Issue No.11 - February 2009

# RSC Policy Bulletin

## The future of UK chemistry research

This edition of the RSC Policy Bulletin contains articles on a range of topics of current interest to, and significance for, all sections of the chemistry community. These include: food security and sustainability; 'greener' pharmaceutical products; the prospective impact of the EU REACH Regulation; and the A-Level selections made by students from an ethnic minority. The bulletin begins with a topic of much current debate, that is, the future provision of resource that will enable the UK chemistry research community to remain internationally competitive.

The Engineering and Physical Sciences Research Council (EPSRC) has recently introduced significant changes to its strategy[1] that have substantially affected the ways that physical science and engineering research within the UK is organised and funded. The nature of these changes and the speed with which they are being implemented, together with the absence of the words 'chemistry' or 'chemical sciences' from any title within the EPSRC programme portfolio, are raising considerable concerns within the UK chemistry research community.[2]

During discussions with members of the chemistry community, including RSC representatives, the view has often been advanced that the EPSRC has not communicated the reasons for the changes in its policy and procedures effectively or comprehensively. Both the EPSRC and the RSC recognise that a successful relationship between a Research Council and the chemistry community requires very effective communications. In order to help achieve this goal, on October 2nd, 2008, RSC Council met Professor David Delpy (CEO of the EPSRC) and Dr. Lesley Thompson (Director, EPSRC Research Base) to exchange views, obtain clarification of EPSRC's funding intentions with regard to chemistry, and to discuss several of the concerns that had been expressed by the UK chemistry community. This meeting was constructive and positive and a summary of this information exchange is available.[3]

The RSC is keen to encourage an improved dialogue between the EPSRC and the chemistry community and the article in this bulletin is intended as a contribution in this respect. The article highlights some of the concerns of the chemistry community and suggests some ways in which the present situation could be improved so that the UK chemistry research community remains internationally competitive. Also, I am determined that the RSC will play a constructive role to ensure that all of the interested parties interact constructively and present a clear and strong case for the future of chemistry research in the UK to the forthcoming International Review of Chemistry in 2009, commissioned by the EPSRC in partnership with the RSC and other bodies including the Institution of Chemical Engineers (IChemE) and the Chemical Innovation Knowledge Transfer Network (CIKTN).[4]

*Professor Dave Garner FRSC FRS*
*RSC President*

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[1] *www.epsrc.ac.uk/AboutEPSRC/StrategyAndPlanning/StrategyAndPlanning.htm*
[2] *Chemistry World 'UK chemists warn of funding crisis', 2008, 5, 7*
[3] *www.rsc.org/epsrcfundingstrategy*
[4] *A full list of advisory bodies can be found at www.epsrc.ac.uk/AboutEPSRC/IntRevs/2009Chemistry/Steering.htm*





### TELL US WHAT YOU THINK

We would be delighted to receive feedback on this issue. Comments can be directed to Dr Isabel Spence:
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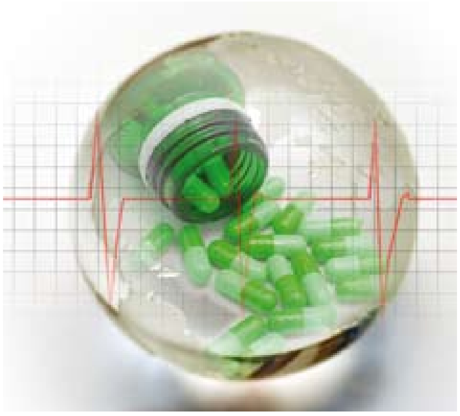

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# EPSRC and the funding of UK chemistry research

The RSC considers issues that relate to the provision of resource to enable the UK chemistry research community to remain internationally competitive.

**Recently, the EPSRC has introduced significant changes to their funding strategy which have raised concerns within some parts of the chemistry community. This article seeks to identify some of the issues causing concern and to suggest ways in which the situation could be improved.**

In 2004, the UK Government launched its 10-year Science and Innovation Framework. This was followed by significant increases in funding for UK science and engineering, in part by supporting university research more realistically with successful grants attracting a substantial increase in the overheads costs (see Figure 1).[1] These increases are now in place and a period of consolidation has commenced, with a greater emphasis on programmes that address particular issues such as energy or the future of the digital economy, as well as new training schemes, such as the Centres for Doctoral Training, and the development of more coherent RCUK priorities.

An important parallel development has been the formation of the Technology Strategy Board in mid-2007. This body is intended to facilitate wealth creation in the UK economy by supporting knowledge transfer and innovation that arises out of the research base and to complement and provide added value to Research Councils' activities.

All of these changes have meant that the Research Councils have had to review their funding strategies and the EPSRC is no exception. More details on the new EPSRC funding structure and strategy are given in the minutes of the discussion between EPSRC and RSC Council on the 2nd October 2008.[2]

Changes of this magnitude that are implemented quickly can produce unintended consequences. An important issue is how major changes in the funding strategy of a Research Council are phased, bearing in mind that the associated research community has previously worked with an established set of approaches and procedures. Also, effective communication between all parties is critical and it is important to recognise that some of the recent changes that have been introduced by the EPSRC originate from changes in UK Government policy.

## First grant anxiety

One of the UK chemistry community's major concerns is the significant decrease in the success rate for first-time grants; from 72% in the last financial year to less than 20% in the half year since April 2008.[3] Many UK chemistry departments have invested in new staff in recent years, recognising the crucial contribution of new ideas and the need to invest in the future of our discipline. Individually and collectively, these new members of staff have considerable potential and the retention of the majority of these new appointees requires that the UK funding system as a whole should provide them with a reasonable chance of securing sufficient research funding to enable them to develop independent research programmes. In this context, the EPSRC's first grants scheme, as operated in recent years, was strategically very valuable.

