

RSC Submission to the Comprehensive Spending Review 2007

The RSC is the UK professional body for chemical scientists and an international Learned Society for advancing the chemical sciences. Supported by a network of over 43,000 members worldwide and an internationally acclaimed publishing business, our activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

Executive summary

The Government has made developing a highly skilled work force, building an excellent education system and creating an environment that promotes innovation and economic investment its highest priorities. The RSC welcomes and supports these developments. The RSC considers that investment should continue to be prioritised for these key areas to secure the gains already made and to ensure future prosperity.

Maintaining strength in UK physical science

The RSC considers that there is a demonstrable case for an additional investment of £3.4bn between 2008 and 2010 to secure sustainability in higher education and to provide excellent science education in schools, allocated as set out below.

Securing the future of the chemical sciences in Higher Education Institutions

Total funding of £338m is needed for physical science and engineering in 2008 in universities, with £128m of those funds required for chemistry. A further £306m per annum is required for 2009 and 2010. This is needed to provide the necessary financial breathing space for Vice-Chancellors to draw up long-term plans for the sustainable provision of strategically important laboratory based subjects which are, by their nature, more expensive to run, and to prevent yet more economically damaging department closures. In the long term, funding for these courses should cover the full cost of provision, as calculated by the Transparent Approach to Costing (TRAC).

Providing the best chemistry education in schools

Good school science facilities

A capital allocation of £1.9bn is required to provide modern science laboratory facilities in all schools at the earliest opportunity, and £70m per annum (£210m between 2008 - 2010) for equipment. Research commissioned by the RSC into the rate of improvements in school laboratories will assess progress in institutions which have benefited from the Building Schools for the Future Programme because we are concerned about the very slow pace of this initiative.

Specialist school teachers in the sciences

Additional funding of £70m per annum (£210m between 2008 - 2010) is needed to provide specialist teachers in the sciences for all students aged 14 -16 years. This should be achieved through an increase in the number of appropriately qualified science graduates who enter the teaching profession, more effective continuous professional development of existing staff and measures to boost retention.

Investing in teachers

Additional annual funding is required to provide all school science teachers with effective subject specific professional development for a minimum of 5 days on at least an annual basis. For chemistry specialists, this will require an extra £2.6m per annum.

We welcome the Chancellor's recent comments that investment in HE in the UK must increase from the current 1.1% of GDP if we are to remain internationally competitive. The development of a more effective science base is essential for the future prosperity of the country, and also the life style we all aspire to, in what will become an increasingly competitive and knowledge-driven world. The RSC is committed to working with Government to support its investment in science and technology and we look forward to discussing our proposals with you.

The Importance of the Chemical Sciences

A major contributor to national wealth

The UK chemicals and pharmaceuticals sectors are major employers and contributors to the UK's national wealth. Over 250,000 people are directly employed in these sectors in over 3,500 companies which range in size from micro enterprises of less than ten people to multinationals. With an annual turnover of £50bn, over 80% of which is exported, these companies and their employees pay taxes of £5bn to government and to local authorities.¹

The pharmaceutical industry is an example of industrial excellence which depends upon a strong scientific base. According to the DTI², the UK pharmaceutical sector is ranked as world class, making the largest contribution from the manufacturing sector to our balance of payments and investing 14.9% of sales in research and development. When combined with the biosciences sector, it accounts for 40% of all R&D spending in the UK. Despite a relatively modest consumption of medicines per capita within the UK, two of the largest eight pharmaceutical companies in the world are British, while the world's largest pharmaceutical company has a substantial investment in the UK.

The higher education sector is a major contributor to UK prosperity in its own right, generating an international surplus of £3.6bn and providing 556,000 jobs in universities and related industries, or 2.7% of the total national workforce.³ The overall quality of UK research is world class, producing 8% of all scientific papers and 9% of citations, all from a country with only 1% of the world's population. In addition, there is a high correlation between the strength of the scientific research which is performed at a particular institution and the level of high technology investment from the private sector in the same region. This investment is not solely due to the existence of spin out companies from the university itself, but is also due to a high concentration of foreign direct investment which these centres of excellence are able to attract to nearby science parks.⁴

The source of our future prosperity

The RSC considers that the base for a group of industries will eventually be located in the region where the most value is added, which usually equates to areas with the highest concentration of highly skilled and knowledgeable employees, irrespective of the nationality of investors. This is a trend which will accelerate as the forces of globalisation bring down the barriers to free trade. Therefore, it is very important to increase the knowledge and skills of the UK workforce, not just amongst highly trained specialists, but also by raising the general level of scientific literacy in our population, if we are to compete internationally.

