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The Journal of the Parliamentary and Scientific Committee.
The Committee is an Associate Parliamentary Group of members of both Houses of Parliament and British members of the European Parliament, representatives of scientific and technical institutions, industrial organisations and universities.

Andrew Miller MP
Chairman, Parliamentary and Scientific Committee

You can almost hear Lady Bracknell shrieking "under a car park" when made aware of the penultimate resting place of one of England's best known monarchs.

The bones of Richard III have turned up in the middle of Leicester, under a spot where a chapel used to be, but which has been a temporary resting spot for Fords and Toyotas for a few decades.

The first clue was that the skeleton displayed mild scoliosis of the spine, which would have given him a slightly lopsided limp.

However it required DNA analysis to put the matter beyond doubt, and where better for this to be carried out than in the Department of Genetics at the local University where Sir Alec Jeffreys discovered DNA fingerprinting around 30 years ago?

After so many generations, testing chromosomal DNA would have been inconclusive, but mitochondrial DNA provided the vital key, as was done recently (with the help of the Duke of Edinburgh) to identify the remains of the Romanovs.

It is always worth remembering that Jeffreys' discovery was serendipitous, carrying out what is sometimes called "blue skies research". The experimental result needed to alight on a highly prepared mind. It also generated significant income for the patent holders.

Coincidentally, DNA testing was also to the fore in the recent (and current) investigation into the presence of horse flesh in the food chain. Additionally, it allowed a huge number of puns in newspaper headlines. I am happy to put some of these rumours to bed by stating that it is most unlikely that a burger company will be sponsoring the next Grand National!

At least we now know that Richard's expiring exhortation "A horse, a horse, my kingdom for a horse" was merely expressing a desire for a burger.

With great speed, the P&SC organised a discussion meeting on the use of random testing to protect the public. This explored several aspects – quality control as determined by the Trade Descriptions Act, as well as potential toxicological consequences. Was the deceased horse taking drugs prior to slaughter, and could these cause harm to burger munchers? It was noteworthy how little the Government spends on such protection of the electorate and their offspring.

The Parliamentary and Scientific Committee

Science in Parliament has two main objectives:
1. to inform the scientific and industrial communities of activities within Parliament of a scientific nature and of the progress of relevant legislation;
2. to keep Members of Parliament abreast of scientific affairs.

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The front cover is a montage from the launch event for the London Mathematical Society report, *Advancing Women in Mathematics: Good Practice in UK University Departments,* on 27th February.

THE ROYAL INSTITUTION 1799- ????

We have recently become used to financial crises threatening the world as we know it being solved at the 11th hour (and usually at the 59th minute).

Against the backdrop of Greece and Cyprus, the travails of the Royal Institution may seem trivial.

Ten (or so) years ago, the organisation was greatly loved, but perceived as being not quite ready for the 21st century.

An ambitious plan to improve the facilities (with help from the Heritage Lottery Fund) transformed the Grade 1 listed building. The Queen came to open it.

Unfortunately, the business plan failed to come to fruition, and a substantial overdraft had to be dealt with.

Since the freehold might be worth three times the debt, a solution was always likely to emerge, but questions of national heritage were bound to intrude.

A public outcry twenty or so years ago resulted in Down House being preserved both as a memorial to Darwin, and as a museum describing the significance for modern science and society of his work. Surely something would "turn up" as Wilkins Micawber might have said.

Our Treasurer, Lord Willis, wrote a piece for the Guardian earlier this year in which he suggested that although the Board had earned our thanks for their attempts, nonetheless "the game is up".

He pointed out that in the time since Davy, Faraday and co had brought scientific enlightenment to the chattering classes of Georgian and Victorian London, many other bodies had now rushed into this area, and many were doing a superb job on tiny budgets. He felt (and many others have agreed) that the building is unnecessarily large for what many perceive to be the RI's core activities.

Photo: Tim Mitchell

He finished by saying that if a sustainable funding model could be found, then he would "gladly retract my blunt assessment of the sad situation facing us".

Many other articles with a variety of points of view followed.

The journal *Nature* pointed out that "people who wish to be informed about a topic no longer need to sit in an uncomfortable seat and listen to a lecture by an *eminence grise*." It felt that the Science Museum might take it over as part of its outreach activities.

On the other hand, Mark Miodownik felt that merely sitting in the lecture theatre where Faraday had demonstrated gave "a tingle at the back of your neck".

For Suzie Sheehy "presenting at the RI is considered an honour" for a practising scientist.

Michael Kenward optimistically pointed out that "the Wellcome Trust seems to be awash with money" and might therefore come to the rescue.

Haroon Rafique, who as a teenager was funded to visit from Rochdale, emphasised that "the point of this excursion was not to be taught. It was to be inspired".

David Logan, an exhibitor there, remembers that "it was a humbling feeling to sit in the lecture theatre, listening to a Nobel Prize winner, while absorbing the atmosphere".

Even more romantically, Andrea Sella felt that "the RI's brand is intimately tied with the location", and likens the building to La Scala or La Fenice!

Alice Thomson, the descendant of both Braggs, remembers that "the RI was haunted by Nobel Prize winners".

Realistically, Shane McCracken calculated the sum required was less than a single Titian for the National Gallery.

Sir Richard Sykes, currently Chair of the Trustees, chipped in with a sturdy rebuttal. He reminded us that the RI had been here before, and had survived. By 1803 it was already £3,000 (equivalent to tens of millions today) in debt. Once the story about the current problem had become public, he had been gratified to experience the level of public support. He is confident that the team (see below) now has an opportunity to create a national strategy for science communication.

Finally, the denouement (we all hope) came at an EGM of the RI on 19th March

It was revealed that an anonymous benefaction had been secured which would alleviate the present squeeze.

A future plan does still need to be mapped out, and several eminent (and busy) scientists have lent their name to this exercise – Brian Cox, Robert Winston, Harry Kroto and Paul Nurse – to name but a few.

Watch this space.

Alan Malcolm

RESISTANCE FIGHTERS

Dr Mark Downs
Chief Executive,
Society of Biology

In the natural struggle to survive, species evolve alongside each other and their environment as part of an evolutionary arms race. Predators evolve ways to catch their prey, and prey species evolve ways to escape capture. Hosts evolve ways to detect and destroy parasites, and parasites evolve ways to evade them. An inevitable consequence of this natural process of competition is antibiotic resistance, and an arms race between organisms and the scientific community.

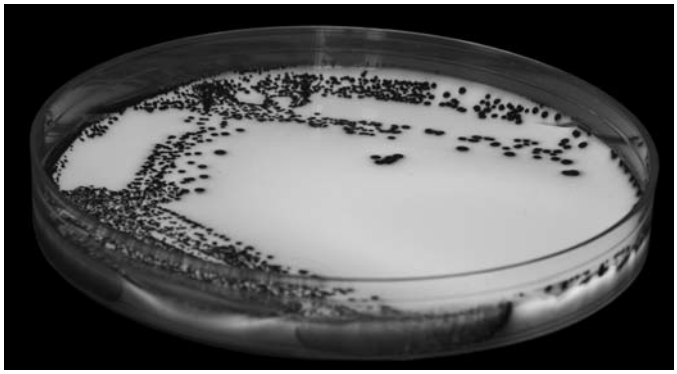
The appearance of new 'super bugs' resistant to much of the available armoury of antibiotics, such as MRSA, is a major threat to human health, and prescribing practices past and present have played a part in causing them to emerge. Resistance, however, is a much wider problem than this and the exact mechanisms often remain unclear.

ANTIBIOTICS IN THE ENVIRONMENT

In the 1950s farmers began to add low levels of antibiotics to animal feed as growth promoters. Antibiotics given to pigs were estimated to save as much as 20% of feed per pound of weight gain. However, there have been reports of antibiotic resistance emerging in animals as a result of antibiotics in feeds, although the story is extremely complex and not fully understood. In 2006 the EU banned antibiotic use at sub-therapeutic levels in animal feed to reduce the non-essential use of antibiotics.

The mechanisms of antibiotic resistance are likewise complex, and research is needed to understand them better. One cause is the transfer of the genes across bacterial groups, with non-pathogenic bacteria acting as reservoirs of antibiotic resistance. Even if very low doses of antibiotic do not kill susceptible bacteria but reduce their growth rates, resistant bacteria can outgrow them.

Bacteria move between animals and humans through air, water, physical contact and via the food chain. Although the use of antibiotics as growth promoters in livestock has been banned, therapeutic doses of antibiotics can still be prescribed by the vet. Antibiotic residues are not always fully metabolised by the animal so there is concern that they can end up in the food chain. Increasing human exposure to these antibiotics might contribute to an increase in antibiotic-resistance.



As well as solutions to antibiotic resistance in human pathogens, we need alternatives to the current battery of antibiotics for use in livestock. There is no single solution, but alternatives could include vaccines and bacteriophages (viruses which infect bacteria).

RESISTANCE IN OTHER SPECIES

Antibiotic resistance is by no means the only type of resistance affecting healthcare and agriculture.

Fungi, like bacteria, are intrinsically capable of developing resistance to antifungal agents, and this may be an under-recognised problem. Fungal infections are especially common in immunosuppressed patients, such as those suffering from AIDS, cancer or cystic fibrosis, and organ transplant patients. Fungi also cause extensive losses to agriculture and forestry; the most recent fungal concern is ash dieback.

. . . Bacteria move between animals and humans . . .

In principle, antibiotic resistance is a subset of a wider problem of drug resistance such as the evolving drug resistance of parasites such as malaria. Likewise, insect vectors of disease are evolving resistance to insecticides, and certain plants are developing herbicide resistance to become so-called 'super weeds.' Short of making a species effectively extinct, as has happened with smallpox, we will only ever have temporary victories in combatting diseases and pests.

CONCLUSION

For all antibiotics, the question of resistance is 'when' rather than 'if' we will ever need new ones. To minimise the impact on human health and our food supply, research is urgently needed to determine the mechanisms of resistance and to create new antibiotics and alternatives. The development of new patient-ready treatments is a long process, beginning with understanding of fundamental biology and progressing to the search for potential treatments. Drug Discovery skills are in danger of being lost in the UK as the pharmaceutical industry restructures at a time when they are most needed. Many of the learned societies are working together to help identify mechanisms to address this.

ANALYTICAL MEASUREMENT AND REGULATION: The Role of the Government Chemist

Nick Boley
Technology and Policy Consultant to the Government Chemist
LGC, Teddington

The role of the Government Chemist was established in 1842 to detect adulterants in tobacco for Her Majesty's Customs and Excise. Since then, the Government Chemist's function has developed with the responsibility to investigate a range of samples and problems on behalf of Government authorities and the public. For nearly half of the 20th Century the Government Chemist existed as a free-standing independent department.

Today the Government Chemist has a statutory role under several Acts of Parliament, including the Food Safety Act, the Agriculture Act and the Medicines Act. Analyses are carried out to resolve disputes between regulatory authorities and traders, and a programme of research develops robust analytical methodology to underpin this work. Dr Derek Craston, the current Government Chemist, is supported by a team of internationally reputable measurement scientists who are on call when queries arise.

The Government Chemist also has an important role within Government. Following privatisation in 1996, an agreement between the Secretary of State for Trade and Industry and LGC secured the continuity of our public functions by appointing the Government Chemist "as a source of advice for HM Government and the wider analytical community on the analytical chemistry implications of matters of policy and of standards and of regulations". This recognised the importance of chemistry and related sciences in many sectors and products within the UK economy. Today the work of the Government Chemist is funded by the National Measurement Office within the Department of Business, Innovation and Skills.

The advisory function is delivered by responding to Government or by publishing consultations, where analytical science plays an important role. These provide information to a broad range of stakeholders who have an interest in developing policy, legislation, and standards on chemical measurement needs associated with regulation. The advisory function also looks at emerging issues requiring new regulation and analytical measurement, and highlights paths to be taken. Small research projects are commissioned in areas of emerging interest, such as the separation of toxic nanosilver from ionic silver. Nanosilver is used as an antimicrobial agent in socks which leaches out during washing and enters waste water streams or to investigate contaminants in carbon dioxide streams in carbon capture and sequestration applications.

A close interaction with policy makers is critical to the Government Chemist role. We therefore recognise the need to build strong relationships with relevant Departments and Agencies to help focus our activities.

It is clear from the activities of the Government Chemist that analytical measurements are important in the development and enforcement of legislation and regulation. Where regulation needs analytical measurements for effective enforcement there is a clear link between the development of regulations and the analytical methodology available. **A regulation that cannot be effectively enforced using existing widely available analytical methodology represents poor regulation.** This is true regardless of whether enforcement would be by an official laboratory, or self-declaration from industry carrying out measurements in-house, and applies equally to UK and EU legislation.

UNDERSTANDING THE MEASUREMENT IMPLICATIONS OF REGULATORY CHANGE

An example of where regulation and analytical measurement capability are potentially out of step comes from the EU's Water Framework Directive (WFD). Discussions are on-going regarding the addition of pharmaceutical products – specifically 17 β-estradiol (E2), 17 α-ethinylestadriol (EE2) and diclofenac – to the list of controlled toxic substances under the WFD. The proposed maximum levels to be permitted in water are extremely low (0.27 parts per trillion (ppt) for E2 and 0.035 ppt for EE2), and the challenge for analytical laboratories in being able to measure these substances accurately and reliably at these levels is huge. The European Commission's Directorate General for the Environment has stated that member states need to solve this problem themselves, effectively distancing themselves from the technical measurement issue. In our opinion, this represents poor legislation, with a stringent measurement requirement being set with apparently no regard for the practicalities of enforcement. **If policies set limits that cannot be effectively monitored, this calls into question the limits and the policies themselves.** It would be preferable initially to set levels commensurate with measurement capability, and commit investment into R&D to lower limits of detection to the desired level, leading to a subsequent downward revision of the limits.

The situation is similar with allergens in foods. There has been an increase in recent years in the percentage of the population who present themselves with a food allergy. For many of these people only a tiny concentration of the allergen is needed to provoke a severe allergic reaction. These levels of

allergens are extremely difficult to measure accurately. Although there are many test-kits on the market, their sensitivity and specificity are often insufficient. Some laboratories, including LGC, are working to improve existing methods and developing new methods based upon liquid chromatography linked to mass spectrometry (LC-MS) for proteins, and DNA based approaches. These developments will enable food allergens to be measured more accurately in support of emerging, and necessary, legislation.

Another area where measurement capability needs to keep pace with developments in regulation, as well as the fast rate of innovation in manufacturing and applications, is in the field of nanomaterials. **The recent proposal from the European Commission for a definition of a nanomaterial had something of a mixed reception.** Some scientists believe that a nanomaterial should not be defined solely by its size, but should include its functionality. Our view is that verifying a material is or is not a nanomaterial on the basis of functionality is not straightforward, and can be open to interpretation.

The proposed definition of a nanomaterial is "a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm." **Experts in the field of nanomaterials may debate whether the defined parameters are or are not appropriate, but at least this definition is measurable.** Analytical methodology has advanced over the past few years, enabling both the size and the number of nanoparticles to be measured. This makes the proposed definition and associated regulations on nanomaterials enforceable.

ENSURING RELIABLE MEASUREMENT

One recurring theme over the past year has been the significant burden of regulation for industry, and the need to ensure regulation is simple and effective. This is particularly pertinent where laboratories in, or engaged by, manufacturers are carrying out important analytical measurements to demonstrate compliance with legislation or regulation. **"Self-regulation" removes the need for time consuming and costly controls by third party regulators, but should be implemented with care.**

A good example of this is for manufacturers of items which are covered by the Restriction of Hazardous Substances (RoHS) directive. Manufacturers self-declare that their products comply with the directive, and do not contain any of the restricted substances above the prescribed limits. But how can we be certain that these measurements are of sufficient accuracy? We are fortunate in the UK that measurement laboratories, in all sectors, have a strong quality ethos, and that there is a national body which is able independently to review the quality of laboratory measurements – UKAS, the United Kingdom Accreditation Service.

Any laboratory making these important measurements in support of regulation can apply to become accredited to the international standard ISO/IEC 17025 for the measurements of interest. To gain, and maintain this accreditation, companies undergo assessment and periodic audits by UKAS, which demonstrate impartially and independently the quality of the laboratory's procedures, and therefore confer confidence in the measurements. Our advice, when responding to consultations, has often included reference to assuring the quality of measurements needed to support proposed legislation. Accreditation is an effective way to achieve this, along with the use of appropriate reference standards and methods.

REDUCING THE NEED FOR ANIMAL TESTING

Complementary to analytical testing is the field of toxicity testing. REACH (Registration, Evaluation, Authorisation & restriction of Chemicals) legislation requires the identification of substances of very high concern and their progressive replacement by suitable and viable alternative substances or technologies. Although it is recognised that this would require the generation of additional toxicological data which would necessitate some additional tests on animals, **REACH clearly states that animal testing should only be carried out at a last resort, and that companies have an obligation under EU law not to test on animals.** Many observers believe that the rate of reduction of animal testing in support of legislation such as REACH and the EU Cosmetics Directive is insufficient, is happening too quickly and runs the risk of making the EU uncompetitive in the cosmetics sector. One of the most significant obstacles is the availability of alternative tests which can provide the same information, with the appropriate confidence level as animal tests. One area showing promising developments for alternative *in-vitro* testing, hence excluding the need for animals, is the field of toxicogenomics. Researchers at LGC have been developing reliable *in vitro* assays that may soon be suitable for regulatory toxicity risk assessment.

Toxicogenomics merges toxicology with genomics and bioinformatics to investigate effects of chemicals in model biological systems. While this has been known over the past 10 to15 years in the pharmaceutical and chemical industries, recent improvements in microarray technology have made measurement platforms more robust, thereby offering a suitable alternative to costly and ethically provocative animal testing. Developments such as these are important in helping the chemical industry carry out toxicity testing more efficiently and effectively, saving industry considerable sums of money. Regulators also need to promote these novel tests and, where appropriate, accept their data, so that animal tests become the last resort when all else fails.

BRINGING ANALYTICAL SCIENCE TO GOVERNMENT

The above examples illustrate that **a close liaison between regulators, legislators and measurement scientists is critical for successful regulation.** This message echoes the enquiry by the House of Lords Scientific and Technology Committee last year into the role of Chief Scientific Advisors, which the Committee stated they would like to see strengthened.

The work of the Government Chemist advisory function provides a unique and valuable resource for Government Departments and Agencies, including in the devolved administrations, in any field where analytical measurement is required to support legislation and regulation. Government Departments and Agencies are key stakeholders in the work we carry out, and we welcome any feedback on how we might improve our services.

ADVANCING WOMEN IN MATHEMATICS: An Opportunity for Change

The London Mathematical Society (LMS) launched its report *Advancing women in mathematics: Good practice in UK university departments* at the House of Commons on 27th February 2013.

The event was hosted by Andrew Miller MP, Dr Julian Huppert MP and Stephen Metcalfe MP, with guest speaker Professor Margaret Wright of the Courant Institute of Mathematical Sciences, New York University and Chair of the International Review of Mathematical Sciences 2010. This is the first launch event that the LMS has held at the House of Commons and the support from MPs, the mathematics community and other STEM organisations was excellent, with around 100 attendees.

Stephen Metcalfe MP and Graeme Segal (LMS President)

Andrew Miller MP opened proceedings by welcoming the attendees and outlining the importance of the mathematical sciences to the country's prosperity, and the need for continued interaction between the mathematical sciences community and Parliament.

Dr Graeme Segal, LMS President, described the reasons behind the LMS report and gave a brief outline. He also thanked Dr Catherine Hobbs and Professors Gwyneth Stallard and John Greenlees from the LMS Good Practice Scheme Steering Group, for their hard work in bringing the report to fruition. He mentioned the late Anne Bennett, who as the LMS Head of Society Business was instrumental in helping to produce the report. It is a lasting legacy to her ability to facilitate collaborative working, her energy and drive, and her real interest ensured that mathematics and women in mathematics are properly represented at the highest levels.


Anna Zecharia, Ellie Cosgrave and Chi Onwurah MP

The guest speaker – Professor Wright – outlined the process behind the International Review of the Mathematical Sciences 2010 and some of its findings in relation to gender diversity. One of the Review's recommendations was that, 'urgent action should be taken to improve participation of women in the mathematical sciences community', which supported the view of the LMS in undertaking this work.

The formal part of the evening was closed by Stephen Metcalfe MP, who reiterated the importance of mathematics. He looked forward to continued dialogue with the community.

The LMS has long been concerned about the loss of women from mathematics, particularly at the higher levels of research and teaching, and the missed opportunities that this represents. Through its Women in Mathematics Committee the LMS established a Good Practice Scheme. Supporting departments participated in a benchmarking survey which led to this report.

Although similar surveys have been carried out for other disciplines, this is the first such

. . . support from MPs was excellent . . .

. . . the late Anne Bennett was instrumental in producing the report . . .

survey undertaken within mathematics. It provides insight into areas of good practice as well as areas for further development.

The report also provides data on the proportions of women at each career stage. Although over 40% of graduates in the mathematical sciences are female, in common with other science, technology, engineering, mathematics and medicine (STEMM) subjects, there is a significant fall in the proportion of women who become academic mathematicians. Only 6% of professors of mathematics in the UK are female. The data contained in the report enabled each department to benchmark itself against the national picture, and will assist departments and the LMS to target appropriate actions.

The event was an opportunity for the mathematical sciences community to meet policy makers and other influential people, and to promote mathematics and the proactive approach the community is taking in addressing the various challenges. The LMS was particularly pleased with the opportunity to discuss these challenges with the three MPs hosting the event, and also with Shabana Mahmood MP, Shadow Minister of State for Universities & Science and Chi Onwurah MP, Junior Shadow Minister for Business, Innovation and Skills who attended the event along with Joan Walley MP.

Professor Gwyneth Stallard, Chair of the LMS Women in Mathematics Committee said, 'The LMS is delighted that so many mathematical science departments are beginning to take these issues seriously. The LMS hopes that this report will provide a valuable resource for those seeking to make changes so that more women can achieve their true potential as mathematicians.'

Mathematical sciences underpin our 21st century technology, economy and society. The flow of trained mathematical scientists relies upon our universities' research and teaching excellence, and developing the rich pool of mathematical talent – both women and men – that is available in the UK. This is an excellent opportunity for the mathematical sciences to make a significant contribution in this area and the publication of this report is a huge step in the right direction.

There is a summary of the issues highlighted in the report in the previous issue of Science in Parliament magazine, *Supporting Good Practice in University Mathematics Departments,* p39-41.

The full report is available on the LMS website at http://www.blitzadv.co.uk/LMS-BTL-17Report.pdf

If you would like a printed copy of the report please contact Dr John Johnston, LMS Communications Officer at john.johnston @lms.ac.uk

Chi Onwurah MP

Joan Walley MP

Stephen Huggett and Catherine Hobbs

. . . this is the first such survey undertaken within mathematics ...

THE NUCLEAR TECHNOLOGY EDUCATION CONSORTIUM

Dr John Roberts
School of Physics & Astronomy, The University of Manchester

Established in 2005 to address the serious decline in nuclear education in the UK, the Nuclear Technology Education Consortium (NTEC)[1] brings together 9 UK universities, plus the Defence Academy, College of Management and Technology, to offer Master's level education in Nuclear Science and Technology. A report in 2002 by the Health and Safety Executive on Nuclear Education in British Universities[2] had concluded that "If nuclear education were a patient in a hospital it would be in intensive care" and recommended that "Immediate action is needed; otherwise nuclear education will slowly disappear". The report stated that "the focus of nuclear education should be on postgraduate courses" and "the move towards modular postgraduate courses and the introduction of postgraduate certificates and diplomas should broaden the appeal of nuclear subjects and attract more students".

Pockets of expertise and enthusiasm for nuclear teaching and research still existed within the universities but with the general decline of the UK nuclear sector from the late 1980s and through the 1990s the strength of the teaching and research groups at the individual universities was quickly diminishing. A consortium approach was therefore seen to be the best way forward. With four years of funding obtained from the Engineering and Physical Sciences Research Council (EPSRC), NTEC was established. The consortium now has ten members:

- University of Birmingham;
- University of Central Lancashire;
- City University;
- Imperial College London;
- Lancaster University;
- University of Leeds;
- University of Liverpool;
- University of Manchester;
- University of Sheffield;
- Defence Academy, College of Management and Technology.