EPSRC admits that the recent drop in success rates is of 'real concern' and recognises a need to consider measures to ensure that people commencing their academic career are properly supported.[3]

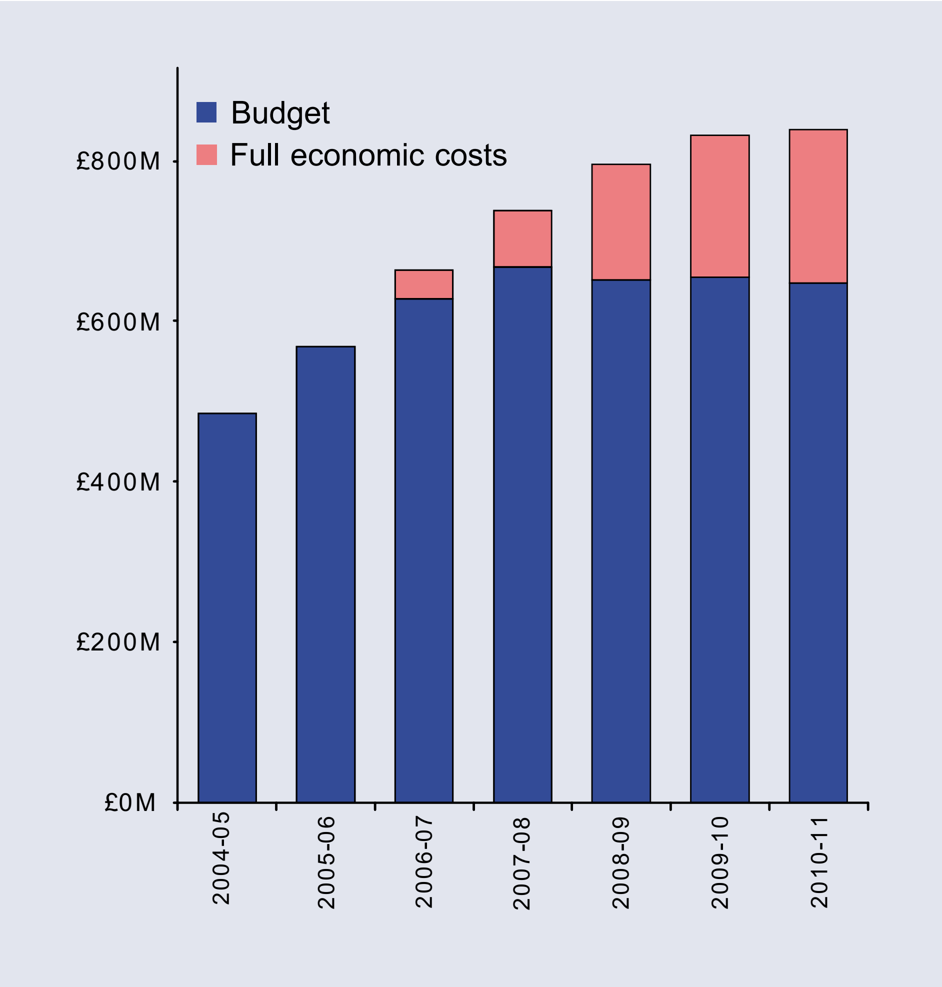



**Figure 1: EPSRC's annual research support including full economic costs.**

This issue was raised with Professor David Delpy by Dr. Brian Iddon MP at the meeting of the House of Commons Select Committee for Innovation, Universities, Science and Skills (IUSS) on November 12th, 2008 (Q23 and Q24).[4] As indicated by Professor Delpy in his response to Dr. Iddon[4] and by Dr. Lesley Thompson,[3] an important factor that has contributed to the significant reduction in the success rate of 'first grant' applications is the removal of the financial cap that limited the amount of resource that could be requested. This has led to applications of more than £1 million for a first grant resulting in fewer and larger grants being awarded, hence the decline in success rates. In addition, there has been a sharp increase in the number of first grant applications to the EPSRC.

We operate in a global market and the brightest of our young academics could move to other countries, notably the USA, if President Obama injects significant new resource in science and technology (Q23).[4] We acknowledge that the successful development of the research careers of a significant number of new appointees to UK chemistry departments is an issue that is bigger than the EPSRC. Universities must recognise their responsibilities in the development of the careers of new academics, especially as fEC now provides universities with additional funds (see Figure 1).

Nevertheless, the RSC has strongly urged the EPSRC to consider adjusting its funding policy to address this problem, one that the RSC considers so vital for chemical science research in the UK to remain internationally competitive. Significant progress has been made as in January 2009 the EPSRC reintroduced a cap of £125,000 pounds to its first grant scheme.

## Poor application success rates

Currently, far more applications are being submitted to the EPSRC than can be funded, resulting in some very low success rates. For example, the proportion of chemistry grants funded through 'responsive mode' applications, where scientists can submit proposals on any subject for any amount, has decreased in the past year from about 25% to an average of 12% over the last 6 months.[3] This is causing great concern within the UK chemistry research community; considerable time and effort is expended in the submission of a grant application and each represents a clear commitment to undertake research. Also, this situation presents a management challenge for the EPSRC, both in terms of a failure to meet applicants' expectations and an inefficient use of reviewers', panel members' and managers' time.

The EPSRC acknowledges that this is a problem and has been looking at ways of addressing the situation and is currently considering a range of demand management approaches in accordance with the RCUK review of the effectiveness of the peer review project to be discussed by EPSRC Council.

Dr. Turner MP of the IUSS Committee questioned (Q28-51) [4] Professor Delpy and Mr. John Armitt (EPSRC Chairman) on the responsive mode success rates and the related matter of the change in EPSRC's strategy to encourage chemists to apply for the funding of longer-term (5 or 6 years) research projects. A consequence of this is that, wherever scientifically or strategically advantageous, an application for a combined programme of work should be submitted - rather than several smaller individual (3-year) ones. According to Professor Delpy this would bring chemistry in line with other disciplines such as physics and biomedical sciences. His objective is "to have one-third of our portfolio in these longer-term more ambitious projects and programmes." (Q29) [4]

Platform and Programme Grants do provide a welcome opportunity for our leading researchers to obtain longer-term funding that can enhance their ability to conduct internationally competitive research. However, the RSC notes that such a move towards larger, collaborative programmes of work will require a cultural change for many within the chemistry community. Consequently, the RSC recommends that the EPSRC should continue to be active in communicating the benefits of this strategy to the community, together with clear explanations of the application procedure and review processes for Platform and Programme Grants. Also, the phasing of the change towards the Platform and Programme Grants needs to be accomplished in a manner that does not lead to major, harmful, perturbations in the total chemistry portfolio.