The challenges of climate change and securing sustainable energy supplies will spawn many of the major industrial opportunities of the 21st Century and it is essential that the UK leads in the generation of solutions and in exploiting market opportunities. The chemical sciences will play a key role in the quest for these solutions, from carbon capture and storage, photo-voltaics and biofuels⁵ to more efficient fuel cells to enable the hydrogen economy⁶, and safer ways of handling and storing the legacy of radioactive waste from our nuclear power plants.⁷

Many of the major industrial sectors of the future will be spawned from scientific research, especially at the exciting areas of interdisciplinary activity, such as surface science and nanotechnology. And this research is being conducted by teams of individuals who are experts in their respective areas of fundamental science, with the chemical sciences playing a central role. One such area which has shown stunning growth over recent years is biotechnology, and the UK is well positioned in this sector with the largest number of biotechnology companies outside the USA. New discoveries at the interface of chemistry and biology have enabled the explosion of knowledge which has occurred over the last 20 years in medicine and crop science. This has created an industry which employs over 40,000 people in the UK and has a market capitalisation of over £5bn, with the UK accounting for 93% of publicly listed European biotechnology companies.⁸

The skills challenge

The chemicals, pharmaceuticals and the higher education sectors all depend heavily on a diverse, regionally dispersed, high quality science base, and emerging sectors, such as biotechnology and renewable power generation, will place an increasing emphasis upon scientific excellence and innovation. The chemical sciences are at the heart of all of these endeavours, so the supply of highly skilled scientists who have a thorough grounding in chemistry and can apply this knowledge to new areas of discovery is fundamental to our ability to compete in the global economy and to our future prosperity.

However, the future supply of physical scientists is under threat from the long term effects of an education system which is insufficiently resourced.

In recent years, the trend of closures of university chemistry departments has been the most visible symptom of this funding shortfall. Perhaps less apparent but no less serious is the impact upon students' aspirations, which could be related to poor school science laboratories and the lack of science teachers with appropriate qualifications to enable students from all backgrounds to reach their potential. The UK needs an educational system which encourages and supports the brightest minds to pursue scientific study and to match this with the demands of our high growth, innovative industrial sectors.

In fact, there are already worrying indications of a failure to satisfy the demand for research, development and business development staff in our most competitive industrial sectors. In the report *Sustaining the Skills Pipeline* by the Association of the British Pharmaceutical Industry, the need to address shortages for a broad range of chemical scientists, including specialists in analytical, physical, synthetic organic and medicinal chemistry, is given a high priority, as is the problem of insufficient "hands on" laboratory experience amongst graduates. Shortages of these skills are predicted to affect the ability of the UK pharmaceutical industry to grow and to have a particularly damaging impact upon their manufacturing operations.⁹ Many companies in the UK are already drawing on overseas chemistry graduates because of a shortage of skills, and some are relocating their operations overseas.

Building a workforce for the knowledge economy

In 2004, the RSC welcomed the launch of the 10 Year Investment Framework for Science and Innovation. Some good progress has been made since then in a number of areas, with the establishment, for instance, of national and regional science learning centres to provide teacher training, and the stated intention to implement the transparent approach to costing (TRAC) methodology in universities. However, we urge the government to focus on the key concern of supporting the provision of laboratory based subjects in universities, and on giving an even higher priority to science education in schools. This is essential if the Investment Framework is to succeed in making Britain the most attractive location in the world for science and innovation.

