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Nuclear Energy – Risks and Advantages

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Social Science Delivery Plan

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New research undertaken for the Science Council shows that science has become increasingly important across all sectors of the UK economy and society with 5.8 million people (1.2m primary science workers and 4.6m secondary science workers) who are employed in science-based roles, representing 20% of the UK workforce. This is projected to increase to 7.1 million people by 2030.

These results emphasise the fundamental importance of science in today's economy and the proliferation of secondary science workers who are dependent on science knowledge and skills as part of their role and who will not previously have been identified as part of the science workforce. Significant numbers of scientists were identified in employment sectors as diverse as health and social care, education, food and farming, communications, finance, retail and public sector services.

Primary science occupations make up the largest share of the workforce in Research and Development. Secondary science occupations make up the largest share of the workforce in the Education (46%), ICT (45%), Health (30%) and Consultancy (25%) sectors. The Health and Education sectors employ 60% of the science workforce and the remaining 40% of the science workforce is distributed across a range of sectors.

Secondary scientists use science in many different ways and the research explains why there is such a huge demand for people with science qualifications and the value of studying science, a message that underpins careers awareness work, and indicates how many more people we will need with these skills by 2030.

However, students are not receiving the practical science education necessary to produce the next generation of scientists. There is evidence that the pressures of managing a busy curriculum, challenges in finding time for specialist continuing professional development, or time to get out of the classroom, are all factors contributing to a decline in the quality of practical science. This is worrying. If the UK is to be confident of producing the next generation of scientists, then schools – encouraged by the Government – must overcome the perceived and real barriers to providing high quality practicals, fieldwork and fieldtrips. Health and safety concerns may be used as a convenient excuse for avoiding practicals and work outside the classroom, but there is no credible evidence to support this frequently cited explanation for a decline in practicals and trips. The Government is therefore urged to provide a detailed strategy on how it intends to achieve its ambition to increase participation in school science subjects.

Andrew Miller MP
Chairman, Parliamentary and Scientific Committee

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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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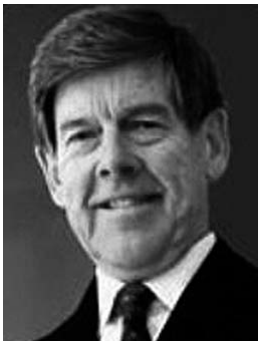
INDUSTRY, INFRASTRUCTURE AND THE ECONOMY



Lord Broers ScD FRS FREng

After several decades of neglect, even deliberate neglect, our political leaders and those concerned with balancing our economy have thankfully returned to reality and understand that it is necessary to restore our manufacturing industry, especially the portion that can meet our infrastructure needs. Much has been written about this, which I will not repeat, but I will put forward some thoughts about how we might recover from this neglect at least when it comes to our transport, energy and communications needs. I will not discuss health because it is even more complex and presents different issues.

To state the obvious, almost everything in the fabric of our country needs maintenance, and apart from items of historical interest that we wish to preserve in their original state, most becomes out of date and needs to be replaced with modern, improved, versions of what already exists – for example roads, trains, and power stations. A small fraction involves harnessing new technologies such as broad-band digital communications.

Recent governments have recognised that we need to support science and technology. It expands our knowledge of the world in the broadest sense and will produce the new ideas and new technologies that will determine the way we will live in the future. But it must do more. It should keep us environmentally responsible and economically competitive by keeping our basic infrastructure up to date. The cost of being forced to have others do this, because we no longer have the ability to do it ourselves, will leave us without the resources to maintain our present standard of living, let alone support a world-competitive science base. But this is precisely what we have been doing. Many of our companies, or foreign owned companies that manufacture here, are no longer world leaders and lose out to overseas competitors when it comes to replacing and improving our infrastructure. The case of Siemens versus Bombardier has attracted attention, but the issue is much broader than just trains, or even transport. It is perhaps most serious when it comes to energy where, for example, we have little industrial strength in renewables and yet our ambitions for implementing renewables, especially wind, are ironically second to none. Our industrial strength in nuclear has dwindled to almost nothing and what we have is not being supported, let alone strengthened, and yet the availability of new nuclear power is part of our energy strategy. Preliminary findings of the House of Lords Science and Technology Select Committee in looking into R&D in the nuclear industry confirm that our position is weak and likely to get weaker.

Correcting these failures is not a short term matter. It takes a decade or more to establish international competitiveness in the type of large companies that can supply our infrastructure, and we need to plan with this time scale in mind if we are to ensure that our UK based industries are in a position to have British workers supplying a significant fraction of our future needs. It is also necessary to sustain a balance between small, medium and large

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companies in our manufacturing industry. At the moment we have many successful high technology SMEs, but they lack British based Tier 1 companies with whom to work. Instead they have to collaborate with overseas companies and have no option but to establish overseas operations thereby placing the new employment and profits, and consequently taxes, overseas. In other words the benefits of their success go overseas rather than boosting the UK economy and increasing employment.

To rectify these failings we need to have national strategies that combine the planning of infrastructure with the planning of industrial capability. There is a small but significant window of opportunity now with the new Technology Innovation Centres where it should be possible for companies to work together with the TSB, and with the academic community, to ensure that our development efforts are in line with government planning. To succeed we should maximise the participation by UK based industry. For example, we should only accept a plan for high speed rail when there is assurance that UK based industry will supply much of the project.

To declare my interest, I have recently become Chairman of the Steering Board of the Transport Knowledge Transfer Network and this is precisely what the members of the Network are trying to promote and enable. We wish to provide a forum where the senior players in the rail, automotive and marine industries can get together and decide what realistically can be achieved in the TICs and through them British based industry. We need to ensure that there are continuing improvements in our transport systems and that British industry and British workers are in a position to provide a large fraction of these improvements by being the low cost producer of the highest performance systems.

The overall problem of course is broader than can be resolved with the TICs, even if we also harness the power of our successful SMEs and startups. The nation as a whole is not spending enough on R&D. We spend 1.79% of GDP on R&D, which is 40% lower than the US, 30% lower than Germany and 20% lower than France. Our situation is unbalanced. We have a science budget of £4.6 billion, which supports a science base that is second only to the USA's and is our greatest asset, but our spending on science is not matched by our spending on development, let alone on manufacturing. The TSB is doing a brave job with its roughly half a billion budget, one tenth rather than several times the research budget, but it is up to the private sector to provide the rest, and it is disappointing that this does not seem to be happening. Largely, it is industry that is not playing their part, with a handful of notable exceptions, such as Rolls Royce, ARM, GKN and Arup. Overall UK industry is not spending at an internationally competitive rate on development, let alone on research, and government must seek incentives that will encourage it to do so. The reduction in corporation tax to 23% in 2015 announced in the budget was a move in the right direction, as were the progressive increases in R&D tax credit, and one can only hope now that they will slow the movement of large company development overseas.

