the training of undergraduate and postgraduate students in *in vivo* techniques, as well as on research using experimental animals. The pharmaceutical industry is already finding it increasingly difficult to recruit staff with this type of experience.

The mechanism for universities to recover overheads for research commissioned by different agencies (eg charities, the European Union and industry) also requires more thought because of the different policies operated by each of them. Although CSR 2004 set aside a further £90 million a year by 2007/8 towards the overheads of charity-commissioned research, the Association of Medical Research Charities has estimated that at least £250 million a year is needed, and it is not clear how the shortfall will be met. It was reported recently that many government departments have not requested additional funding to enable them to pay full economic costs; this may require them to reduce the volume of research that they commission. The Federation is concerned that the requirement for institutions to recover full costs may make UK applications for European Union funding non-competitive when compared with those from other EU member states, and result in the UK losing its status as a favoured partner in European collaborations. Two major pharmaceutical companies that the Federation consulted described three types of collaborative research between universities and industry which should have different levels of attached overheads: standard contract research, which should incur full overhead; true collaborative research initiated by industry; and research initiated by the university that may be of marginal interest to industry. For the latter two, the industrial collaborator should pay a smaller proportion of the full overhead cost and the balance be met by a government pool as in the case of research charities. There is already evidence that companies in the pharmaceutical sector are increasing collaborations in the US and France, where overheads are often lower.

3.2 Knowledge transfer between universities and industry

It is entirely reasonable, and well-accepted, that the government's investment in the science base should be matched by a determination of the scientific community to aid the translation of new discoveries into products and services to benefit the health, wealth, and quality of life of the general population. The positive impact of government policies on the knowledge transfer activities of Britain's publicly-funded research institutions is well-documented (eg HEFCE Higher Education-Business Interaction Survey 2001-2[19]; the Lambert Review of Business-University Collaboration 2003[6]; the Treasury's Science and Innovation Investment Framework 2004[5]). Table 5.1 in the latter publication lists a number of parameters that demonstrate that the working relationship between universities and business has continued to improve since 1995/6. Interaction is particularly strong in the pharmaceutical / biotechnology sector. This sector consistently comes top in the DTI's annual R&D Scoreboard, and in the 2004 analysis it was one of the few sectors in which the intensity of R&D spending (spend as a percentage of sales income) was higher than the international average[20].

In the Biosciences Federation survey of Heads of Department more than two-thirds considered there to be good engagement of their departments with industry (Box 1, Q19). Difficulty in establishing contacts between appropriate individuals in academia and industry sectors appeared to be a barrier to further collaboration, as was a lack of appreciation of each other's capabilities and requirements (Q20). A significant number of respondents complained also that the increasingly heavy administrative, teaching and research burden placed on senior academics leaves little time to explore industrial interactions. The two pharmaceutical companies consulted considered that some university technology transfer offices hinder collaboration by seeking unrealistic contractual agreements, and said that they would welcome a more professional and timely response when setting up collaborations. They agreed with the university view that more interaction between scientists in the two sectors would be beneficial for understanding each other's needs.

The Biosciences Federation is pleased that the government's benchmarks of success in knowledge transfer from universities have reduced the emphasis on the *number* of spin-off companies generated. Quality is more important than quantity, since in a highly competitive commercial environment only well-run companies will survive. More sensitive and refined methods of gauging success are needed. Universities must be encouraged to use whichever form of technology transfer is most appropriate for their own expertise and industry requirements, as the Lambert report[6] recommended. There is still much scope for technology transfer offices to improve their effectiveness in order to take some of the direct responsibility for commercialising discoveries from researchers. The Federation welcomes the introduction of professional accreditation for technology transfer managers and hopes that this will lead to more consistent standards within the profession. The government must accept, too, that the objective of knowledge transfer is to benefit the community as a whole rather than to create a significant new source of revenue for academic research institutions[6].

The Federation's academic survey revealed some confusion about the funding of applied research that needs to be clarified. Roughly half the Department Heads did not see a clear differentiation between applied research that could be funded through the RAE and that more appropriate for 'third-stream' funding (Q17). Lambert recommended that the latter funding stream should be focused on departments performing work of real value to business that does not necessarily rank as world class in academic terms, and so is poorly recognised in the RAE; and that Regional Development Agencies should identify those departments and distribute the funding. Instead, CSR 2004 left the responsibility for its distribution with the Funding Councils, and it is not clear to what extent its use matches the Lambert intentions.