These partners offer twenty modules across all aspects of Nuclear Science and Technology relevant to the UK's nuclear energy programme, including courses to suit students looking to enter the new build or decommissioning sectors. A key feature of the NTEC programme is that it was developed in response to the requirements of industry, and in collaboration with industry. This means that not only is the content of the course matched to their needs but the "short course" format of one-week concentrated modules is also the preferred delivery method. This allows full-time students to complete the Master's programme in one year and part-time students who are already employed by industry to finish in three years.

To qualify for the Master's degree, students must pass eight of the modules and submit a dissertation. Part-time students study four modules in each of their first two years and submit their dissertation after project work in the third year. Full-time and part-time students can also obtain a Postgraduate Diploma by omitting the dissertations and a Postgraduate Certificate by completing four core modules. All modules are also suitable for Continuous Professional Development so companies can send their employees on an intensive one-week course on a specific subject.

A development in 21st century education is the provision of university courses via e-Learning, sometimes known as Distance Learning, as the student does not attend the sessions, but accesses them via their computer. The ten most popular NTEC modules are available is this format which has allowed students from all over the world to study, as well as increasing the flexibility to allow more UK based employers to take the course. The Learning Outcomes of both delivery methods are identical so students qualify with the same degree and, if they wish, can mix Distance Learning with attendance to balance their workload over the one year or three year period. The programme is accredited by the Engineering Council on behalf of the main engineering Learned Societies, which allows the students to use their qualification towards Chartered Engineer status.

Industry input has been a vital component of NTEC since its establishment and continues

. . . concentrated modules is the preferred method . . .

. . . self-sustainable on the fee income . . .

to be so today. Major nuclear companies from the UK are represented on the External Advisory Board to provide guidance and feedback to the Steering Group, which is made up of representatives from each of the partner institutions. There is also student representation on the Steering Group to ensure there is transparency to all the decisions, and to provide feedback from current students. All policy decisions are made at Steering Group level and implemented by the NTEC Co-ordination Centre which is based in the School of Physics and Astronomy at The University of Manchester. The NTEC Management Structure is shown in Figure 1.

The UK nuclear industry also contributes in a number of other ways:

- Providing an industry location for the Master's projects;
- Industry lecturers support the programme to provide real case studies;
- CPD and part-time student fees support full-time students;
- Industry recruitment of NTEC students after graduation;
- The mix of young professionals with full-time students on the modules helps the students to make good career choices.

Due to the integrated nature of the industry support, the NTEC programme is now self-sustainable on the fee income – in particular the fees obtained from the UK nuclear companies. This income enables NTEC to offer full fee waivers and a £7,500 stipend to full-time students with an upper second class degree or above, and a reduced fee of £4,000 for students with a lower second class degree. In this way industry is increasing the skills of their current workforce and increasing the number of students they can recruit with the required qualification in Nuclear Science and Technology.

The real test of the success of any vocational programme is whether or not the students are recruited by industry at the end of their course. With the majority of students successfully managing to find an MSc project placement in industry it acts as a long-term job interview. Both employer and employee get to know each other during the three-month project period. This increases the prospect of both students and employers finding the best fit, leading to the student having a flying start to their career.

. . . students and employers finding the best fit . . .

With the recent announcement in March 2013 by the Energy Secretary Ed Davey that planning consent had been granted for the construction of a new nuclear power station at Hinkley Point, the 500 students that have passed through the NTEC programme are ready, enthusiastic and above all educated, to contribute to the new build programme in the UK, as well as the safe decommissioning of the existing fleet. In addition to this contribution to the UK nuclear industry, NTEC has also paved the way for a renaissance of nuclear courses at UK universities[3]. The success of NTEC and the parallel resurgence of the UK nuclear sector has encouraged many universities to hire more staff for their nuclear research groups. This has in turn led to a number of the universities establishing their own undergraduate or postgraduate nuclear courses, taught in the traditional manner. These provide additional places to educate the UK nuclear workforce of the future; a future where the UK nuclear universities collaborate with the UK nuclear industry for the benefit of the UK nuclear industry, and therefore ultimately the whole of the UK.

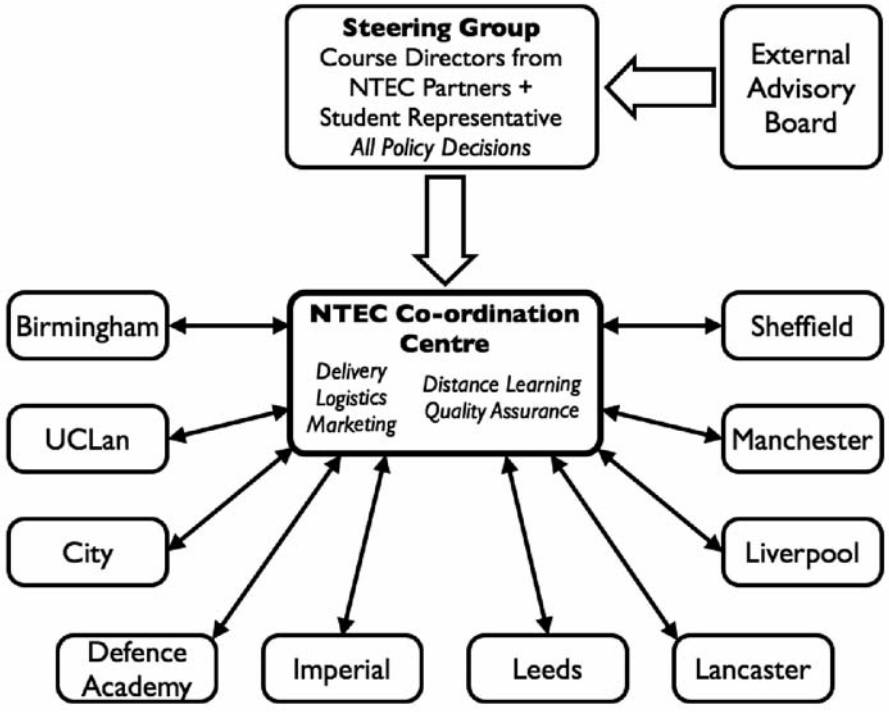


Figure 1: The NTEC Management Structure

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3. www.nuclearliaison.com.

ROYAL SOCIETY YEAR OF SCIENCE AND INDUSTRY

Dr Simon Campbell CBE FRS
Royal Society

In the 1660's Robert Boyle, one of the founders of the Royal Society, wrote a scientific wish list. He dreamed, among other things, of flying machines, GPS and commercial agriculture. Now we all know these changed our lives for the better, and subsequently achieved major commercial success. Later the Industrial Revolution brought scientists, engineers, technologists and entrepreneurs together to apply science to industry and the economy. Some outstanding outcomes include the steam engine providing power, chemistry and geology improving ceramics and the use of natural resources, mechanics and engineering constructing machines for transport and manufacture. Since the Enlightenment, innovative science has continued to be the bedrock for industry to translate into new products with both commercial and social benefits.

The situation in today's harsh economic climate is no different, as there is a general recognition that world class science and engineering are essential for revitalising our economy and generating long term growth, but funding must be internationally competitive.

Drawing on the advice of the science community, the Government has set out eight future technologies in which it believes the UK has the potential to be world-leading, and which will bring economic growth. Announced by the Chancellor at the Royal Society in November 2012, they include the 'Big Data' revolution and innovations in energy efficient computing; synthetic biology; regenerative medicine; agri-science; energy storage; advanced materials; robotics and autonomous systems; and satellites and commercial applications of space.

The Royal Society is committed to innovative science, and is supporting the Chancellor's challenge to the scientific community for Britain to lead the world in these areas. It recognises that world class research and development in UK industry is essential for transforming innovative ideas into commercially successful products, economic growth and securing the science base. Via its science and industry programme and other initiatives, the Society aims to understand and respond to the needs of industry. It is focused on engaging with the industrial sector to develop arguments that higher investment in the UK science base is essential for international competitiveness.

. . . new products with social benefits . . .

The Royal Society is highlighting innovation through a Year of Science and Industry. Launched at the Society's 'Labs to Riches' event at the end of 2012, this brings together industry, academia and the public across a range of events. These include scientific meetings, prize lectures, workshops and industrial symposia – all of which are contributing to a better understanding of industrial research and development and a greater appreciation for the quantity and quality of innovative scientific research

. . . impact in translational biomedicine can be maximised . . .

taking place throughout the UK.

In February 2013 a Royal Society Theo Murphy International Meeting examined the computational methods developed for the storage and indexing of massive data, and a further meeting was held in London focused on 'Taking x-ray phase contrast imaging into mainstream applications'. In the coming months there will be meetings on cell polarity research and how its impact in translational biomedicine can be maximised; Moore's Law and how microelectronics will deliver new and non-electronic functionality for optical, chemical and biological systems; sustainable computing; regenerative medicine; and drug discovery, regulation and the law. In addition the Royal Society will be holding a symposium with key industry representatives which will investigate the major issues facing them today and over the coming years and identify common themes for effective translation in the various sectors.

These have expanded the Society's calendar, which already includes initiatives in scientific excellence such as the Royal Society Industry Fellowship scheme and the Brian Mercer Awards for Innovation and Feasibility. Information on events as part of the Year of Science and Industry can be found at royalsociety.org/events/2013/year-science-industry/

Sometimes a distinction is drawn between basic or discovery science and applied science, as though they exist as separate endeavours. In practice, research is a continuum from discovery science through translation to subsequent exploitation. Paul Nurse, the President of the Royal Society, characterises this as an interactive ecosystem, with knowledge generated at different places within a continuum influencing both upstream in the creation of discoveries, and downstream in the production of new applications. He cites the case of the steam engine which influenced the formulation of thermodynamics. George Porter, a former President, once referred to there being two types of science "applied and not yet applied".

. . . influenced the formulation of thermodynamics . . .

There can be cultural differences between academia and industry which is an important area we will explore with our Year of Science and Industry. The key elements are people and their ideas. We have to ensure that where there are barriers to permeability between sectors, we can break them down. A company will need designers, production line workers, accountants and the innovation ecosystem needs a variety of skills found in different places. We need scientists to mix with the best minds from industry, the City, the public services, the media, to spark off new ideas so that research can benefit us all.

The ecosystem will only flourish with proper financial investment. Last year the Chancellor told an audience at the Royal Society 'We have great science in Britain. We are backing it. And we will do more.' Indeed, the Government has found funding to support the UK's research even during budget constraints. It clearly understands that ideas, innovation and commercialisation drive future prosperity. However, while this investment is essential and appreciated, it allows UK research no more than to stand still. The UK produces the most academic papers per financial unit spent in the G8, but other nations set investing in research at a higher priority. China, India, South Korea and Taiwan are all more ambitious. Germany has committed an extra €12bn to education and research, with a view to driving national prosperity. Finland and Sweden are pumping money into research, spending nearly 4% of GDP on R&D. By contrast, the UK trails the big spenders, with the public and private sectors combined investing only 1.79% of gross domestic product in research in 2010. Economies across the world are putting their weight behind science, while UK investment is lagging.

When we talk about the relationship between science and industry we have to look at business spend on R&D, an essential part of national investment. In Japan and South Korea this is over 70% of R&D spend. *Where* businesses spend their resources is increasingly competitive. The UK has nurtured world renowned pharmaceutical and automotive companies, and design pioneers and cutting edge new technology, but industry spends less on R&D in the UK than our competitors.

The Royal Society's Year of Science and Industry will identify and help overcome barriers between our world class science base and industry. We are aware of the challenges that face the UK's economy, but our activities can leverage a cultural shift that will increase the flow of ideas and investment between academia and industry and rekindle the entrepreneurial spirit of the enlightenment and the industrial revolution. The UK remains a genuine world leader in research – we now need to ensure that we translate new discoveries into an innovation-based and sustainable economic recovery.

TALKING TECHNOLOGY

Dr Matthew Aylett
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"Speech is the mirror of the soul; as a man speaks, so is he" – Publilius Syrus Roman author, 1st century BC

We know there is something special about speech. Our voices are not just a means of communicating, although they are superb at it, they also give a deep impression of who we are. They can betray our upbringing, our emotional state, our state of health. They can be used to persuade and convince, to calm and to excite. The power of speech is key to our parliamentary democracy. A debate requires the ability to speak, the rough and tumble of parliamentary life revolves around what politicians say rather than what they write. So, what can we do if a person loses the power of speech? What can we do if we want to grant the power of speech to our machines and tools? The answers lie with speech synthesis (also known as text to speech – TTS) technology.

Speech synthesis has progressed enormously since the trademark Stephen Hawking voice which was based on synthesis developed in the mid-eighties. Hawking has retained the same system, despite issues with naturalness, because it has become his personal voice. If he used a modern more natural system no one would recognise him. This issue of personalisation has become a major driving force behind modern speech synthesis technology. In the past a company would only offer a Male and Female British RP accent. Now companies offer many voices with many regional accents. CereProc, an Edinburgh company, even offers a Glaswegian accented system for Android. However, for people suffering from a speech disability, the voice they are really searching for is their own.

Roger Ebert, arguably America's most famous film critic, lost the ability to speak after a thyroid cancer operation. Although he used speech synthesis available on his Apple Mac to communicate, he was frustrated because the voice did not sound like him. CereProc stepped in to help him. Using hours of Roger's commentaries from DVDs, they were able to create a voice that mimics his original speaking style. These techniques were also used by CereProc to create a satirical 'Bush-o-matic' website which mimicked the speech of George W Bush, and, during the US presidential elections, a version of Barack Obama and Mitt Romney.

. . . something special about speech . . .

However many people do not have a large bank of clean recorded audio with which to build a synthetic version of their voice. Current speech synthesis research is exploring how to mimic a subject's voice with less audio, and for that audio to be less cleanly recorded. Currently 3-5 hours of speech is required to produce a voice that sounds almost completely natural, however with a new statistical modelling approach good quality voices can be produced with 40 minutes of audio, and voices that sound like a person, although with reduced quality, with even less data. This ability to clone voices with less data raises a host of ethical and legal issues. To what extent does your voice belong to you? Audio recorded by radio, TV and for audio books is typically owned by the company producing the audio, not by the speaker. The recent GOS foresight report on 'Future Identities' highlighted the blurring and complexity of identity caused by hyper-connectivity, the ability to seamlessly create synthetic copies of voices from limited data presents an even greater challenge to understanding, controlling and facilitating digital identity.

For Roger Ebert, having a synthetic voice **mimic** his speaking style was not enough:

"I now propose a test for computer voices – the Ebert test. If a computer voice can successfully tell a joke and do the timing and delivery as well as Henny Youngman, then that's the voice I want."
TED Talk – Roger Ebert: Remaking my voice

Offering a sensitive means of controlling the artificial voice as well as building a voice which allows emotional variation is still

. . . the voice they are really searching for is their own . . .

very much a research question. Commercial speech synthesis can offer some emotional variation but it is very much limited compared to virtuosity and flexibility of the human voice. Current systems are typically controlled either by eye-gaze or by typing which make fluid conversation almost impossible.

Despite the social and medical need for voice replacement, this has not been the driving force behind increased current commercial and academic interest in speech synthesis. Instead it has been the popularity of mobile devices and the advent of pervasive computing. Apple's SIRI has increased the profile of using synthetic speech synthesis to allow our tools and machines to communicate with us. A sub-plot of an episode 'The Big Bang Theory' explored the idea of one of the characters falling in love with SIRI. Indeed, a machine that speaks and interacts through speech can be a disconcerting experience. However the potential power for speech to be used to make devices easier to use, and to help us manage the ever increasing sea of digital data that surrounds us is huge. Speech interfaces can also offer a non-technical interface that can be used more readily by sectors of the community which have encountered barriers to using modern technology.

American companies have been quick to see the potential of this new speech synthesis technology. Nuance bought two European rivals in 2011, with both Google and Amazon following suit. Europe, with its high technology infrastructure and multiple languages has previously been a dominant player in Language technology. With stiff competition from Asia together with buying power from the US, this may be about to change. There is now only one independent speech synthesis company in the UK (CereProc) and only one other in the rest of Europe (Acapela).

. . . increased commercial interest in speech synthesis . . .

SIRI has demonstrated how powerful speech technology becomes when connected with language processing and search technology. The ability to offer users information when they are on the move *eyes-free* is only worthwhile if you have information to give them. Here natural language processing (NLP) systems are critical. Such systems can summarise, search out and organise information that is of personal interest, speech synthesis can then generate personalised podcasts in the same way political researchers summarise information for MPs and Ministers. Being able to deliver intelligently summarised information as audio can help build communities, educate, and allow busy professionals a means of keeping up to date with a rapidly changing world.

As we bring ever increasing artificial intelligence (AI) algortihms together with both speech technology and computer animation, we are able to produce virtual characters and virtual representations of ourselves. Such technology is already being used in computer games, virtual training systems and in social computing. A natural sounding, flexible synthetic voice is a key to these applications.

The ability to give a natural sounding voice to animated characters, virtual agents and robots using speech synthesis is a reality. The scope for delivering information using synthesis is immense. However, just as our own power of speech reflects our own humanity, so speech synthesis can add a touch of humanity to our machines and tools, and, in the end, this sensation of seeing ourselves in our machines is perhaps the most strange and fascinating aspect of current speech synthesis technology.

HOW DOES SPEECH SYNTHESIS WORK?

Most commercial speech synthesis systems have a neutral speaking style and are an example of *unit selection* or *concatenative* synthesis. In simple terms, the synthetic speech is made from taking lots of small pieces of speech, taken from recordings of a human voice, and sticking them together in order to create the required series of sounds, intonation and voice quality for a new message. Such synthesis systems have four main components, a large database of recordings in the order of 3-5 hours of speech, a set of features that describe a new phrase or sentence, a search algorithm that finds the best pieces of speech in the database to match these features, and a method to smoothly glue these pieces together to produce the new phrase.

The advantage of using this approach is that the normal voice quality of the speaker is retained, and with enough material, the joins are not noticeable. However the system can only produce speech in the same style it was recorded in and, if some sounds are missing, they cannot be reproduced.

An alternative approach using a statistical model to abstract the sounds in a speech database with reference to the context the sound appears in. This model is then used to recreate completely a speech waveform using digital signal processing techniques. One advantage is that because no single unit is used, an error in the data will be absorbed into the model and its impact reduced. Another is that if a sound or transition doesn't exist in the data, it can be extrapolated from another speaker's data. This has three main effects, less data can be used to produce an acceptable quality voice, the synthetic voice is very stable and intelligible, however the voice quality does not sound as natural.

Current research is also interested in using a hybrid version of these systems in order to try and gain the advantages of both.

CLIMATE CHANGE AND THE POLAR REGIONS

Dr Emily Shuckburgh
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British Antarctic Survey

Stretching back to Scott's doomed *Terra Nova* expedition, the enigmatic polar regions have long been a source of fascination for explorers and scientists alike. Today the polar regions remain a fertile ground for scientific exploration, serving as natural, interdisciplinary laboratories for the pursuit of new knowledge that can refine our understanding of the Earth system. However, the reality of climate change has meant they have taken on a new poignancy, for these frozen worlds are undergoing rapid changes with global impacts.

The polar regions provide an unrivalled time-machine, giving us insight into past climates through ice cores. As layer after layer of snow falls, a climate history accumulates. As the snow compacts to ice it traps tiny bubbles of air with it. By drilling down through the ice we are able to delve back in time. From the air bubbles we can determine the carbon dioxide levels in the atmosphere in the past and by analysing the water in the ice we are able to estimate the temperature (the latter is possible because the oxygen in the water comes in different chemical forms known as isotopes and the ratio of those isotopes varies according to the temperature of the atmosphere when the snow was formed).

As part of an international effort drilling deep into the ice in Antarctica, my colleagues at the British Antarctic Survey (BAS) have acquired a climate record going back an incredible eight hundred thousand years – a full six hundred thousand years before *Homo Sapiens* is thought to have evolved in Africa. As the orbit of the Earth has moved slowly, over tens of thousands of years, closer to or further away from the Sun, the temperature has varied between short warm periods and long, much colder ice ages. The carbon dioxide levels have varied up and down too, in step with the temperature. The evidence suggests that carbon dioxide is released by the ocean in warmer periods and taken up in cooler times. The greenhouse effect then kicks in and, according to the carbon dioxide levels in the atmosphere, the temperature rises or falls further. This all describes the slow natural cycle of climate change.

. . . a climate history accumulates . . .

However, since the start of the industrial revolution, the burning of fossil fuel has meant carbon dioxide in the atmosphere has rapidly increased by about 40%, to a value that far exceeds that found in the ice core record. This has short-circuited the natural cycle – changes to the Earth's orbit are not significant over this brief time period, but the greenhouse effect has meant that temperatures have risen substantially. Now the average surface temperature is about 0.8°C warmer than at the beginning of last century.

Not everywhere has warmed by the same amount: the Arctic has seen the greatest

Fig 1: A section through an ice core showing the trapped bubbles of air (© British Antarctic Survey)

. . . changing the ocean circulation . . .

temperature increase over the past few decades and the Antarctic Peninsula has also seen considerable change. I visited Iqaluit in the Canadian Arctic in 2010 and the local people told me how the changes they have seen over recent decades have impacted their daily lives, as their ice-world rapidly melts into a watery mud-scape. The loss of sea ice in the Arctic has been particularly dramatic. The sea ice reaches its minimum extent each year at the end of the summer melt season in September. In 2012 it covered just 3.4 million square kilometres, almost 50% less than the average coverage over 1979-2000. This is a huge reduction in area that is roughly equivalent to three quarters of Europe!

The changes to the polar regions can impact the rest of the planet. Some recent studies have linked unusual weather in the UK and North America to the decline in Arctic sea ice, and a comprehensive review[1] has detailed the impact of the melting of the polar ice sheets on global sea level, concluding that they have collectively contributed about 0.6 mm per year since 1992. Relatively warm water from the Southern Ocean can be brought up under Antarctica's ice shelves and melt them from below. Evidence suggests that this is resulting in the loss of ice from the West Antarctic Ice Sheet[2] and associated sea level rise. About 10% of the world's population, a similar or greater proportion of the infrastructure and many of the great trading hubs and world cities are in low-lying coastal regions and are thus at risk from sea level rise[3].

Despite their similarities there

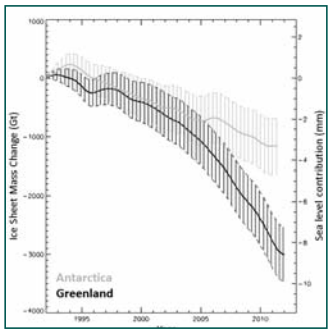

Fig 2: Changes in ice sheet mass and the contribution to sea level. Adapted from Shepherd et al, 2012.

are also key differences between the Arctic and the Antarctic. The most fundamental is perhaps that Antarctica is land surrounded by ocean whereas the Arctic is an ocean surrounded by land. A consequence of this is that strong winds are able to circulate around Antarctica in a way that does not happen to the same extent in the Arctic. As the climate changes, these Antarctic winds are anticipated to increase in strength and this may alter the amount of carbon dioxide that is taken up by the Southern Ocean, which at present equates to about 10% of man-made emissions, by changing the ocean circulation. A reduction in the ocean uptake would mean the atmospheric levels of carbon dioxide would rise faster and that would increase the rate of climate change.

Unlike in the Arctic where sea ice has been decreasing everywhere, in the Antarctic there has been a complicated pattern of sea ice change in recent years with some regions showing an increase and others a decrease. It has been suggested that this may be due to the changing wind patterns[4]. Along the Antarctic Peninsula the sea ice has been decreasing, which some scientists suspect has led to ecosystem changes. Shrimp-like krill appear to have dropped in number significantly over recent decades, perhaps by as much as 80%. A key part of their lifecycle is spent under the sea ice and so a change in sea ice can have direct consequences. Krill are a central component of the food web and therefore their demise has the potential to affect many other species. Decreases in populations of Adélie and chinstrap penguins have been observed along the Antarctic Peninsula[5], and there are no longer any emperor penguins inhabiting Emperor Island where once there were some 150 breeding pairs[6]. It is not known whether these losses are directly attributable to the sea ice changes, but a link is plausible.