Securing the future of the chemical sciences in Higher Education

Cost driven department closures

Three years ago, at the time of the RSC submission to the last Comprehensive Spending Review in 2004, the chemistry departments at the University of Swansea, Kings College London, Salford University and De Montfort University had closed. At that time, the RSC predicted that if nothing were done then all chemistry departments except those rated 5 and above in the 2001 Research Assessment Exercise (RAE 2001) would be at risk of closure. Therefore, it has been worrying to see the realisation of this prediction, with the closures of chemistry courses at the University of Exeter, Anglia Ruskin University and the University of Coventry. In fact, the recent discussions on the proposed closure of the chemistry department at the University of Sussex, which received a rating grade of 5 in RAE 2001, demonstrate that departments which produce research of international standing (and 3 Nobel laureates in the case of Sussex) are also at serious risk of closure. The reprieve for chemistry at the University of Sussex arrests this trend, at least temporarily, but the issue of insufficient funding remains. It is essential to maintain a diverse provision of chemical science training across the UK as industry is suffering particularly from a reduction in part time education and specific technical training.

Hard evidence

The RSC recently conducted research into the costs of running chemistry departments¹⁰ at eight UK universities, which received ratings from 3b to 5* in RAE 2001. This research, using TRAC methodology, showed that all eight departments were operating with budget deficits, which allocates all central costs and adjustments to budget centres. The most significant factors affecting costs were the high proportion of laboratory work undertaken by undergraduates, the high level of skilled supervision that this requires and the high cost of laboratory space. The total deficit in those eight departments was £17m, and hence we estimate that the total deficit across chemistry departments across the UK is of the order of £100m.

The introduction of fees will bring in some extra income but a proportion of the increase in fees will be used to fund bursaries. In the first year, increased fees may bring in around £4m extra which will reduce the overall deficit from £100m to £96m for all UK university chemistry departments. By 2009, when the increased fees will apply to all years in Higher Education, the total increase in income may be around £14m. Extrapolation of the chemistry data across physical science and engineering leads to a conservative estimate of an annual deficit of £306m.

Departmental closures, when set against the healthy, sustained demand by students to enrol on chemical science courses, and the evident relationship between a strong, regionally diverse science base and economic prosperity, indicate a systematic failure to meet demand with supply. The consequence of allowing these closures to continue in a random manner, regardless of the country's strategic needs, will make the government's stated intention to increase the number of students on physical science courses unattainable and jeopardise any long term effort to increase our economic competitiveness.

The RSC is calling upon the government to provide funding which is sufficient to cover the full cost of providing such courses. This will remove the perverse financial incentive for Vice-Chancellors to make department closures which are against the national interest and will enable them to find sustainable models for laboratory based subjects.

Solving the short term problem

Additional annual funding of £338m for physical science and engineering is needed between 2008 and 2010 in universities. £128m of these funds are required for chemistry, with £96m to provide the necessary financial breathing space needed by Vice-Chancellors to draw up these long-term, sustainable plans which widen student participation and meet the needs of industry, and £32m to cover testing and implementation of these plans under the *Chemistry for Our Future* program (see appendix).

Providing longer term stability

The RSC considers that funding for laboratory based science and engineering courses should cover the full cost of their provision, as calculated with TRAC methodology. This may mean weighting funding in favour of subjects of national importance, such as science and engineering.

Demand for university physical science courses

Studying the physical sciences at university has been declining over recent years but encouragingly, applications to read chemistry increased by 5.8% in 2005, compared to an average fall in demand of 3.4% for all university courses.¹⁰ This is a continuation of recent growth in demand, with acceptances to study chemistry increasing by 12.5% in 2005 and by 1.2% in 2004.

The increasing demand for these courses, most of which are of 4 years in duration, is particularly impressive when the significant debts that graduates will incur with the introduction of variable tuition fees are taken into account, but comes as no surprise following our research on the rewards obtained from studying these subjects. Research by the RSC and Institute of Physics showed that the average monetary value over a lifetime to a graduate of a degree in chemistry or physics is at least £60,000 greater than the average for all subjects and that the additional taxation revenues to the Exchequer, over a working lifetime, exceed £130,000.¹¹

Providing excellent chemistry education in schools

A step change is needed in the quality of science education in UK secondary schools if we are to sustain and increase the supply of scientists and engineers and to improve overall levels of scientific literacy and skills in society.

Highly motivated teachers, with a high level of specialist subject knowledge, are usually the most important factor in a student's educational attainment and in their decision to study to a higher level. As the Prime Minister stated during the RSC Parliamentary Links Day in 2005: "It is our teachers on whom we depend for inspiring, encouraging and training the next generation of scientists.... Unless we reward and value the people who transfer knowledge from one generation to the next we will suffer the consequences in declining prosperity."