The RSC emphasises that the balance of funds awarded for chemistry research Programme and Platform grants *vis a vis* smaller grants should not become too skewed in favour of the former. In this context, it must be understood that a template derived from the research portfolio of another field of science should not necessarily be assumed to be appropriate for chemistry. If the present low level of funding available for responsive mode applications continues, the development of new chemical ideas and concepts will be significantly inhibited as these often emerge from independent researchers having the operational freedom to explore novel ideas, often requiring relatively little resource.

It is important to note here that without resorting to special pleading, a good case can be made for smaller grants in chemistry. Consequently, the RSC believes that it is important for policy makers, whether they be within the Research Councils or in Governmental strategy groups, to be aware that ambitious and transformative research does not always have to be 'big science'. For example, much of organic synthesis research consists of small projects which collectively have provided an invaluable 'tool box' of methods and reagents that has been crucial in the synthesis of many molecules of enormous commercial importance to UK plc, especially for the pharmaceutical industry.[5]

## Grand challenges for chemical sciences and engineering

The EPSRC has been involved in a consultation with the scientific community to identify several 'Grand Challenges' for the chemical sciences and engineering to address over the next 20 to 40 years. The outcomes of the Grand Challenges debate will feed in to the International Review of Chemistry and should help drive the UK research strategy and justify the (overall) allocation of funds for chemical research. As noted above, scientific advances often require only a modest resource. Thus, the invention of the next generation of health care therapies still remains a major 'Grand Challenge' and small science chemical synthesis will remain at the heart of it.

In an independent exercise, the RSC is currently carrying out a 'Roadmap'[6] initiative which - amongst other things - aims to identify the priority areas where the chemical sciences can

contribute in a major way to solving some of the global challenges with which we are all presented. Examples include new means of generating and storing energy, or environmentally sustainable ways of providing adequate food, healthcare and water for an increasing population. Hopefully, the RSC 'Roadmap' will align with and complement EPSRC's Grand Challenges, although this is not a specific objective of either exercise. Both exercises will provide the UK chemistry community with a valuable opportunity to enhance the profile and significance of our subject and to emphasise the need to provide adequate research funding so that the challenges identified can be addressed effectively. However, the chemistry community needs to be aware that there is no extra money attached to the EPSRC Grand Challenges Initiative. The EPSRC hopes that, where appropriate, the community will frame their responsive mode proposals in the context of Grand Challenges.

Judging from the results of a very positive EPSRC Workshop on Chemistry Grand Challenges, which was held in Manchester in November 2008, the chemistry community is more than capable of identifying several challenges that are vital, exciting and scientifically demanding. The RSC will press for at least some of these to be incorporated in future RCUK Global Challenges.

### Full economic costing

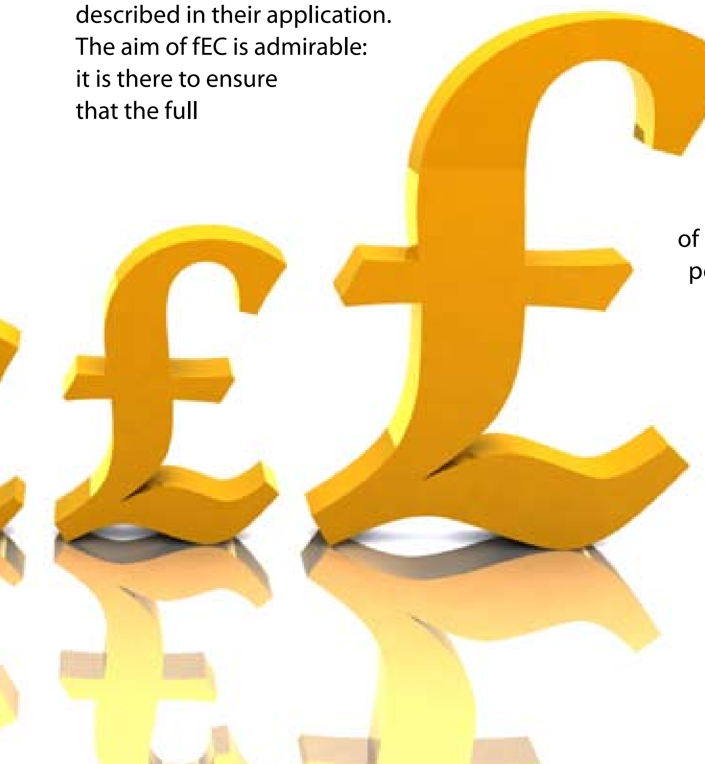
Full economic costing (fEC) was introduced in 2005 and requires research grant applicants to provide a forecast of the full economic costs involved in undertaking the research project described in their application. The aim of fEC is admirable: it is there to ensure that the full cost of carrying out research in a modern university is understood and met. Currently, the fEC support level is 90%.

EPSRC has made it clear that Higher Education Institutes (HEIs) should "ring fence" fEC income for equipment replacement and laboratory maintenance (to ensure the provision of the so-called "well-founded laboratory"). However, there are concerns, including those raised by the IUSS Committee (Q25)[4], as to how universities will use the resource provided by fEC, especially because of the financial pressures that many are experiencing. Therefore, it is essential that the Research Councils and the UK Government should ensure that HEIs are fully aware of how fEC support should be used and ensure that this is accomplished. Also, we note that, in this respect, the Government has a major responsibility to recognise and address the potential for shortfalls in capital replacement and new capital acquisition. This is an issue that impinges on all science and engineering disciplines.