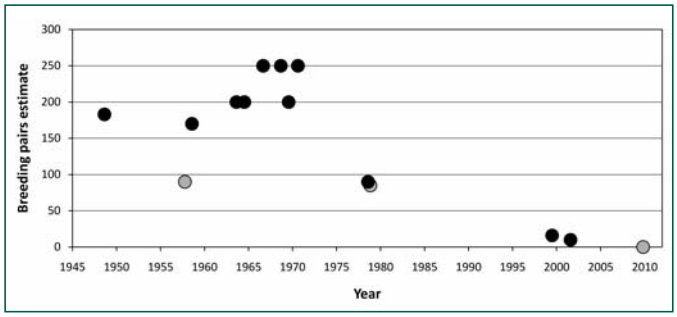

Fig 3: Estimated number of emperor penguin breeding pairs on Emperor Island. Black circles indicate counts made during winter and grey circles counts made later in the breeding season during spring, potentially after some egg/chick loss. From Trathan et al, PLOS One, 2012.

The other critical aspect of ecosystem damage related to man-made carbon dioxide emissions is ocean acidification. The oceans are thought to be acidifying at a faster rate than at any time in the past 300 million years. This acidification has a particular impact on calcareous skeletons or shells of marine life and some of the first signs of damage to marine snails in the Southern Ocean have recently been observed by BAS scientists[7].

A final compelling reason to focus on the polar regions is that they harbour some of the key risks of rapid or irreversible change such as melting permafrost releasing methane, influx of fresh melt water disrupting the Gulf Stream and collapsing ice sheets raising sea level. The ice core record from Greenland highlights the fact that dramatic changes have occurred in the past, especially around the North Atlantic, with periods of temperature change in Greenland of 10°C in less than a human lifetime. Similarly in Antarctica dramatic changes have been observed, such as the sudden collapse in a matter of weeks of Larsen B ice shelf (more than twice the size of Greater London), which occurred in 2002. The geological record indicates that Antarctica's ice sheets have varied in extent considerably in the past and there are concerns that large parts of the West Antarctic Ice Sheet could collapse in the future, leading over several centuries to more than 3 metres of sea level rise.

Thus the polar regions, though remote, are rightly

. . . no longer emperor penguins inhabiting Emperor Island . . .

emblematic of threat posed by man-made climate change, both in terms of their own survival and their global impacts.

How then can science help policy-makers and society in general make well-informed decisions concerning the future? The modern industrial economy is deeply rooted in a fossil-fuel based system, with carbon emissions steadily increasing year-on-year. An examination of the latest climate projections [8] indicates that without action to reduce our emissions we are likely to move beyond a threshold of 2°C increase in global average surface temperature compared with pre-industrial times by the middle of this century. By the end of the century on our current emissions trajectory we could exceed 4°C, taking us into a very different world where the risk of rapid or irreversible change is greatly enhanced.

To prevent this, global emissions need to peak soon – within years rather than decades [9]. That necessitates transformational change on a scale that is simply not currently happening. Rising to that grand challenge will require leadership and political will, together with technological and social innovation, and the engagement of society as a whole. Success would mean preserving the polar regions as a source of fascination for future generations of scientists and explorers, and perhaps more importantly protecting society from the worst of the damaging impacts of climate change.

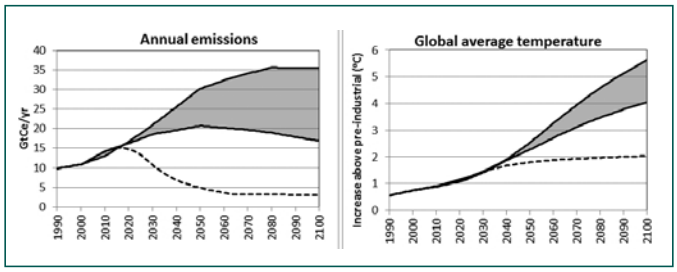

Fig 4: Annual emissions of greenhouse gases and associated global average temperature for three future emissions scenarios. The solid lines show two 'business-as-usual' scenarios: a fossil fuel intensive (A1FI) one and a more diverse energy mix (A1B). The dashed line shows a strong climate change mitigation policy where global emissions peak in 2016 and decrease by 5% per year thereafter). Adapted from Arnell et al, 2013.

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CLIMATE CHANGE AND THE POLAR REGIONS

CLIMATE CHANGE AND THE POLAR REGIONS: impacts of a disappearing Arctic sea ice cover

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Since the Industrial Revolution, the Arctic has been warming more rapidly than any other region, with an amplification factor of 2-4 over the planet as a whole. Since 1850 this rapid warming has produced a temperature increase (averaged over the year) of 3°C for stations north of 60°N, while the planet as a whole has experienced 0.8°C. Since 1950 the sea ice extent in every season has been seen to be reducing. In particular the summer (mid-September) sea ice extent shrank from 8 million km^2 in the 1970s, to only 4.2 million km^2 in 2007, and to an all-time low in 2012 of 3.4 million km^2. Viewed from space, the top of the world now looks blue instead of white in summer, a profound change. This shrinkage is expected to continue. Some climate models predict an 'ice-free' Arctic summer by 2040 while others predict an ice-free September within a very small number of years, before 2020 and possibly as early as 2015. An empirical analysis based on ice volumes rather than just areas also predicts a fundamentally ice-free Arctic by summer 2015 using satellite-tracked ice areas and submarine-surveyed ice thicknesses. On this basis there seems little doubt that by summer 2015 the Arctic Ocean will be fundamentally ice-free, with probably a narrow fringe of older (multi-year) ice remaining around the north coasts of Ellesmere Island and Greenland, these being the only areas where multi-year ice, once

. . . change in planetary albedo . . .

dominant in the Arctic, retains a strong presence.

The summer retreat of sea ice has been accompanied by a significant decrease in sea ice extent in other seasons, notably an earlier start to the spring retreat, also by a decline of more than 40% in sea ice mean thickness and a reduction of 73% in the frequency of pressure ridges, which have always been a significant barrier to navigation.

This reduction in sea ice area is having major impacts on both a regional (Arctic) and a global scale. Of special concern are positive feedback loops, where a change in sea ice extent initiates another undesirable or unexpected change. The first of these is a change in planetary albedo, leading to an acceleration of the global warming rate. Albedo, the fraction of incoming solar radiation reflected by a surface, is high for fresh snow (0.8-0.9) and even dirty melting snow and ice (0.5-0.6) but low for open water or bare land surface (less than 0.1). This means that the loss of sea ice area in summer is associated with a large increase in absorbed solar radiation. This is made worse by the fact that the northern hemisphere snowline is also retreating; in June 2012 the snow area showed a record 6 million km^2 negative anomaly relative to the average for the past 30 years, clearly driven by warmer air masses moving over Arctic land areas due to sea ice loss in the ocean itself. It has been estimated that the loss of summer sea ice and snow area on land are together giving, through albedo change, the same additional global warming as the last 25 years of added CO_2.

A second easily detected change is an acceleration in the summer melt of the surface of the Greenland ice sheet, leading to Greenland making a greater contribution to global sea level rise. Prior to 1985 no summer melt was detectable on Greenland, but the area subject to melt has steadily increased (in early July 2012 97% of the ice sheet surface showed melt) and Greenland is now contributing 300 km^3 of water annually to the world ocean (an average of 142 km^3 per year since 1992, but rising steadily), making it the largest single contributor to global sea level rise. As a result, estimates of global rise this century are now being revised upwards: in IPCC AR4 they were 30-70 cm, but higher values, with a wider range of uncertainty, are expected from AR5. This leads to an increased risk of disastrous storm surges in vulnerable areas like the Bay of Bengal.

In addition, another potential risk from the Arctic relates to methane release. Methane is being released as permafrost on land slowly melts, and already global atmospheric methane levels, stable in the early 2000s, are being observed to increase, with the source being identified by modelling as the Arctic. More serious and immediate may be an offshore release. Scientists estimate that approximately 50 Gt of methane is ready for abrupt release at any time in the East Siberian Arctic Shelf area (ESAS) alone, due to the shallow continental shelf seabed warming as summer sea ice retreats, which causes offshore permafrost to melt. Recent observations by Semiletov et al indicate that underwater methane release, in the form of large bubble plumes, is already occurring in this region. Economic modelling attributes $60 trillion in costs to this one effect, with the economic burden felt disproportionately (80%) by poorer regions.

Set against these unfavourable, and deeply worrying, regional physical changes are positive regional economic opportunities. Oil exploration and production will be easier; the favoured option of a dynamically positioned drillship supported by a group of icebreakers breaking up ice around it to relieve potential pressure is applicable to first-year ice areas which now compose most of the Arctic ice cover, though the environmental threat of an under-ice blowout remains a potent factor.

. . . melt of the surface of the Greenland ice sheet . . .

Shipping will be easier: both the Northern Sea Route (across the north of Russia) and the Northwest Passage are now ice-free for 2-3 months per year, and in 2012 40 commercial ships sailed through the Northern Sea Route including a loaded liquified natural gas (LNG) carrier. In future, with an ice-free summer Arctic, a true trans-Arctic shipping route from Bering Strait to Europe via the North Pole will be possible, and even in winter the first-year ice and lack of pressure ridges will allow ice-strengthened ships to cross the Arctic. Already the retreat of sea ice, and its penetrability to radiation even before its disappearance (via light penetration through melt pools) are resulting in an earlier and more prolific spring plankton bloom in ice-free regions, suggesting that a future Arctic will have a high fisheries potential. Tourism will undoubtedly flourish. At the same time, global risks to various economic sectors will increase: it has been hypothesized that the retreat of sea ice is connected with, and may be a causal factor for, the change in shape and nature of the jet stream which has been a factor in 2012 drought, crop losses and weather extremes at mid-latitudes including Hurricane Sandy. If this is found to be the case, then insurance losses alone make sea ice retreat one of the most expensive natural fluctuations currently afflicting the earth.

. . . more prolific spring plankton bloom . . .

WHY SHOULD THE UK CARE ABOUT THE ARCTIC?

An oceans and climate perspective

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We all know that the Arctic is the cold bit at the northern end of the planet, but a functional definition is actually quite tricky. An easy choice might be "north of the Arctic circle", where the Arctic circle is the parallel of latitude 66˚34′ N. For any latitude at or north of it, the sun can remain continuously above (or continuously below) the horizon for twenty-four hours. However, this definition would cut off the southern third of Greenland, and since Greenland supports an ice cap about three kilometres thick, it should sensibly be included as "Arctic". A practical definition would most likely entail use of the word "cryosphere", which means the part of the planet influenced by the freezing of water, but more care is needed: it is snowing in Hampshire as I write this, but that does not make Hampshire part of the Arctic. Similarly, altitude is relevant: permanent glaciers exist at the tops of high mountains, like the Alps and Kilimanjaro, but they are not Arctic either.

It is illuminating to take an imaginary tour around the latitude circle of 60°N, starting in the UK: the Shetland Islands span a degree of latitude, from Sumburgh Head at 59°51′N to Muckle Flugga at 60°51′N. The climate of the Shetlands is cool, damp and breezy. Now travel eastwards, across the northern North Sea to southern Scandinavia, passing close by Oslo and Stockholm, then crossing the Baltic – which freezes in winter – to the environs of Helsinki and St. Petersburg. Stretching ahead are the trackless wastes of the Siberian permafrost and tundra, one-third of the circumference of the Earth at this latitude – 6000 kilometres. Perhaps the major geographical features here are the great rivers – the Lena, the Yenisei and the Ob – which, with the many lesser rivers, drain 10% of the Earth's total flow of river water into the Arctic Ocean; and in winter, these rivers freeze. In clipping the northern end of the Sea of Okhotsk, our tour leaves Siberia, passing across the Kamchatka Peninsula to enter the Bering Sea, the northernmost extremity of the Pacific Ocean, covered with sea ice in winter at this latitude.

. . . cut off the southern third of Greenland . . .

. . . trackless wastes of the Siberian permafrost . . .

Continuing east, we touch land on Alaska, running close to the coast of south central Alaska; Anchorage is a little to the north, and Juneau to the south. Next, the Canadian interior bears comparison to Siberia, albeit less extensive. We soon run into some interesting bodies of water. Hudson Bay (which freezes in winter), and Hudson Strait (which also freezes in winter), its connection to the Labrador Sea, a marginal basin of the North Atlantic. The Labrador Sea is a very interesting place because it is one of very few locations in the world ocean where deep convection occurs. Strong, cold, winter winds pull so much heat out of the ocean that the water can become dense enough to overturn to depths of up to two kilometres. At the eastern edge of the Labrador Sea lies Cape Farewell, the southern tip of Greenland; then the East Greenland Current, with its winter burden of sea ice, much of which flows out of the Arctic through Fram Strait, far to the north. Finally we meet the temperate waters of the eastern North Atlantic, and return to the Shetlands.

. . . Labrador Sea is a very interesting place . . .

So all round 60°N, it is not just the land but also the seas that freeze hard during winter, with the exception of the north-east Atlantic (and the Shetlands); and it is straightforward to extend this analysis to show that it is the whole north-west European seaboard, encompassing the British Isles and western Norway, that experience a relatively privileged climate, notable for its anomalous warmth. It is said that the UK has a "maritime" climate, but it is clear from the tour of 60°N that simple proximity of a sea or ocean is not sufficient in itself to make a maritime climate a (relatively) warm one. The UK sits on the east side of a warm ocean over which westerly winds blow, and those winds draw their warmth from ocean waters which began their journey to our latitudes far to the south. So why do we have warm ocean waters travelling northwards near the UK?

The answer lies in the complicated mathematics that describe fluid flow on a rotating planet, heated (by the sun) from above; and there are two fluids to consider – the atmosphere, which is not strongly constrained by orography, and the ocean, which is absolutely constrained by land. To pursue the narrative explanation rather than the mathematical, consider the whole of the Atlantic Ocean, from its furthest southern part at its junction with the Southern (Antarctic) Ocean, north through the Equator as far as Iceland. The Atlantic supports a Meridional Overturning Circulation (or MOC), where "Meridional" simply means "in the north-south sense" ("zonal" is the adjective describing "east-west"). It is only in relatively recent decades that the importance of the MOC to climate has been appreciated. The MOC has been called the "Conveyor Belt" because (at its most simple) it represents warm Atlantic waters travelling northwards in the upper ocean (the top kilometre), balanced by a southward transport of cold Arctic waters at depth (between about one and four kilometres depth). The "Overturning" part of the MOC describes how the upper and lower limbs of the "conveyor" are connected – deep waters are drawn up to the surface around Antarctica by divergence caused by sustained and powerful winds, while in the Arctic, the supply of deep waters is maintained by the extreme cold making surface waters dense enough (mainly through cooling) to sink to great depths. Labrador Sea convection (mentioned above) is part of this sinking process. This has been called the "pump and valve" mechanism, where southern winds (and some other processes) are the pump that powers the system, and the northern manufacture of dense waters comprise the "valve", by opening a connection between surface and deep waters.

Essentially, the MOC is responsible for delivering the heat that makes the UK climate mild. In 2004, Hollywood released a somewhat absurd blockbuster called "The Day After Tomorrow"; in one memorable scene, climate is changing so fast that it chases a character down a corridor! While scientists such as the present writer had a good laugh at the film's expense, it was much later that I realised that there was one truth contained within this film: that there is no future guarantee of a perpetually benign and stable climate. Studies of past climate and modelled scenarios of possible future climate have revealed a vulnerability of the MOC. The addition of large quantities of fresh water to the northern high-latitude oceans can act like a lid, reducing or stopping the deep convection that opens the "valve" of the MOC, and thereby slowing (or in extreme cases, stopping) the MOC, with the effect that the delivery of ocean heat to the UK's latitudes is reduced: in a warming world, it is possible that localised cooling may occur. A close study of the potential sources of increased fresh water input to the ocean shows that a sufficient quantity could be delivered in three ways: from increased rainfall over Siberia, which would intensify the delivery of river water to the Arctic; by "draining" a layer of diluted seawater occupying the upper two hundred metres of the Arctic Ocean (this would require a change in ocean circulation); and by increasing the rate at which summertime melting of the Greenland ice cap occurs. As a matter of interest, for the terms of this argument, Arctic sea ice does not figure strongly because it is a relatively small quantity of fresh water. We know that over the last several decades, Siberian river flow and the Greenland melt rate have been increasing.

So it is indeed possible that the MOC could be "distressed", to the detriment of UK (and European) climate; but it is important to note that I have described a scenario: a set of circumstances which could occur, but we do not know how likely (or unlikely) it is; no degree of probability is (yet) ascribed. Some aspects of climate are very well understood, such as the impact of increasing atmospheric greenhouse gas concentrations on temperature; but there are many aspects of the (extremely) complex climate system which remain less well-understood, and in need of further study – such as the interaction of oceans and cryosphere and their impact on climate.

. . . the UK has a "maritime" climate . . .

. . . delivering the heat that makes the UK climate mild . . .

Meeting of the Parliamentary and Scientific Committee on Tuesday 26th February

EXTREME SPACE WEATHER; impacts on engineered systems and infrastructure

Professor Paul S Cannon FREng
Royal Academy of Engineering

IMPACT

Infrequent solar superstorms generate X-rays and solar radio bursts, accelerate solar particles to relativistic velocities and cause major perturbations to the solar wind. These environmental changes can cause detrimental effects to the electricity grid, satellites, avionics, air passengers, signals from satellite navigation systems, mobile telephones and more. They have consequently been identified as a risk to the world economy and society.

Explosive eruptions of energy from the Sun which cause minor solar storms on Earth are relatively common events. By contrast, extremely large events (superstorms) occur very occasionally – perhaps once every century or two. Most superstorms miss the Earth, travelling harmlessly into space. Of those that do travel towards the Earth, only half interact with the Earth's environment and cause damage.

Since the start of the space age, there has been no true solar superstorm and consequently our understanding remains limited. There have, however, been a number of near misses and these have caused major technological damage, for example the 1989 collapse of part of the Canadian electricity grid. A superstorm which occurred in 1859, now referred to as the 'Carrington event' is the largest for which we have measurements.

How often superstorms occur and whether the above are representative of the long term risk is not known and is the subject of important research. The consensus is that a solar superstorm is inevitable, a matter not of 'if' but 'when?'. One contemporary view is that a Carrington-level event will occur within a period of 250 years with a confidence of ~95%.

Mitigation of solar superstorms necessitates a number of technology-specific approaches which implies reducing as much risk as is reasonably possible, and then adopting operational strategies to deal with the residual risk. In order to achieve the latter, space and terrestrial sensors are required to monitor the storm from its early stages as enhanced activity on the Sun through to its impact on Earth. Forecasting a solar storm is a challenge, and current techniques deliver limited advice.

. . . superstorms occur very occasionally . . .

In a 'perfect storm' a number of technologies will be simultaneously affected which will substantially exacerbate the risk. Mitigating and maintaining an awareness of the separate and linked risks over the long term is a challenge for government, for asset owners and for managers.

ELECTRICITY GRID

A plausible worst case scenario would have a significant impact on the national electricity grid. Modelling indicates around six super grid transformers in England and Wales and a further seven grid transformers in Scotland could be damaged through geomagnetic disturbances and taken out of service. The time to repair would be between weeks and months. In addition, current estimates indicate a potential for some local electricity interruptions of a few hours. Because most nodes have more than one transformer available, not all these failures would lead to a disconnection event. However, National Grid's analysis is that around two nodes in Great Britain could experience disconnection.

SATELLITES

Some satellites may be exposed to environments in excess of typical specification levels, so increasing microelectronic upset rates and creating electrostatic charging hazards. Fortunately the

. . . some satellite designs would prove more vulnerable . . .

conservative nature of spacecraft designs and their diversity is expected to limit the scale of the problem. Our best engineering judgement, based on the 2003 storm, is that up to 10% of satellites could experience temporary outages lasting hours to days as a result of the extreme event. It is unlikely that these outages will be spread evenly since some satellite designs and constellations would prove more vulnerable than others. In addition, the significant cumulative radiation doses would be expected to cause rapid ageing of many satellites. Very old satellites might be expected to start to fail in the immediate aftermath of the storm while new satellites would be expected to survive the event but with higher risk thereafter from incidence of further (more common) storm events.

AIRCRAFT PASSENGER AND CREW SAFETY

Passengers and crew airborne at the time of an extreme event would be exposed to an additional dose of radiation estimated to be up to 20 mSv. This is significantly in excess of the 1 mSv annual limit for members of the public from a planned exposure and about three times as high as the dose received from a CT scan of the chest. Such levels imply an increased cancer risk of 1 in 1,000 for each person exposed. This must be considered in the context of the lifetime risk of cancer, which is about 30%. No practicable method of forecast is likely in the short term since the high energy particles of greatest concern arrive at close to the speed of light. Mitigation and post event analysis is needed through better onboard aircraft monitoring. An event of this type would generate considerable public concern.

GROUND AND AVIONIC DEVICE TECHNOLOGY

Solar energetic particles indirectly generate charge in semiconductor materials, causing electronic equipment to malfunction. There is very little evidence regarding the impact of solar energetic particles on ground infrastructure and it is consequently difficult to extrapolate to a solar superstorm. More evidence of normal and storm time impacts is available in respect to avionics. During a solar superstorm the avionic risk will be ~1,200 times higher than the background level and this could increase pilot workload. Avionics are designed to mitigate functional failure of components, equipment and systems and consequently they are also robust to solar energetic particles.

. . . increase pilot workload . . .

GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS)

A solar superstorm might render GNSS partially or completely inoperable for between one and three days. The outage period will be dependent on the service requirements. For critical timing infrastructure it is important that holdover oscillators be deployed capable of maintaining the requisite performance for these periods. UK networked communications meet this requirement. There will be specialist applications where the loss or reduction in GNSS services cause operational problems. These include aircraft and shipping. Today, the aircraft navigation system is backed up by terrestrial navigation aids; it is important that alternative navigation options remain available in the future.

CELLULAR AND EMERGENCY COMMUNICATIONS

The UK's commercial cellular communications networks are much more resilient to the effects of a solar superstorm than those deployed in a number of other countries (including the US) since they are not reliant on GNSS timing. The UK implementation of the Terrestrial European Trunked Radio Access (TETRA) emergency communications network is dependent on GNSS. Consequently, mitigation strategies, already in place, are necessary.

HIGH FREQUENCY (HF) COMMUNICATIONS

HF communications are likely to be inoperable for several days during a solar superstorm. HF communications are used less than hitherto. However, it does provide the primary long distance communications for long distance aircraft (not all aircraft have satellite communications and this technology may also fail during an extreme event). For those aircraft in the air at the start of the event, there are well-defined procedures in the event of a loss of communications. In the event of a persistent loss of communications over a wide area, it may be necessary to prevent flights from taking off. In this extreme case, there is no defined mechanism for closing or reopening airspace once communications have recovered.

MOBILE SATELLITE COMMUNICATIONS

During an extreme space weather event, L-band (~1.5GHz) satellite communications might be unavailable, or provide a poor quality of service, for between one and three days owing to scintillation. The overall vulnerability of L-band satellite communications to superstorm scintillation will be specific to the satellite system. For aviation users the operational impact on satellite communications will be similar to HF.

RECOMMENDATIONS

The Royal Academy of Engineering study [Cannon et al., 2013a; b] makes a number of technical recommendations.

In order to ensure a space weather resilient infrastructure the Academy recommends that a UK Space Weather Board be set up with cross-government department responsibilities.

. . . well-defined procedures in the event of a loss of communications . . .

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SPACE WEATHER: A space insurance perspective

David Wade
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Since the Space Age began 55 years ago, approximately 6,500 satellites have been launched. Approximately 1,000 of these satellites are still active[1]. Society has become increasingly reliant upon the services provided by satellites. Space weather is known to pose a peril to satellites and in extreme events it is likely that a number of satellites will suffer temporary outages, and a small number may be permanently lost.

Whilst satellites have so far demonstrated their resilience to space weather, a true stress test of an extreme space weather event has not occurred during the Space Age. Are we prepared for such an event?

RELIANCE

The prominence of satellite services has increased significantly over the past ten years. Forty per cent of UK households now receive their television service via satellite[2] and satellite navigation has spawned a vast number of new services and efficiency gains. Delivery companies, for example, have reduced fuel consumption by 13% whilst increasing fleet utilisation by 27% through the use of satellite navigation[3] and precision agriculture has improved crop yields and reduced the use of fertiliser and pesticide. In the years to come, new satellite-based services will allow shipping to be tracked worldwide to the benefit of national security and safely allow a reduction in the separation of aircraft to cater for the increasing density of air traffic.