[19] *Higher Education- Business Interaction Survey 2001-2* (2004) HEFCE third annual survey

[20] See www.innovation.gov.uk/projects/rd_scoreboard/home.asp

3.2.1 Industry pull or university push needed?

The Lambert Review[6] considered that the main challenge for the UK is not about how to increase the supply of commercial ideas from the universities into business, but about how to raise the overall level of demand by business for research from all sources. The pharmaceutical / biotechnology sector can be excluded from this comment because it has a long and successful history of seeking academic research collaborations, but other sectors need to be stimulated if the target of increasing overall R&D spending in the UK to 2.5% of GDP is to be met. The first annual review of the 10-year Science and Innovation plan reported that industrial R&D investment has stagnated in recent years[21]. The government introduced and extended tax incentives for companies to invest in R&D in the 2000 and 2002 CSR, introduced a new Technology Strategy Group in the DTI in 2004 to help businesses exploit technologies from the research base, and gave Regional Development Agencies added responsibility for supporting local businesses and facilitating academia-industry links in 2004, but there is a limit to what direct government intervention can achieve. A recent survey found that 76% of UK companies have not increased their R&D spend as a result of the tax credit[22]. Many companies said they find the process of claiming the credit difficult, and in a critical newspaper article tax experts described the scheme as a "shambles"[23]. Clearly, it needs to be better administered, made simpler, and worth more financially to companies; but tax incentives alone are not the key since the pharmaceutical industry invested heavily in R&D even before these were introduced.

The two pharmaceutical companies consulted considered that CASE and LINK schemes have encouraged investment in R&D by bioscience companies and should be extended to include fellowships and sabbaticals to develop greater understanding and respect between industrial and academic scientists. CASE schemes allow companies to play a role in training students in areas that are important to them, while LINK programmes give academic post-doc scientists an opportunity to bring new perspectives and diverse thinking to bear on industrial challenges.

The government needs to be careful that its pressure on the academic sector to drive industrial engagement in R&D does not lead to an over-emphasis on short-term research objectives. Applied science projects of direct benefit to industry will be starved of input if, upstream, there is insufficient funding, and encouragement, for fundamental research. The government has come under fire from the Royal Society and Save British Science for intervening too much in the funding of research by attempting to pick winning areas to support with directed initiatives. The Federation's survey of Heads of Department also found that more than two-thirds consider that the balance between directed funding for initiatives and non-earmarked responsive mode funding is too skewed towards the former (Box 1, Q6), and a similar proportion think that too much emphasis is placed on research funded by the Research Councils becoming more closely aligned with the immediate needs of the economy (Q7). There are many examples of important applications of fundamental research only being recognised in the longer term. The two pharmaceutical companies consulted stated emphatically that Research Council funding should focus on basic research. The Federation is pleased to note in the Research Councils' 2005 delivery plans that BBSRC intends to increase responsive mode funding by 4% a year, and is inviting applications for a portfolio of 5-7 year grants that allow the pursuit of more risky research projects. **The Councils need sufficient money to fund both agreed research priorities and investigator-led more speculative research**

The Federation urges that the recommendation in the 2003 DTI innovation report for the Director General of the Research Councils to agree further goals with the Research Councils to increase their knowledge transfer and interactions with business should not result in the application of over-restrictive and bureaucratic metrics to assess Research Council performance. The Councils are already heavily and successfully engaged in knowledge transfer, as exemplified in the Research Councils UK publications *Science Delivers* [24] and *Material World: Knowledge Economy* [25]. The US leads the world in research outputs[9] and has the strongest biotech industry. Nevertheless, colleagues at the Federation of American Societies for Experimental Biology (FASEB) confirmed that the major US funding programmes do not attempt to pick winners in terms of technology transfer. Both the National Institutes of Health and the National Science Foundation continue to fund untargeted basic research primarily. FASEB considers the major force behind the boom in US technology transfer to be the Bayh-Dole Act, which gives academic researchers title to the intellectual property developed under federal grants and encourages universities and academic scientists to seek out industry [26].