### Core funding requirements

Although the UK chemistry community is generally enthusiastic about multidisciplinary research, there is a fear that the extent and quality of research in 'core' chemistry could be substantially eroded under the new EPSRC funding structures (*vide infra*). Such a situation would not only lead to a decline in the strength of chemistry as a discipline in the UK but would also significantly restrict its contributions to the development of multidisciplinary research projects.

The EPSRC budget is planned to increase over the period 2009-2011. However, as Figure 1 shows, any increase in the budget is accounted for by fEC. Therefore, in real terms (i.e. after taking inflation into account) researchers are likely to see a reduction in total funding of approximately 10% over that period.



Within the new funding structure, a proportion of funds will be allocated to priority themes of research (these are distinct from Grand Challenges) and the remaining funds are committed to the essential platform area. The essential platform area covers funding for responsive mode research. Funding for the priority themes is expected to remain constant over the period 2009-2011. Thus, the ~ 10% reduction in funding will be concentrated disproportionately on responsive mode.

In response to the above scenario, the EPSRC continues to acknowledge the importance of a strong central core of chemistry research. It points out that £866 million is allocated to the essential platform programme and stresses that core research can also be funded under the priority themes. Therefore, the chemistry research community should consider these themes when applying for funding.

### PhD studentships

The PhD students are the lifeblood of the research school in UK chemistry departments and, when qualified, make a significant contribution to the UK economy.

The EPSRC funds PhD studentships under several different schemes. A key scheme has been, and will continue to be, the Doctoral Training Accounts (DTAs). Recently, however, the EPSRC has changed the way in which DTA funds are distributed at the local level, with DTAs no longer being given to universities with a specific departmental breakdown. Rather, a composite sum is given directly to the university with the magnitude of each DTA being closely associated with the level of EPSRC grant income across that university. Therefore, in effect, each university has the responsibility of deciding how this resource should be distributed across its constituent departments.

This change devolves administrative responsibility to each university in that it now has to develop administrative structures and policies to distribute the monies. The UK chemistry community is concerned that new mechanisms for the distribution of PhD studentships may handicap chemistry research. For example, a university may choose to distribute DTA funds according to its business strategy rather than to support its scientific strengths. The view of the EPSRC is that strong chemistry departments will continue to be recognised as strategically important to their HEI and, therefore, will be suitably recognised by their university. The RSC is not fully convinced of this.

Alongside the change in their DTA strategy, the EPSRC has also introduced funding for Doctoral Training Centres (DTCs) at universities. These can have an intake of up to 10 PhD students p.a. for a specific area of research (e.g. the

**PhD students are the lifeblood of the research school in UK chemistry departments**

Chemistry/Life Sciences Interface). The RSC welcomes this initiative, provided that DTCs do not totally supersede DTAs. The RSC believes that an ideal ratio could be ~60:40 with a preponderance of DTAs. The RSC has discussed this matter with the EPSRC and is pleased to report that DTAs will not be phased out. Furthermore, the EPSRC emphasises that approximately 45% of chemistry related research grants have Project Studentships associated with them. It continues to recognise the importance of PhD funding and has confirmed that it will be entering into a dialogue with the chemistry community to establish the appropriate balance of schemes for PhD training.

The EPSRC has stated that it is conscious of the need to produce a sensible balance when allocating funds across the PhD studentship portfolio. In this context, the RSC is pleased with the announcement from the EPSRC in December 2008 of the funding of a set of new centres for doctoral training, many of which relate directly to the chemical sciences, such as sustainable chemical technologies, formulation engineering, chemical synthesis, biopharmaceutical process development and systems biology.

### EPSRC's National Services

The failure to renew the National Service for Computational Chemistry Software (NSCCS) earlier this year caused widespread concern since many members of the chemistry community regarded this as a vital resource and have pointed out that its strengths, and the strategic importance of theoretical and computational chemistry, were recognised in the 2002 International Review of Chemical Research in the UK.[7] The NSCCS service supported a wide range of chemistry research by its compilation of a critical mass of software and the expertise of its staff and played a major role in keeping the UK internationally competitive in theoretical chemistry and allowed non-specialists to develop multidisciplinary research with calculations complementing experimental investigations.

Of particular concern is the mechanism that EPSRC chose to review the renewal of the NSCCS, i.e. as a responsive mode application where it was in competition with submissions to undertake original research[4] (Q31-33 & 99,100) – the grant round in question funded 7 applications out of 45 with the NSCCS submission being ranked 14th. National Services support original research and do not necessarily undertake it; therefore, it is inappropriate to review a bid to renew (or establish) a National Service in a responsive mode 'competition'. The RSC accepts that National Services will not be funded *ad infinitum* and the advantages that these centres offer have to be balanced against competing demands for resources. However, we urge the EPSRC to consider mechanisms for the reviews that focus on the strategic significance of the service.

### International Review of Chemistry 2009

The EPSRC, in partnership with the RSC and others including the IChemE and the CIKTN,[8] will be carrying out an International Review of Chemistry in April 2009. This review is part of a series aimed at benchmarking the strength of UK research activity against world competitors and at highlighting strengths together with any gaps or missed opportunities. A panel of independent internationally renowned researchers, led by Professor Michael Klein from the University of Pennsylvania, will visit a number of UK research groups and access a wide pool of experts and supporting data to help them reach their conclusions.

Institutions and stakeholders, including the scientific community, will be given the opportunity to contribute throughout the review process. Prior to the panel's visit, the EPSRC will be seeking views from the UK chemistry community via a questionnaire concerning the current state of chemistry research within the UK – strengths and weaknesses, potential new research areas and possible threats. All recipients will be advised that the outcomes from this questionnaire could be important for the future of UK chemistry. Also, the RSC will submit its own contribution to the International Review, following wide consultation with the UK chemical science community.

