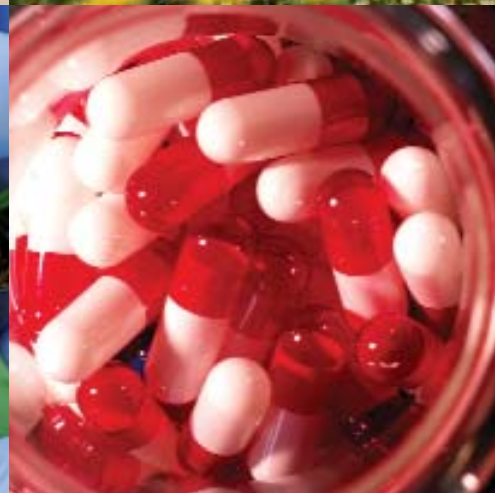
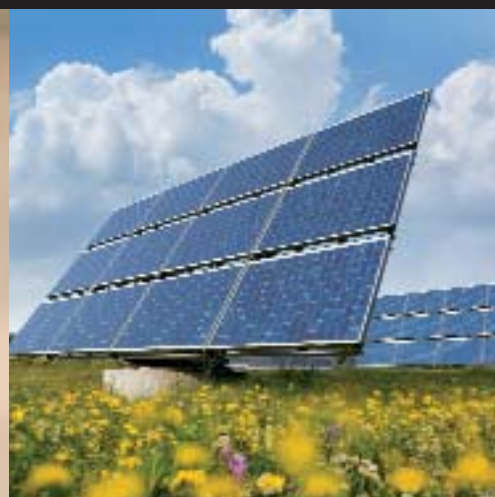


Chemistry for Tomorrow's World

A roadmap for the chemical sciences
July 2009



ABOUT THIS PUBLICATION

The world is undergoing unprecedented change. With rising populations, and the realities of climate change, our fragile environment and resources are being stretched beyond their limits. Over the past year, the Royal Society of Chemistry (RSC) has gathered expertise and views from its members and the wider community from around the world. Through a series of workshops and online consultation we have identified priority areas and opportunities for the chemical sciences. This document summarises the outcome of the consultations and identifies the key challenges of immediate concern. These should drive the UK and international science agendas for the next 5–10 years.

ABOUT THE RSC

Since 1841, the RSC has been the leading society and professional body for chemical scientists and we are committed to ensuring that an enthusiastic, innovative and thriving scientific community is in place to face the future. The RSC has a global membership of over 46,000 and is actively involved in the spheres of education, qualifications and professional conduct. It runs conferences and meetings for chemical scientists, industrialists and policy makers at both national and local level. It is a major publisher of scientific books and journals, the majority of which are held in the Library and Information Centre. In all its work, the RSC is objective and impartial, and it is recognised throughout the world as an authoritative voice of chemistry and chemists.



GLOBAL CHALLENGES

With global change creating enormous challenges relating to energy, food and climate change, action is both necessary and urgent. The Royal Society of Chemistry is committed to meeting these challenges head on and has identified where the chemical sciences can provide technological and sustainable solutions.

The RSC is in the ideal position to enable solutions to the world's problems by working in partnership with governments, professional bodies, non-governmental organisations, academics and industry, across the world. We will help decision makers to generate policy which is based on the best available evidence, and we will support the science needed to tackle complex challenges.

“ Can nine billion people be fed? Can we cope with the demands in the future on water? Can we provide enough energy? ...And can we do all that in 21 years time? That's when these things are going to start hitting in a really big way. We need to act now. We need investment in science and technology, and all the other ways of treating very seriously these major problems. 2030 is not very far away.”

**Professor John Beddington,
UK Government Chief Scientific Adviser**



The theme of climate change underpins the majority of the challenges facing today's society

Addressing global challenges means advancing fundamental scientific knowledge, supporting excellence in chemical science research and maximising the number of future breakthroughs. It will require an interdisciplinary approach and the RSC will build bridges between chemistry's sub-disciplines, and with other sciences and engineering. The RSC's internationally active networks will be instrumental in implementing this approach.