The annual worldwide revenue of the satellite services sector has grown from US$ 46.4 billion in 2001[4] to US$ 107.7 billion in 2011[1]. This only accounts for the direct sale of satellite services. Revenue from downstream services, such as the use of the Global Positioning System (GPS) are not included within this figure, yet satellite navigation services already account for between 6% and 7% of the gross domestic product of Western countries; approximately €800 billion in the European Union alone[5].

EFFECTS ON SATELLITES

The near-Earth space environment is characterised by two toroidal radiation belts girdling the Earth, known as the Van Allen radiation belts. Low Earth Orbiting (LEO) satellites in Sun-synchronous or polar orbits such as those used for imaging purposes and Medium Earth Orbit (MEO) satellites used for navigation are exposed to the inner radiation belt. The design of satellites operating in these orbits needs to account for the significant radiation dose such satellites will receive over their lifetimes. The 400 or so geostationary satellites, such as those used for communication services, reside in geostationary orbit, 36,000 km above the equator. At this location the satellites orbit within the outer radiation belt and are exposed to solar events which can significantly enhance the background radiation levels.

Charging, both on the surface of the spacecraft, as different regions, perhaps with different materials, charge to different levels, and internal charging, as high energy electrons penetrate into the body of the spacecraft can occur and can damage sensitive microelectronic components. Energetic protons will reduce the efficiency of solar cells which may, for example, require communications channels to be turned off to compensate for the loss of power. Ions will produce single event effects (SEE's) which are often temporary in nature, but which can cause permanent physical damage in a minority of cases. During an extreme space weather event a satellite may also receive sufficient radiation to exceed its specified lifetime dose. Whilst this rarely leads to losses, it does age the satellite which may require plans to replace the satellite to be brought forward[6].

Little can be done to reduce the risk posed to a satellite by an extreme space weather event once the satellite is in orbit, although satellite operating companies may choose to

. . . satellites have demonstrated resilience to space weather . . .

suspend manoeuvres, or call in extra satellite controllers to cope with any anomalies that do result.

SPACE INSURANCE EXPERIENCE

With little chance to react once a satellite has been launched it is essential that the satellite has been designed to withstand the environment within which it is expected to operate.

Satellites are affected by the space environment and 19% [7] of satellite anomalies are deemed to be, at least in part, attributable to space weather. An anomaly however can be as simple as a device suffering a spurious switch off which can be reset. In many such cases the end user of the satellite service would not even be aware that an anomaly had taken place. In other cases, where a satellite loses its ability to point, for example, an anomaly may result in a temporary outage which would require ground intervention. Only in a small number of incidents, where permanent physical damage is caused to the satellite and the value of the asset is impaired will an insurance claim be payable.

. . . an anomaly may result in a temporary outage . . .

Over the past 25 years, space insurance claims due to space weather have amounted to US$ 275 million; just 2% of the total claims of US$ 12.3 billion. Does this mean that the space insurance community can ignore the effects of space weather? Absolutely not! Claims due to space weather may be a small proportion of the total claims paid, but an extreme space weather event still poses the ultimate low frequency, high severity risk that the space insurance community faces.

REALISTIC DISASTER SCENARIOS

For insurance underwriting purposes, realistic disaster scenarios (RDS's) are defined [8] so that estimates can be maintained of the worst case loss that may result from a particular event. The space RDS's are being revised, but two RDS's related to space weather are currently included in the updated definitions.

In the first of these scenarios an anomalously large solar proton event is envisaged. The event would last long enough that all satellites, particularly those in geostationary orbit, would be exposed to the proton stream. The increased flux of protons would degrade the efficiency of the satellite's solar arrays. Many satellites have power margins in excess of that required, and space insurance policies include minimum power margins that must be maintained. Other policies cover satellites on a total loss only basis. Such policies will not be triggered by an attritional loss of power. Taking these factors into account, and based on the US$ 23.5 billion of insured exposure in-orbit as of January 2013, an insurance loss of approximately US$ 1 billion would be expected under this scenario.

. . . degrade the efficiency of the satellite's solar arrays . . .

The second space weather RDS considers a defective satellite design or a workmanship issue which leaves a particular system or component sensitive to space weather effects. With many satellite manufacturers launching numerous examples of the same type of satellite, differences, albeit minor, in workmanship and build quality can affect the sensitivity, thus it is realistic that a small number of satellites could become total losses. With many satellites' insured values exceeding US$ 300m and some exceeding US$ 400m, a loss of up to US$ 1.2 billion for this scenario is feasible.

. . . differences in build quality . . .

These figures only represent the loss to the space insurance market. The loss of revenue for the satellite operating company, as well as from downstream services, would make the true economic impact many times greater than the insurance loss. It is impossible to determine an accurate figure, the total loss from a single extreme space weather event would be in the region of tens of billions of dollars.

NOT ARMAGEDDON

Although we have not experienced an extreme space weather event during the Space Age, experience suggests that satellites have been able to demonstrate a good degree of resilience. An extreme event may be expected to result in a temporary outage of as many as one hundred satellites [6], or 10% of the in-orbit fleet, with a much smaller number permanently disabled by the event. With the ever-increasing reliance we place in satellite services, there is no room for complacency. We need to continue to monitor the space environment, improve our models, learn how to forecast and fully incorporate these models into the design process to make sure we are not caught off guard the next time an extreme event occurs.

. . . no room for complacency . . .

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EXTREME SPACE WEATHER; impacts on engineered systems and infrastructure

Chris Train
Network Operations Director,
National Grid

National Grid takes the threat of disruption from severe space weather seriously. We work with government, industry, academia and other organisations to understand and combat this threat. National Grid has modelled the impact of an extreme space weather event on the national transmission network and has concluded that widespread damage resulting in decade-long disruption to power supplies is unrealistic. A 1 in 100 year space weather event could cause damage and some short term (on the order of 12-24 hours) disruption, but National Grid's policies and operational procedures would minimise the impact on end users of the electricity network.

National Grid operates the high voltage electricity transmission network in Great Britain, and owns the transmission network in England and Wales. In England and Wales the transmission voltages are 400 KV and 275 KV, and in Scotland 132 KV is also used. The network has over 7900 km of overhead lines and underground cables feeding in to over 900 substations, with approximately 1400 high voltage transformers. In an extreme space weather event, magnetic material that crosses the interplanetary space from the sun to the earth induces electric fields in the interior of the earth. If the local geology is resistant to the flow of electric current, then these geomagnetically induced currents are forced out of the ground, passing through the earthing cables of the high voltage transformers, flow along the transmission lines and cables, returning to earth through transformer earths at the far end of the line. The higher the voltage, the lower the resistance of the transmission lines, so the more likely it is that these induced currents will flow into the system. We are fortunate that, unlike many countries, we do not have voltages above the 400 KV level.

Effects from space weather disturbances have been known for many years, but it was only in the second half of the twentieth century that electricity grids became developed enough for effects to manifest themselves on transmission networks. The first and so far largest space weather event known occurred in 1859. The initial disturbance on the sun was observed by the British astronomer Richard Carrington – hence the Carrington Event. Clearly there was no electricity transmission network in 1859, but there was widespread disruption to the telegraph network in Europe and North America. Estimates put the severity of the Carrington Event at 1% or less. Other storms worthy of note that have occurred during the time period since the development of electric grids include the 1989 Quebec Blackout storm and the 2003 Halloween storm. In 1989 a storm about 10 times less intense than the Carrington Event caused the collapse of the grid in the Canadian province of Quebec, bringing the network down within 90 seconds. Effects were felt much less in the UK, but two transformers on the GB grid were damaged and removed from service.

. . . collapse of the grid in Quebec . . .

Electricity grids are affected by space weather events because of the effect of geomagnetically induced currents on high voltage transformers. These currents appear to the transformer as direct currents, rather than the alternating currents they are designed to operate with. They cause an enormous

. . . well developed plans for restoration of power . . .

intensification of the magnetic field inside the transformer. There are three consequences of this saturation of the transformer's internal magnetic field. First, the magnetic energy escapes from the core of the transformer, and along the escape paths there are intense localised heating effects. The transformer's coolant overheats, setting off alarms which disconnect the transformer, and in the worst cases insulation can catch fire causing irreparable damage. Secondly, the transformer is operating outside its design parameters. It becomes a consumer of "reactive power". This causes the voltage on the network in the local vicinity to fluctuate, getting lower, and there is a danger that the voltage can collapse to zero, which leads to a power outage. There are devices on the network to stabilise the voltage against these fluctuations. However, these are sensitive to distortions – harmonics – in the waveform of the alternating current, and are protected by automatic relays. Unfortunately the third effect of the induced currents is to distort the waveform coming out of the transformer, making it more likely that the relays protecting the corrective equipment will trip, and remove the devices from service just when they are most needed. It was a combination of these two latter effects that caused the Quebec blackout in 1989.

In order to understand the effects of an extreme space weather event on today's transmission network, National Grid has modelled the effects of a Carrington-like event. This involves modelling the magnetic field caused by the impact of the coronal mass ejection, the currents generated deep within the earth's crust, the local geology below our feet, down to more than 500 km, the electrical properties of the transmission grid as the current flows up into 7900 km of transmission lines, and the effect of the induced currents on the high voltage transformers, giving their likelihood of failure. The risk that National Grid was most keen to address was the widespread damage to high voltage transformers. This is because these 3 to 4 million pound-worth machines take several years to build, and the worldwide manufacturing capability for them is low. If the UK and other major industrialised countries needed large numbers of transformer replacements it would be many years before electricity grids were as resilient and robust as they are today. National Grid's analysis shows that widespread damage is unrealistic, although some transformer damage would probably occur, on the order of 15 transformers countrywide. However, the electricity grid has more transformers on it than are needed to ensure that it is resilient to multiple failures. National Grid carries a stock of spare transformers. These factors make it unlikely that there would be significant impacts on the public. Where damage does occur the redundant transformers would take up the burden until a replacement could be installed – this is a large scale undertaking, and takes at least 8-16 weeks. It is possible that one or two small substations in relatively unpopulated areas could find their substation out of action, and special measures would have to be taken, in conjunction with the local distribution operators, to minimise the inconvenience.

More likely is the scenario of voltage fluctuations. In areas dependent on the precise structure of the particular event, the induced currents will cause localised problems on the network, which may lead to power outages. While serious for people affected, National Grid has well developed plans for restoration of power, typically within 12 hours. The effects are much more short term than the previous (fortunately unrealistic) scenario of widespread collapse.

National Grid has been preparing for extreme space weather since realising the implications from the experience of the 1989 storm. As time has passed scientific understanding of the phenomenon has increased and understanding of the potential risks has developed. Since 1999 new National Grid transformers have been built to a higher standard to improve their tolerance to geomagnetically induced currents. We have also substantially increased our spares holding. Some aspects of the design of our grid give a natural resilience against space weather: we do not use ultra-high voltages, the line lengths are relatively short, the network is highly connected, substations have extra resilience through the redundancy of operational spares. All these factors help to mitigate the risk.

National Grid continually monitors the state of the sun, looking for signs of impending space weather events. We have close contacts with space weather prediction bodies, and have a bespoke monitoring system designed in conjunction with the British Geological Survey, who also provide us with space weather forecasts. We have carefully rehearsed operational plans for minimising the impact of a space weather event through operational procedures. The operational procedures are similar in many ways to the procedures we employ in times of exceptional terrestrial weather, and National Grid has an exemplary track record in managing these risks.

One mitigating technology we have not yet used are blocking devices. These claim to be able to interrupt the flow of the induced currents while allowing the normal alternating current to flow unimpeded. Such devices are at present in their infancy – only one manufacturer has developed such a device – and there is much testing and trialling of the technology to be done before National Grid decides whether such devices are suitable for our system. We are keeping a close watching brief on these developments.

The science of space weather and its impacts on our technological infrastructure is developing fast, but much remains to be learnt. National Grid is at the forefront of international efforts to understand and prepare for such events. We work closely with partners in government, industry, academia and international partners to develop the knowledge and expertise to protect out customers and our country against this and other threats.

. . . National Grid has an exemplary track record . . .

INTERNET AND WEB PIONEERS WIN THE INAUGURAL QUEEN ELIZABETH PRIZE FOR ENGINEERING

On 18 March 2013, the first Queen Elizabeth Prize for Engineering (QEPrize) was awarded to five pioneering individuals who collectively created one of the most complex and exceptional systems: the Internet, the World Wide Web and the Mosaic web browser.

The announcement of the winners was made by Lord Browne, in the presence of Princess Anne and politicians of all parties: Rt. Hon Oliver Letwin, Rt. Hon Vince Cable, Chuka Umunna, as well as other Members of the Commons and the Lords. The formal prize ceremony will take place on 25 June 2013, when Her Majesty the Queen will present the award to Dr Robert Kahn, Dr Vinton Cerf, Louis Pouzin, Sir Tim Berners-Lee FREng and Marc Andreessen.

The distinguished panel of international judges made their decision in a dramatic final meeting a few days before the announcement. This followed a long and detailed judging process over the preceding months involving two groups of Royal Academy of Engineering fellows, one which solicited nominations and the other which sifted through them. The quality and range of entries was extremely high and were received from all over the world.

The judging panel for the inaugural cycle comprised: Professor Frances Arnold, Lord Broers (Chair), Professor Brian Cox, Madam Deng Nan, Professor Lynn Gladden, Diane Greene, Professor John Hennessy, Professor Dr Dr h.c. Reinhard Hüttl, Professor Calestous Juma, Professor Hiroshi Komiyama, Dr Dan Mote, Narayana Murthy, Dr Nathan Myhrvold, Professor Choon Fong Shih and Paul Westbury.

The QEPrize was launched in November 2011 to identify, reward and celebrate an outstanding advance in engineering, for up to three individuals, which has proved of global benefit to humanity. All three party political leaders attended and addressed the launch and there has been Cross-Party consensus in the prize's goals. Awarded every other year, the winners, of any nationality, will have been responsible for advancing the application of engineering knowledge that has produced tangible and widespread public benefit. In exceptional circumstances, the prize can be awarded to more than three individuals and in reviewing the nominations the international team of judges concluded that just such an exception should be made.

The Internet and the World Wide Web, integral to the lives of over 2bn people worldwide, have revolutionised the way we communicate and access information. Kahn, Cerf and Pouzin developed the Internet and protocol standards, which provide the fundamental infrastructure needed to connect billions of computers to each other. Berners-Lee's Web builds on this, allowing access to a huge amount of information. Andreessen made this information infinitely easier to access, with the creation of a user-friendly browser and made it available to everyone. Lord Broers, Chairman of the Judging Panel, described the achievement as the "biggest piece of hardware ever built… these five visionary engineers, never before honoured as a group, led the key developments that shaped the Internet and Web as a coherent system and brought them into public use."

The judges considered that the technical prowess of the winning group of five engineers was equalled by their generosity in sharing their work freely. Their approach allowed the Internet and the Web to be adopted rapidly around the world and to grow organically thanks to open and universal standards. Together these technologies led to the information revolution, of as much significance as the industrial and agricultural revolutions were in their day and are now used by over a third of the world's population. The Prime Minister, David Cameron, said of the winners; "The Internet and the World Wide Web… are engineering innovations that have given rise to new industries, and a huge number of jobs. They have enabled the world to access information and knowledge as never before."

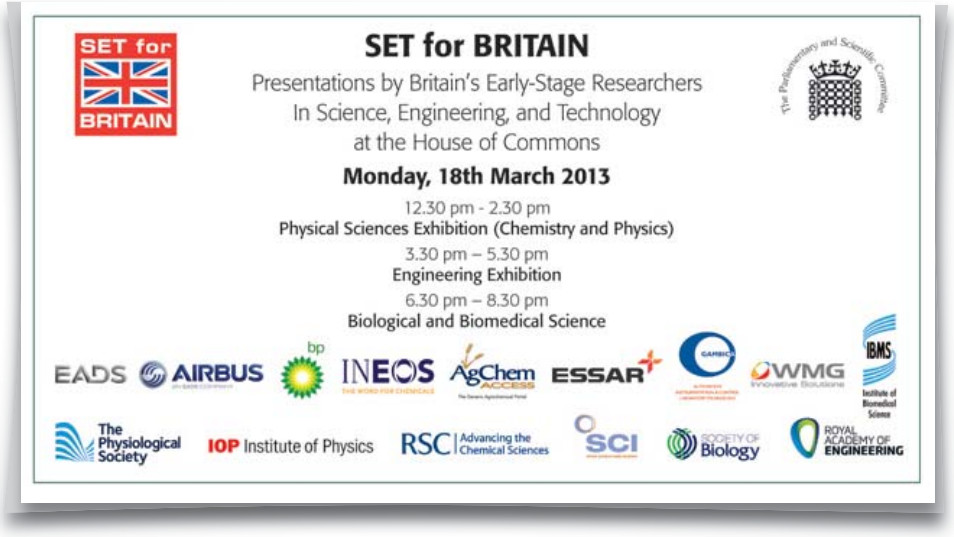
The Internet and the Web have grown from modest beginnings to hosting over 50 billion pages of information today. All five winners have been instrumental in guiding this process, technically and politically.

This award was created to raise the profile of engineering and to emphasize its importance to society, celebrating achievement along the way. Vint Cerf described this succinctly; "The Queen Elizabeth Prize for Engineering is a stunning and welcomed recognition of the power of engineering to effect change."

With this award, the next stages will be equally important; encouraging young people to think deeply about engineering, and society to appreciate its breadth and scope. "I firmly believe our field's best days are ahead of us," said Andreessen, "and I can't wait to see what the next generation of engineers will accomplish."

SET FOR BRITAIN 2013

On Monday 18th March SET for Britain 2013, the annual poster competition and exhibition, was held in the House of Commons Terrace Marquee. Andrew Miller MP, Chairman of the Parliamentary and Scientific Committee, acted as host to early-career researchers from all over the country who brought their posters to Westminster to take part in the competition and to present their research to their local Members of Parliament. During the course of the day the SET for Britain organisers were delighted to welcome 77 Parliamentarians from both Houses.



The competition was divided into three sections: Physical Sciences (Chemistry and Physics), Engineering, and Biological and Biomedical Sciences. The posters in each section were judged by experts from the Royal Society of Chemistry, the Institute of Physics, the Royal Academy of Engineering, the Society of Biology and The Physiological Society.

The judges' difficult task had begun two months earlier with the selection of 180 posters (60 in each section) for the exhibition from a field of over 500 high quality entries.

Medals were awarded to the winners in each discipline, together with Gold, Silver and Bronze Awards of cash prizes. These awards were made possible by generous donations from INEOS Group, BP, EADS, Airbus, AgChemAccess, Essar, GAMBICA, WMG and the Institute of Biomedical Science.

Finally, the winners of the four Gold awards were judged on the strength of their skill in communicating the scientific concept in their poster by Dr David Dent, Dr Doug Naysmith and Andrew Miller MP. The Westminster Medal, donated by the SCI in memory of Dr Eric Wharton, who established SET for Britain, and ran the events for many years with his wife Sue, was presented to Dr Valeska Ting, winner of the Gold award in the Engineering session.

PRIZE WINNERS

CHEMISTRY

Gold Award: £3,000 and Roscoe Medal: **Mr Christopher Spicer**, Department of Chemistry, University of Oxford: SUZUKI BIOLOGY: PALLADIUM MEDIATED REACTIONS UNDER AMBIENT CONDITIONS

Silver Award: £2,000: **Mr Stephen Bromfield**, Department of Chemistry, University of York: HEPARIN RESCUE: SELF-ASSEMBLING NANOSYSTEMS AS POTENTIAL PROTAMINE REPLACEMENTS

Bronze Award: £1,000: **Mr Timothy Rooney**, Department of Chemistry, University of Oxford: DEVELOPING SMALL MOLECULE INHIBITORS OF THE CREBBP BROMODOMAIN-HISTONE INTERACTION

PHYSICS

Gold Award: £3,000 and Cavendish Medal: **Miss Claire Woollacott**, School of Physics, University of Exeter: DIRAC-LIKE PLASMONS IN HONEYCOMB LATTICES OF METALLIC NANOPARTICLES

Silver Award: £2,000: **Mr Christian Baker**, Acoustics and Ionising Radiation, National Physical Laboratory: IMPROVED ULTRASOUND CT OF BREASTS FOR CANCER SCREENING

Bronze Award: £1,000: **Ms Emma Wisniewski-Barker**, Physics and Astronomy, University of Glasgow: SLOW DARKNESS

Chemistry Prizewinners:
Tom Crotty (Director, INEOS Group), Dr Stephen Benn, Christopher Spicer (Chemistry Gold Award Winner), Andrew Miller MP, Professor Lesley Yellowlees (President, Royal Society of Chemistry), Stephen Bromfield (Chemistry Silver Award Winner), Steve Brambley (Deputy Director, GAMBICA), Timothy Rooney (Chemistry Bronze Award Winner), Paul Biebuyck (Registrations Manager, AgChemAccess).

Physics Gold Award:
Tom Crotty (Director INEOS Group), Claire Woollacott (Physics Gold Award Winner), Dr Stephen Benn and Andrew Miller MP

Chemistry Gold Award:
Tom Crotty (Director, INEOS Group), Christopher Spicer (Chemistry Gold Award Winner), Andrew Miller MP

Physics Prizewinners:
Tom Crotty (Director INEOS Group), Christian Baker (Physics Silver Award Winner), Dr Stephen Benn, Professor Sir Peter Knight (President, Institute of Physics), Claire Woollacott (Physics Gold Award Winner), Andrew Miller MP, Paul Biebuyck (Registrations Manager, AgChemAccess), Emma Wisniewski-Barker (Physics Bronze Award Winner), and Steve Brambley (Deputy Director, GAMBICA).

ENGINEERING

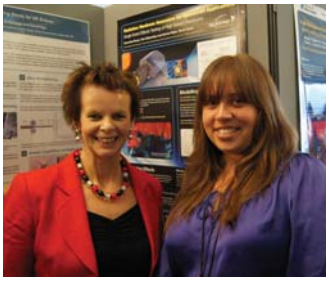
Gold Award: £3,000 and Engineering Medal: **Dr Valeska Ting**, Department of Chemical Engineering, University of Bath: PUSHING HYDROGEN TO THE LIMIT: ENGINEERING NANOMATERIAL SYSTEMS FOR STORAGE OF SOLID-LIKE HYDROGEN

Silver Award: £2,000: **Dr Paul Richmond**, Automatic Control and Systems Engineering, University of Sheffield: HIGH PERFORMANCE MASSIVE SCALE AGENT-BASED SIMULATION

Bronze Award: £1,000: **Mr George Gordon**, Electrical Engineering, University of Cambridge: MODE-DIVISION MULTIPLEXING FOR ULTRAFAST OPTICAL FIBRE COMMUNICATIONS

Thomas Hoskins and Shabana Mahmood MP

Andy Slaughter MP and Mark Glanville



Anne Milton MP and Samantha Rason

Omar Abdelkerim and Rt Hon Hazel Blears MP

Jim Cunningham MP and Jesper Christensen

Engineering Gold Award:
Philip Greenish (Royal Academy of Engineering), Dr Valeska Ting (Gold Award Winner) and Neil Scott (Vice President, Engineering, Airbus).

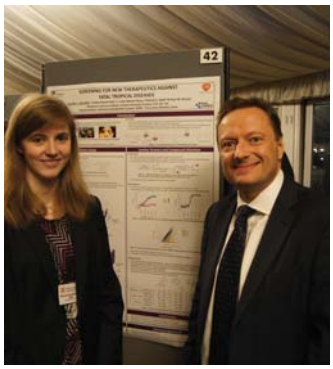
Engineering Group Prizewinners
Neil Scott (Vice President, Engineering, Airbus), Dr David Clark (Principal Fellow, WMG), Philip Greenish (Royal Academy of Engineering), George Gordon (Bronze Award Winner), Dr Stephen Benn, Dr Valeska Ting (Gold Award Winner), Andrew Miller MP, Dr Paul Richmond (Silver Award Winner), Volker Schultz (CEO, Essar Oil UK Ltd) and Mrs Sue Wharton.