[21] The 10-year Science and Innovation Investment Framework Annual Report 2005 (2005) HM Treasury, Department of Trade and Industry and Department for Education and Skills

[22] Research Fortnight, 11 May 2005

[23] Daily Telegraph, 6 June 2005

[24] *Science Delivers* (2002) Research Councils UK

[25] *Material World: Knowledge Economy* (2004) Research Councils UK

[26] Garrison H (2004) Personal communication from FASEB's Director of Public Affairs to M Withnall

Table 4. Higher Education Statistics Agency data on the numbers of science students in Higher Education (see www.hesa.ac.uk)

Subject	Total HE students							
	2003/4	2002/3	2001/2	2000/1	1999/00	1998/9	1997/8	1996/7
Biological sciences (total)	147355	125860	94560	93730	90740	89338	87987	81750
Biology	25400	24410	22010	22310	22660	23347	23100	23962
Psychology	64480	50780	32820	31045	29340	28244	28133	25120
Sports science	22325	17585	-	-	-	-	-	-
Molecular biology, biophysics plus biochemistry	9805	9280	9160	9655	9800	9910	9800	9954
Chemistry	18525	19015	19085	19660	20910	21905	22010	22679
Physics	13360	12830	12310	12905	13150	13695	13982	14366
All subjects	2.25M	2.18M	2.09M	1.99M	1.86M	1.85M	1.80M	1.76M

3.3 The flow of people into science and technology

The closure of university chemistry departments because of a difficulty in attracting students, and because chemistry is an expensive subject to teach, has been much in the news over the last two years. Bioscience is just as expensive to teach as the physical sciences. Biological sciences as a whole has not yet lost student numbers, but there is mounting evidence of a shift in course choice away from molecular biosciences towards newly-fashionable subjects such as psychology, sports science and forensic science (see Table 4). This is disturbing since molecular bioscience underpins the whole of modern biology. Some of the new courses are to be praised for repackaging core science in a way that is more attractive to students, but all too often such courses are fragmented so that the graduate does not acquire a deep knowledge of any individual subject and may face poor career prospects.

The reasons for the declining popularity of science, and careers in science, were examined in depth in the 2002 Roberts Review[4]. They included a failure of school science to excite the imagination, a perception that science is a difficult and dull subject to study at university, an uncertain career structure in academic science, and perception of non-competitive salaries in scientific R&D. The government has introduced a series of initiatives in successive CSR to improve the teaching of science in schools, including financial incentives to encourage good graduates into teaching, improving the facilities for teaching science, and co-funding National Science Learning Centres to enable science teachers to update their skills and knowledge. At the same time the new 21st Century Science curriculum is being trialled that aims to make science teaching more relevant to everyday lives, and to cater better for the needs of those who will end their study of science at the age of 16 as well as those who will go on to further and higher study. These are all sensible initiatives that the Biosciences Federation supports. A working group on enthusing young people about bioscience established by the Federation recently called in addition for a greater focus on practical work and fieldwork, for the application of knowledge to be better-rewarded in assessment, and for greatly-improved careers advice at key decision-making stages of education[27]. School students are often unaware of the wide range of careers to which training in science can lead.

[27] *Enthusing the Next Generation* (2005) A report on the bioscience curriculum by a working group established by the Biosciences Federation

3.3.1 The output from university science courses

The Federation considers government higher education teaching policy to be poorly thought out and with few signs of integration of activities. The combination of greater indebtedness as a result of increased tuition fees and uncertain career progression in academic science are likely to deter graduates from continuing training for a PhD. **The progressive increase in PhD stipends in recent years may help, but in the Federation's survey more than two-thirds of the Heads of Department did not consider that this has resulted in better students being recruited to doctoral courses.** Stipends are still lower than salaries that could be earned elsewhere (Box 1, Q14). The government has encouraged more young people to attend university, and given universities incentives to take more students. This has resulted in much larger class sizes, a larger tail of weaker students, and an increasing inability of bioscience departments to provide the amount and type of practical training and project work that future employers require (Q12). There was almost unanimous agreement among Heads of Department that the current unit of resource for teaching bioscience is inadequate (Q11). A consequence is that the pharmaceutical companies consulted referred to "*graduates coming through who often do not have the basic knowledge and core skills needed for a career in science*". The Funding Councils must undertake a proper study to elucidate the *real* cost of teaching science subjects rather than the *current apparent* cost, taking into account the purpose of the courses and the need to reduce the student:staff ratio to an appropriate level.