I will finish with some comments about morale. I spent many years in industrial development and one of the first lessons I learned was that a team that felt that they were winning, and could see that management was supporting them, was likely to produce two to three times more than a team that was under continual critical review. This seems to work even on a national scale. Our scientists after a decade of strong government support have good morale and are producing more than their counterparts around the world. But the situation is not as favourable in our industrial laboratories where many of our successful large companies have been threatening government that they are going to move their R&D overseas. They wouldn't do this if they were confident that they were being adequately supported. Governments have reacted but the effects have had little noticeable effect. We are increasingly seen as a place where companies will only operate because the low Pound allows relatively low labour costs, and there are few countries, either developed or developing, where so little emphasis is placed on self-reliance in being able to manage our own support systems.

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We are at a critical point. We still have several large world competitive companies that believe that the UK is the best place from which to operate, and a host of successful SMEs. There are also some green shoots such as the recent announcement by Land Rover/Jaguar to expand their development of engines and provide 750 new jobs, and our civil engineers have excelled themselves in capability and leadership in delivering the infrastructure for the Olympics. But we still need to work better as a nation in coordinating government and industrial planning. It seems at times that government planning falls victim to party politics. Instead of the planning process being open and transparent so that everyone with the ability to contribute can do so, plans are kept under wraps, almost being kept as secret weapons that can be used to gain political advantage over the opposition. This process does not serve us well especially as the problems to be solved are uncontroversial. Let's regain our confidence, restore open planning, and better harness the huge industrial potential of the U.K.

SOCIAL SCIENCES TAKING THE LONG VIEW

Professor Paul Boyle
ESRC Chief Executive

My first year as Chief Executive has been a challenging, but ultimately successful, year for the Economic and Social Research Council (ESRC). In a year of uncertainty the ESRC has proved it has the skills, flexibility and vision to succeed. This year we responded to the Comprehensive Spending Review with a balanced but ambitious ESRC Delivery Plan 2011-2015, which is now starting to be implemented, while increasing the efficiency of our operations. The Plan describes the leadership role we will continue to play to maximise the UK's strength in social science research and training, and to increase the benefits of publicly funded research to the economy and society.

As the national challenges facing the UK have become more acute we have sharpened our focus with the introduction of three strategic priorities: Economic Performance and Sustainable Growth; Influencing Behaviours and Informing Interventions; and A Vibrant and Fair Society. These were developed during a lengthy consultation process and they encapsulate some of the most important issues facing Britain and the wider world. Over the last few months I have been across the country sharing the Delivery Plan with the social science community, government departments, as well as the private and third sectors and I have been grateful for the positive support for our work.

Impact remains a key objective of the research we fund. Social science research plays a key role in developing our understanding of business practices, tactics and the wider social and economic effects. For instance, the collaboration between Future Foundation and the ESRC Centre for Business, Relationships, Accountability, Sustainability and Society (BRASS) has shown how social science supports some of Britain's biggest brands. Royal Mail and the travel company Thomson worked with social science researchers to understand better how changing consumer attitudes to climate change may impact on their businesses in the future.

ESRC research also informs policy, both in the UK and internationally. One example of this has been through the introduction of a new police intervention for crowd control across Europe. The study confirmed that by keeping a low profile and intervening early, police can work with crowds to deal with potential trouble more effectively. In the UK, ESRC research has led to a far better understanding of how poverty and low pay persist and the factors that influence social mobility. These findings have informed policies for combating child poverty, the reform of the UK tax system, and the Department for Work and Pensions' *Opportunity for All* programme. ESRC research also changes lives; data from the UK Millennium Cohort Study has recently provided evidence on maternal employment and child socio-emotional behaviour in the UK. The study found that there are no significant detrimental effects on a child's social or emotional development if their mother works during the child's early years. This is important given some of the mixed messages that exist around the effects of women's engagement with the labour market on their children.

In addition to supporting world-leading social science research, the ESRC funds and maintains some of the world's greatest data resources. In particular, these include world-leading longitudinal studies (where individuals are repeatedly surveyed over their lives to help build a picture of their changing social and economic circumstances) such as *Understanding Society.* This is the largest panel study in the world, interviewing 40,000 households or 100,000 individuals annually, and whose first findings were published in early 2011.

We have learnt, for example, how bullying often begins at home; how certain social groups are excluded from some types of social participation; and how where you live can affect your life chances. Looking forward the

study will continue to contribute to our understanding of how households and families are changing. We were also delighted to receive a £28.5 million commitment from the Government's Large Facilities Capital Fund to establish a new Birth Cohort and a Birth Cohort Facility which will support this and previous cohorts. The Birth Cohort Study will capture around 100,000 children in pregnancy and will follow them throughout their lives, in much the same way as the 1946, 1958, 1970 and millennium cohorts continue to do.

We have also made strategic investments in studies based on routinely collected administrative data, such as the Scottish Longitudinal Study which links census, medical and educational data for a sample of the Scottish population, and we are investigating how we can link further data sources to improve research and policy evaluation. These nationally comprehensive datasets provide exciting new insights which would be impossible to garner from individual surveys.

Partnerships are vital to our work. We work with a range of organisations, increasing the potential impact of our research and creating opportunities to secure funding from outside the research base. This includes working closely with other Research Councils as there is a growing recognition across the breadth of academic enquiry that inter-disciplinary approaches are often required and that social science has a vital role to play. Take, for example, climate change. We rely on natural scientists to provide reliable evidence on the extent of global warming, and what the contribution of human activity is to this. However, we require social scientists to help us understand how to change people's behaviour so that society becomes more sustainable; to provide advice on how to calculate realistic approaches to carbon trading; and to work with governments to help develop sustainable policies that are acceptable to business and the public.

We also co-fund research and people exchange activities with public, private and third-sector bodies. For example, the Financial Services Knowledge Transfer Network, funded in partnership with the Technology Strategy Board, aims to improve business performance and innovation in financial services by providing a forum for knowledge exchange. The Network has already opened up opportunities for collaboration with the financial services sector, including the development of a new Knowledge Transfer Partnership involving the risk management and insurance intermediary Willis, and the Insurance Intellectual Capital Initiative. The Knowledge Transfer Partnership programme enables organisations across the private, public and third sectors to improve their competitive-ness and productivity through accessing the knowledge, skills and technology that reside within UK universities. Over 55 new partnerships were funded this year; partners included Barclays Bank, AGE UK, Pfizer UK Group Limited, Teenager Cancer Trust, and Birmingham City Council.