### Financial considerations

The RSC, with others, is working in collaboration with the EPSRC on a study to detail the very positive economic impact of chemistry research for UK plc. The RSC intends that the resultant document will emphasise the importance and benefits of chemistry research to our economy to promote the provision of increased funding in the future. Thus, the major contributions of chemistry research to the UK economy, notably the scientific advances achieved and the doctoral and post-doctoral scientists produced, do justify a significant investment of research funding to ensure that the UK remains internationally competitive across all aspects of modern chemistry research. One vital contribution is our excellence in synthetic organic chemistry that underpins the success enjoyed by the pharmaceutical industry over the last 20 years with at least 10 of the top-selling drugs worldwide (over $1billion annual sales at peak) having UK-trained PhD organic chemists as named inventors[5].

Furthermore, chemistry is a strategically vital subject, the success of which is crucial to many other fields of scientific and technological development. Thus, chemistry is located at the centre of the scientific spectrum and is involved in multidisciplinary research with the other sciences – notably the biological, medical, material and physical – and is developing significantly improved relationships with engineering disciplines, especially chemical.

The wide perspective of chemical activities allows research chemists to apply for funding from many sources. The Biological and Biotechnology Sciences Research Council supports an increasingly large amount of research at the chemistry/ biology interface and there are significant funds available for interdisciplinary research that involves chemistry from sources such as the Medical Research Council, The Wellcome Trust and other health charities. Also, industrial sources provide a significant amount of research funding. Recently, industry has joined forces with the Technology Strategy Board (TSB) to fund vital components of our chemistry research portfolio. The European Research Council is also emerging as a key funder of UK chemistry research and it was very encouraging that five of the UK's leading chemists each received a major grant from the ERC last year. In spite of this, the level of funding provided by the EPSRC to the chemistry community remains crucial if the UK is to remain internationally competitive and the subject is to continue to make major contributions to UK plc. In this respect, we do urge the community to be aware of the full range of opportunities that are available within the new EPSRC structure.

### What's in a name?

A significant concern of the UK chemistry community is the absence of the words 'chemistry' or 'chemical sciences' from any title within the EPSRC programme portfolio. As a consequence, the chemistry community feels that it could lose its identity within the EPSRC and that chemistry research may suffer. For example, subsuming chemistry within the "Physical Sciences" title could serve to reduce the profile of chemistry within an academic institution and adversely affect the DTA allocation.

We observe that the EPSRC policy of including 'Chemistry' within the 'Physical Sciences' programme is out of line with European practice. The RSC strongly encourages the EPSRC, under its present portfolio structure, to rename the 'Physical Sciences' programme 'The Chemical and Physical Sciences' programme.

### The role of the Royal Society of Chemistry

The RSC has a responsibility to facilitate a dialogue between the UK chemistry research community and the providers of research funding. Greater clarity is required regarding the nature and impact of recent changes in the EPSRC funding strategy and the RSC will endeavour to ensure that a clearer and more effective dialogue takes place in the future.

As noted above, the RSC is working in collaboration with the EPSRC on a study to detail the very positive economic impact of chemistry research for UK plc. We have noted above that the RSC's Roadmap[6] will probably complement EPSRC's Chemistry Grand Challenges. Both exercises will highlight the vital roles for chemistry, alone and in combination with other scientific and engineering disciplines, to address the problems we face in sustaining of life on earth as we know it.

The RSC regards the International Review of Chemistry as an excellent opportunity for the chemistry community to contribute to the shaping the future of chemistry research in the UK and to ensure the provision of the necessary funding. The RSC's submission to the International Review will be produced following extensive consultation with the UK chemistry community and your comments and suggestions in respect to this and related matters are welcomed.

**For more details or to comment, please contact Dr Isabel Spence (spencei@rsc.org) or Professor Dave Garner (dave.garner@nottingham.ac.uk)**

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*1 © EPSRC www.epsrc.ac.uk*

*2 http://www.rsc.org/epsrcfundingstrategy*

*3 Chemistry World "UK chemists warn of funding crisis", 2008. 5, 7*

*4 http:www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/uc1170-i/uc117002.htm*

*5 Chemistry World "Organic chemistry rises to the healthcare challenge", 2008, 5, 39*

*6 RSC Roadmap for Advancing Chemistry for the Benefit of Society http://www.rsc.org/ScienceAndTechnology/ roadmap/index.asp*

*7 http://www.epsrc.ac.uk/aboutEPSRC/IntRevs/2002ChemIR.htm*

*8 Full list of advisory bodies can be found at http://www.epsrc.ac.uk/AboutEPSRC/IntRevs/2009Chemistry/Steering.htm*

# Greener pharmaceutical products

The ability to minimise the environmental impact of pharmaceutical products is growing in importance for the drug industry. In a report commissioned by the RSC, the challenges and opportunities for incorporating green chemistry techniques into drug design have been explored.

**In a report commissioned by the RSC and AstraZeneca, the Green Chemistry Network looked at the issues surrounding the adoption of green chemistry techniques in drug design. Researchers and industrial chemists involved in all stages of drug design discussed the opportunities and barriers for lowering the environmental impact of drug synthesis.**

Each stage in the lifecycle of a pharmaceutical product has an associated environmental impact from resource consumption, to energy and reagent use during manufacture, to the drug's, or its metabolites', eventual emergence in the environment. Issues of sustainability will continue to grow in importance; the long development time of a pharmaceutical product before it reaches the market means the industry will need to be far-sighted in its plans for keeping in line with the drive towards increased sustainability.

## Drivers for the incorporation of green chemistry

There are several drivers for the incorporation of green chemistry techniques into drug design. These include: increasing petrochemical prices and problems with chemical supplies; the increasing cost of storing hazardous substances and disposal of hazardous waste; increasing energy costs; stricter legislation affecting chemicals eg. REACH; increasing public concern surrounding pharmaceuticals in the environment and the introduction of environmental risk assessments as part of the authorisation process for new pharmaceutical products.