This document summarises the first stage of this initiative, which started in January 2008, to address how the chemical sciences can support society in a changing world. We brought together over 150 experts in seven workshops to discuss issues facing today's society, identifying seven priority areas

(see opposite). Within these seven areas, 41 challenges were defined and the role that chemistry will play in providing solutions was examined. In addition, the expertise, attitudes and opinions of the wider community were incorporated via a web based consultation.

Throughout this exercise, we have attempted to align the RSC with existing strategies and priorities from a range of partners, who were involved in the consultation process, strengthening our relationships.

These seven priority areas have many areas of overlap, with strong links between associated challenges. The themes of sustainable development and climate change underpin the majority of the challenges.



The seven priority areas are summarised here. The key opportunities for the chemical sciences, in each priority area, are highlighted on our website.

www.rsc.org/roadmap

Energy Creating and securing environmentally sustainable energy supplies, and improving efficiency of power generation, transmission and use

Food Creating and securing a safe, environmentally friendly, diverse and affordable food supply

Future cities Developing and adapting cities to meet the emerging needs of citizens

Human health Improving and maintaining accessible health, including disease prevention

Lifestyle & recreation Providing a sustainable route for people to live richer and more varied lives

Raw materials & feedstocks Creating and sustaining a supply of sustainable feedstocks, by designing processes and products that preserve resources

Water & air Ensuring the sustainable management of water and air quality, and addressing societal impact on water resources (quality and availability)

TOP-TEN CHALLENGES FOR THE CHEMICAL SCIENCES

To ensure progress is made where it matters most, we have identified 10 of the 41 challenges as priorities for the next 5–10 years, following consultation with the chemical science community. Listed alphabetically, these are:

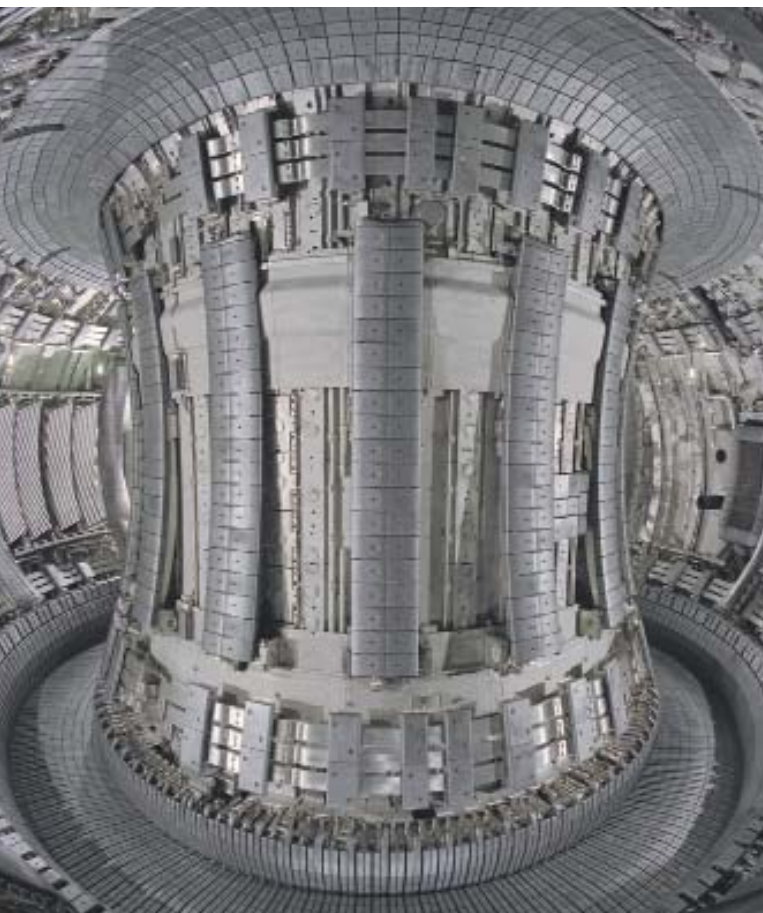


Image: EFDA-JET

Scientists are investigating materials that can withstand the extremely hot plasmas created in nuclear fusion trials – fusion could play a pivotal role in our future clean energy mix