The Higher Education Academy Centre for Bioscience recently reported a study in which it consulted former students from 4 universities, now in various forms of employment, on how well prepared they had been for their jobs[28]. The graduates were satisfied with the provision of subject knowledge and presentation and communication skills, but considered that their courses failed to provide sufficient practical knowledge and expertise. This endorses the industry view, and would be replicated across nearly all universities.

The Federation is unclear as to whether Foundation degrees are meant to be a vocational qualification in their own right, or a stepping-stone to a full degree. Bioscience industry requires people with vocational qualifications having the former stature of Higher National Certificate and Higher National Diploma, now largely abandoned, where the skills and knowledge of the holder were well understood. More young people need to be encouraged to pursue sub-degree technical courses rather than academic degrees for which they may be poorly equipped, and which may lead to frustrated career aspirations. It is right and proper for industry to be closely involved in the design and content of vocational courses, but the Federation considers that there should be more limited involvement of industry and of Skills Councils in academic courses, which must be more than just a training for employment.

3.3.2 The work environment in academic science

The financial reward from working in academia has always been relatively poor, but academic freedom and job security and satisfaction have been considered to compensate to some extent. The work environment is no longer regarded as a positive benefit; it is affected by greatly increased bureaucracy to satisfy accountability considerations (survey, Q10), uncertainty in career progression, progressively less competitive salaries, increased teaching workload arising from university expansion without a commensurate increase in teaching resource, pressure to perform in research to bring in research grants and RAE money, and restriction of academic freedom by funding increasingly being ring-fenced for particular projects. In the Federation's survey a large proportion of Department Heads reported difficulties in recruiting and retaining high quality teaching and research staff (Q16)

Actions arising from the Roberts review have largely benefited researchers at the start of their careers in terms of improved PhD stipends and starting post-doc salaries. The increased funding for the science base from the OST has not been matched by an increase from the Department for Education and Skills (DfES) to make academic salaries more competitive. The 2004 CSR only announced a relatively small pot of money to enable universities to adopt a more flexible approach to rewarding performance. A symposium organised by Save British Science in 2004[29] attended by representatives from academia, government, industry and research charities prepared an idealised average salary trajectory with age that took into account the need for salaries to be competitive in the market place and affordable to the tax payer. The cost to implement the scheme (£250 million a year in England) would be less than 6% of the government's current annual expenditure on science, engineering and technology R&D in the science base. The reasoning behind the proposed salary trajectory should be considered seriously by the DfES and the Treasury.

Fixed term contracts legislation is intended to benefit young researchers by requiring universities to manage their careers better. However, because of the uncertainty of grant renewals, there is a real risk that when the legislation begins to 'bite' in 2006 there will be a surge of researchers made redundant rather than offered open-ended contracts. This is already happening in many institutions, and is exacerbated by the fact that the principal investigator is responsible for paying the costs of redundancy, which are based on the length of employment at an institution and not on the length of the grant. The new fellowship scheme for promising young researchers that resulted from the Roberts review was introduced without appropriate discussion with universities. It places institutions in difficulty by having to offer permanent positions at the end of fellowships to researchers who were very early in their careers, and relatively unproven, at the start of the fellowships.

[28] Brown CA, Calvert JE, Chairman P, Newton C, Wiles K and Hughes IE (in press) *Skills and knowledge needs among recent bioscience graduates – how do our courses measure up?* Bioscience Education E-journal 6 (see www.bioscience.heacademy.ac.uk/journal/vol6/index.htm)

[29] *Attracting the Best* (2004) Report of a Save British Science symposium on recruiting world class researchers in UK universities

3.4 The bioscience industrial sector

In 2003 the Bioscience Innovation and Growth Team (BIGT) described UK bioscience as being at a cross-roads[30]. The UK is the European leader in bioscience industry and second only to the US in world rankings. It has a number of competitive advantages such as a strong academic research base and a number of maturing biotech companies; improving university-industry links; sophisticated capital markets for bioscience investment; and a single provider healthcare system to facilitate biomedical development. But it faces growing competition from Asia-Pacific countries, and the risk is that the bioscience sector will relocate to the US. For example, for the first time ever, 2003 saw a decline in pharmaceutical R&D investment in the UK together with an 18.5% decrease in capital investment[31]. Today there are no global R&D headquarters for any of the major pharmaceutical companies in the UK.