## Key barriers

There are, however, a number of perceived barriers to the incorporation of green chemical techniques into drug design. The process of designing, developing and manufacturing active and safe drugs is a difficult and time-consuming process. For instance, it is estimated that only one in a million compounds from those initially tested by high-throughput screening is likely to make it onto the market,[1] so any drive to include green chemistry in this area may be perceived as another hurdle.

The industry values reliability in its chosen methodologies and new, greener practices may be viewed as risky or too time consuming. Regulatory pressure in terms of quality and safety of pharmaceutical manufacture potentially leads to perceived risks in adopting new practices over tried and tested methodologies. Therefore opportunities for reducing time and cost through the exploitation of these practices must be demonstrated, as well as the provision of internal support to allow the establishment of their reliability and also applicability throughout the business.

There is also a lack of external drivers for change. The general public does not apply the same logic to pharmaceuticals as it does to other products where there is a significant demand for demonstrably greener products. The benefit to human health of environmentally persistent drugs is thought to outweigh the harm caused to the environment. There is also a moral issue; it would be unethical to deny people beneficial pharmaceutical products on solely an environmental consideration.

## Green chemistry techniques

Green chemistry can be applied to the pharmaceutical industry, since the diverse range of theoretical routes to pharmaceutical products allows greater flexibility in choice of starting materials and reagents. Many companies now have in-house green chemistry teams and initiatives to drive uptake of green chemistry practices within the business. Effort has been concentrated on improvements to process and manufacturing, such as reduction in waste and hazardous materials. Important techniques in this area include the use of catalysts; the reduction in reaction steps by telescoping stages together; and the use of low energy, high efficiency techniques such as microwaves for heating. Although most of the progress in the incorporation of green chemistry techniques has been applied to process chemistry there are still improvements that can be made. These include the minimisation of waste and the use of alternatives to increasingly rare and expensive metal catalysts. It is essential that research continues in this area and that the pharmaceutical industry gives a steer to the academic community. Process

chemists with experience in using new greener techniques should be encouraged to transfer skills and knowledge of efficient processes to other areas, acting effectively as green 'champions'.

**Platform chemicals from renewable sources**

The vast majority of organic chemicals (>90%) in current use are derived from petroleum-based feedstocks. To be truly sustainable, many chemical industries (including pharmaceuticals) will require a shift towards the use of renewable feedstocks through better utilisation of biomass.[2]

The use of large and complex molecules derived from natural sources as a starting material for drug production is current practice in the pharmaceutical industry. However, the use of biomass as a source of (small) platform molecules, from which a range of drugs can be derived, represents an area of green chemistry that remains to be exploited. Similarly, many solvents can be derived from renewable sources and utilisation by the industry remains simply a question of there being a sustainable and reliable supply at competitive prices.

**Green chemistry tools**

A number of pharmaceutical companies are dedicating a great deal of effort to the use of metrics to measure the efficiency of their manufacturing processes. A wide range of so-called green metrics are available that can be applied to syntheses by all pharmaceutical chemists at any stage in drug design. The need for applying metrics is simple; it allows the benefits of clean synthesis methods to be clearly quantified and allows benchmarking between different synthetic routes. Green selection and decision criteria allow products to be made with improved environmental profiles with no hindrance to their performance.[3]

In-house green chemistry tools also provide methods of life cycle analysis, taking into account the effect of yield and reagent excess, the energy burden and the input of materials to the synthesis. However the impact of feedstocks and product fate including issues such as toxicity and biodegradability are overlooked because they are not part of the manufacturing process.

In order to measure the total environmental impact for a product, there is a need for greater understanding of impact across the entire supply chain. For this to be achieved, new or modified tools to allow chemists to assess the impact of their processes need to be developed with some level of standardisation of metrics. This could then be applied across the pharmaceutical sector, leading to the sharing of best practice.

**Designing 'greener' drugs**

An important principle of green chemistry is to design chemicals and products which degrade at a reasonable rate after use so that they do not accumulate in the environment. Designing drugs that are biodegradable can be difficult as a pharmaceutical compound's activity is dependant upon its precise chemical structure, and requires some stability to give a reasonable shelf life. Rapid biodegradation within the body could lead to serious side effects.

Recent research has identified methods to improve degradation such as the incorporation of a "chemical switch" into the drug, which would lead to rapid decomposition on activation. Another route could be the attachment of "affinity" groups to the drug. These groups allow the drug to be removed from the water supply at sewage treatment plants by sticking to a complementary support as part of the treatment process. An alternative approach to designing biodegradability into a drug would be simply to design environmental persistence out. This can only be achieved by chemists with the awareness of the environmental impact of certain functional groups or common metabolites. A possible strategy would be to look outside of the pharmacophore (the biologically active part of a drug molecule) to identify any potential structures or functional groups that would cause environmental issues and design these out at an early stage.

The pharmaceutical industry could also benefit from knowledge transfer from the agrochemical industry, which has long been subject to tight regulation with regard to the end-of-life impacts of their products. Ideally, this knowledge could be developed into a tool or set of guidelines which allow chemists to evaluate the environmental acceptability of a drug molecule and provides guidance on the likely acceptable molecular properties. This would allow the drug to be designed to be more environmentally friendly from the start and provide information at key decision points in the drug design process so that 'green credentials' could become one of the factors during candidate selection process.

**Encouraging 'green thinking'**

Central to the implementation of green chemistry in drug design is the knowledge of synthetic and analytical chemists working in the industry. Pharmaceutical companies should work with academia to encourage the introduction of green chemistry into syllabuses and graduate training so that 'green thinking' occurs naturally when carrying out drug design. Within the industry, better communication and knowledge transfer will assist in the sharing of ideas and best practice.

Multidisciplinary teams working closely with process chemists and engineers will ensure 'green' considerations continue as synthetic routes are scaled-up. Finally, the pharmaceutical industry should continue to forge strong links with academia to influence research and allow quick dissemination of break-through findings in this field.