BIOLOGICAL AND BIOMEDICAL SCIENCES

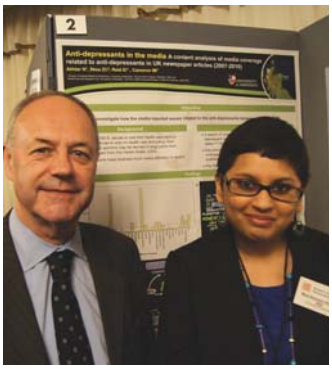
Gold Award: £3,000 and GW Mendel Medal: **Miss Joanna Brunker**, Medical Physics and Bioengineering, University College London: PHOTOACOUSTIC DOPPLER FLOWMETRY: STUDY OF BLOOD FLOW IN TUMOURS

Silver Award: £2,000: **Mr Nick Morant**, Research and Development, GeneSys Ltd/University of Bath: PATHOGEN DETECTION: FAST, SIMPLE, PORTABLE

Bronze Award: £1,000: **Dr Nicola Hemmings**, Animal and Plant Sciences, University of Sheffield: HOW EXAMINING EGGS CAN SAVE ENDANGERED SPECIES



Jason McCartney MP and Jennifer Norcliffe



Frank Doran MP and Nooreen Akhtar

Bioscience Gold Award:
Professor Jonathan Ashmore FRS (President, The Physiological Society), John Pierce (Chief Bioscientist, BP), Dr Mark Downs (Society of Biology), Joanna Brunker (Gold Award Winner), Dr Stephen Benn (Society of Biology).

Sir Gerald Howarth MP and Nick Morant, winner of the Silver award

Bioscience Prizewinners:
The Rt Hon Lord Jenkin of Roding, Dr Mark Downs (Society of Biology), Professor Jonathan Ashmore FRS (President, The Physiological Society), Joanna Brunker (Gold Award Winner), Dr Stephen Benn (Society of Biology), Dr Nicola Hemmings (Silver Award Winner), Andrew Miller MP, Nick Morant (Silver Award Winner), Derek Bishop (President, Institute of Biomedical Science), John Pierce (Chief Bioscientist, BP).

WESTMINSTER MEDAL

Westminster Medal in memory of Dr Eric Wharton (overall winner): **Dr Valeska Ting**, Department of Chemical Engineering, University of Bath: PUSHING HYDROGEN TO THE LIMIT: ENGINEERING NANOMATERIAL SYSTEMS FOR STORAGE OF SOLID-LIKE HYDROGEN

The four Gold Award Winners compete for the Westminster Medal, which was won by Dr Valeska Ting.

VOICE OF THE FUTURE

Stephen McGinness
House of Commons Science and Technology Committee

The Voice of the Future was a concept pitched to the Science and Technology Select Committee by Dr Stephen Benn, a tireless campaigner within the science policy community. Currently employed by the Society of Biology, Dr Benn first came to the Committee with the idea for Voice of the Future in 2012. He had a 'crazy' idea about the select committee being asked questions by young scientists and possibly even the Science Minister.

The Speaker opened the event, seen with Stephen Benn

There were several practicalities. A select committee is not a free for all question fest and to be truly within the Committee's interests there had to be some element of scientists learning about how a committee works. Having been sold on the idea, the Committee was keen to promote the connection between scientists and the policy that set the framework within which they operated. Dr Benn set about the potential of adding the Minister.

In the end, he secured not only the Minister but the Shadow Minister and even the Speaker of the House of Commons to open the event.

The first Voice of the Future in 2012 was a great success. Everyone turned up, questions were asked and answered and it was broadcast on BBC Parliament. It did not, however, do everything envisaged. It was not broadcast live, which made commentary and receipt of questions much more difficult. Neither did it have the Chief Scientific Adviser answering questions. There were also a whole range of practical issues that only emerge when you actually try to DO something.

The second event in March 2013 showed progress. There was a better handling of questions; more organised distribution of those questions amongst participants; live broadcasting, from both the parliament website and from BBC Parliament; and it featured the participation of the Government Chief Scientific Adviser. This was more like the success sought for the first event.

While the key concept of young scientists asking questions seems an easy one, there is a huge set of logistics in gathering together the questions, making sure as many of the learned societies as possible get the spotlight, ensuring the questions are appropriate for the context, and in deciding who will ask what question. Our learning on questions was not about making them appropriate; it was about trying to ensure people were aware they would be asking a question, and that they would be in place at the right time. It would be almost as pointless asking politicians about details of science as asking scientists about Parliamentary procedure. You might get an answer, it may even be correct, but it would be unlikely to provide any insight.

The questions are submitted via learned societies and are chosen for particular witnesses, edited to make them easier to read out, and for witnesses to understand, grouped into

themes and allocated to individuals. As far as possible the original sense of the question is retained. There is a very limited amount of time and a desire to allow as many people as possible to ask a question. That meant that there was rarely time to facilitate supplementary questions.

It may not be surprising but common themes through the submitted questions were participation of women and science careers. I think these were the hardest questions to answer because the solutions need to address problems that are systemic, chronic and of concern to those asking the questions in the most fundamental way.

Rt Hon David Willetts MP, Minister for Universities and Science

The Science Minister, Rt Hon David Willetts MP, set out the compromises to be made in the provision of university education and the support for early academic careers, and where other countries had made different decisions. He pointed out that just because a scientist was not in academia did not mean that they were not pursuing a scientific career. All agreed that a way had to be found to

Sir John Beddington, Government Chief Scientific Adviser

ensure women are better represented at the high tables of science. Pamela Nash MP possibly hit the nail on the head when she indicated that science has probably gone further along that line than Parliament. This may be something scientists and universities need to sort out, rather than government and politicians.

As one of the organisers, I believe that Voice of the Future was a success. It is amazing that, on budget day, a Minister, a

Shabana Mahmood MP, Shadow Minister for Universities and Science

The Select Committee

shadow Minister and eight Select Committee Members prioritised their time to attend. That shows commitment from our political classes. I was also impressed with the number of young scientists willing to spend a morning away from the lab to talk policy. We need that engagement.

What needs to change? We have some way to go to ensure that the scientists attending leave with an appreciation of what Parliament is and what they can expect from it. The format needs some tweaking. If there was one aspect that participants found difficult (garnered from a

Sarah Newton MP and Stephen Metcalfe MP

few after event conversations and twitter commentary) was that the questions were too 'stand alone'. The politicians were not subjected to intense scrutiny.

This is part of the learning that takes place after each iteration. It would be interesting to hear from the learned societies, and from those who attended, about what is important. Time is limited and there are many people who would like to be involved.

What is more important? Is it better to cover a range of issues with less follow-up and more people involved or would it be better to focus on a smaller range of issues that provide fewer people a better chance to challenge responses?

Voice of the Future is an important platform for scientists and politicians to talk science. I hope that this year's event was better than last year's and that we will see continued improvement in both the format and in the engagement from the science community.

To watch Voice of the Future, go to http://www.parliament.uk/ science/ and follow the link to Voice of the Future 2013 on the S&T Select Committee's homepage.

THE BIG BANG FAIR

The Big Bang Fair 2013 took place from 14-17 March at ExCeL London, welcoming over 65,000 visitors to the four-day science and engineering extravaganza.

The Fair celebrates and raises the profile of young people's achievements in science and engineering and encourages young people to take part in science, technology, engineering and maths initiatives with support from their parents and teachers.

A record number of visitors, interactive activities and special guests made up the UK's largest celebration of science and engineering for young people.

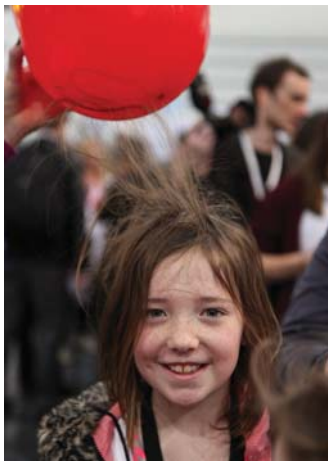
The Fair offered over 100 activities and live performances designed to bring science and engineering to life for young people, from custard-powder flame-throwers and vegetable-orchestras with Gastronaut Live to a journey through a human body with the NHS.

Prime Minister David Cameron, Business Secretary Vince Cable, and Equalities Minister Jo Swinson were among those who visited.

Prime Minister David Cameron said: "If we're going to succeed as a country, we need to train more scientists and more engineers and we need more women to go into these areas. Kids can come here and see what science can do to tackle problems but it also inspires and excites."

The finals of the 2013 National Science + Engineering Competition were held at the Fair.

Fred Turner, 17, from Crossley Heath School in Halifax was named UK Young Engineer of the Year, having impressed the judges with his project Genetics at Home, a fully working Polymerase Chain Reaction (PCR) machine which allows people to carry out basic genetic



tests at home, for a fraction of the cost of existing technology.

UK Young Scientist of the Year is Emily O'Regan, 18, from Newcastle College in Newcastle-Upon-Tyne. Emily secured her title with her project which studied breeding habits of the endangered Chilean flamingos in captivity at the Wildfowl and Wetlands Trust Washington Wetland Centre.

The Big Bang UK Young Scientists & Engineers Fair is led by EngineeringUK and exists to inspire the UK's next generation of scientists and engineers.

To find out more about The Big Bang Fair visit www.thebigbangfair.co.uk

Next year the Fair takes place at the NEC, Birmingham from 13-16 March.

MRC MILLENNIUM MEDAL

The Medical Research Council has announced that its Millennium medal for 2013 is to be shared by two illustrious biochemists.

Both Sir Greg Winter and Sir Philip Cohen are no strangers to the receipt of awards

Indeed both started by winning the Colworth Medal (sponsored by Unilever) from the Biochemical Society for an outstanding young British biochemist.

Phil was one of the earliest recipients – in 1977

While Greg won it in 1986

They also have in common that they have spent virtually their entire research career in one place.

Phil Cohen was one of the founders of the Department of Biochemistry in Dundee, and was largely responsible for turning it from scratch into one of the most successful laboratories in Europe, and one of the largest employers in the City of Dundee. No department has produced more Colworth medal winners.

He started his work on phosphorylation during his post doctoral work in Ed Fischer's laboratory in Seattle, and since then has never looked back.

The subtle interlinking of kinases and phosphatases, and their effect on cell regulation have been grist to his mill for more than 30 years. He and colleagues have shown the effects in numerous metabolic processes.

A phosphorylation cascade involves the phosphorylation of a protein which then becomes an active kinase, and this in turn can phosphorylate other kinases activating them, and on and on. At each step, there is a very large amplification of the original signal so that a very small initial signalling event can be converted into a very large response.

He was made a Fellow of the Royal Society in 1984 and knighted in 1998.

Greg Winter started in protein sequencing in the days before DNA took over. He moved on from his interest in enzymes to the structures of antibodies. He worked out how to engineer antibodies themselves, and most importantly, domains within them which were nonetheless biologically active.

He set up Cambridge Antibody Technology more than 20 years ago. It remains one of the most successful academic spin out companies in the life sciences in the UK.

HUMIRA, an antibody against TNF (Tumour Necrosis Factor) alpha is now marketed by Abbott Laboratories, and has annual sales in excess of $1bn.

He has simultaneously received one of the Canada Gairdner Awards for 2013.

He was made a Fellow of the Royal Society in 1990, and knighted in 2004. He has just taken over from Martin Rees as Master of Trinity College, Cambridge.

Alan Malcolm

COMMERCIALISING RESEARCH: Tensions between academic research and commercialisation

Steven Tait
Business Manager, MRC Technology

There is increasing interest in the commercial translation of fundamental academic research. I will explore the tension between the role of the academic research world and the need for commercialisation of outputs. This highlights key issues in the development of academic research towards commercial outcome and point to solutions to the problems when commercial and academic worlds meet.

THE ROLE OF MRC TECHNOLOGY

MRC Technology is the technology transfer organisation for the Medical Research Council and is responsible for the Intellectual Property (IP) and commercialisation of research done at the MRC's Units and Institutes around the UK. MRC Technology activities include: filing patents, licensing technology to companies, spin-out creation from IP developed at the MRC and organising contracts for collaborations with industry.

Unlike other technology transfer offices we also have in-house development labs creating new early stage medicines. This was started to bridge the gap between MRC researchers, providing knowledge about the biology of disease, and the development of new drugs and chemistry. This now provides access to all researchers in the UK. MRC Technology bridges the gap between innovative biology and the point at which companies are able to take on projects for further development. We leverage our expertise in antibody engineering technology developed at the MRC.

MRC work on therapeutic humanised monoclonal antibodies, pioneered by Sir Gregory Winter, has resulted in major therapeutic advances and the introduction of a new class of therapeutics. Work done by MRC Technology, to create such antibodies in collaboration with pharmaceutical companies, has produced two medicines that are now having a significant impact in the treatment of MS and rheumatoid arthritis.

We also offer services to medical charities in the UK to help them get most out of their research funding: to monitor how their funding is used to develop treatments and expertise in assessing translation and commercial and development opportunities.

MRC Technology is positioned between industry and academia to deliver new technologies but also to develop technologies with academia and collaborating with other institutions to provide new medicines.

COMMERCIALISING ACADEMIC RESEARCH

Research provides insights into potential new products. The UK remains at the forefront of efforts to commercialise academic research.

The challenge is – what can be protected, what is worthwhile protecting and, crucially, will that protection aid the development of the technology or medicine. This is a crucial test in publicly funded research that would not apply in a business context. In patenting we are not simply looking for a monopoly position that can be exploited – that monopoly position should be to benefit the development of the technology. We don't assume "blocking positions" simply to corner a market.

For academia there may be an opportunity to bring in industry funding and achieve cash returns from the sale or licence of technology. This has advantages as an opportunity for re-investment but can be a two-edged sword: Industry partners often cite over-valuation by academic technology transfer organisations as a barrier to co-operation with academia. There is potential for poor communication and conflicting goals and perceptions. Valuation

. . . labs creating new early stage medicines . . .

. . . Academia contributes to product development . . .

is only one potential area for conflict.

TENSIONS AND POTENTIAL CONFLICT

Realising commercial end-points is not the prime motivation for academic research. Academic research doesn't start from the premise "what product does the market need". Academia contributes to product development but we need to understand how such interactions are best managed.

One of the prerequisites for academic scientific research is the requirement to publish. In a commercial environment there would necessarily be much tighter control of publication and indeed the need for secrecy. Often a source of friction, the requirement for publication may seem very strange to industry partners who may be paying for the work and have to forego control over it.

Academia produces

. . . requirement for publication may seem very strange . . .

technology at an early stage in development. In the pharmaceutical industry the certainty of bringing a product to market will be at best poorly understood and very risky – there is a huge attrition rate. Further, in the protection of IP we have to balance the need to publish with filing patents. Patents arising from academic research must be filed at an earlier stage, often before the full development of the invention, and this can compromise value.

The collaborative nature of academic research can make IP ownership complex which implies a cost to manage such interactions. This is sometimes a huge frustration for industry partners as they end up dealing with a multitude of parties and can provide for complex diligence processes.

In licensing technologies to companies there are significant barriers to overcome

- **Not invented here –** companies may be resistant to taking on a technology they have not invented, it increases risk.
- **Investment will be high with an unproven market,** with very new products there may not be a developed market so difficult to assess the reach, impact and value of the potential product.
- **The risk may be too great** and the product development may languish.

Development programmes can be long-term and the early stage nature of academic IP also contributes to differing views on value – clearly a source for conflict between University and industry partners.

Conducting research at universities can be expensive. For SMEs the costs can be prohibitive and this discourages interactions between smaller companies and universities. For larger companies it discourages research with universities outside business critical areas.

POTENTIAL SOLUTIONS

Differing views on publication have to be managed; we work towards managing the requirement for publication to ensure adequate time to protect valuable IP. This can be limiting but it is necessary to balance the requirement to publish and commercial considerations. There will remain a potential challenge to realise the full potential value of academic research.

- Reduces costs, and risk, for the company.
- Co-development can overcome "not invented here" syndrome.
- The university is able to call on the market and commercial focus of the company which gives confidence to the funding agency.

Valuation is a negotiation, but both sides need to understand how the technology will

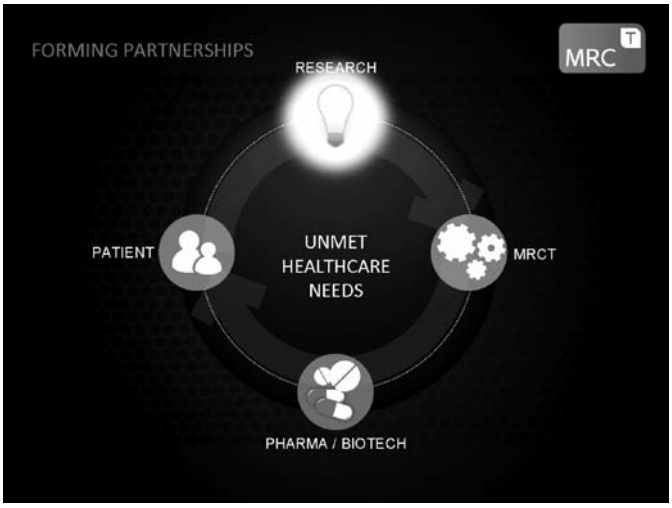
. . . research at universities can be expensive . . .

There are various initiatives to grow interactions and relationships and exchange ideas (for instance the MRC's and the Technology Strategy Board's Biomedical Catalyst schemes) and to overcome a number of the issues:

- Allow companies and universities to work together within a framework developing the partnership, fostering interaction between people.

generate value and work towards a fair share for the academic partner. The university needs to understand how the business will profit from the new technology and the business needs to help this understanding.

The key focus is providing environments both physical and funding in which industry and academia can interact. This not only promotes exchange of idea but exchange of working practice and engagement.



MRC Technology seeks to deliver new medicines and new medical technologies, commercialising academic research and partnering with industry.

COMMERCIALISATION OF RESEARCH

Dr Louise Leong and Dr Bina Rawal
Association of the British Pharmaceutical Industry

With the creation of the UK Strategy for Life Science under the sponsorship of the Prime Minister, the Government clearly sees the Life Science industry as a key sector underpinning long term economic growth for UK plc, as well as a key contributor to the wellbeing and health of the nation.

The biopharmaceutical industry is the industry sector that invests most heavily in R&D – £4.85 billion in 2011 [1], is the largest investor in health research [2], provides 67,000 highly skilled jobs, brings life-saving medicines to society, and generates over £6billion trade surplus annually [3].

In this article we focus on gaps in the translation of biomedical research towards effective treatments for patients, how this can be bridged, and what more needs to be done.

The research and development of new medicines for unmet medical need is a long, complex and risky process that takes on average 10-15 years, and costs £1billion per medicine [4]. Industry funds much of this upfront and bears the risks. This underlies some of the key barriers to commercialisation of research. Other factors influencing biomedical innovation and their desired state include:

- Intellectual capital: The desired state would be a talent pool of researchers with access to funding schemes and excellent technology transfer offices.
- Research and development: Support for biomedical clusters; flexible collaborations between businesses; more industry-academic-NHS collaborations.
- IP: Appropriate protection of intellectual property in line with risk and cost of development.
- Clinical and regulatory: Continued streamlining and harmonisation of research and governance processes; new approaches for cost and risk sharing attempted.
- Market incentives: Incentives for both incremental and radical innovation; matching schemes for public and private investment; leveraging charitable investment and other capital.

Much of fundamental science underpinning our understanding of health and disease, and early discovery research using disease models, is carried out in academia. Target identification and validation, preclinical safety, early and late phase trials and meeting regulatory requirements for marketing authorisation (ie for a new medicine to be licensed for use in patients) is conducted in industry, whether in-house in pharmaceutical companies or outsourced to CROs.

A substantial part of today's health burden is in complex chronic and heterogenous disease or syndromes, such as diabetes and metabolic disease, inflammatory disease whether respiratory, joint, or neurological, and dementias. Industry has therefore sought to overcome scientific and technological challenges through greater precompetitive collaboration, both between companies, as well as across sectors with academia and health service clinicians. This larger R&D ecosystem includes the medical research charities and patients.

. . . £6billion trade surplus annually . . .

The translational gap that was the focus of a recent meeting of the Parliamentary and Scientific Committee was in the commercialisation of academic research beyond proof of concept, ie the "valley of death". This may involve the funding of proof of concept studies from discovery, to the point where a potential medicinal candidate is of interest to a drug developer to take on and pursue further clinical development. Investors in such translational research face similar pressures to industrial R&D as outlined above, such as the risk of candidate attrition and long timelines of development impacting on their return on investment. Investors are now investing at later, more mature stage of development, requiring greater proof of concept. In many cases, early assets from academia may not be validated, or the potential market misunderstood. Despite big strides being made in the UK in the last decade, the academic-business cultural divide as well as university technology transfer barriers can lead to overvaluations of assets. Investment is often serial, with a chain of investors each building on the asset, and with exit-oriented objectives.

How might this translational gap be bridged? A diversity of funding sources to plug the gap sees an increasing role for charitable organisations and public funders (eg US National Institutes of Health, and Wellcome Trust's *Seeding Drug Discovery*), while traditional investors have included business angels and small investors, venture capital and independent corporate venture arms, and public markets. Investor education and engagement on the medicine development process and perceived risk is important. Actions to reduce risk can be useful, to increase knowledge and confidence in assets. Examples of such initiatives in the UK include the NIHR Translational Research Partnerships; academic-industry research consortia; innovative development/licensing approaches (eg adaptive licensing); and retaining the value of exploitation in the UK

. . . increasing role for charitable organisations . . .

by improving the clinical research/trial environment. Commitments in the Life Science Strategy have been helpful, such as the Biomedical Catalyst fund, and fiscal measures such as the Patent Box and R&D tax credits.

The UK possesses historical strengths that we should capitalise and build on:

- High public sector investment in the life science research talent pool
- A cultural willingness to take risks and accept failures
- Mobility of people between research organisations and industry
- Availability of specialist, early-stage capital
- Structured networks and communication forums to connect researchers with businesses
- Meaningful incentives for research organisations and researchers as well as companies
- Geographical proximity between research organisations and SMEs, eg incubators
- Fiscal and regulatory environment, such as the protection of IP, taxation and regulation
- The unique feature of "cradle to grave" continuum of care through the NHS for the majority of the population

At the same time, there are also increasing pressures in life sciences to address. For example, the decline of the UK's global share of clinical trials (including for performance reasons) [5], a weakening commercial environment in the UK in terms of usage of innovative medicines, uncertainty around the pricing framework which traditionally has been perceived as stable and predictable, and an understanding of the link between the commercial environment and R&D investment particularly in clinical research. For example, the UK is now the lowest and slowest adopter of new medicines in the EU [6]. The UK Life Science Strategy has sought to address some of these barriers – government's commitments are welcome, and success is contingent on competing globally.

WHAT MORE CAN BE DONE?

- Leading edge R&D relies on a healthy science base and **continued public sector investment** into science and research, and graduates with right mix of talent that modern drug development requires;
- **Stronger collaborative culture** across industry, academia, NHS
  - NHS understanding of translational barriers and how new medicines are developed
  - More partnership working with shared common ambition
  - People **mobility** – more is needed across sectors
- **Biomedical catalyst fund** welcomed – but its scope should be widened beyond SMEs – as pump-prime to overcome risk barriers. For example, as a vehicle to ensure there is funding aligned with large national initiatives when created, particularly the Translational Research Partnerships
- **Culture of research** to be embedded in the NHS
  - Trial recruitment targets hit at pace and scale – time, quality, cost
  - Investment in Clinical Research Networks is sustained for them to deliver
- **Health Data initiative** – investment in **CPRD** for staff, capabilities and technology

We see a number of potential measures to facilitate knowledge exchange, with cross-sector involvement:

- Mentorship from industry clinical pharmacologists and preclinical development experts in drug discovery
- Mentorship from clinical and biology experts from NHS and academia respectively for industry teams
- Sharing of training resources
- Sponsored innovation briefings

Ideas for sharing the risks and costs of innovation include:

- Enlarging the pre-competitive space
- Adaptive licensing as a flexible and iterative approach to drug development
- The ability to more efficiently answer research questions, develop personalised/stratified medicine or monitor drug safety through access to anonymised health data and data linkages
- Use of worldwide data and observational studies to improve understanding of use of medicine in a global setting

How will we know when success has been achieved? Some quantitative metrics may include growth in R&D investment (new bioscience clusters/parks, manufacture facilities for high value products, pipeline growth and product launches, trade balance), increase in clinical trials activity. While qualitative measures may include reputational perception (UK as a preferred partner/location), uptake of ideas by others, and the shaping of policy.