We also need our school children to be taught in an environment which is conducive to effective teaching and which inspires them to study the sciences to higher levels. The government white paper *Science and Investment Framework 2004 – 2014*, agrees with the RSC that the quality of school laboratories is vital to pupils' education.

Specialist school teachers in the sciences

All 14-16 year olds must be taught the sciences by teachers who have a specialism in the subject taught, and the proportion of graduate teacher trainees who have at least a 2.1 degree classification should be significantly increased.

We welcome the Government's intention¹³ to increase the proportion of science teachers with a specialism in chemistry from 24% to 31% by 2014.

We also welcome the statement by the Chancellor of the Exchequer in his 2006 budget speech to increase the number of science teachers by 3,000 and the new entitlement to study the full range of science subjects at GCSE level for those achieving level 6 at Key Stage 3.¹⁴ However, we await more specific plans on how the Government will achieve these aims.

The RSC believes that the Government is faced with an insurmountable challenge if it intends to achieve its targets for science teacher recruitment without effective measures to tackle a number of problems.

High resignation rates

The report, *Teachers Leaving*, highlighted the problems with satisfying the current demand for teaching staff. Of particular concern was the fact that 40% of final year students on teacher training courses do not make it into the classroom, and the fact that there are twice as many teachers in the 40-49 age range, who will be approaching retirement in the next decade, compared to the cohort who are entering the profession.¹⁵

Current recruitment measures not working

Graduates from the physical sciences are proportionally under represented in initial teacher training when compared against the demand for chemistry and physics teachers and this imbalance is reflected in the ranks of qualified science teachers, where less than 50% of teachers of chemistry at Key Stage 4 in England are chemistry graduates. Addressing this problem is clearly a priority when we consider that the match between the teacher's initial qualification and the subject taught has a high positive correlation with teaching outcomes. Measures are needed to address this recruitment problem and to retrain existing staff if the government's aims of having 31% of teachers with a specialism in chemistry and 25% with a specialism in physics by 2014 are to be met.

Major improvements need to be made in the provision of professional development for school science teachers. Head teachers need more support to enable them to release experienced staff to attend external training sessions. Thought also needs to be given to the regional provision of training centres – at present there are only 9 regional Science Learning Centres (SLCs), all of which are in England.

Additional annual funding is required to provide all school science teachers with effective subject specific professional development for 5 days on at least an annual basis. For chemistry specialists, this will require an extra £2.6m per annum.

Good school science facilities

The UK needs £1,380m to raise all English school laboratories to a good standard, and an additional £51m per annum is needed for teaching materials as set out in the appendix. For the whole of the UK, the RSC estimates that £1.9bn is needed for school laboratories and £70m per annum for resources.

In 2004, the RSC showed that 65% of school science laboratories were, at best, of a basic standard, with 21% considered unsafe or poor. We are concerned that the lack of good facilities and equipment in schools is discouraging students from studying science, or from entering the teaching profession.¹⁶

The RSC welcomes the Government's Building Schools for the Future (BSF) programme, which aims to improve the quality of school buildings, including science laboratories, as a means of tackling this problem. However, the long, 10 – 15 year timescale for this programme will mean that a generation of pupils in many parts of the country will continue to miss out on a modern science education. We are also concerned about the lack of a specific commitment to upgrade all school laboratories to a good standard under this programme and the fact that funds are not ring-fenced for laboratory modernisation.

Two years after the launch of the BSF programme, the government has been unable to provide a response to our enquiries on the current state of modernisation of school laboratories as this information is, apparently, unknown. Therefore, the RSC has commissioned further research to review the progress that has been made.

We hope that investment in laboratories and equipment is set to match the levels that are needed and that our research will show that the rate of improvement in school science facilities and equipment matches that envisaged in the BSF programme.

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Appendix

Estimation of funding required to sustain laboratory based courses in HE

The RSC Study, *The Costs of Chemistry Departments in UK Universities*, examined the finances of eight chemistry departments with a wide variation in research quality and in student intake. The funding deficit for all eight departments totalled £17m. Extrapolating this to all 45 UK chemistry departments gives a total annual funding deficit in the order of £96m, when the additional income from top up fees, minus expenditure on student bursaries, is taken into account. This comes to a total of £306m when all laboratory based subjects are included.