A number of the competitive advantages above have been strengthened by the policies of the government. The government has also acted upon two of the specific BIGT recommendations for securing the UK's position as a global leader in bioscience by 2015 – the creation of the UK Clinical Collaboration in CSR 2004 to bring together the Department of Health, the NHS, the Medical Research Council, medical charities and industry for patient benefit; and the creation of a National Biomanufacturing Centre in the north-west to offer early stage development and manufacturing services and act as an enabler to bioscience innovation. While the performance of Regional Development Agencies has been patchy overall, there are excellent examples of regional biotechnology development, and it is probably in this sector that research institutions have been most successful in knowledge transfer to business.

The defects in the supply of trained scientists discussed in section 3.3 could hinder the development of the biosciences industrial sector:

- The pharmaceutical industry has pointed out that it is increasingly having to recruit science graduates from abroad because insufficient graduates with appropriate knowledge and skills are emerging from UK universities;
- Bioscience research is increasingly cross-disciplinary and quantitative, yet too few people are studying physical sciences or maths;
- Students are not receiving sufficient practical training either at school or university, leaving them ill-equipped for R&D careers;
- There are insufficient numbers pursuing technical courses, making it difficult for industry to recruit good quality technicians.

The Federation recommends that the government should act to ensure that the requirement for academic institutions to recover the full costs of research does not lead to bioscience industry being charged excessively for genuinely collaborative work and hence to a reduction in such interactions. Access to the UK's excellent science base has been a major reason for pharmaceutical companies maintaining a research presence in the UK. It should be noted, too, that emerging biotechnology enterprises also operate on a world stage and will not automatically continue to invest here – it is up to government to sustain and enhance a competitive environment.

The government has been keen to engender greater public confidence and improved engagement in scientific research and its innovative applications. A recent MORI poll conducted for the OST found clear evidence of increasingly positive attitudes to science and technology among the UK population[32]. For instance, 85% thought that science makes a good contribution to society and there were positive associations of science with advancement and progress, particularly in the field of healthcare. Working with charitable organisations to ensure the coherence of public engagement initiatives, as proposed in the 10-year Science and Innovation plan, is probably the best way forward. The acceptance of embryonic stem cell research in the UK demonstrates what can be achieved by being open and engaging with the public on all the issues. On the other hand, the government must accept its share of responsibility for failing to present a convincing case to the public for the long-term potential health and nutritional benefits of genetically modified food plants. **As a result the UK has lost its cutting edge position in horticultural and agricultural bioscience and the consequent disinvestment has damaged the prospects of commercialisation in these fields.**

Animal rights extremism remains a potent threat to the bioscience sector. It discourages researchers from working with animals and universities from providing training, and imposes a financial burden as research institutions or companies spend money on tighter security or lose investors or suppliers who fear for their own safety. It is a serious disincentive to global bioscience companies retaining research facilities in the UK. The government was slow to take action initially, but improvements to the Criminal Justice and Police Act, and the tough measures introduced in the 2005 Serious Organised Crime and Police Act are to be applauded. The police must be given the resources to apply the new measures effectively, and the government must state unequivocally that it supports properly licensed research using animals. It is encouraging to note that the ABPI recorded a smaller number of incidents of harassment in the first half of 2005 but there is no room for complacency, as evidenced by the recent closure of the Darley Oaks guinea pig breeding farm after its owners faced years of intimidation.

[30] *Improving National Health, Increasing National Wealth* (2004) A report to Government by the Bioscience Innovation and Growth Team

[31] Association of the British Pharmaceutical Industry Annual Review (2004)

[32] *Science in Society* (2005) A report from MORI for the Office of Science and Technology

4. Building on the government's investment

The purpose of the government's investment in science and innovation has been to ensure the UK's long-term competitiveness in an increasingly knowledge-driven economy. Policies followed have resulted in an enormous and continuing improvement in research infrastructure in most universities; a better balance between the two arms of dual support offering the promise of sustainability for the future; a new realisation of the vital necessity for knowledge transfer activities in Britain's academic institutions and a recognition of the importance of openness and engaging with the public in order to foster support for scientific advances; and a growing bioscience industry sector that is strong in R&D. The Biosciences Federation welcomes these outcomes and encourages the government to continue in the general direction set out in the 10-year Science and Innovation plan. Faced with competing calls for money, the government must not be tempted to cut back spending on science and innovation since the *Evidence Ltd* annual report found the UK only 6th among leading G8 nations in science investment as a proportion of GDP.