The ABPI is actively engaged on much of the above, to improve the environment for R&D in the UK. We will continue to:

- Engage a broad network of stakeholders across industry, government, academia, the third sector, NHS, and patient groups;
- Be a trusted broker for a range of R&D collaborations;
- Maintain a reputation for knowledge sharing and future-proofing of the skills base;
- Provide rational, well-supported and authentic input into policy debates and new regulation;
- Champion the UK as a highly conducive environment for R&D.

References

1 Office for National Statistics, UK BERD 2011

2 *UK health research analysis 2009/10*. UKCRC 2012

3 HMRC 2011

4 *The R&D Cost of a New Medicine*. Office for Health Economics, December 2012 http://www.ohe.org/publications/article/the-rd-cost-of-a-new-medicine-124.cfm

5 *All together now: Improving cross-sector collaboration in the UK biomedical industry*. NESTA March 2011

6 IMS Health World Review Analyst, 2010 & 2012, OECD Health Database, OHE analysis 2012

COMMERCIALISATION OF RESEARCH
Realising the commercial potential of university research

Professor Stephen Caddick
Vice-Provost, Enterprise, UCL

If we are to unleash the potential of our academic entrepreneurs, government, universities and the business community need to remove the barriers to commercialisation of research.

THE PURPOSE AND IMPACT OF UNIVERSITIES

Universities carry out three core activities. Firstly, education: to enable students to develop a deep understanding of their subject of choice and acquire relevant skills. Secondly, fundamental research: to create new knowledge and insight. Thirdly, impact: to apply knowledge outside academia for the good of society.

UK universities do an exceptionally good job at the first two. While there is much exemplary achievement in the third element, universities need a supportive environment to boost their academic endeavours.

Academic research has the power to change lives through broader application, and the major challenges we face – climate change, food security, health, digital innovation – will need a combination of curiosity-driven and applied research to develop solutions.

We know that many transformational findings are likely to emerge from unfettered research. Research Councils UK estimates that £45bn of current economic value in the UK accrues as a consequence of investment in fundamental research. As President Obama noted in his 2013 state of the union speech, "Every dollar we invested to map the human genome returned $140 to our economy." Sustained investment in 'blue skies' research will create discoveries and new knowledge that will drive innovations and industries.

Our universities contribute substantially to the economy. The UK HE sector employs more than 650,000 people and, according to a study by Universities UK in 2009, generated more than £59bn per annum in the economy. Many universities are their region's largest employer and most play a key role in attracting overseas investors.

THE KNOWLEDGE EXCHANGE LANDSCAPE

The commercialisation of research has, over the last few decades, become an important element of knowledge exchange (KE). This is the process by which we enable the communication, translation and application of knowledge between academic and non-academic communities. There are many forms of KE, among them consultancy, continuing professional development, and collaborative and contract research (see panel). These generate £3.3bn per annum, income which universities reinvest in students, staff and our communities, to fuel education, research and innovation.

New inventions or discoveries made in academic laboratories have the potential to be converted into a commercial product. Although such ventures can generate a financial return for universities, this may not be the primary driver. Data show that income derived by UK universities directly from IP is around £70m per annum, approximately 1.1% of research income, whereas in the USA it exceeds £1.1bn, more than 3% of research income. Nevertheless a commercial approach is pursued because it is the most effective method for maximising the impact and benefit of academic research.

COMMERCIALISATION IS A KEY INSTRUMENT FOR EFFECTIVE KNOWLEDGE EXCHANGE AND IMPACT

How have universities evolved their approach to commercialisation?

The most common approach is for universities to establish technology transfer offices (TTOs), dedicated to the

commercialisation of research. Typically, their mission is aligned with the core values of the university rather than oriented toward profits. They seek to maximise the impact of the knowledge created through commercialisation and to reinvest any surplus in the academic mission.

TTOs work to take promising ideas through proof-of-concept and into the early phases of commercialisation. The business managers need to be skilled in working with the academic community and balance academic imperatives with commercial considerations.

However, it is still relatively difficult for academic entrepreneurs to successfully spin-out companies in the UK. The most significant barrier is the lack of financial capital available for long-term development work and to maintain the costs of patents. Inventors and universities often find themselves "diluted out" before the enterprise reaches a significant value. There is pressure to seek capital overseas, where a healthier, less risk-averse investor community exists. Until we make it easier for entrepreneurs to access local capital, their bridge across the 'valley of death' will take them overseas.

The relative inaccessibility of finance might explain the strong preference within the UK to progress innovation through partnering and licensing. In such cases a third party organisation takes the lead in development phases and the inventors are rewarded through a revenue sharing arrangement.

BUILDING ON OUR SUCCESS IN KNOWLEDGE EXCHANGE AND COMMERCIALISATION

The UK is far better at KE and commercialisation than is often recognised, but we can, and must, do better. If we are to do so we must be more ambitious, so that the individual entrepreneurs and innovators can realise their potential. There are some specific actions that universities and government can take.

WHAT CAN UNIVERSITIES DO BETTER?

Universities need to do more to foster a culture of entrepreneurship within their academic and student communities. This means re-examination of their policies, promotion criteria and reward structures, and the provision of time to pursue innovation.

UK's knowledge exchange contributes more than £3bn to the economy

	2003-04	2006-07	2010-11
Collaborative research	645	736	872
Contract research	688	862	1,053
Consultancy	251	317	370
Facilities and equipment-related services	95	102	129
Continuing professional development and Continuing Education	352	534	606
Intellectual property	46	64	69

Income generate by UK universities in 2011 through services to business, including commercialisation of new knowledge, delivery of professional training, consultancy and services amounts to more than £3bn – SOURCE HEFCE

Key facts on commercialisation of UK HEI's intellectual property from 2010/11 HEBCI survey

- 268 new businesses were set up based on research from UK universities.
- More than 1250 active spin-off companies employing 18,000 people with a turnover of £2.1 billion
- UK universities formed one new company per £24 million of research funding during 2010-11, compared with £56 million in USA
- Graduates established more than 2800 new enterprises
- UK universities made 2,256 patent applications with 757 patents granted
- Intellectual property income for UK universities was £69M in 2010/11

Source HEBCI survey – 2010/11

Selected commercial successes from UK academic research

Company or Product	Academic Researchers	Outcome
Biovex - cancer vaccines	Coffin / Latchman (UCL)	$1bn (2010)
CAT - antibodies	Winter (LMB, Cambridge)	$1.3bn (2006)
CDT – polymer bases LED'S	Friend / Holmes (Cambridge)	$170M
Domantis – domain antibodies	Winter / Tomlinson (Cambridge)	£230M (2006)
MTEM – hydrocarbon detection	Zielkowski (Edinburgh)	$275M (2007)
Renovo – wound healing	Ferguson / O'Kane (Manchester)	£275M (2007)
Solexa – DNA sequencing	Balasubramanian / Klenerman (Camb)	$600M (2007)
Simulect - antibody	Akbar, Amlot / Janossy (RF, UCL)	>$500M

Universities need to tear down bureaucracy within their organisations and be less risk averse. Universities need to invest more in innovation within their organisations and be more explicit about both its value to society and its role in enhancing the university mission. Finally, universities need to get better at working with business, seeing long-term collaborations as an investment, rather than a source of short-term income.

WHAT CAN GOVERNMENT DO?

Government has a key role. Firstly, it needs to recognise our universities' strengths, rather than simply assuming that all good innovation happens overseas. Secondly, we need continued investment in translation and innovation, but not at the expense of funding for basic research. We have a wide range of effective instruments in place: HEFCE, Research Councils, the Technology Strategy Board (TSB) and Capital for Enterprise, so let us use them rather than invent new ones. Thirdly, government needs to focus on policy initiatives that will benefit the UK, rather than those – such as IP giveaways and ill-considered open access requirements – that will benefit our competitors' economies. Fourthly, we need a coherent and modern approach to industrial strategy, and we need to create the conditions for individuals to succeed: backing, not picking, winners. Our business community needs a simpler approach to regulation, improved infrastructure, a skilled workforce and an attractive tax environment. Finally, we need to make it clear we are open for business, and that means competing effectively for global talent and making the UK the destination of choice for world-class innovators, entrepreneurs and employees wherever they come from.

SUMMARY

Commercialisation of the intellectual property generated through research is an important part of the knowledge exchange landscape in the UK. Despite this, at present there are significant barriers, which impede the UK's academic entrepreneurs. If we are to unleash the entrepreneurial spirit and potential of the academic community, we need concerted effort from universities, from government and from business partners.

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The economic impact of Russell group universities

http://www.russellgroup.ac.uk/Economic-impact/

SIN: Overseas Champions of UK Science and Innovation

Sam Myers

In today's competitive and evolving global marketplace for science and innovation, the Government's global Science and Innovation Network (SIN) is harnessing opportunities for the UK through international partnerships. In this article, Sam Myers explains how SIN is championing UK science and driving growth through collaboration and influence overseas. Sam has worked for SIN since 2007, establishing the strategy for Britain's engagement with Southeast Asia and now leading the Asia Pacific region from Beijing, China.

The international marketplace for science and innovation has never experienced such competition and upheaval as in recent years. Established players in Europe and the USA have been challenged and in many cases displaced by newcomers in the Gulf, South America and Asia Pacific. Despite the excellent funding settlement secured for the UK science budget, our proportion of GDP spent on R&D stands at 1.8% (£26bn), less than half that of Finland. China's growth in science demonstrates the challenge facing the UK: Chinese R&D investment has increased 20% annually for over a decade, reaching £100bn in 2012. This has propelled them into second place globally by research publication volume.

. . . China's growth in science . . .

However, it is not time to hang up our British lab coats yet. Our scientific heritage continues to serve us well: with just 1% of the world's population, we publish 14% of the world's highest impact science, and are home to a fifth of the world's top 20 Universities. Pound for pound British researchers are the most efficient in the G8, and this attracts more foreign-funded R&D to the UK than any other country.

So Britain is in the global innovation race. But how do we make sure we lead the pack? And how do we support UK companies to source the best technologies and attract further

inward investment? Part of the answer lies in the Government's Science and Innovation Network (SIN), which champions UK science and innovation on the global stage.

SIN is a network of 90 experts based in 28 countries. We combine British and local talent and are embedded in Embassies, High Commissions and Consulates across the world. SIN's mission is to identify and help harness the value of science and innovation discoveries and investments overseas for the benefit of the UK. Our small size and regional structure enables us to respond quickly to local opportunities. The Science and Innovation Network spans four regions: the Americas, Europe, Middle East/Africa/India, and Asia Pacific. And we have three key roles: influencing, informing, and collaborating.

. . . British researchers are the most efficient in the G8 . . .

. . . improvements in intellectual property protection . . .

With the emerging science powers, influencing is central to securing new UK innovation opportunities. For example, through our network we have achieved significant improvements in intellectual property protection and the Chinese government now recognise the benefits of reform. Our work has paved the way for deals in research and innovation, like a £45m joint R&D fund between Research Councils UK and Chinese counterparts, and a mapping deal for a British satellite company worth £110m. And we have improved our performance in joint scientific research: the UK has risen from third to second place partner of choice for China, beaten only by the USA.

SIN has an important role in reporting information and analysis from around the world back to UK policymakers. Our expertise and access is critical to inform UK domestic policy and direct our international strategy. For example in recent years SIN teams have helped the Government to understand where competitor nations are focusing their R&D efforts, to help UK Ministers direct public R&D expenditure to the right areas. We have also reported on new innovation policy interventions and shaped the roll-out of Britain's *Catapult* centres, which are bringing together the best of academic and private sector science to develop new products and economic growth.

SIN works with British organisations to stimulate new science and innovation partnerships overseas. In India, we have supported Research Councils UK to agree over £100m deals in joint programmes including green energy, stem cells and food security. We have also supported new partnerships in Southeast Asia, where top British food researchers are working on a £300k joint programme with Vietnam to develop new strains of rice that are resistant to climate change. And a new partnering programme in China has already attracted £6.5m Chinese funding into British technologies including heat-sensing coatings to prevent baby burns.

SIN officers are located close to the best opportunities and with the right skills and mission to deliver for the UK. Other established science powers like France and Germany deploy more staff and funding into overseas R&D engagement than we do. But SIN's responsive network and focus on innovation means we are better placed to help Britain go for gold.

Readers of Science in Parliament are invited to make contact with the Science and Innovation Network teams – to find out more, please visit: https://www.gov.uk/global-science-and-innovation-network

FRENCH RESEARCH AND HIGHER EDUCATION REFORM

Matthew Houlihan

In March 2013, the French government published a draft law aimed at reforming its university and public research systems which have been criticised for being state-centric, bureaucratic and complex. What are the main measures and what could this mean for the UK?

RESEARCH AND HIGHER EDUCATION IN FRANCE

France has a strong, well-financed research system. The OECD calculates that the equivalent of $51bn was spent on R&D in France in 2011 when public and private sector expenditure is totalled up. This compares to $39bn in the UK, and $19bn in Spain. This investment produces internationally renowned researchers – in March this year, for example, Louis Pouzin was announced as a co-winner of the Queen Elizabeth Prize for Engineering for his ground-

breaking research in the 1960s that paved the way for the birth of the internet. Serge Haroche won the Nobel Prize for Physics last year and five of his compatriots have received Nobel prizes in scientific disciplines over the past ten years.

Furthermore, France boasts the largest fundamental research organisation in Europe – the publicly-funded *Centre National de la Recherche Scientifique* (CNRS) which has a budget of near €3.4bn in 2013 and employs 11,415 researchers and 14,090 engineers and support staff. It has other public research organisations to be proud of too – the CEA is a powerhouse of energy research with a €4.3bn annual budget and CNES is Europe's premier national space agency. France also has one of the world's most generous schemes to incentivise private sector R&D spend through its tax system.

In terms of Higher Education, France has strong elite universities (the Grandes Ecoles) and has some of Europe's leading business schools.

REFORM

Despite these strengths, the current French government sees the various initiatives introduced by previous French governments to support research efforts and to modernise higher education as confusing and damaging. It has criticised the public support for research as being too complex and recent reforms to universities as leading to funding shortages. French universities are also perceived to be lagging in international comparisons. In the 2012-13 Times Higher Education World University Rankings, for example, the highest placed French university comes in at 59th – there are eight British universities ranked above it (many in France argue that the criteria used to compile these lists work against French universities).

Following a consultation process involving a number of hearings across France, Geneviève Fioraso, France's Higher Education and Research Minister introduced a draft law which she hopes to use to reduce burden on researchers (eg in terms of evaluation of performance and bidding for funding), widen participation in higher education and simplify its public research system. However, despite modest moves towards greater autonomy for public universities from the state introduced under President Sarkozy, there are no real attempts to advance in this direction.

Some of the main measures in the draft law that could be of interest to a UK audience include:

- Attempts to attract more foreign students to France by allowing more courses to be offered in English. This complements legal changes introduced last year to lift certain restrictions on the ability of non-EU students to work in France following their studies.
- A drastic reduction in the types of degree that can be awarded in France. The French government points out that there are currently around 10,000 different types of masters degree on offer in France – something that it sees as being confusing to businesses who are looking to take on graduates.
- A doubling of industry placements for students as part of their studies from the current level of 110,000 per year.
- The scrapping of France's current research and university evaluation agency with the promise of a lighter-touch regime to follow.
- The introduction of more on-line courses, both through existing universities and through a new institution called *'France Université Numérique'* with a view to widening access to higher education.
- New, internationally visible, knowledge clusters. The government wants to see existing research centres and higher education institutions that are in close geographical proximity working more closely together, sharing a common strategy and objectives, especially relating to research and technology transfer.

FRANCO-BRITISH LINKS

So why does all of this matter to the UK? France is an important research and higher education partner for the UK. Even without considering the deep private sector R&D links, there is a vast amount of collaboration between researchers in France and in the UK. According to the French Embassy in London, 11.7% of internationally co-authored papers involving a UK academic have a French partner. In this regard, France is only behind the US and Germany as a partner for UK academics. French researchers, businesses and universities are also important partners for the UK when it comes to forming consortia to make bids under the EU's €10bn per year research funding programme. And France is an invaluable partner when it comes to international research facilities such as CERN and the ITER nuclear fusion research facility that are too expensive for either country to build on its own. Through the Erasmus programme, UK universities received 6,455 French students in 2010/11 with 4,254 British students going the other way and there were 13,325 French students at British Higher Education institutions in 2010/11 in total.

The changes the French government hopes to introduce through the draft law show that France is continuing to seek to up its game in terms of the support it offers its research and higher education communities and a clear recognition that it needs to think more and more internationally to strengthen its institutions. This clearly poses some potential challenges for UK universities, especially in terms of attracting foreign students, but also hopefully opportunities, for example through offering joint courses and ever stronger research collaboration.

The draft law will now pass to the French parliament where it will be debated.

British Embassy Paris Science and Innovation Team

The British Embassy in Paris has a Science and Innovation team which facilitates strategic science and innovation-related collaboration between the UK and France. If you think you could benefit from our help, please contact:

Matthew Houlihan: matthew.houlihan@fco.gov.uk **Alison MacEwen: alison.macewen@fco.gov.uk**

HOUSE OF COMMONS SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY

The Science and Technology Committee is established under Standing Order No 152, and charged with the scrutiny of the expenditure, administration and policy of the Government Office for Science, a semi-autonomous organisation based within the Department for Business, Innovation and Skills.

The current members of the Science and Technology Committee are:

Jim Dowd (Labour, Lewisham West and Penge), Stephen Metcalfe (Conservative, South Basildon and East Thurrock), Andrew Miller (Labour, Ellesmere Port and Neston), David Morris (Conservative, Morecambe and Lunesdale), Stephen Mosley (Conservative, City of Chester), Pamela Nash (Labour, Airdrie and Shotts), Sarah Newton (Conservative, Truro and Falmouth), Graham Stringer (Labour, Blackley and Broughton), David Tredinnick (Bosworth), Hywel Williams (Plaid Cymru, Arfon) and Roger Williams (Liberal Democrat, Brecon and Radnorshire).

Andrew Miller was elected by the House of Commons to be the Chair of the Committee on 9 June 2010. The remaining Members were formally appointed to the Committee on 12 July 2010. Caroline Dinenage, Gareth Johnson, Sarah Newton and Hywel Williams were formally appointed to the Committee on 27 February 2012 in the place of Gavin Barwell, Gregg McClymont, Stephen McPartland and David Morris. Jim Dowd was formally appointed to the Committee on 11 June 2012 in the place of Jonathan Reynolds. David Morris was formally re-appointed to the Committee on 3 December 2012 in the place of Gareth Johnson. David Tredinnick was formally appointed to the Committee on 4 February in place of Caroline Dinenage.

CURRENT INQUIRIES

Forensic Science Services (FSS) follow-up

On 22 November 2012, the Committee announced an inquiry: FSS Follow-up. The Committee invited written submissions by 10 January 2013.

On Wednesday 30 January 2013 the Committee took evidence from Alison Fendley, Executive Director, Forensic Archive Ltd, Dr Gill Tully, Consultant, Principal Forensic Services Ltd, and Helen Kenny, Former Branch Secretary for the FSS, Prospect Trade Union.

On Wednesday 6 February 2013 the Committee took evidence from Professor Martin Evison, Director, Northumbria University Centre for Forensic Science (NUCFS), Dr John Manlove, Manlove Forensics Ltd, and David Richardson, Chief Executive, LGC Forensics; and then from Chief Constable Chris Sims, Association of Chief Police Officers (ACPO), Gary Pugh, Director of Forensic Services, Metropolitan Police Service and, Kevin Morton, Director of Scientific Support Services, Yorkshire and the Humber.

On Wednesday 13 February 2013 the Committee took evidence from Karen Squibb-Williams MA, Strategic Policy Adviser, Crown Prosecution Service, Michael Turner QC, Chairman, Criminal Bar Association, and Richard Atkinson, Chair of Criminal Law Committee, Law Society.

On Wednesday 6 March 2013 the Committee took evidence from Professor Bernard Silverman, Chief Scientific Adviser, Home Office and Andrew Rennison, Forensic Science Regulator.

On Wednesday 13 March the Committee took evidence from Jeremy Browne MP, Minister of State for Crime Prevention, Home Office and Stephen Webb, Former Director, Finance and Strategy Directorate, Crime and Policing Group, Home Office

The written and oral evidence received in this inquiry is on the Committee's website. A Report is being prepared.

Water Quality

On 19 December 2012, the Committee announced an inquiry: Water Quality. The Committee invited written submissions by 8 February 2013.

On Wednesday 27 February the Committee took evidence from Richard Aylard, Thames Water, Marco Lattughi, Environmental Industries Commission, and Mike Murray, Association of the British Pharmaceutical Industry; and then from Professor Andrew Johnson, Centre for Ecology and Hydrology, Rob Collins, Blueprint for Water Coalition, and NERC; and then from Dr Sue Kinsey, Marine Conservation Society, and Professor Richard Thompson, Plymouth University.

On Monday 4 March 2013 the Committee took evidence from Ian Barker, Head of Water, Land and Biodiversity, Environment Agency, Nick Cartwright, Environment and Business Manager, Environment Agency and Regina Finn, Chief Executive, Ofwat.

On Wednesday 6 March 2013 the Committee took evidence from Peter Gammeltoft, European Commission.

On Wednesday 13 March 2013 the Committee took evidence from Richard Benyon MP, Parliamentary Under-Secretary for Natural Environment, Water and Rural Affairs, Department for Environment, Food and Rural Affairs, Rory Wallace, Head of the Water Framework Directive Team and Dr Caroline Whalley, Priority Substances Policy/Technical Advisor.

The written and oral evidence received in this inquiry is on the Committee's website. A Report is being prepared.

Clinical Trials

On 13 December 2012, the Committee announced an inquiry: Clinical Trials. The Committee invited written submissions by 22 February 2013.

On Wednesday 13 March, the Committee took evidence from Professor Sir Michael Rawlins, Chair of the Academy of Medical Sciences Regulation and Governance Review, Dr Keith Bragman, President, Faculty of Pharmaceutical Medicine, and Dr Fiona Godlee, Editor in Chief, British Medical Journal,

On Monday 22 April 2013 the Committee took evidence from Catherine Elliott, Director, Clinical Research Interests, Medical Research Council, Sharmila Nebhrajani, Chief Executive, Association of Medical Research Charities, Professor Peter Johnson, Chief Clinician, Cancer Research UK and Representative from the Wellcome Trust; and then from Dr Bina Rawal, Director of Research, Medical and Innovation, Association of the British Pharmaceutical Industry, Dr James Shannon, Chief Medical Officer, GlaxoSmithKline and Mr William M Burns, Member of the Board of Directors, Roche.

The Committee intends to hold further oral evidence sessions.

The European and UK Space Agencies

On 15 February 2013, the Committee announced an inquiry: The European and UK Space Agencies. The Committee invited written submissions by 12 April 2013. The Committee expects to hold oral evidence sessions later in 2013.

Climate: public understanding and its policy implications

On 28 February 2013 the Committee announced an inquiry: Climate: public understanding and its policy implications. The Committee invited written submissions by 22 April 2013. The Committee expects to hold oral evidence sessions later in 2013.

REPORTS

Engineering Education

On 8 February 2013, the Committee published its Seventh Report of Session 2012-13, *Educating tomorrow's engineers: the impact of Government reforms on 14-19 education*, HC 665

Bridging the valley of death

On 13 March 2013, the Committee published its Eighth Report of Session 2013-13, *Bridging the valley of death: improving the commercialisation of research*, HC 348

Marine Science

On 11 April 2013 the Committee published its Ninth Report of Session 2012-13 – *Marine Science*, HC 727

GOVERNMENT RESPONSES

Government and UK Collaborative on Development Sciences Response to the Committee's report 'Building scientific capacity for development'

On 24 January 2013 the Committee published the Government and UK Collaborative on Development Sciences Response to the Committee's report on Building scientific capacity for development.

Natural Environment Research Council Response to the Committee's report 'Proposed merger of British Antarctic Survey and National Oceanography Centre'

On 30 January 2013 the Committee published the Natural Environment Research Council Response to the Committee's report on Proposed merger of British Antarctic Survey and National Oceanography Centre.