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Communicating what we do is also essential. As a social scientist it is clear to see how we are shaping evidence based policy but I'm not convinced that the public has a clear understanding of what social science is and the contribution that it is making. We need to engage with the public and explain the value of our work. Hence, we are currently organising the annual Festival of Social Science for the public which helps to promote the work of social scientists beyond the research community. This week-long series of events, which celebrates the breadth of research being undertaken in the UK, runs between 29 October and 5 November and in previous years has involved over 18,000 members of the public.

In January 2011 we also launched our new website which offers improved navigation, greater ease of use and better access to our dynamic research catalogue. Visitors can access topical features, case studies, informed debate and expert opinion on a range of topics including climate change, ageing, employment and crime.

I am pleased to be part of such a dynamic and talented organisation. We have some exciting new opportunities developing over the next 12 months including the second wave of results for *Understanding Society*, the recruitment of mothers for the Birth Cohort Study, the introduction of our dedicated Future Research Leaders scheme for our early career researchers; a new Secondary Data Analysis scheme which will encourage greater use of the large-scale data resources we fund; and we are exploring the possible development of a 'what works' initiative – the establishment of a network of policy evaluation centres. The development of the social science skills base within the UK continues to be a priority for the ESRC and we are taking a strategic lead to improve the quality of postgraduate training across the social sciences. Our new national network of 21 Doctoral Training Centres will play a pivotal role in enhancing postgraduate training provision and provide the highly skilled social scientists required to meet the research challenges of the future, both within and outside academia.

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Our commitment to supporting excellence has never wavered and we will continue to support the pursuit of excellence, ensuring that social science research continues to make a difference to UK society and internationally.

RISKY BUSINESS?

David Simmons
Managing Director, Enterprise Risk Management (ERM), Willis Re

I recently read an article by a Fleet Street editor who I much admire (and co-incidentally used to play ukulele with) in which he hoped that the UK Met Office wouldn't adopt US style probability weather forecasts, eg there is a 50% chance of rain today. Rather he said he just wants to know if it will rain or not. In a different vein, I remember a senior government minister saying after a major rail crash that he wanted a risk free railway; an admirable ambition. The only problem is that both the editor and the politician are asking for the impossible.

It is a basic human want to have certainty. Indeed my local vicar once preached that chance was the devil's work. Science used to be predicated on the more you observe, the more you learn and can predict. Even Albert Einstein believed this, famously saying that God does not play dice. It has now been proven that, at a sub-atomic level at least, this is not true. Quantum theory tells us that no matter how much we watch, we can never know what a particular quantum of light will do. Albert Einstein and my vicar were wrong; chance is inherent in creation.

What does this mean to us mortals on Earth? Risk is a fundamental part of the human existence but one which is poorly understood. Almost every day there seems to be a 1 in 100 weather event hitting some part of the world. Is this not evidence of rapid worsening of the climate? Maybe, but it is also due to problems of definition, understanding and data. What do we mean by 1 in 100, the worst flood that that town has seen or the worst that has been seen in the UK, in Europe, the world? More likely it is the first, the worst recorded in that local area. The world is a big place, it would be a surprise if somewhere on Earth did not have a 1 in 100 event for rainfall, drought, wind, flood, earthquake or some other peril almost every week. As global communications increase, more severe events are being recorded and, as the global population increases, their human impacts are worse.

I studied Mathematics at university but wanted a general business career. What better than insurance, an industry based upon appreciation of risk? How wrong can you be? When I started in the industry over 30 years ago, London was the centre of the global insurance and reinsurance industry, and at the heart of that market was Lloyd's of London. It was the age of the star underwriter. These golden men were born not made, with an innate ability to pick risks. In truth the market functioned by collective knowledge and opinion, it was not by any means analytical. But things were stirring. Lloyd's began collectively to make market losses for the first time in its history. It was clear that some risks, eg asbestosis, had not been recognised or properly priced. That time also saw a number of "professional reinsurers" in Europe and later Bermuda defining themselves by use of analytical techniques. Apart from the intriguing implication that the London market was not professional, a real concern was that the "professionals" were cherry-picking good risks by advanced analytics leaving the dross to the London market. What followed was predictable, a Gadarene rush into analytics.

Now, whilst this was good news, especially for a jobbing mathematician, the results were also horribly predictable. Early models were generally poor but implicitly believed. Many, in truth most, senior managers did not understand the models and, vitally, did not understand their limitations. Rather like the newspaper editor wanting to know for certain whether it will rain tomorrow, the systems we were modelling were just too complex to be able to say with any certainty what, say, the average annual windstorm losses for an average UK property insurance company might be, let alone how big a loss they might expect every 100 years.

But 1 in 100 year numbers were what people wanted to hear. Our models came up with 1 in 100 year numbers for senior managers, ratings agencies, reinsurers etc to use, but in truth we, the modellers, let alone the users of the information, had little idea how reliable these estimates were. This is no surprise as the modellers were learning as they went. We were beginning to learn more about how the global climate works, but it is a hugely

complex system that our best models even now only approximate. We also knew as little as the insurers themselves about the properties the insurers covered, eg where they were and how they were built. We knew little about flood defences and little about drainage systems, where they were and how well they were maintained. We knew little about how the buildings responded to strong winds or floods as past loss data was sparse.

Over time we have got better; much, much better. For example, London based reinsurance broker Willis Re has created the Willis Research Network (WRN), explicitly to use the best of UK and international science to understand these problems, improve modelling assumptions and reduce the uncertainty around them. The WRN is now the world's largest industry/academic collaboration, now totalling over 50 research partners.

But despite these gains, significant uncertainty remains. On the way to a conference in Hong Kong recently I tallied up 15 major areas of uncertainty in an average catastrophe model, uncertainties we can reduce but can never eliminate. There is now much debate amongst modellers about how best that inherent uncertainty should be represented.

But a typical senior insurance manager still wants to hear one number. They want to know what their 1 in 100 number is so that they can plan accordingly; is it £200m or £250m? They don't want to hear that it could be between £175m and £350m with a 95% confidence interval. They want a certainty that doesn't exist. A modeller who gives him this number without caveats is either a charlatan or a fool.

Over 10 years ago a conference in Cambridge asked the world's leading experts in Extreme Value Theory, the branch of mathematics that tries to estimate the probability of extreme events with limited data, to estimate the likely return period of the major January 1990 UK wind storm. Estimates ranged from 1 in 250 to 1 in 500. The market was working on the assumption of around 1 in 50. At this extreme level of remote probability, uncertainties are immense.