**For further information, please contact Dr Elizabeth Milsom (Milsome@rsc.org)**

[1] *T.I. Oprea, Journal of Computer-Aided Molecular Design, 2002, 16, 325*

[2] *J. H. Clark and P. Smith, Innovations in Pharmaceutical Technology, 2005, 94.*

[3] *D.L. Hjeresen. M. M. Kirchhoff and R. L. Lankey, Corporate Environmental Strategy, 2002, 9, 259.*

# REACH applies to you

## Many businesses assume that the REACH Regulation only applies to large chemical companies - they could not be more mistaken.

**REACH is a new European Union (EU) Regulation concerning the Registration, Evaluation, Authorisation and restriction of Chemicals which came into force on 1 June 2007. This new legislation is intended to give the public greater protection from intentionally produced chemicals. The RSC has produced a concise guide to REACH to alert professional chemists and enterprises that use chemicals to their new legal obligations and responsibilities.**

REACH applies to substances manufactured or imported into the EU in quantities of one tonne per year or more. If you manufacture, import or use chemicals within the EU you will almost certainly have new legal obligations as a result of the REACH Regulation.

A key element of the REACH Regulation is that it shifts the 'burden of proof' from the authorities to industry, which will now have to demonstrate that a chemical can be used safely for a specific use. Manufacturers, importers, and, for the first time, downstream users (businesses that use chemicals supplied by manufacturers or importers) will have to provide information to enable the end-user to manage the risk.

### Registration

Registration is the main element of REACH. Under REACH, enterprises that manufacture or import more than one tonne of a chemical substance per year would be required to register it in a central database established by the European Chemicals Agency (ECHA). This involves providing information on intrinsic properties and hazards and on safe ways of handling the chemical for specified uses. It is estimated that around 30,000 substances will require registration.

Registration will take place in three phases over a period of 11 years because of the large number of chemical substances involved. In order to benefit from the extended registration periods, manufacturers and importers of chemical substances should have pre-registered substances with ECHA by 1 December


**RSC produces a coincise guide to REACH**

2008. If this pre-registration was not performed, then full registration is required immediately. It will be illegal to manufacture or supply substances within the EU which have not been registered.

Enterprises should also have compiled an inventory of every chemical substance that comes into, is part of, or goes out of their enterprises prior to the pre-registration phase. If this has not been done then they urgently need to understand how REACH is going to impact on their supply chains. Enterprises should build relationships with their suppliers and downstream users. They need to establish if suppliers will maintain the supply of substances important to their businesses and if it is commercially viable for suppliers to do so.

The passage of information up and down the supply chain is a key feature of REACH. Users should be able to understand what manufacturers and importers know about the dangers involved in using chemicals and how to control risks. However, in order for suppliers to be able to assess these risks they need information from the users about how substances are used.

### How Reach applies to you

If you are involved in the manufacture, import or use of chemicals in the EU then REACH applies to you. Almost every business in the UK will have responsibilities under REACH. It is therefore important to understand what your role is.

Businesses that manufacture any given substance or import one tonne or more from outside the EU each year are responsible for registering a dossier of information about that substance with the ECHA. Manufacturers and importers have to provide information to downstream users on appropriate risk management measures for each registered use of a chemical substance.

Downstream users use a substance, either on its own or in a preparation, in the course of their industrial or professional activities. Downstream users have a duty to use chemicals safely according to the risk management information provided by manufacturers and importers for each registered use of a chemical substance. Downstream users also have a mandatory obligation to inform manufacturers and importers how they use chemical substances so that they can develop appropriate risk management procedures and to communicate new information on the hazardous properties that may become available.

Distributors and consumers are not considered to be downstream users in terms of REACH. However businesses that sell chemicals (distributors) have specific duties to pass information down to their customers, and also to pass information back to their own suppliers when customers ask them to do so.

REACH is the most comprehensive piece of chemical regulation to appear anywhere in the world. Its 840 pages and thousands of pages of guidance apply to virtually every use of every chemical, both naturally occurring and synthetic that is manufactured, imported or used within the 27 member states of the European Community. A concise 24-page guide to REACH has been produced by the Environment Health and Safety Committee of the Royal Society of Chemistry to alert professional chemists and enterprises that use chemicals to their new legal obligations and responsibilities. *A Brief Guide to REACH: What You Need to Know* can be downloaded from the RSC website at: http://www.rsc.org/ScienceAndTechnology/EHSCGuidance.asp

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# Why choose chemistry and physics?

## The RSC and Institute of Physics have commissioned a report looking at the factors affecting A-level and undergraduate subject choice by ethnic minority students.

**Following the 2006 statistical report looking at the representation of ethnic groups in chemistry and physics, the RSC and the Institute of Physics (IOP) commissioned a qualitative study to investigate the factors affecting subject choice by ethnic minority students. The results have revealed that a hierarchy of influential factors exists and that they affect young people from different Black and Minority Ethnic (BME) groups in different ways.**

In 2006, the RSC and the IOP commissioned a statistical study to investigate the representation of ethnic groups in chemistry and physics.[1] The study revealed a 'leaky educational pipeline', whereby at each stage of decision making, from GCSE through to postgraduate study, certain ethnic minority chemistry and physics students are disproportionately lost to alternative subjects and career paths. The findings of the study suggested that subject-decision making amongst BME students may be influenced by factors that are different to those affecting white students.

In a separate study, the National Federation for Education Research (NFER) evaluated the RSC careers materials and part of this work looked at other influences on career choices of pupils.[2] However, this study did not look at how these influential factors affected different ethnic groups, nor did it set out to establish the hierarchy of these factors.

The RSC and IOP wanted to discover the nature and influence of factors affecting decision making amongst BME students. The NFER were commissioned to investigate the factors affecting the decisions made by BME groups as to whether or not to study chemistry or physics at A-level and at university.