- **Agricultural productivity**
significantly and sustainably increase agricultural productivity to provide food, feed, fibre and fuel
- **Conservation of scarce natural resources**
develop alternative materials to conserve precious resources and new processes to extract valuable materials from untapped sources
- **Conversion of biomass feedstocks**
develop biorefineries using different types of biomass to provide energy, fuel and a range of chemicals with zero waste
- **Diagnostics for human health**
enable earlier diagnosis and develop improved methods to monitor diseases
- **Drinking water quality**
use new technologies to help provide clean, accessible drinking water for all
- **Drugs & therapies**
harness and enhance basic sciences to transform drug discovery, development and healthcare, delivering new therapies more efficiently and effectively
- **Energy conversion and storage**
improve the performance of energy conversion and storage technologies, such as batteries, and develop sustainable transport systems
- **Nuclear energy**
ensure the safe and efficient harnessing of nuclear energy, through the development of fission and investigation into fusion technologies
- **Solar energy**
develop existing technologies into more cost efficient processes and develop the next generation of solar cells to realise the potential of solar energy
- **Sustainable product design**
take into account the entire life cycle of a product during initial design decisions to preserve valuable resources



Novel membrane technologies developed by chemists could provide new energy efficient ways to purify drinking water at the location where it is used



Chemists are exploring nano-structured electrodes for batteries that will have shorter charging times and longer lifetimes



Understanding bacteria and viruses at a molecular level is key to the identification of novel antibiotics and for the development of antivirals



Chemists are developing new polymers and nano-materials for solar cells, which could lead to cheaper and more versatile ways to harness the sun's energy



Chemists are identifying better catalysts, microbes and enzymes to improve our capability to convert biomass into materials for fuel and a range of other chemicals

MAKING IT HAPPEN

Chemistry has great capacity to solve many of the global challenges that society is facing, and the RSC is fully committed to ensuring its potential is realised. We must ensure that the output from our detailed consultations with the chemical science community materially drive the UK and international science and education agendas.

These challenges can only be addressed if we provide for an excellent, diverse and well-maintained science base, a good supply of well-trained individuals, and an innovative climate from which good ideas can flourish, be exploited and be communicated around the world.

There is a number of existing core RSC initiatives that we can build on by considering the priorities identified through this work. There are also exciting opportunities to develop new projects that will enable us to tackle each of the key challenges.

No country can afford a skills shortage, which could leave the next generation ill-equipped to tackle major scientific and technological challenges. A diverse and technically innovative workforce is fundamental to developing and applying new technologies.

Beginning in schools, where most young children are first introduced to the excitement of chemistry, it is vital to raise students' interest and curiosity in the sciences. This should be nurtured through their entire education experience and should stimulate an appreciation for chemistry, an interest in pursuing a career in science or engineering and a commitment to life-long learning. We need to enhance links between industrialists, academics and educationalists, to ensure that students from all backgrounds are made aware of the diverse range of available scientific careers. It is also vital to establish a globally relevant framework for chemistry education, and for governments to ensure that new curricula and assessments are in line with the clear findings from research in science education.

The RSC is involved with a large range of education initiatives. These aim to help chemistry teachers inspire their students, ensure that the curriculum is relevant, and ease the transitions between all levels of chemistry education. We are also developing resources and programmes with support from a number of industrial partners. With Pfizer, for example, we are linking education to the future skills requirements of industry, to develop a talent pool of chemists who are equipped to deal with the challenges of a professional environment. We will continue to review and build on such projects to ensure they are effective. The RSC will seek to increase the numbers of students studying chemistry in further and higher education, and aim to ensure that classes are taught by appropriately qualified specialists, and that students are assessed in a suitable way.

“More than any other single step, the provision of more, better-qualified science teachers in secondary schools would inspire and equip intellectually a whole new generation.”

Richard Pike, RSC Chief Executive

Industry also has a vital role to play in the continuing development of a highly skilled workforce. Investment in on-the-job training and lifelong learning will help to develop the skills required to adapt to technological advances and ensure that the chemical sciences remain competitive. The RSC will also continue to support industry by recognising and encouraging excellent professional development, such as through accreditation, and we will build on the existing range of RSC training schemes to meet the changing needs of industry.