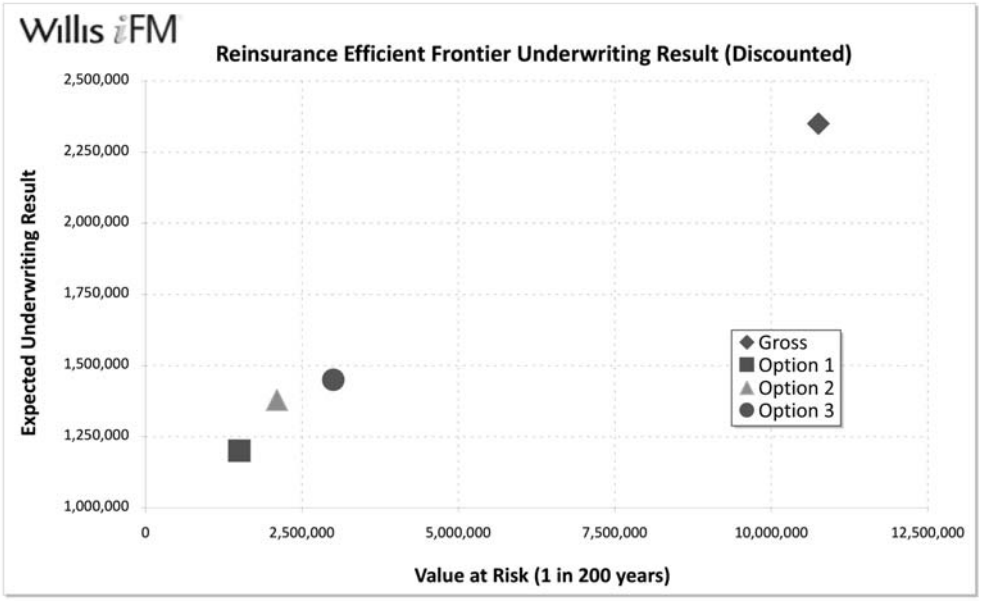
Unfortunately, now regulators want similar numbers. In fact, the new pan-European insurance regulatory regime Solvency II asks insurers to estimate the amount of capital they will require to make full payments to their policyholders for the worst year they can expect every 200 years.

The good news is that the UK insurance industry is now fully aware of risk and uncertainty; the subject is now out in the open. Our regulator, the FSA, is active within the EIOPA (the European regulator) to ensure that this topic is intelligently handled. Greater reliance is now being made for stress tests of model assumptions and scenario modelling used to make sure that foreseeable events are not overlooked within a complex, complicated model. Using Donald Rumsfeld's logical framework, we need to know all we can about what we know, we need to clearly recognise what we know we don't know (or can never know) and we should not delude ourselves that there will not be some complete surprises, the unknown unknowns or black swans.

The insurance industry has similarly learned to understand the relationship between risk and return, the rail safety problem. Much as the minister may wish, he cannot eliminate risk on the railways. He may spend more and more to reduce risk, but there comes a point where the cost is not worth the benefit. For example, say, spending £xbn reducing risk on derailment on one line from 0.5% (1 in 200) to 0.4% (1 in 250) may perhaps be better spent improving local roads with a much greater improvement in number of lives saved at much more likely probability levels. Most would agree that it is better to save 3 lives on average every year than 50 in a rare event that may happen only every 200 years, despite the political embarrassment that would be caused by such a rare event happening on your watch.

The insurance industry now commonly uses this relationship between risk and return to inform decision making. A typical risk return chart is shown below. On one axis, normally the horizontal, we measure risk, the thing we don't want to happen. This could be the number of lives lost, it may be how much capital a company could lose, it could be the probability of missing a target made to shareholders. On the other axis is a measure of return, how much money we make on average, or its flipside, how much the strategy costs on average.

A typical risk return chart is below:



Here the risk on the horizontal axis is the measured 1 in 200 worst case, ie how much capital does the firm need – the further to the left the better. On the vertical axis is the average underwriting result of the company – the higher the better.

So ideally we would want to be at the top left of this chart. The sad truth is that we can't get there. It is generally true in life and business that the more risk we take, the more money we are likely to make. The more we eliminate risk, the more it costs us. The "gross" option (in insurance speak with no risk hedging) gives us the highest average result but also the highest risk as measured by the 1 in 200 year worst case event. Option 1 by contrast reduces the risk by some 85% but sees average profit halve. The company may decide that the gross option is too risky but they can survive losing £2.5m every 200 years. In that case, the gross option and Option 3 are too risky and can be rejected. But which of Options 1 and 2 should they pick? In this case there is no right answer. It is perhaps probable that they would go with Option 2, the risk is still well within their acceptable tolerance and little worse that Option 1 but the average result is 15% higher.

The decision has been rationalised, the choice can be defended, debated and challenged. In reality things can be more complicated, there may be more than one risk measure (eg protecting capital but also minimising earnings volatility), but this framework has revolutionised decision making in insurance risk hedging (reinsurance) over the last 15 years. Yes the issues we debated earlier, uncertainty around our estimates must be considered (eg the bars in the chart), but the process of modelling, forcing a transparency of assumption and a robustness of decision making has been undeniably beneficial.

Can these techniques be used more widely in other areas of decision making? I certainly can see no reason why not. Even the less numerate in the insurance industry (the insurance market remains predominantly a people business though now an increasingly technical one) have now grasped and embraced these concepts and we are certainly beginning to understand best practice around its use. The Willis Research Network has recently been expanded to provide a forum to debate these issues, the WRN Economic Capital Forum.

Serious investment decisions demand proper modelling of the reduction of risk compared to the cost of investment. Without a proper understanding of risk, how can sensible decisions be made?

WHAT IS SECOND TIER PROTECTION (STP)?

John S S Grant MBE

John Grant is a UK & European Patent Attorney registered with CIPA and EPI respectively; UK Registered Trade Mark Attorney registered with ITMA; Representative for Trade Marks and Designs at OHIM; Provision of IP Services to Trevor Baylis Brands plc and other private clients; Represents TBB plc at the Intellectual Property Awareness Network (IPAN).

In layman's parlance, Second Tier Protection (STP) is a lesser form of Intellectual Property (IP) that is intended for the protection of devices, apparatus and the like where the technical advance is not as high as it might be for obtaining the Grant of a full Patent; nevertheless, STP in its many guises is established in some 77 countries worldwide and finds extensive usage in some European countries but especially in China, Japan and South Korea.

Presently, STP is called: Utility Model in China; Innovation Patent in Australia; Utility Model in Japan, Italy; Germany (Gebrauchsmuster); France (Certificat d'Utilité) and Spain; Short Term Patent in Holland and Ireland and Short Patent in Belgium.