### Choices and influences

The study showed a hierarchy of factors acting on students' decisions to study chemistry and physics. Highly influential factors include enjoyment of chemistry and physics, future ambitions, perceptions of careers with a chemistry or physics degree and the relevance of chemistry or physics study to life. Factors with a medium influence include the way chemistry and physics are taught, teachers, images of scientists, and family influences. Factors with a low influence include the difficulty of chemistry or physics, role models, careers advisors and peers. Considering one of the influences, the family, the study found that, although in the eyes of young people, their families are not one of the main influences on their decisions to study chemistry or physics, they do have some influence, and families do encourage them towards certain subjects and careers. Whilst families are happy for their children to study chemistry and physics at A-level, most discourage them from studying these subjects at university in favour of more vocational options (e.g. medicine, dentistry).

This can be attributed to a lack of knowledge among the parents of BME students of careers available with a chemistry or physics degree, and a perception that chemistry and physics study would not lead to a job (e.g. medicine and dentistry) in the same way that other degrees would. There was some evidence that chemistry was regarded differently to physics, with chemistry A-level being seen by young people as a stepping stone to other careers (e.g. medicine).

### Ethnic differences

There were differences in the extent and nature of the influencing factors across the different BME groups: the influence of families was stronger for Bangladeshi and Pakistani interviewees than other groups and weaker for Chinese interviewees; Pakistani and Indian interviewees were more likely than other groups to be steered away from chemistry and physics careers through the influence of significant proportions of their families who were in other professions, such as medicine and pharmacy; some Black Caribbean and Black African interviewees were told by their families that they had to work twice as hard as other groups in order to overcome disadvantage.

It is important to note that the influencing factors discussed all had varying degrees of impact on decisions, and were often cross-linked and inter-dependent. For example, enjoyment, and to some extent perceptions of careers with a chemistry or physics degree, and the relevance of chemistry or physics study to life (which were rated as being high influence factors), are dependent upon the quality of teaching the students have received (which was rated as a medium influence factor).

### What next?

Whilst the main factors influencing young people from BME groups to move away from chemistry and physics are consistent across all the groups, there were differences in the nature and extent of the different factors influencing the different groups. Recommendations include providing information to ethnic minority families and young people regarding the range of options available to them after physics and chemistry degrees, and increasing the visibility and number of role models to demonstrate to young people that there is ethnic diversity amongst those in physics and chemistry-related careers. Both of these are particularly important for Bangladeshi, Indian and Pakistani young people.

**For further information please contact Sarah Dickinson (dickinsons@rsc.org)**

[1] *Representation of Ethnic Groups in Chemistry and Physics, Elias et al, 2006*

[2] *An evaluation of the RSC careers materials (http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/CareersEval.asp)*

# The vital ingredient

## Food security and sustainable food production will only be possible with the application of science and engineering across the entire food supply chain.

**The world faces a food crisis caused by climate change and competing land and energy demands, due to population growth and rising prosperity. In our latest report, *The vital ingredient*, the RSC and IChemE explore the opportunities for chemical science and engineering along the length of the food supply chain, from farm to landfill, and identify the implications for food policy.**

In January 2009, the RSC and IChemE launched a major report[1] exploring the chemical science and engineering solutions for food production and sustainability. A number of recommendations made in the report are discussed in this article.

### Society engagement

The role of science and engineering in providing our food is often misunderstood. People can be suspicious of new technologies, such as genetic modification (GM), because they are concerned that corporate profits may come before public interest.[2] A more effective and earlier dialogue is required between the public, government, regulators, media, NGOs and industrial representatives. The learned societies must work together and with key stakeholders to lead the debate on benefits and risks, and build trust amongst consumers by addressing their concerns.

### A global challenge

By 2030 the world's population will have increased by 1.7 billion to over 8 billion, bringing with it the need to meet growing calorific demand. It is necessary to consume a variety of foods for a healthy diet; safe, healthy and nutritious food fulfil the fundamental requirements of energy and growth for human beings. Whilst food scarcity and malnutrition are problems in the developing world, issues related to excess production and consumption are arising in the developed world.

**Science is integral to food security and sustainability.**

Chemical science and engineering can provide sustainable ways to meet the increasing demands for food from a growing global population, whilst providing the knowledge required for processing and manufacturing foods of high nutritional value.

### Why invest in science and technology?

The need for nutritious food is only one of the driving forces for investment in science and engineering. Others include the responsible use of limited natural resources, which encompasses responding to climate change, sustaining biodiversity and reducing energy consumption across the food supply chain.

Profitable production and supporting the livelihoods of those that work in the food industry are also major economic drivers for investment in science and technology.

### A highly skilled and entrepreneurial community

The technical solutions for food production and sustainability identified in the report will need to be taken forward by highly trained people with sufficient scientific knowledge to understand the challenges. Such individuals must be present throughout an organisation, right to the top. Understanding at this level is crucial to ensure the required changes are initiated across the food supply chain. A skilled workforce must be found by forging closer links between the food sector, universities and their students to ensure that graduates are made aware of the breadth of opportunities within the food sector and that they have the appropriate skills to achieve sustainable food production. Attracting talented students into the food industry is vital to secure a sustainable food supply for future generations.

An entrepreneurial environment should be encouraged within industry by ensuring that innovation is not stifled by regulation. Regulation should be based on risk; substances should not be banned on the basis of intrinsic hazard alone. Risk (which includes both hazard and exposure) is a better measure because it is based on the likelihood that an intrinsic hazard associated with a substance will cause actual harm.

### RSC Food 2009

*The vital ingredient* highlights the contribution that the chemical sciences and engineering make to food security and sustainable food production. In 2009, the theme for RSC public engagement activities will be food, looking at all aspects of the supply chain from field to fork and eventually to waste disposal and recycling. The highlight of the year will be Chemistry Week 2009 (7th-15th November), a weeklong UK wide celebration of the chemical sciences.

**For further information please contact Dr Farrah Bhatti (bhattif@rsc.org)**

[1] *The Vital Ingredient* www.rsc.org/thevitalingredient
[2] *Public Perceptions of Genetically Modified Food and Crops, and the GM Nation?* Wouter Poortinga and Nick F. Pidgeon Centre for Environmental Risk, University of East Anglia



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