Whilst appreciating these successes, the Federation identifies a number of outcomes that have not been positive and that the government should address in order to build on its achievements. In some areas the government has created barriers to success by an over-emphasis on accountability bringing in undesirable bureaucracy and skewing priorities; by over-centralisation; and by not fully appreciating the way that scientific discovery works. Funding initiatives such as SRIF have frequently required part-matching contributions from universities, which have placed some institutions in financial difficulties. The formulaic approach to funding has created waste at all levels as universities have tried to conform to centrally set norms, and has reduced the flexibility of institutions to manage their own affairs. To reduce bureaucratic inefficiency the government needs to find ways of reducing the central direction and top-down managerial control, whilst ensuring that universities accept responsibility for the sustainability of their outputs.

Central to the government's vision is the ability to recruit talented young people into science, yet education policy seems particularly inconsistent and characterised by a lack of coherent and integrated thinking. One factor contributing to the relatively lower popularity of core science courses in universities is that school students are increasingly avoiding subjects in which it is perceived to be difficult to achieve good grades. The emphasis placed by the DfES on school league tables of examination results means that there is little incentive for schools and colleges to discourage this attitude by stressing the importance of science. It would be valuable for the government to emphasise that it does not consider all subjects to be equivalent when assessing school performance. Commenting on the current year's A-level results, the Director General of the Confederation of British Industry stressed in August 2005 *"The strength and future success of the UK economy relies on the education system producing students of a high calibre in disciplines such as science"*[33]. The Biosciences Federation sees no virtue either in the arbitrary target of 50% of young people participating in higher education. The policy needs to be thought out and explained - too many students enter academic courses for which they are poorly qualified, and too few pursue technical courses. Furthermore, despite the abundant evidence that university bioscience departments are struggling to provide an appropriate level of practical training, HEFCE refuses to reconsider the unit of resource for teaching science subjects before 2007/8. Finally, bioscience graduates with larger student debt will be put off taking a PhD fearing that future pay and conditions in research careers are not particularly good. These are hardly the outcomes expected from a government that is committed to increasing the number of trained scientists in the workforce.

[33] Sunday Telegraph
14 August 2005

The lack of joined-up thinking extends to academic careers. While implementing a number of recommendations from the Roberts Review of 2002, the government has done little to improve pay and conditions for experienced academic researchers and teachers. Obtaining the best output from university academics requires the government to establish the conditions for a supportive and enabling work environment, yet many academics face a heavier teaching workload from the increase in student numbers as well as mounting administrative responsibilities. There may be valid reasons for the latter, but paper production for accountability purposes should be kept to a minimum. Most universities are experiencing difficulties in recruiting and retaining world-class researchers in science, with evidence that an increasingly high proportion of good applicants for research jobs come from outside the British system. Money should be made available to enable universities to apply a more sophisticated system of rewards for contributions to teaching, research and administration.

Concern was expressed by Heads of Bioscience Departments that the allocation of ring-fenced pots of money to the Research Councils for identified priority research areas has resulted in insufficient money being available for responsive-mode applications. The Federation considers that prioritisation is an essential element of any government Research and Technology strategy. In order to ensure that its research priorities are backed by a majority of the science community, and that the community is capable of responding, the government should consult more widely at an early stage of policy development. Clarity at this point would pave the way for improved delivery from researchers. Any ring-fenced initiatives that emerge in specific areas of research must be funded by new money, and not from the already inadequate responsive mode budget.