In some countries the STP is registered without examination although such a procedure has to be undertaken if an infringement action is contemplated. The various forms of STP have different terms depending upon IP Law of the territory; thus, in Belgium a Short Patent has a term of 6 years while a Utility Model in Japan can be for 10 to 15 years.

Over the last two decades there have been several proposals for the implementation in the United Kingdom (and Europe) of STP in the form of a 'Utility Model'. The proposals were from, inter alia, CIPA in 1992 and the Max Planck Institute in 1993; thus, on 6th-8th July 1994, a Symposium was held at Brocket Hall to review the Proposal for a European Utility Model as

proposed by the Max Planck Institute. The outcome of the Symposium was somewhat negative with doubts being expressed in relation to the form of the STP, the languages that it should be published in and the vexed question of whether the Applications for STP should be examined or not. Consequently, the issue was left on the table and has not really been addressed since.

In recent times it has been suggested that a European Utility Model would serve the interests of lone inventors and SMEs to be of benefit to UK PLC insofar that it is recognised that the SMEs are the driving force that will lead the country on the path to economic recovery, financial stability and prosperity.

The proposal that STP could be a step in the right direction was included in some of the responses made in the call for evidence that was considered in the Review by Professor Hargreaves; however, the topic never made it to the final report stage.

HOW WOULD STP BENEFIT SMES et al?

Amongst the main disadvantages that have to be overcome by lone inventors and SMEs is the uncertainty that Intellectual Property Rights (IPRs) can be protected at a cost they can afford. The cost of a full patent in the United Kingdom can be as little as £280 if the Applicant has the ability to draft a Specification and Claims that will pass muster not only before the Patent Office Examiner but also before a Court if the Inventor's monopoly is attacked in an infringement action. On the other hand, if the services of a Patent Attorney are used, the initial costs of filing a Patent Application may be not less than £3000 with attendant additional monies becoming due if and when an Examiners Report raises objections that have to be responded to by reasoned argument. The financial burden on the lone inventor and/or an SME could be alleviated if STP was available at a lower cost for a short term whether or not the STP was subjected to an examination procedure.

In China, according to Tony Mak, there were 315,000 Utility Models granted in 2010, see the article printed at page 231 et seq of the CIPA Journal for April 2011. He also noted that 99.96% of the patentees were Chinese entities. It is not suggested that there would be a similar proportion of applicants for STP in the United Kingdom if a Utility Model law was to be promulgated; however, without such a Law we can only postulate the effect it might have on the economic development of the country.

Unfortunately, the likelihood of a United Kingdom and/or a European Utility Model is something of a pipe dream and, even if there was to be an accord between the various countries of Europe, it would be many years before a law for STP would be promulgated. In the mean time, there is no reason why lone inventors, SMEs and even larger entities could not take advantage of the STP that is available in any of the 77 countries where such provision is established. This can be most advantageous in places like China, South Korea and Japan so that dealing with manufacturers in those countries, for products to be sold in Europe and elsewhere, would give added safeguard against copying by the manufacturer for his own disposal.

One way of ensuring that the appointed manufacturer is not tempted to manufacture products and to market them in territories where the inventor has no patent and/or design protection is to offer the manufacturer a licence deal at an equitable royalty rate that allows him to legitimately make the products for the inventor while being able to exploit markets where the inventor has no interest.

It is considered that any Applicant for patent protection in any territory where STP is available should seek their Patent Attorney's advice in relation to the usefulness of adding Applications for STP to their portfolio, especially where the protection being sought is for high value goods, apparatus and machinery. Having an STP, albeit for a short term may ensure that possible infringement of one's IPRs is prevented or at least reduced.

An interesting article appeared in *The Mail on Sunday* 8th May 2011, which article reported that manufacturers from the lighting and sound industry where calling on the Government to introduce an intermediate Intellectual Property (IP) system in order to enable them to compete worldwide. Obviously, STP in the United Kingdom would not protect any overseas markets for an invention, which would have to be the subject of an STP or full Patent wherever the invention was going to be marketed.

INDIA – UTILITY MODELS – ONGOING DIALOGUE

A most comprehensive Discussion Paper on Utility Models, from the Indian 'Department of Industrial Property and Promotion', has been received with positive acclaim. This is especially so by the Government of India Department of Micro, Small and Medium Enterprises (MSME). However, as with the negative response to the proposals for a UK and/or Europe wide provisions for Utility Models in the 1990s, there have also been some very negative opinions that may result in the topic remaining on the table with only a passing lip service being paid to the advantages that might accrue from the promulgation of Utility Model Law in India.

It has been suggested that the economic fortunes of India could benefit from the introduction of Utility Models, particularly as such protection at a reasonable cost would help to launch products on the home market and encourage MSME enterprises to enter the export market thereby bringing benefits to the larger Indian economy.

The dissenters, as with the voices against a UK and/or European Utility Models, have raised the issues of unexamined rights and uncertainty when faced with possible infringement of third party rights. One comment on Google even noted that at least two European countries have repealed their Utility Model law because of the lack of certainty.

Perhaps we may see Utility Model Law introduced in India, but not for some time. We shall just have to wait and see!

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UNDER THE RADAR: LYME BORRELIOSIS IN THE UK

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Wendy Fox has a background in zoology. She is a founding member and Chair of the charity Borreliosis & Associated Diseases Awareness (BADA-UK). Wendy was left paralysed from the waist down and partially sighted by Lyme borreliosis after she suffered a brain and spinal cord swelling.

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INTRODUCTION

Lyme borreliosis (LB) is recognised to be an emerging disease and a significant public-health threat but, despite a year-on-year rise in case numbers, this disease remains an overlooked and under-researched condition, and a lack of awareness could significantly increase its prevalence. This was the main reason for the presentation and documentation that was on display in the House of Commons, Upper Waiting Hall, 15-19 November 2010.

BACKGROUND

LB (also known as Lyme disease or Borreliosis) is a spirochaetal infection usually transmitted via the bite of a hard-bodied tick; most commonly Ixodes ricinus (known as the sheep tick, wood tick, castor bean tick and deer tick). Certain soft-bodied ticks can also transmit LB to people. Transplacental transmission has been demonstrated; and potentially via infected blood products.

To date, *Borrelia burgdorferi* (B.b.), the causative agent of LB, can be divided into at least 15 genospecies. B. *afzelii*, B. *bavariensis*, B.b. *sensu stricto* (s.s.), B. *garinii* and B. *spielmanii* are all known to be capable of causing disease but there is currently a lack of consistent evidence to determine whether other genospecies such as B. *bissettii*, B. *lusitaniae* and B. *valaisiana* are also pathogenic. The group as a whole is referred to as B. *burgdorferi sensu lato* (B.b. s.l.) and the term Borreliosis is used to describe an infection of any genospecies.