Chemistry for our Future Programme

In March 2006 the Higher Education Funding Council for England (HEFCE) awarded £3.6M for a two year pilot project - the first phase of *Chemistry for our Future* (CFOF). This Royal Society of Chemistry (RSC)-led initiative aims to ensure a strong and sustainable higher education chemical science base in the UK. The programme is a direct result of the recommendations of the Roberts Review of Strategically Important and Vulnerable Subjects published in June 2005.

The project, due to start in September 2006, involves stakeholders from across the chemistry community. The pilot will need to demonstrate evidence of change in order to bid for additional funding of around £24m for a further six years. The completion of the 8 year project will be dependent on submission of a successful bid and the HEFCE having the finance to support the full programme.

Although the HEFCE funding is for England, the RSC will use its resources to promote CFOF across the UK and we estimate that a further £8m will be required for the roll out of good practises which are generated by this programme across Scotland, Wales and Northern Ireland, bringing the total to £32m.

The proposal

The programme proposal has four strands, with two cross-cutting themes running throughout:

Strand 1: Roll out of the existing *Chemistry: The Next Generation* Project

Strand 2: Supporting key educational interfaces

Strand 3: Higher education chemical sciences curriculum development

Strand 4: Smarter use of existing laboratory facilities

Cross-cutting theme A: Careers

Cross-cutting theme B: Sharing good practice

Further details about *Chemistry for our Future* can be found at www.rsc.org/cfof.

Calculation of funding required to provide continuous professional development for all chemistry teachers

The government aims to have 31% of a total 33,000 science teachers to have a chemistry specialism by 2014. The RSC recommends a minimum of 5 days training per annum for each of these specialists.

Average daily cost of supply teacher	£158
Average daily cost of training	£100
Number of teachers requiring training	1,980

$$\begin{aligned}\text{Additional cost of CPD} &= (\text{cost of course} + \text{cost of cover}) \times \text{no. of teachers needing} \\ &\quad \text{training} \times \text{number of days training} \\ &= (100 + 158) \times 1,980 \times 5 \\ &= \text{£2.6m}\end{aligned}$$

Estimation of funding required to raise all secondary school science laboratories in England to a good standard

Laboratory quality	Estimated cost to raise to "Good" standard (A) in England
To upgrade all unsatisfactory/unsafe to good standard	£361m
To up-grade all basic laboratories to a good standard	£321m
Build new laboratories where necessary	£510m
Provide sufficient fume cupboards	£41m
Upgrade all preparation areas to a good standard	£89m
Extend preparation areas	£24m
Provide sufficient dishwashers	£6m
Minimum cost of lift provision	£28m
Total	£1.38bn

Additional notes

1. DfES statistics show that at the end of August 2002, there were 2.9 million pupils in English secondary schools in compulsory education
2. The statistics further suggest that about 160,000 students will study science post-16.
3. The cost of essential equipment has risen from £11.38 per pupil aged 11 to 16 in a class of 24 pupils in 1997 to £22.08, while the cost of providing desirable equipment for 11 - 16 age range is £31.24 per year.
4. The actual figure allocated to science departments for this age range is £8.78 per pupil, but the real spend varies from £71.43 at one extreme to 64p at the other.
5. The costs of building new laboratories or refurbishing existing ones have been reported in the DfES "Science accommodation in secondary schools 80" revised 1999. These costs have been further updated here by applying a correction from the RPI.
6. The cost of building a new laboratory is therefore taken to cost £145k, while refurbishment costs for a 90 square metre laboratory is likely to be in the range of £36 - 55k. Table 3 sets out the costings for all laboratories to a minimum standard of "good" or better.
7. RSC commissioned CLEAPSS, specialists in this field to conduct the survey and prepare the figures.
8. Questionnaires were sent to half of all maintained secondary schools in England (including middle deemed secondary), and resulted in a return rate of 42%. Analysis of responses show a high degree of consistency across the subgroups below:
 - Schools in high, medium and low spending local authorities
 - Comprehensive, grammar, secondary modern, specialist science, specialist (non science)
 - Community, foundation, voluntary controlled, voluntary aided; and
 - Age ranges: 11-16, 11-18, 14-18, middle deemed secondary

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