The Federation agrees the benefits of monitoring Research Council performance to ensure sustained commitment to knowledge transfer and interaction with business. But the Federation urges that the metrics used should be agreed with the Councils, and not restrict their flexibility nor lead to skewed priorities, which would be counter-productive. Furthermore, knowledge transfer has to be valued by the recipient so the government needs to address also the industry demand for innovative R&D. Any drive to increase knowledge transfer that is not valued will be costly on the researcher's time and likely to lead to increasing frustration. **There has been a sea-change among academics in attitudes to engaging with industry and to entrepreneurship, and financial incentives should suffice to maintain a healthy level of knowledge transfer. The HEIF pool of money needs to be increased to encourage greater participation by universities, and the respective purposes of RAE and HEIF funds clarified.**

The BIGT report concluded that most of the responsibility for achieving a successful future for UK bioscience lies with industry choosing the best technologies on which to focus and pursuing viable business strategies to achieve profitable growth. The government role is to create a steady, dependable and supportive environment. In this respect government policies must focus on maintaining the flow-through of young people into science, the capacity of academic institutions to perform excellent research, removing any barriers such as those identified in this report that restrict engagement between academia and bioscience industry and knowledge transfer between the two, and on creating a favourable taxation regime that is well administered and non-bureaucratic.

Acronyms

ABPI	Association of the British Pharmaceutical Industry
BBSRC	Biotechnology and Biological Sciences Research Council
BIGT	Biosciences Innovation and Growth Team
CSR	Comprehensive Spending Review
DoH	Department of Health
DTI	Department of Trade and Industry
FASEB	Federation of American Societies for Experimental Biology
FEC	Full economic cost
GDP	Gross Domestic Product
HEFCE	Higher Education Funding Council for England
HEIF	Higher Education Innovation Fund
HEROBC	Higher Education Reach Out to Business and the Community
JIF	Joint Infrastructure Fund
MRC	Medical Research Council
NHS	National Health Service
OST	Office of Science and Technology
PSA	Public Service Agreement
RAE	Research Assessment Exercise
RCUK	Research Councils UK
RDA	Regional Development Agency
SRIF	Science Research Investment Fund

Member Societies of the Biosciences Federation

Association for the Study of Animal Behaviour
Biochemical Society
British Andrology Society
British Association for Psychopharmacology
British Biophysical Society
British Ecological Society
British Lichen Society
British Mycological Society
British Neuroscience Association
British Pharmacological Society
British Phycological Society
British Society of Animal Science
British Society for Cell Biology
British Society for Developmental Biology
British Society for Immunology
British Society for Medical Mycology
British Society for Neuroendocrinology
British Society for Proteome Research
British Toxicological Society
Experimental Psychology Society
Genetics Society
Heads of University Biological Sciences
Heads of University Centres for Biomedical Science
Institute of Animal Technology
Institute of Biology
Institute of Horticulture
Laboratory Animal Science Association
Linnean Society
Nutrition Society
Physiological Society
Royal Microscopical Society
Society for Applied Microbiology
Society for Endocrinology
Society for Experimental Biology
Society for General Microbiology
Society for Reproduction and Fertility
Universities Bioscience Managers Association
UK Environmental Mutagen Society

Additional Societies represented by the Institute of Biology

Anatomical Society of Great Britain & Ireland
Association for Radiation Research
Association of Applied Biologists
Association of Clinical Embryologists
Association of Clinical Microbiologists
Association of Veterinary Teachers and Research Workers
British Association for Cancer Research
British Association for Lung Research
British Association for Tissue Banking
British Biophysical Society
British Crop Production Council
British Grassland Society
British Inflammation Research Association
British Marine Life Study Society
British Microcirculation Society
British Society for Ecological Medicine
British Society for Parasitology
British Society for Plant Pathology
British Society for Research on Ageing
British Society of Soil Science
Fisheries Society of the British Isles
Freshwater Biological Association
Galton institute
Institute of Trichologists
International Association for Plant Tissue Culture & Biotechnology
International Biodeterioration and Biodegradation Society
International Biometric Society
International Society for Applied Ethology
Marine Biological Association of the UK
Primate Society of Great Britain
PSI - Statisticians in the Pharmaceutical Industry
Royal Entomological Society
Royal Zoological Society of Scotland
Scottish Association for Marine Science
Society for Anaerobic Microbiology
Society for Low Temperature Biology
Society for the Study of Human Biology
Society of Academic & Research Surgery
Society of Cosmetic Scientists
Society of Pharmaceutical Medicine
UK Registry of Canine Behaviourists
Universities Federation for Animal Welfare

Additional Societies represented by the Linnean Society

Botanical Society of the British Isles

Biosciences Federation, Peer House, Third Floor
8-14 Verulam Street, London WC1X 8LZ

T 020 7269 5717   F 020 7269 5720   www.bsf.ac.uk