Signs and symptoms may vary between genospecies. There is recent evidence, for example, that B. *afzelii* causes an annular Erythema Migrans (the rash associated with LB) and B. *garinii* a homogenous lesion which seems to develop more rapidly. Not all patients present with Erythema Migrans. This may also suggest genospecies variation in some cases, as does the fact that Lyme arthritis is rare in Europe but much more common in North America.

Ticks acquire Borrelia bacteria from reservoir hosts, such as small mammals and birds, when they take a blood meal. Transmission to other hosts, including humans, occurs during the following feed.

Hard-bodied ticks are present in many forested, heathland or moorland areas but they are also present in more urban parklands and gardens. European studies found Borrelia-infected soft ticks in urban pigeon roosts. One study demonstrated that tick larvae and nymphs parasitise certain garden birds as frequently as white-footed mice, the principal reservoir host of B.b.s.s. in North America.

Many people assume that LB has made its way to the United Kingdom following the first documented outbreak in 1975 in Old Lyme, Connecticut. LB has actually been known in Europe under different names since Arvid Afzelius associated *Ixodes ricinus* with Erythema Migrans in 1909.

OCCURRENCE

Certain areas in the UK are considered high risk for LB, such as the New Forest, Exmoor, other woodland or heathland areas of southern England, the Lake District, the Scottish Highlands and Islands, the North Yorkshire moors, Thetford Forest, and the South Downs. However, as stated by the Health Protection Agency (HPA), *"any area where Ixodid ticks are present should be regarded as a potential risk area"*. Considering that ticks have been highlighted as a significant threat in the World Health Organisation's 'Public Health Significance of *Urban* Pests', most areas that support varied wildlife, whether rural or urban, are likely to support a tick population to some degree, and a proportion *will* carry infective agents.

There has been a marked rise in the incidence of LB since 2001, when there were just 268 laboratory-confirmed cases in England and Wales. In 2009 (the latest available data) there were 973. The HPA acknowledges that this data is incomplete and doesn't account for cases diagnosed and treated on the basis of clinical features such as Erythema Migrans, without laboratory tests. They estimate that between 1,000 and 2,000 additional cases occur each year in England and Wales.

An equal increase has occurred in Scotland with just

28 cases in 2001, rising to 605 in 2009. Dr Darrel Ho-Yen, head of Scotland's Lyme disease testing service, has stated that he believes the actual number of cases could be ten times the recorded data if taking into account *"wrong diagnoses, tests giving false results, sufferers who weren't tested, people who are infected but asymptomatic, failures to notify and infected individuals who don't consult a doctor".*

Improved awareness may account for some of the increase but other factors such as an increase in the tick population and its distribution, plus an increase in outdoor pursuits have also played their part.

DEFICIENCY IN MEDICAL AWARENESS

A casual survey, conducted by the charity Borreliosis & Associated Diseases Awareness UK (BADA-UK), revealed that a number of General Practitioners believe that there is no Lyme disease in the UK. In one instance, a doctor stated that there are no ticks present in the UK. Of the 489 respondents to the survey, 72% had used incorrect methods of tick removal which may increase the chance of disease transmission, often having been advised by a vet, GP, practice nurse or NHS Direct.

Although rural physicians in highly endemic areas tend to be better informed, there are exceptions. Some doctors dismiss the possibility of LB in diagnosis on the basis that the patient did not present with a rash.

Another difficulty in LB diagnosis is the limitations with blood-testing techniques. Patients may be tested before they have an immune response and therefore a false-negative result can be returned. Seroconversion may occur with a second test. Health Protection Scotland highlights the fact that some patients may be seronegative, *"often because of early antibiotic treatment"*. They go on to state that, *"The serodiagnosis of late Lyme disease requires good, specific clinical histories, and with some patients there may need to be a trial of treatment".*

Conversely, patients may have antibodies without having a current infection (this can occur through regular occupational or recreational exposure to tick bites). Other conditions (eg Glandular Fever, Syphilis and certain autoimmune diseases) can result in false-positive reactions to LB. It is due to these limitations that the HPA states, *"The significance of any result, negative or positive, should be interpreted carefully by clinicians in the overall context of the patient's clinical findings and tick exposure risk history".*

In an analysis of laboratory-confirmed cases in 2008, the HPA recorded that just 32% of the 813 cases reported Erythema Migrans and just 40% a tick bite. As ticks may be the size of a poppy seed, feeding in inaccessible places and often under body hair, the latter is unsurprising.

Common advice, often perpetuated from out-dated papers, is that a tick must be attached for some considerable time for transmission to occur (ranging between 24, 36 and 48 hours). Yet, an extensive literature review to determine the sources for these claims revealed that although longer tick-attachment times do increase the risk of infection, a minimum attachment time for transmission to occur has never been established. Claims that the risk of infection is non-existent if the tick is removed within 48 hours are not supported by the published data. Other frequently published statements that the risk is minimal if the tick is removed within 24 hours are misleading, and data indicate there is significant risk within 24 hours of attachment. European experimental data indicate significant risk within 16.5 hours and demonstrate that partially-fed ticks would efficiently re-attach to a new host, having already gone through the physiological mechanisms allowing spirochaetes to have migrated to the salivary glands prior to re-attachment.

Crucial facts about where ticks may be present, their inconspicuous nature, disease transmission, symptom variation, and testing limitations are not filtering through to most General Practitioners; the first port of call for patients.

PROPHYLAXIS – NOT SO PROLIFIC

A secret survey of UK county and district councils was conducted by BADA-UK to determine the availability of information about ticks and LB. 124 councils were telephoned to obtain information for public and staff visiting areas of potential tick exposure. Each council web site was also examined. Only 7.26% (9/124) of authorities surveyed provided information to staff; of this subset, 22.22% provided leaflets or electronic documentation. 55.56% mentioned LB within standard health and safety guides and 22.22% claimed to have information on their web site. 7.26% (9/124) of councils claimed to have information for public use. Of this subset, 55.55% provided web-based material. Arun and the New Forest District Councils stood apart by providing comprehensive information. Many environmental health departments were unaware that LB is reportable under the 'Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995' (RIDDOR).

Health and safety in the workplace documents, and for visiting public, from sources such as the Health and Safety Executive, were also reviewed by BADA-UK. It revealed a significant lack of information regarding hazards and risk avoidance, and out-dated and conflicting data. In one document, *'Baseline incidence of ill health in agriculture in Great Britain',* it was stated that LB is acquired from straw.