Government and Economic and Social Research Council (ESRC) Responses to the Committee's report 'The Census and social science'

On 15 March 2013 the Committee published the Government and Economic and Social Research Council (ESRC) Responses to the Committee's Third Report of Session 2012–13

FURTHER INFORMATION

Further information about the work of the Science and Technology Committee or its current inquiries can be obtained from the Clerk of the Committee, Stephen McGinness, or from the Senior Committee Assistant, Darren Hackett, on 020 7219 2792/2793 respectively; or by writing to: The Clerk of the Committee, Science and Technology Committee, House of Commons, 7 Millbank, London SW1P 3JA. Enquiries can also be e-mailed to scitechcom@parliament.uk. Anyone wishing to be included on the Committee's mailing list should contact the staff of the Committee. Anyone wishing to submit evidence to the Committee is strongly recommended to obtain a copy of the guidance note first. Guidance on the submission of evidence can be found at www.parliament.uk/commons/selcom/witguide.htm. The Committee has a website, www.parliament.uk/science, where all recent publications, terms of reference for all inquiries and press notices are available.

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

RECENT POST PUBLICATIONS

Reporting Greenhouse Gas Emissions

January 2013 *POSTnote 428*

Climate change is a global challenge addressed by a combination of international and domestic initiatives. Accurate inventories of greenhouse gas emissions are needed to ensure the integrity of these policies. This POSTnote examines how greenhouse gas inventories are measured, reported and verified.

Biodiversity and Planning Decisions

February 2013 *POSTnote 429*

Built developments and mineral extraction can bring social benefits. However, if developments decrease biodiversity there could be a net loss of human well-being. Planning policy is devolved and this POSTnote sets out how the information on impacts of proposed developments on biodiversity is given to planners in England. It also summarises approaches to enhance biodiversity and avoid, mitigate and compensate for negative impacts.

STEM Education for 14 – 19 year olds

March 2013 *POSTnote 430*

Science, Technology, Engineering and Mathematics (STEM) education plays a vital role in equipping young people with the knowledge and skills needed to participate in and contribute to society. This POSTnote reviews the current state of STEM education for 14-19 year olds in the UK, highlighting key challenges and ongoing policy reforms.

Preventing Mitochondrial Disease

March 2013 *POSTnote 431*

Mitochondria convert biological fuels like sugars and fats into the energy a cell needs. Women with a disease caused by faulty mitochondria pass their condition on to their children. Researchers are developing treatments to prevent this by using healthy mitochondria from a female donor. This note describes these treatments and looks at the issues raised by their potential use in IVF.

Accessing Public Transport

March 2013 *POSTnote 432*

A growing and ageing population will place increased demands on public transport, both in terms of carrying more people and making it more accessible to people with disabilities. This POSTnote looks at the current barriers to and future opportunities for improving the accessibility of the public transport system.

Stem Cell Research

March 2013 *POST Long Report*

This Report presents a summary of progress in the underlying science of stem cell research over the last decade.

Livestock Vaccines

April 2013 *POSTnote 433*

UK agriculture is constantly faced with the threats and economic consequences of various diseases of livestock. Vaccination of livestock is one approach to disease prevention and control. This POSTnote examines the use of vaccines and outlines the pros and cons of using vaccination in livestock.

CURRENT WORK

Biological Sciences – HIV Prevention in the UK, Managing Online Identity, Minimum Age of Criminal Responsibility, Epigenetics and Health, Reducing Greenhouse Gas Emissions from Livestock, Cosmetic Procedures, Khat, Drug Driving.

Environment and Energy – Non-native Invasive Plant Species, Environmental Impacts of Tidal Barrages, Selection of Marine Conservation Zones, Intermittent Electricity Generation, Urban Green Infrastructure, Insect Pollination.

Physical sciences and IT – Opening Up Public Sector Data, Accessing Public Transport.

Science, Technology and the Developing World – Uncertainty in Population Projections.

CONFERENCES AND SEMINARS

Broadband Britain: on target for 2015

On 12th February, POST hosted an event to provide a review of progress towards the UK's broadband targets and give Members the chance to ask questions about broadband issues affecting their constituencies. This gave parliamentarians and others the opportunity to hear from experts in broadband technology on the progress towards the UK's targets. This meeting, chaired by Therese Coffey MP, heard from Pamela Learmonth, CEO, Broadband Stakeholder Group, Matt Yardley, Partner, Analysys Mason and Raj Sivalingam, Associate Director, Telecoms and Spectrum, Intellect.

STAFF, FELLOWS AND INTERNS AT POST

Fellows

Nadia Richman, Zoological Society London, Natural Environment Research Council

Alastair Brown, National Oceanography Centre, Natural Environment Research Council

Brett Edwards, Bath University, Wellcome Trust

Dave Parker, University of Bristol, RSoC

Luke Gibbon, University of Strathclyde, Wellcome Trust

Amy Zhang, University of Cambridge, RSoC

Daniel Amund, London Metropolitan University, IFST

HOUSE OF COMMONS LIBRARY SCIENCE AND ENVIRONMENT SECTION

Scientists and other staff in the Science and Environment Section provide confidential, bespoke briefing to Members and their offices on a daily basis. They also provide support to Commons Select Committees, and produce longer notes and research papers which can be accessed on line at http://www.parliament.uk/topics/topical-issues.htm

Opposite are summaries of some recently updated published briefings.

For further information contact
Dr Patsy Richards Head of Section
Tel: 020 7219 1665
email: richardspa@parliament.uk

RECENT PUBLICATIONS

Energy Bill: Committee Stage Report

RP 13/19

This is a report on the House of Commons Committee Stage of the Energy Bill 2012-13. It follows Library Research Paper 12/79 prepared for Second Reading. There is as yet no date set for Report Stage and Third Reading. Some substantive Government amendments were made to the Bill in Committee. New clauses added the power to set, after 2016, a 'decarbonisation range' for the electricity sector in secondary legislation. Further new clauses were introduced on providing cheapest tariffs, with a 'sunset clause'. Several consultations associated with the Bill have closed but the results are not yet known, and others are on-going. This leaves open the possibility of further Government amendments to the Bill, which is a carry-over Bill, later.

All Government amendments so far have been accepted, but no non-Government amendments or new clauses have been adopted. Those rejected included; setting a decarbonisation target for 2030 sooner, ensuring greater transparency for setting the 'strike price' paid for low carbon generation and around early investment contracts, stronger requirements on offering cheapest tariffs, providing for a 'strategic reserve' as well as a 'capacity market' to provide extra electricity capacity, extending the small scale feed-in-tariff to larger community schemes, and for energy efficiency incentive Regulations.

Seabass Fishing

SN/SC/0745

The European seabass is an important commercial fish species. It is also one of the most important fish species for recreational fishermen in the UK due to its "famed fighting prowess". The species is thought to be particularly vulnerable to over-fishing. It is not possible to assess fully the health of the seabass population at this stage due to a lack of evidence. However, the available evidence suggests that there has been a population decline in recent years. An international scientific body recommended that bass catches be reduced by 20% in 2013 to protect the stock.

A minimum landing size (MLS) of 36 cm was introduced in 1990 to protect the stock, along with a range of other measures. Sport fishing bodies, whose members highly value the challenge offered by larger fish, have campaigned to increase the MLS for bass. They argue that many adult female seabass do not breed until they are at least 40-45 cm, and that increasing the MLS to 45 cm will help to ensure that more females can breed before they are caught. However, such a change would have economic implications for some commercial fishermen. The Government has launched a national survey of angling, which may provide additional catch data for this species. It has also launched an assessment of seabass stocks to determine whether the MLS should be increased.

Planning Reform Proposals

SN/SC/6418

Since the Coalition Agreement, major reforms to the planning system have taken place with the introduction of the Localism Act 2011 and the National Planning Policy Framework. The Government has stressed that the planning system should work proactively to support economic growth and it is still concerned that various aspects of the planning system are burdened by "unnecessary bureaucracy that can hinder sustainable growth." A number of reforms are now contained in the Growth and Infrastructure Bill, Bill 75 2012-13, but in addition to this a number of other announcements on planning reform have also been made, which do not have provisions in the Bill, including:

- to allow change of use for certain buildings without needing planning permission;
- to increase existing permitted development rights for extensions to certain homes and business premises for a three-year period; and
- to give a financial incentive to neighbourhoods which have adopted a neighbourhood development plan to receive 25% of the community infrastructure levy revenues from approved developments.

It also remains the Government's long-standing aim to abolish regional spatial strategies, which is still an on-going process. This note sets

out more information about the key planning reform announcements and the proposals.

Horse Meat Controls and Regulations

SN/SC/6534

On 16 January 2013 the Food Standards Agency (FSA) announced that the Food Safety Authority of Ireland (FSAI) had found horse and pig DNA in a range of beef products on sale at several supermarkets including Tesco, Aldi, Lidl, Iceland and Dunnes Stores. This has sparked widespread testing of beef products across the EU revealing further incidences of contamination. The House of Commons Environment, Food and Rural Affairs Committee's recent report Contamination of Beef Products (February 2013) found that the "current contamination crisis has caught the FSA and Government flat-footed and unable to respond effectively within structures designed primarily to respond to threats to human health".

This note sets out some of the key elements of the controls and regulations governing meat safety and the use of horse meat. Horse meat can be prepared and sold in the UK if it meets the general requirements for selling and labelling meat. There are three abattoirs operating in the UK, licensed to slaughter horses for human consumption. It is also legal to export live horses from the UK for slaughter if they have the necessary paperwork such as a horse passport, export licence and health certification. However, this is not usual practice.

Since 2005 all horses have been required by EU law to have a passport for identification. Horses born after July 2009 must also be microchipped. The passport must accompany the horse whenever it is sold or transported, slaughtered for human consumption or used for the purposes of competition or breeding.

Biomass

SN/SC/6586

The use of renewable fuels in energy generation is an EU policy and there is an EU wide mandatory target of 20% of all energy being generated from renewables by 2020. Biomass is seen as a key contributor to meeting these aims and is a generic term for any organic material that can be used to produce heat, electricity or transport fuel. UK Government has set out policies to support the use of biomass in energy generation in its UK Biomass Strategy published in 2012. The Government has also consulted on proposed improvements to the biomass sustainability criteria used to determine support for biomass through the Renewables Obligation.

Icy Fishing: UK and Iceland fish stock disputes

SN/SC/6511

In spite of generally excellent bilateral relations, Iceland and the UK have had a number of fisheries disputes. The Cod Wars from 1958 to 1976 saw violent clashes between Icelandic and British fishing vessels as Iceland asserted control over the seas surrounding the island. There are now increasing tensions between the two parties after Iceland started catching large quantities of mackerel. Iceland has been condemned for 'plundering' the stock and for threatening its long-term future. The stock is worth some £200 million to the UK economy. Iceland claims it has a legitimate right to the fish, which are found within its territorial waters.

The dispute has become known as the Mackerel War, and trade sanctions have been threatened by the EU. The dispute could jeopardise Iceland's EU accession. This note gives a short history of the Cod Wars and describes the current mackerel dispute. It also briefly describes the renowned Icelandic sustainable fisheries model.

Nuisance Calls: Unsolicited sales and marketing, and silent calls

SN/SC/6033

Nuisance calls (ie unsolicited – and unwanted – marketing messages, silent or abandoned calls) cause widespread harm and inconvenience which have been acknowledged by the previous and current Government and the relevant regulators – Ofcom (the communications regulator) and Information Commissioner's Office (ICO). Both Ofcom and the ICO have enforcement powers in this area and Ofcom has tightened its rules concerning silent calls after consultation. In 2010, Parliament approved an increase in the financial penalty available to Ofcom in enforcing its rules on nuisance calls from £50,000 to £2 million.

As well as Ofcom, the Information Commissioner's Office (ICO), the Telephone Preference Service (TPS) and Silent CallGuard all offer advice and assistance. The level of complaints to these organisations helps the regulators to develop proportionate, enforcement measures. This note sets out the key regulations which seek to address nuisance calls and the main sources of assistance and their limitations. It also summarises Ofcom's action plan to tackle nuisance calls that was announced on 8 January 2013.

ACTIVITIES

Presentations

In March 2013 Library staff organised a presentation for Members and their Staff on Constituent involvement in Local Plan making and the use of neighbourhood planning powers. The presentation included speakers from the Royal Town Planning Institute and the Department for Communities and Local Government.

Members of the section addressed Industry in Parliament Trust fellows on how parliamentarians access research, and contributed to a workshop in Amman for committee chairs of the Iraqi Parliament on research support for parliamentary committees.

Visitors to SES

The Science and Environment Section has hosted a number of external specialists in recent months. These external specialists have received training in parliamentary research and briefing, and have contributed to the wider work of the section. They include:

- Charity Alesi, a science policy analyst from the Ugandan Parliament;
- Mike Fell, a POST fellow currently working on a PhD on Smart Energy at the University College London Energy Institute
- Sarah Coe, specialist for the Environment, Food and Rural Affairs Select Committee; and
- Steve Habberley, specialist for the Communities and Local Government Select Committee

HOUSE OF LORDS SCIENCE AND TECHNOLOGY SELECT COMMITTEE

The members of the Committee (appointed 16 May 2012) are Lord Broers, Lord Cunningham of Felling, Lord Dixon-Smith, Baroness Hilton of Eggardon, Lord O'Neill of Clackmannan, Lord Krebs (Chairman), Lord Patel, Baroness Perry of Southwark, Lord Rees of Ludlow, the Earl of Selborne, Baroness Sharp of Guildford, Lord Wade of Chorlton, Lord Willis of Knaresborough and Lord Winston.

Two members of the Committee will rotate off and be replaced at the beginning of the new Session.

Open access

The Committee undertook a short inquiry into the implementation of the Government's open access policy. It issued a call for evidence to key stakeholders for this short inquiry. The Committee took oral evidence in January, 2013 and published its findings in February 2013 (http://www.publications.parliament.uk/pa/ld201213/ldselect/ldsctech/122/12202.htm).

The report was debated on 28 February (http://www.publications.parliament.uk/pa/ld201213/ldhansrd/text/130228-0002.htm).

It followed-up this up with a letter to RCUK expressing concern about its revised open access policy in March (http://www.parliament.uk/business/committees/committees-a-z/lords-select/science-and-technology-committee/news/open-access-response-to-rcuk/).

A Government response to the report is expected at the end of April.

Regenerative medicine

The Committee launched an inquiry into regenerative medicine before the summer recess. A group from the Committee visited the California Institute for Regenerative Medicine. Oral evidence was taken from October to March 2013. The transcripts of these evidence sessions and written submissions made are available on the Committee's website. The Committee expects to report in Summer 2013.

Higher Education in Science, Technology, Engineering and Maths (STEM) subjects

The Committee's report was debated on the floor of the House on 21 March (http://www.publications.parliament.uk/pa/ld201213/ldhansrd/text/130321-0003.htm).

Sports and exercise science and medicine

In May 2012, the Select Committee launched a short inquiry into sports and exercise science and medicine to consider how the legacy of London 2012 could be used to improve understanding of the benefits exercise can provide for the wider public and in treating chronic conditions. The Committee explored how robust this science is and how lessons learnt from the study of athletes can be applied to improve the health of the population generally. The Committee held a seminar on 29th May 2012, and took oral evidence during the month of June from sports and exercise scientists and clinicians, UK Sport, and officials and Ministers from the Department of Health and the Department for Culture, Media and Sport. The Committee published its report on 17 July 2012. The Government response was received in October 2012. The report will be debated in the House.

Forward work programme

Single oral evidence sessions are planned with Sir John O'Reilly (Director General for Knowledge and Innovation, Department for Business, Innovation and Skills) and Sir Mark Walport (Government Chief Scientific Adviser). As with all public evidence sessions, anyone is welcome to attend these meetings – they generally take place in Committee Room 4 of the House of Lords Committee Corridor (although this should be checked against the website and screens on the day).

Details of further inquiries will be published on the Committee's website once agreed.

FURTHER INFORMATION

The written and oral evidence to the Committee's inquiries mentioned above, as well as the Calls for Evidence and other documents can be found on the Committee's website. Further information about the work of the Committee can be obtained from Chris Atkinson, Committee Clerk, atkinsoncl@parliament.uk or 020 7219 4963. The Committee Office email address is hlscience@parliament.uk .

SELECTED DEBATES

Listed opposite (grouped by subject area) is a selection of Debates on matters of scientific interest which took place in the House of Commons, House of Lords or Westminster Hall between 7th January and 27th March.

ANIMAL HEALTH AND WELFARE

Animal Experiments	5.2.13	HoC 33WH	Henry Smith
Antibiotics (Intensive Farming)	9.1.13	HoC 142WH	Zac Goldsmith
Bee Health	26.3.13	HoC 460WH	Sarah Newton
Bee Population	10.1.13	HoL 307	Lord Moynihan

EDUCATION

Design and Technology Curriculum	20.3.13	HoC 285WH	Peter Luff
Education Committee Report (GCSE Reform)	31.1.13	HoC 1121	Graham Stuart
Examination Reform	16.1.13	HoC 877	Stephen Twigg et al
Higher Education in Science, Technology, Engineering and Mathematics: S&T Committee Report	21.3.13	HoL 759	Lord Willis of Knaresborough
National Curriculum	26.3.13	HoL GC233	Lord Nash
Visas: Student Visa Policy	31.1.13	HoL 1698	Lord MacGregor of Pulham Market
Vocational Education	28.2.13	HoL GC238	Lord Lucas

ENERGY

Biomass Power Generation	20.3.13	HoC 294WH	Nigel Adams
Energy Infrastructure (UK Supply Chain)	26.3.13	HoC 1605	Peter Aldous

HEALTH

Anorexia	25.2.13	HoL 918	Lord Giddens
Eating Disorder Awareness	14.2.13	HoC 323WH	Caroline Nokes
Global Health	25.3.13	HoL GC217	Lord Crisp
Horsemeat	31.1.13	HoC 251WH	Steve Reed
Medical Implants (EU and UK) Select Committee Report	6.3.13	HoC 1032	Andrew Miller
Medical Innovation	16.1.13	HoL 756	Lord Saatchi
Neglected Tropical Diseases	30.1.13	HoL 1603	Baroness Hayman

MISCELLANEOUS

Biological Threats	10.1.13	HoL GC107	Lord Harris of Haringey
Engineering Careers	13.2.13	HoC 305WH	Nadine Dorries
Protecting the Arctic	7.2.13	HoC 147WH	Joan Walley
Publishing Industry	6.2.13	HoL GC49	Lord Dubs
Research Councils UK: Open Access Policy (S&T Report)	28.2.13	HoL 1196	Lord Krebs

SCIENCE DIRECTORY

THE FOLLOWING ORGANISATIONS HAVE ENTRIES IN THE SCIENCE DIRECTORY:

Association of the British Pharmaceutical Industry
AIRTO
AMPS
Biochemical Society
The British Ecological Society
British In Vitro Diagnostics Association (BIVDA)
British Measurement and Testing Association (BMTA)
British Nutrition Foundation
British Pharmacological Society
British Psychological Society
British Science Association
British Society for Antimicrobial Chemotherapy
British Society for Immunology
Cavendish Laboratory
Chartered Institute of Patent Attorneys
Clifton Scientific Trust
The Council for the Mathematical Sciences
Eli Lilly and Company Ltd
EngineeringUK
The Food and Environment Research Agency
GAMBICA Association Ltd
The Geological Society
Institute of Food Science & Technology
Institute of Marine Engineering, Science and Technology (IMarEST)
The Institute of Measurement & Control
Institute of Physics
Institute of Physics and Engineering in Medicine
Institution of Chemical Engineers
Institution of Civil Engineers
Institution of Engineering Designers
The Institution of Engineering and Technology
Institution of Mechanical Engineers
LGC
The Linnean Society
L'Oréal
Marine Biological Association
Met Office
MSD
National Physical Laboratory
Natural History Museum
NEF: The Innovation Institute
Nesta
The Nutrition Society
PHARMAQ Ltd
The Physiological Society
Prospect
The Royal Academy of Engineering
Royal Botanic Gardens, Kew
The Royal Institution
The Royal Society
The Royal Society of Chemistry
Society for Applied Microbiology
Society for General Microbiology
Society of Biology
Society of Chemical Industry
Society of Cosmetic Scientists
Society of Maritime Industries
Universities Federation for Animal Welfare
The Welding Institute

Research Councils UK
Biotechnology and Biological Sciences Research Council (BBSRC)
Economic and Social Research Council (ESRC)
Engineering and Physical Sciences Research Council (EPSRC)
Medical Research Council (MRC0
Natural Environment Research Council (NERC)
Science and Technology Facilities Council (STFC)

Association of the British Pharmaceutical Industry

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The ABPI is the voice of the innovative pharmaceutical industry, working with Government, regulators and other stakeholders to promote a receptive environment for a strong and progressive industry in the UK, one capable of providing the best medicines to patients.

The ABPI's mission is to represent the pharmaceutical industry operating in the UK in a way that:

- assures patient access to the best available medicine;
- creates a favourable political and economic environment;
- encourages innovative research and development;
- affords fair commercial returns

AIRTO

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AIRTO – The Association for Independent Research and Technology Organisations – is the foremost membership body for organisations operating in the UK's intermediate research and technology sector. AIRTO's members deliver vital innovation and knowledge transfer services which include applied and collaborative R&D, frequently in conjunction with universities, consultancy, technology validation and testing, incubation of commercialisation opportunities and early stage financing. AIRTO members have a combined turnover of over £2Bn from clients both at home and outside the UK, and employ over 20,000 scientists, technologists and engineers.

AMPS

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Website: www.amps-tradeunion.com

We are a Trades Union for Management and Professional Staff working in the pharmaceutical, chemical and allied industries.

We also have a section for Professional Divers working globally. We represent a broad base of both office and field based staff and use our influence to improve working conditions on behalf of our members.

We are experts in performance based and field related issues and are affiliated to our counterparts in EU Professional Management Unions.

Biochemical Society

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The Biochemical Society exists to promote and support the Molecular and Cellular Biosciences. We have over 6000 members in the UK and abroad, mostly research bioscientists in universities or in industry. The Society is also a major scientific publisher. In addition, we promote science policy debate and provide resources, for teachers and pupils, to support the bioscience curriculum in schools. Our membership supports our mission by organizing scientific meetings, sustaining our publications through authorship and peer review and by supporting our educational and policy initiatives.

The British Ecological Society

The British Ecological Society
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Ecology into Policy Blog
http://britishecologicalsociety.org/blog/
Twitter: @BESPolicy

The British Ecological Society's mission is to advance ecology and make it count. The Society has 4,000 members worldwide. The BES publishes five internationally renowned scientific journals and organises the largest scientific meeting for ecologists in Europe. Through its grants, the BES also supports ecologists in developing countries and the provision of fieldwork in schools. The BES informs and advises Parliament and Government on ecological issues and welcomes requests for assistance from parliamentarians.

British In Vitro Diagnostics Association (BIVDA)

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BIVDA is the UK industry association representing companies who manufacture and/or distribute the diagnostics tests and equipment to diagnose, monitor and manage disease largely through the NHS pathology services. Increasingly diagnostics are used outside the laboratory in community settings and also to identify those patients who would benefit from specific drug treatment particularly for cancer.

British Measurement & Testing Association, BMTA

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BMTA is the trade and technology association for laboratory-based organisations and testing and calibration service providers. We have over 100 member companies representing the interests of over 450 UKAS accredited laboratories. BMTA provides its members with a wide range of liaison, lobbying, technical event and information services. BMTA is also very active in training initiatives and provides its members with access to European issues through our membership of EUROLAB.

British Nutrition Foundation

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The British Nutrition Foundation (BNF) was established over 40 years ago and exists to deliver authoritative, evidence-based information on food and nutrition in the context of health and lifestyle. The Foundation's work is conducted and communicated through a unique blend of nutrition science, education and media activities.

BRITISH PHARMACOLOGICAL SOCIETY

Today's science, tomorrow's medicines

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The British Pharmacological Society is the primary UK learned society concerned with research into drugs and the way they work. Our 3000+ members work in academia, industry, regulatory agencies and the health services, and many are medically qualified. We cover the whole spectrum of pharmacology, including laboratory, clinical, and toxicological aspects. Inquiries about the discovery, development and application of drugs are welcome.

The British Psychological Society

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The British Psychological Society is an organisation of over 48,000 members governed by Royal Charter. It maintains the Register of Chartered Psychologists, publishes books, 11 primary science Journals and organises conferences. Requests for information about psychology and psychologists from parliamentarians are very welcome.

British Science Association

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Imran Khan will be Chief Executive from 2.4.13

Our vision is a society in which people are able to access science, engage with it and feel a sense of ownership about its direction. In such a society science advances with, and because of, the involvement and active support of the public.