To maintain the flow of future breakthroughs, it is critical to advance fundamental knowledge and to support curiosity driven research. This will be achieved by maintaining a long-term commitment to areas of underpinning science, including analytical science, catalysis, chemical biology, materials chemistry and synthesis, which are the foundations of innovation. These examples do not form an exhaustive list, but they provide an indication of the critical role that fundamental chemistry plays, in partnership with other disciplines.

The RSC will maintain its key role of facilitating discussions between governments, funding organisations and the wider chemical science community. We will seek to secure sufficient funds for fundamental research in chemistry, and for applied research and development, both of which are central to addressing the key challenges.

There also needs to be a sustained commitment to innovation from the leaders of key organisations to establish a culture where investment in research and innovation can thrive.

More effective interaction with smaller companies and better cooperation along the supply chain should increase the probability of successful innovation. We will continue our work with partners on a national, regional and local level to support innovation and knowledge transfer, especially with small companies, and we will review our activities to ensure these initiatives are effectively realising their potential.

Taking a proactive approach in informing policy makers so that chemical control legislation is scientifically sound, risk-based, proportionate,



Biologically synthesised chemicals, such as pheromones, are a fascinating starting point for chemists developing new pest control strategies

workable and sustainable is vital in ensuring that innovation is not stifled, and people are protected.

We will continue to take a leading role in informing and advising governments. As the largest member society within the European Association of Chemical and Molecular Sciences (EuChemS), the RSC plays an important part in supporting the development of European policy. We will continue to offer timely expertise, and present the best available evidence in all areas of chemistry, to promote informed discussions between policy makers in the UK, at the European level, and around the world.

The priority areas addressed in this work are of truly global concern and will require the collaboration of scientists and engineers internationally. To this end, we will build on the international networks of the RSC and provide new forums to share new scientific knowledge.



Building and supporting a skilled and innovative workforce for the future will be vital to developing and applying new technologies

NEXT STEPS FOR THE RSC

This process has highlighted a number of exciting and important opportunities and will drive the scientific agenda for the RSC and wider community over the coming years.

For each one of the challenges listed, we will develop an associated project, and for areas where the RSC has already done major pieces of work – e.g. energy, food and water – a process of careful review will take place.

In the short term, we will open a dialogue with a number of key existing and potential partners, along with RSC member networks, to produce a comprehensive implementation plan. This process will include a series of workshops to define critical gaps in knowledge, which are limiting the technological progress within the fields of the 10 key challenges.

Over the next five years, we will manage a comprehensive programme of initiatives aligned with these challenges and their associated opportunities for the chemical sciences.

This work provides a great opportunity to build on the RSC's global networks and we must collaborate with scientists around the world to take this work forward. The RSC has international cooperation agreements with seven other chemical societies. We are also supporting links across Africa as part of the Pan Africa Chemistry Network, and facilitating connections with India through the Chemistry Leadership Network. Building on this, we will establish a new electronic network for chemists in industry and academia, which will enhance global connections, and increase our potential to influence policy makers around the world.

In order for this initiative to have real impact, and to drive the science and education agendas in the future, the chemistry community must act together. Your support, advice and expertise are needed in order to continue to move forward with this programme.

There are many ways to get involved to help us inform key stakeholders, disseminate and exploit new and existing knowledge, as well as help to facilitate the discussions that need to be had around the world.

“This is a very exciting time for scientists who can use their expertise, enthusiasm and vision to address the global challenges that we now face. Let us ensure that future generations enjoy a life of quality and beauty by the intelligent application of chemical knowledge.”

**Professor C David Garner CChem FRSC FRS,
RSC President**

CONTACTING US

For more on this important RSC initiative, and for updates as these projects evolve, please visit our website.

www.rsc.org/roadmap

To work with us and to find out about the latest events and projects in your region – please contact us at roadmap@rsc.org or at our Cambridge office on 01223 420066.

Alternatively, contact one of our specialists at the RSC.

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