SLIPPING UNDER THE RADAR

Many documents advise on zoonoses of low prevalence, particularly Leptospirosis (of which in 2009 there were just 52 cases). Such concentrated focus on less-prevalent zoonoses is almost certainly deflecting attention from an equally serious and escalating disease.

With no vaccine available against LB, and five other tick-borne diseases endemic to the UK, awareness is vital. One controlled trial of a primary prevention program for Lyme disease and other tick-borne illnesses (TBI), conducted by Daltroy et al in southeastern Massachusetts, demonstrated lower rates of TBI amongst those receiving TBI education, and a significant increase in the likelihood of precautionary behaviour.

To date, BADA-UK (a volunteer-run charity) has the only proactive public-education strategy in place. The environment is there to be enjoyed by everyone and it is vital for people to be better informed, rather than unknowingly exposed. Consistent and effective communication is key to preventing more people from becoming infected.

AVOIDING THE PERFECT STORM: MEETING THE NEED FOR NEW ANTIBIOTICS

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THE IMPENDING CRISIS

Global concerns are growing within medical and academic circles over the urgent need to secure the long-term availability of effective antibiotic treatments. Modern healthcare is facing a perfect storm. The inexorable rise in antibiotic resistance, the continuing emergence of multidrug-resistant infections and a market failure of antibiotic development leading to a near depletion of the antibiotic pipeline could have devastating effects on global health. The magnitude of the crisis we face becomes apparent when we note that sixteen new antibacterial agents were approved and brought to market between 1983-1987, compared with an estimated two to four agents between 2008-2012[1]. It is by no means clear if even these can, or will, address the clinical issues we currently face.

Over the past 80 years human health has enjoyed the unprecedented benefits brought about by the discovery, development and widespread use of antibiotics. There are few people alive today in the developed world who can remember what it was like to live in a world without them. We have high expectations – survival to adulthood is expected, treatment of common and less common infections is expected, as is a productive work force and an ability to live into old age. Antibiotics play a defining and key role in ensuring these expectations are met.

Twenty-first century medicine delivers increasingly complex treatments and health benefits to many, from improved quality of life and increased life expectancy for cystic fibrosis sufferers, to joint replacements, life-saving transplants and chemotherapy treatments. Whilst such advances are to be applauded, governments, health professionals and society must acknowledge that they are only possible in the presence of effective antibiotic treatments. The dearth of new antibiotics reaching the marketplace potentially threatens not only the management of the much reported "superbugs" such as MRSA, but also many routine treatments and procedures across all branches of medicine. A return to a pre-antibiotic era is an all-too-real possibility and living with the spectre of untreatable infections could be a reality within our lifetimes.

ACTION TO DATE – PAST AND PRESENT

In 2009 the World Health Organisation[2] declared antibiotic resistance as one of the three greatest threats to human health, acknowledging the gravity of the situation through World Health Day in April 2011 – 'Antimicrobial Resistance: No Action Today and No Cure Tomorrow'[3]. There have been many attempts to bring the grave concerns about the lack of new antibiotics to the attention of government agencies, healthcare professionals and the public. Between 1998 and 2008 over twenty enquiries, reports and recommendations were published from within the UK alone (www.antibiotic-action.com/resources). Despite these sustained attempts there is little evidence of progress and efforts have failed to generate interest adequate to stimulate action or bring about change. It is difficult to imagine similar lethargy were it publicly reported that only two new cancer agents were under consideration, or there were only three new cardiology drugs in the pipeline. One would expect a rightful outcry from cancer and heart patients and their representative groups, and it is difficult to envisage there not being one.

The past two years have seen a gathering of pace within Europe and the US. Both the

European Union[4], through ReAct, and the Infectious Diseases Society of America (IDSA)[5] established initiatives to raise awareness of the problems of resistance and the need to replenish the antibiotic pipeline. The IDSA also lobbied the US Government in an attempt to gain its urgent attention and re-stimulate drug development[6] and ReAct arranged an event in March 2010 at the European Parliament which raised the issue and discussed potential solutions, and followed in May with a seminar on this topic in Brussels. In July 2009 the British Society for Antimicrobial Chemotherapy (BSAC) established an initiative called 'The Urgent Need to Regenerate Antibacterial Drug Discovery and Development' (TUN), which included advisors from the American Society for Microbiology (ASM), IDSA and ReAct. Taking a different route from the norm, the working party chose to steer clear of rehearsing the known evidence or arguments for containing resistance; instead a decision was made to develop a framework for action (www.bsac.org.uk/News/TUN) that would identify opportunities for collaboration and action.

In developing its framework for action, TUN explored the status of research from basic through to translational, ie from small molecule inhibitors of potential new or novel targets through to isolation or synthesis of such inhibitors to drugs, and made proposals to maintain a pipeline of novel inhibitors for development as drugs[7]. Secondly, the initiative explored the regulation of antibiotics; the problems specific to antibiotic drug development and how these could be overcome; being always mindful that regulation exists to safeguard public health and accepting that this premise cannot be compromised[8]. The working party questioned whether there were lessons from the past, such as the accelerated approval processes that brought antiviral therapies for the treatment of HIV/AIDS so speedily to market, that could be trialled and adopted for antibiotic agents. Lastly, the group explored the economics of antimicrobial drugs[9]. This topic provoked the most controversy, and may ultimately prove the most challenging to resolve. There are pre-existing tensions that need to be addressed – the widespread introduction of antimicrobial stewardship programmes is contributing to attempts to contain resistance and improve appropriate use. It is important to ensure that such stewardship is itself used appropriately and not perceived to be, or indeed used as, a budgetary lever. Raising the value of life-saving antibiotics to match that of other life-saving treatments is a challenge most aptly addressed in a recent article[10] by Professor Richard Wise, who chaired TUN. Proposals to overcome this hurdle included different guidelines for both regulation and licensing antibiotics (due to the very different properties of these drugs), licensing new drugs via the 'orphan drug route', and public-private partnerships where both development costs and profits are shared.

Combined international efforts are also in place, with the report of a transatlantic taskforce (EU and US) on antimicrobial resistance (TATFAR) due for publication in autumn 2011. TATFAR's remit was, ringing by now familiar bells, the exploration of the need to re-invigorate the research and development pipeline for novel antibiotics.

The conclusions of these initiatives are the same – antibiotic resistance and the urgent need for new antibiotic agents is a global problem requiring urgent redress by multi-agency, multi-stakeholder, multi-disciplinary action.

SO WHAT WAY FORWARD?