Established in 1831, the British Science Association is a registered charity which organises major initiatives across the UK, including National Science and Engineering Week, the British Science Festival, programmes of regional and local events and the CREST programme for young people in schools and colleges. We provide opportunities for all ages to discuss, investigate, explore and challenge science.

British Society for immunology

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The BSI is one of the oldest, largest and most active immunology societies in the world. We have over 4,000 members who work in all areas of immunology, including research and clinical practice.

The BSI runs major scientific meetings, education programmes and events for all ages. We disseminate top quality scientific research through our journals and meetings and we are committed to bringing the wonders and achievements of immunology to as many audiences as possible.

British Society for Antimicrobial Chemotherapy

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Founded in 1971, and with 800 members worldwide, the Society exists to facilitate the acquisition and dissemination of knowledge in the field of antimicrobial chemotherapy. The BSAC publishes the *Journal of Antimicrobial Chemotherapy* (JAC), internationally renowned for its scientific excellence, undertakes a range of educational activities, awards grants for research and has active relationships with its peer groups and government.

Cavendish Laboratory

UNIVERSITY OF CAMBRIDGE

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The Cavendish Laboratory houses the Department of Physics of the University of Cambridge.

The research programme covers the breadth of contemporary physics

Extreme Universe: Astrophysics, cosmology and high energy physics

Quantum Universe: Cold atoms, condensed matter theory, scientific computing, quantum matter and semiconductor physics

Materials Universe: Optoelectronics, nanophotonics, detector physics, thin film magnetism, surface physics and the Winton programme for the physics of sustainability

Biological Universe: Physics of medicine, biological systems and soft matter

The Laboratory has world-wide collaborations with other universities and industry

Chartered Institute of Patent Attorneys

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Members of CIPA practise in intellectual property, especially patents, trade marks, designs, and copyright, either in private partnerships or industrial companies. Through its new regulatory Board, CIPA maintains the statutory Register. It advises government and international circles on policy issues and provides information services, promoting the benefits to UK industry of obtaining IP protection, and to overseas industry of using British attorneys to obtain international protection.

Clifton Scientific Trust

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Clifton Scientific Trust Ltd is registered charity 1086933

The Council for the Mathematical Sciences

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The Council for the Mathematical Sciences is an authoritative and objective body that works to develop, influence and respond to UK policy issues affecting mathematical sciences in higher education and research, and therefore the UK economy and society by:

- providing expert advice;
- engaging with government, funding agencies and other decision makers;
- raising public awareness; and
- facilitating communication between the mathematical sciences community and other stakeholders

Eli Lilly and Company Ltd

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Lilly UK is the UK affiliate of a major American pharmaceutical manufacturer, Eli Lilly and Company of Indianapolis. This affiliate is one of the UK's top pharmaceutical companies with significant investment in science and technology including a neuroscience research and development centre and bulk biotechnology manufacturing operations.

Lilly medicines treat schizophrenia, diabetes, cancer, osteoporosis, attention deficit hyperactivity disorder, erectile dysfunction, depression, bipolar disorder, heart disease and many other diseases.

EngineeringUK

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EngineeringUK is an independent organisation that promotes the vital role of engineers, engineering and technology in our society. EngineeringUK partners business and industry, Government and the wider science and technology community: producing evidence on the state of engineering; sharing knowledge within engineering, and inspiring young people to choose a career in engineering, matching employers' demand for skills.

The Food and Environment Research Agency

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The Food and Environment Research Agency's over arching purpose is to support and develop a sustainable food chain, a healthy natural environment, and to protect the global community from biological and chemical risks.

Our role within that is to provide robust evidence, rigorous analysis and professional advice to Government, international organisations and the private sector.

GAMBICA Association Ltd

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GAMBICA Association is the UK trade association for instrumentation, control, automation and laboratory technology. The association seeks to promote the successful development of the industry and assist its member companies through a broad range of services, including technical policy and standards, commercial issues, market data and export services.

The Geological Society

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The Geological Society is the national learned and professional body for Earth sciences, with 10,000 Fellows (members) worldwide. The Fellowship encompasses those working in industry, academia and government, with a wide range of perspectives and views on policy-relevant science, and the Society is a leading communicator of this science to government bodies and other non-technical audiences.

Institute of Food Science & Technology

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IFST is the independent qualifying body for food professionals in Europe. Membership is drawn from all over the world from backgrounds including industry, universities, government, research and development and food law enforcement.

IFST's activities focus on disseminating knowledge relating to food science and technology and promoting its application. Another important element of our work is to promote and uphold standards amongst food professionals.

Institute of Marine Engineering, Science and Technology (IMarEST)

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Established in London in 1889, the IMarEST is a leading international membership body and learned society for marine professionals, with over 15,000 members worldwide. The IMarEST has an extensive marine network of 50 international branches, affiliations with major marine societies around the world, representation on the key marine technical committees and non-governmental status at the International Maritime Organization (IMO) as well as other intergovernmental organisations.

The Institute of Measurement and Control

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Reg Charity number: 269815

The Institute of Measurement and Control provides a forum for personal contact amongst practiioners, publishes learned papers and is a professional examining and qualifying organisation able to confer the titles EurIng, CEng, IEng, EngTech; Companies and Universities may apply to become Companions. Headquartered in London, the Institute has a strong regional base with 15 UK, 1 Hong Kong and 1 Malaysia Local Section, a bilateral agreement with the China Instrument Society and other major international links.

IOP Institute of Physics

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The Institute of Physics is a leading scientific society. We are a charitable organisation with a worldwide membership of around 50,000, working together to advance physics education, research and application.

We engage with policymakers and the general public to develop awareness and understanding of the value of physics and, through IOP Publishing, we are world leaders in professional scientific communications. Visit us at www.iop.org.

Institute of Physics and Engineering in Medicine

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IPEM is a registered, incorporated charity for the advancement, in the public interest, of physics and engineering applied to medicine and biology. It accredits medical physicists, clinical engineers and clinical technologists through its membership register, organises training and CPD for them, and provides opportunities for the dissemination of knowledge through publications and scientific meetings. IPEM is licensed by the Science Council to award CSci, RSci and RSciTech, and by the Engineering Council to award CEng, IEng and EngTech.

IChemE

ADVANCING CHEMICAL ENGINEERING WORLDWIDE

The Institution of Chemical Engineers

With membership approaching 38,000 members in 120 countries, IChemE is the global membership organisation for chemical engineers. A not for profit organisation, we serve the public interest by building and sustaining an active professional community and promoting the development, understanding and application of chemical engineering worldwide.

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Kuala Lumpur | London | Melbourne | Rugby | Shanghai | Wellington

Institution of Civil Engineers

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Representing over 80,000 professional civil engineers around the world, ICE actively contributes to the development of public policy at all levels of government in areas concerning infrastructure, engineering and our quality of life.

Established in 1818, ICE is recognised worldwide for its excellence as a centre of learning, as a qualifying body and as a public voice for the profession. Our members design, build and maintain the infrastructure that keeps our country running.

Under our Royal Charter, we have a duty to provide independent, expert advice on infrastructure issues for the benefit of the public and to serve wider society. We are seen by Parliament and industry alike as the authoritative voice of infrastructure.

Institution of Engineering Designers

iED support inspire achieve

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The only professional membership body solely for those working in engineering and technological product design. Engineering Council and Chartered Environmentalist registration for suitably qualified members. Membership includes experts on a wide range of engineering and product design disciplines, all of whom practise, manage or educate in design.

IET

The Institution of Engineering and Technology

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The IET is a world leading professional organisation, sharing and advancing knowledge to promote science, engineering and technology across the world. Dating back to 1871, the IET has 150,000 members in 127 countries with offices in Europe, North America, and Asia-Pacific.

Institution of Mechanical Engineers

Institution of MECHANICAL ENGINEERS

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The Institution provides politicians and civil servants with information, expertise and advice on a diverse range of subjects, focusing on manufacturing, energy, environment, transport and education policy. We regularly publish policy statements and host political briefings and policy events to establish a working relationship between the engineering profession and parliament.

LGC

LGC *Setting standards in analytical science*

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LGC is an international science-based company and market leader in the provision of analytical, forensic and diagnostic services and reference standards to customers in the public and private sectors.

Under the Government Chemist function, LGC fulfils specific statutory duties as the referee analyst and provides advice for Government and the wider analytical community on the implications of analytical chemistry for matters of policy, standards and regulation. LGC is also the UK's designated National Measurement Institute for chemical and biochemical analysis.

With headquarters in Teddington, South West London, LGC has 36 laboratories and centres across Europe and at sites in China, Brazil, India, South Africa and the US.

The Linnean Society of London

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The Linnean Society of London is a professional learned body which promotes natural history in all its branches, and was founded in 1788. The Society is particularly active in the areas of biodiversity, conservation and sustainability, supporting its mission through organising open scientific meetings and publishing peer-reviewed journals, as well as undertaking educational initiatives. The Society's Fellows have a considerable range of biological expertise that can be harnessed to inform and advise on scientific and public policy issues.

A Forum for Natural History

L'ORÉAL UK AND IRELAND

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L'Oréal employs more than 3,500 scientists around the world and dedicates over 500 million euros each year to research and innovation in the field of healthy skin and hair. The company collaborates with a vast number of institutions in the UK and globally.

Marine Biological Association

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For over 125 years the Marine Biological Association has been delivering its mission *'to promote scientific research into all aspects of life in the sea, including the environment on which it depends, and to disseminate to the public the knowledge gained.'* The MBA has extensive research and knowledge exchange programmes and a long history of providing evidence to support policy. It represents its members in providing a clear independent voice to government on behalf of the marine biological community.

Met Office

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The Met Office doesn't just forecast the weather on television. Our forecasts and warnings protect UK communities and infrastructure from severe weather and environmental hazards every day – they save lives and money. Our Climate Programme delivers evidence to underpin Government policy. Our Mobile Meteorological Unit supports the Armed Forces around the world. We build capacity overseas in support of international development. All of this built on world-class environmental science.

MSD

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MSD is a tradename of Merck & Co., Inc., with headquarters in Whitehouse Station, N.J., U.S.A.

MSD is an innovative, global health care leader that is committed to improving health and well-being around the world. MSD discovers, develops, manufactures, and markets vaccines, medicines, and consumer and animal health products designed to help save and improve lives.

National Physical Laboratory

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The National Physical Laboratory (NPL) is the United Kingdom's national measurement institute, an internationally respected and independent centre of excellence in research, development and knowledge transfer in measurement and materials science. For more than a century, NPL has developed and maintained the nation's primary measurement standards - the heart of an infrastructure designed to ensure accuracy, consistency and innovation in physical measurement.

Natural History Museum

The Science of Nature

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We maintain and develop the collections we care for and use them to promote the discovery, understanding, responsible use and enjoyment of the natural world.

We are part of the UK's science base as a major science infrastructure which is used by our scientists and others from across the UK and the globe working together to enhance knowledge on the diversity of the natural world.

Our value to society is vested in our research responses to challenges facing the natural world today, in engaging our visitors in the science of nature, in inspiring and training the next generation of scientists and in being a major cultural tourist destination.

NEF: The Innovation Institute

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The Innovation Institute is the leading provider of innovation and growth solutions to business, education and government. Through our strategic programmes we help our clients and stakeholders to:

- Achieve performance excellence
- Drive entrepreneurship
- Diversify products and markets
- Develop innovative cultures
- Influence policy to stimulate innovation

Our charitable arm, the New Engineering Foundation, supports vocational scientific and technical skills development at strategic level. In addition, our Institute of Innovation and Knowledge Exchange is a professional body and "do tank", led by the Innovation Council to support the role of innovation in society.

Nesta

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Nesta is the UK's innovation foundation with a mission to help people and organisations bring great ideas to life. We do this by providing investments and grants and mobilising research, networks and skills.

Nesta doesn't work alone. We rely on the strength of the partnerships we form with other innovators, community organisations, educators and investors too.

We are an independent charity and our work is enabled by an endowment from the National Lottery.

Nesta Operating Company is a registered charity in England and Wales with a company number 7706036 and charity number 1144091. Registered as a charity in Scotland number SC042833. Registered office: 1 Plough Place, London, EC4A 1DE.

www.nesta.org.uk

The Nutrition Society

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Founded in 1941, The Nutrition Society is the premier scientific body dedicated to advance the scientific study of nutrition and its application to the maintenance of human and animal health.

Highly regarded by the scientific community, the Society is the largest learned society for nutrition in Europe. Membership is worldwide and is open to those with a genuine interest in the science of human or animal nutrition. Principal activities include:

1. Disseminating scientific information through its programme of scientific meetings and publications
2. Publishing internationally renowned scientific learned journals, and textbooks
3. Promoting the education and training of nutritionists
4. Engaging with external organisations and the public to promote good nutritional science

PHARMAQ Ltd

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PHARMAQ is the only global pharmaceutical company with a primary focus on aquaculture. We provide environmentally sound, safe and efficacious health products to the global aquaculture industry through targeted research and the commitment of dedicated people. Our product range includes vaccines, anaesthetics, antibiotics, sea lice treatments and biocide disinfectants. We also recently acquired a diagnostics company, PHARMAQ Analytiq, which offers a range of diagnostics services that help to safeguard fish welfare and improve productivity in the global aquaculture industry.

The Physiological Society

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The Physiological Society brings together over 3000 scientists from over 60 countries. Since its foundation in 1876, our Members have made significant contributions to the understanding of biological systems and the treatment of disease. The Society promotes physiology with the public and Parliament alike, and actively engages with policy makers. It supports physiologists by organising world-class conferences and offering grants for research. It also publishes the latest developments in the field in its two leading scientific journals, The Journal of Physiology and Experimental Physiology.

Prospect

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Prospect is an independent, thriving and forward-looking trade union with 120,000 members across the private and public sectors and a diverse range of occupations. We represent scientists, technologists and other professions in the civil service, research councils and private sector.

Prospect's collective voice champions the interests of the engineering and scientific community to key opinion-formers and policy makers. With negotiating rights with over 300 employers, we seek to secure a better life at work by putting members' pay, conditions and careers first.

ROYAL ACADEMY OF ENGINEERING

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Founded in 1976, The Royal Academy of Engineering promotes the engineering and technological welfare of the country. Our activities – led by the UK's most eminent engineers – develop the links between engineering, technology, and the quality of life. As a national academy, we provide impartial advice to Government; work to secure the next generation of engineers; and provide a voice for Britain's engineering community.

Royal Botanic Gardens, Kew

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RBG Kew is a centre of global scientific expertise in plant and fungal diversity, conservation and sustainable use, housed in two world-class gardens. Kew is a non-departmental public body with exempt charitable status and receives approximately half its funding from government through Defra. Kew's Breathing Planet Programme has seven key priorities:

- Accelerating discovery and global access to plant and fungal diversity information
- Mapping and prioritising habitats most at risk
- Conserving what remains
- Sustainable local use of plants and fungi
- Banking seed from 25% of plant species in the Millennium Seed Bank Partnership
- Restoring and repairing habitats
- Inspiring through botanic gardens

Kew's mission is to inspire and deliver science-based plant conservation worldwide, enhancing the quality of life.

The Royal Institution Science Lives Here

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Twitter: ri_science

The core activities of the Royal Institution centre around four main themes: science education, science communication, research and heritage. It is perhaps best known for the Ri Christmas Lectures, but it also has a public events programme and an online science short-film channel, as well as a UK-wide Young People's Programme of science and mathematics enrichment activities. Internationally recognised research programmes in bio- and nanomagnetism take place in the Davy Faraday Research Laboratory.

The Royal Society

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The Royal Society is the UK academy of science comprising 1400 outstanding individuals representing the sciences, engineering and medicine. It has had a hand in some of the most innovative and life-changing discoveries in scientific history. Through its Fellowship and permanent staff, it seeks to ensure that its contribution to shaping the future of science in the UK and beyond has a deep and enduring impact.

RSC Advancing the Chemical Sciences
The Royal Society of Chemistry

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http://www.chemsoc.org

The Royal Society of Chemistry is a learned, professional and scientific body of over 48,000 members with a duty under its Royal Charter "to serve the public interest". It is active in the areas of education and qualifications, science policy, publishing, Europe, information and internet services, media relations, public understanding of science, advice and assistance to Parliament and Government.

Society for Applied Microbiology

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*Sf*AM is the oldest UK microbiological society and aims to advance, for the benefit of the public, the science of microbiology in its application to the environment, human and animal health, agriculture and industry.

*Sf*AM is the voice of applied microbiology with members across the globe and works in partnership with sister organisations to exert influence on policy-makers world-wide.

Society for General Microbiology

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SGM is the largest microbiological society in Europe. The Society publishes four journals of international standing, and organises regular scientific meetings.

SGM also promotes education and careers in microbiology, and it is committed to represent microbiology to government, the media and the public.

An information service on microbiological issues concerning aspects of medicine, agriculture, food safety, biotechnology and the environment is available on request.

Society of Biology

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The Society of Biology has a duty under its Royal Charter "to serve the public benefit" by advising Parliament and Government is a single unified voice for biology: advising Government and influencing policy; advancing education and professional development; supporting our members, and engaging and encouraging public interest in the life sciences. The Society represents a diverse membership of over 80,000 - including, students, practising scientists and interested non-professionals - as individuals, or through learned societies and other organisations.

Society of Chemical Industry (SCI)

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SCI is an inclusive, multi-disciplinary forum connecting scientists and business people to advance the commercial application of chemistry and related sciences for public benefit. SCI is open to all to join and share information, ideas, innovations and research. Members can network with specialists from sectors as diverse as food and bio-renewables, water, waste and environment, energy, materials, manufacturing and health.

Society of Cosmetic Scientists

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Advancing the science of cosmetics is the primary objective of the SCS. Cosmetic science covers a wide range of disciplines from organic and physical chemistry to biology and photo-biology, dermatology, microbiology, physical sciences and psychology.

Members are scientists and the SCS helps them progress their careers and the science of cosmetics ethically and responsibly. Services include publications, educational courses and scientific meetings.

Society of Maritime Industries

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The Society of Maritime Industries is the voice of the UK's maritime engineering and business sector promoting and supporting companies which design, build, refit and modernise ships, and supply equipment and services for all types of commercial and naval ships, ports and terminals infrastructure, offshore oil & gas, maritime security & safety, marine science and technology and marine renewable energy.

Universities Federation for Animal Welfare

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Registered in England Charity No: 207996

UFAW is an international, independent scientific and educational animal welfare charity. It works to improve animal lives by:

- supporting animal welfare research.
- educating and raising awareness of welfare issues in the UK and overseas.
- producing the leading journal Animal Welfare and other high-quality publications on animal care and welfare.
- providing expert advice to government departments and other concerned bodies.

The Welding Institute

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The Welding Institute is the leading engineering institution with expertise in solving problems in all aspects of manufacturing, fabrication and whole-life integrity management.

Personal membership provides professional development for engineers and technicians, and registration as Chartered or Incorporated Engineer, or Engineering Technician.

Industrial membership provides access to one of the world's foremost independent research and technology organisations.

TWI creates value and enhances quality of life for Members and stakeholders through engineering, materials and joining technologies.

Research Councils UK

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Each year the Research Councils invest around £3 billion in research covering the full spectrum of academic disciplines from the medical and biological sciences to astronomy, physics, chemistry and engineering, social sciences, economics, environmental sciences and the arts and humanities.

Research Councils UK is the strategic partnerships of the seven Research Councils. It aims to:

- increase the collective visibility, leadership and influence of the Research Councils for the benefit of the UK;
- lead in shaping the overall portfolio of research funded by the Research Councils to maximise the excellence and impact of UK research, and help to ensure that the UK gets the best value for money from its investment;
- ensure joined-up operations between the Research Councils to achieve its goals and improve services to the communities it sponsors and works with.

Biotechnology and Biological Sciences Research Council (BBSRC)

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BBSRC invests in world-class bioscience research and training on behalf of the UK public. Our aim is to further scientific knowledge to promote economic growth, wealth and job creation and to improve quality of life in the UK and beyond. BBSRC research is helping society to meet major challenges, including food security, green energy and healthier, longer lives and underpins important UK economic sectors, such as farming, food, industrial biotechnology and pharmaceuticals.

Economic and Social Research Council

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The ESRC is the UK's leading research and training agency addressing economic and social concerns. We pursue excellence in social science research; work to increase the impact of our research on policy and practice; and provide trained social scientists who meet the needs of users and beneficiaries, thereby contributing to the economic competitiveness of the United Kingdom, the effectiveness of public services and policy, and quality of life. The ESRC is independent, established by Royal Charter in 1965, and funded mainly by government.

EPSRC

Engineering and Physical Sciences Research Council

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EPSRC is the UK's main agency for funding research in engineering and physical sciences, investing around £800m a year in research and postgraduate training, to help the nation handle the next generation of technological change.

The areas covered range from information technology to structural engineering, and mathematics to materials science. This research forms the basis for future economic development in the UK and improvements for everyone's health, lifestyle and culture. EPSRC works alongside other Research Councils with responsibility for other areas of research.

Medical Research Council

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Over the past century, the MRC has been at the forefront of scientific discovery to improve human health. Founded in 1913 to tackle tuberculosis, the MRC now invests taxpayers' money in the highest quality medical research across every area of health. Twenty-nine MRC-funded researchers have won Nobel prizes in a wide range of disciplines, and MRC scientists have been behind such diverse discoveries as vitamins, the structure of DNA and the link between smoking and cancer, as well as achievements such as pioneering the use of randomised controlled trials, the invention of MRI scanning, and the development of therapeutic antibodies. We also work closely with the UK's Health Departments, the NHS, medical research charities and industry to ensure our research achieves maximum impact as well as being of excellent scientific quality.

Natural Environment Research Council

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The NERC invests public money in cutting-edge research, training and knowledge transfer in the environmental sciences – through Universities and our own research centres. We work from the poles to the ocean depths and to the edge of space, researching critical issues such as biodiversity loss, climate change and natural hazards. Through collaboration with other science disciplines, with UK business and with policy-makers, we deliver knowledge and skills to support sustainable economic growth and public wellbeing – reducing risks to health, infrastructure and supply chains, and the natural environment on which we all depend.

Science & Technology Facilities Council

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The Science and Technology Facilities Council is one of Europe's largest multidisciplinary research organisations supporting scientists and engineers world-wide. The Research Council operates world-class, large-scale research facilities and provides strategic advice to the UK Government on their development. The STFC partners in two of the UK's Science and Innovation Campuses. It also manages international research projects in support of a broad cross-section of the UK research community, particularly in the fields of astronomy, nuclear physics and particle physics. The Council directs, co-ordinates and funds research, education and training.

SCIENCE DIARY

THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE

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annabel.lloyd@parliament.uk
www.scienceinparliament.org.uk

Tuesday 14 May 17.30
Water Purity
Speakers: Clive Harward, Head of Water Quality and Environmental Performance, Anglian Water Group; Kevin Prior, Chair, Royal Society of Chemistry Water Sciences Group; Professor Helen Jarvie, Centre For Ecology And Hydrology, Wallingford.

Tuesday 11 June 16.30
Annual General Meeting

17.30
Discussion Meeting on Antibiotics

Tuesday 9 July 17.30
Bees and other Insects beneficial to Humans

Tuesday 22 October
Smart Buildings

Tuesday 5 November
Annual Lunch

Tuesday 19 November
A Good Immigration Policy for Science

Tuesday 10 December
Deep Sea Mining to include Protection of the Seabed

THE ROYAL SOCIETY

Website: royalsociety.org

The Royal Society hosts a series of free events, including evening lectures and conferences, covering the whole breadth of science, engineering and technology for public, policy and scientific audiences. Events are held at the Royal Society's offices in London, at the Royal Society at Chicheley Hall, home of the Kavli Royal Society International Centre, Buckinghamshire and other venues.

Many past events are available to watch or listen to online at http://royalsociety.tv The collection includes events with speakers such as Jocelyn Bell Burnell FRS, Val McDermid and Professor Brian Cox OBE.

Details of all our events can be found on our website at royalsociety.org/events

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THE ROYAL INSTITUTION

21 Albemarle Street
London W1S 4BS.

Details of future events can be found at www.rigb.org
Booking is essential. For more information and to book visit www.rigb.org
There is a charge for tickets.
Members go free.

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

For details of events organised by POST visit

http://www.parliament.uk/mps-lords-and-offices/offices/bicameral/post/post-events/

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