It is imperative that the profile of this issue is raised if progress is to be made. In September 2011 BSAC launched 'Antibiotic Action (http:\\antibiotic-action.com), comprising a worldwide alliance of groups including IDSA, ReACT and UK/international charities and not-for-profit agencies. Antibiotic Action aims to engage all with a vested interest in antibiotics, especially agencies that represent patients who are reliant upon effective antibiotics. Antibiotic Action will be the catalyst through which this issue is moved from the medical arena to the public arena, calling on individuals and organisations – be they health related or lay – to sign either a UK or international petition calling for urgent action in this area. Viral communications have been initiated via Twitter and Facebook, a mobile phone app is in the pipeline, and the Antibiotic Action website is a rich repository of information, including stories from patients for whom antibiotics are or have been essential.

A Parliamentary launch meeting is being held on 9 November at the House of Commons, immediately following which the UK petition will be presented to the Prime Minister at 10 Downing Street. It is essential that all stakeholders, and particularly politicians, become involved and engaged in this issue so that ways to stimulate antibiotic discovery, research and development are found so that new drugs are available to treat infections in patients of the 21st century. Antibiotic Action, with the support of UK politicians, hopes to be the global platform by which this is achieved.

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Visit to LGC's Teddington HQ by Members of the House of Commons Select Committee on Science & Technology and the Parliamentary & Scientific Committee

Tuesday 14th June 2011

Katherine Passerieu
Passerieu Consulting

INTRODUCTION

The visitors were received by and introduced to David Richardson, LGC's Chief Executive, Dr Derek Craston, Government Chemist and MD, LGC Science & Technology, Dr Steve Wood, Head of Regulatory Services, Dr Paul Debenham, Director, Innovation & Development, Dr Julian Braybrook, Head of Strategy, Measurement Research, Peter Bedson, Head of Operations, Measurement Research, Ric Treble, Scientific Advisor for LGC Forensics and LGC Standards and Richard Gardner, GK Political.

DAVID RICHARDSON, CHIEF EXECUTIVE

David Richardson welcomed the visitors and emphasised that the Laboratory of the Government Chemist was established in 1842 by Robert Peel who also founded the police, so connection between police and science was established from the outset. George Phillips, whose picture is on display, was the first Government Chemist. The original raison d'être was to help the government claw back customs revenue. People were importing gin and tobacco, paying some duty and then diluting it and adulterating it and selling it off for a lot more money. George Phillips didn't feel this was a good idea! I suspect that his boss, the Prime Minister, didn't feel very happy about it either! So the Laboratory of the Government Chemist was brought into being to use science to help government collect revenue, but in particular of course, to make sure that the regulatory function around that was properly fulfilled.

LGC's modern history started in 1996. They were privatised at the same time as two other government laboratories by a Conservative administration. They have grown organically since then out of all recognition. In those days LGC was about two hundred and fifty people, based very largely on this site and working entirely for government in the UK. They are now nearly fifteen hundred people based at thirty-one labs and centres all around the world and operate in different countries and different scientific disciplines.

Most recently LGC changed ownership again. This is their third private equity iteration since privatisation and they are now backed by Bridgepoint who have about €11.5 billion of funds invested all around Europe. Over sixty thousand people work for Bridgepoint companies and LGC felt that Bridgepoint were a new owner who really understood and was sympathetic not only to the objectives of the business but also to the history and the way LGC do business here.

LGC expertise extends across a broad range of scientific activities with capability in regulatory and statutory testing – this is their history, heritage and legacy and where they have continued to invest and develop. But they have expanded that to include laboratory management, R & D, surveillance, measurements, standards and a whole range of other disciplines, including scientific project management. Although they are a private sector business, they still undertake a number of important regulatory and statutory functions for government.

Dr Derek Craston is the Government Chemist and LGC is the designated National Measurement Institute for chemistry and biochemical analysis and a national reference laboratory. LGC therefore have an international role to maintain on behalf of the UK, which is at the forefront of measurement science internationally.

LGC considers itself to be in the top tier of National Measurement Institutes in the world, alongside the likes of the USA and Korea. The UK therefore has a strong voice in international measurement, which is important for UK plc and supports international trading relationships. LGC turnover has progressed steadily upwards and last year income was just over £130m and earnings were of the order of £20m.

Many of the LGC businesses have their origins in the Government Chemist function and LGC work in measurement science. For example, LGC have created what is now the largest private sector forensic science provider in this country and probably elsewhere, and their reference materials business in eighteen countries has a turnover exceeding £60m.

The four divisions within which LGC operate are
1) forensics science;
2) standards including reference

materials and proficiency testing schemes;
3) genomics, primarily DNA sequencing, particularly in the agricultural sector; and
4) science and technology, which includes statutory functions.

Perhaps the best known of the LGC businesses is LGC Forensics, involving nearly ninety different disciplines where the provision of a comprehensive suite of services is critical to police forces and other customers. This range of services enables police to manage cross-boundary cases. It is an important strategic priority for LGC to be represented in as many disciplines as possible. For example, computer analysis for child protection and e-crime is an increasing part of the police's crime fighting inventory of skills. LGC also have expertise in and have been involved in cold cases.

Last year LGC completed a very interesting piece of work in Fromelles in Northern France, which is a First World War mass grave. Nearly three hundred bodies were exhumed, of which LGC have now helped to identify ninety-seven. The soldiers have received headstones in a new cemetery that was opened last July by Prince Charles.

Genomics is a DNA sequencing operation in Berlin with some R & D in Teddington. LGC are not involved in GMOs, but rather with accelerated breeding programmes, where the technique is to cross two plants and see (through DNA sequencing) whether the genes have been expressed through into the next generation, enabling customers to really speed up that process of producing crop varieties that are more drought resistant or are likely to stay redder and firmer on the shelf if they happen to be a tomato. LGC are also expanding into other growth areas, especially pharmacogenetics.

LGC's biggest division is in Standards, involving providing reference materials to support globally a very large number of laboratories. Reference materials are produced in Luckenwalde, south of Berlin, which are distributed from LGC Standards headquarters in Wesel in Western Germany and about seventeen other sales offices around the world. LGC also operate training schemes and proficiency testing schemes for laboratories so that they can check quality and ensure that they are operating to high standards when compared with other laboratories worldwide. LGC also undertake work outsourced from the major blue chips and also provide their in-house reference materials. The Standards division is the largest LGC division with a turnover of nearly £60m.

LGC Science & Technology represent nearly a quarter of the LGC business. They are still largely a UK business geographically, but this will shrink as a percentage because the international part of the business will grow. LGC, through the acquisition of HFL Sport Sciences, have recently opened a laboratory in Kentucky to test race horses, using the skills developed in the UK to help underpin the horseracing industry in the US, especially in relation to gambling and animal welfare. LGC expect the US to become an increasing focus for what they do.

In addition to the UK, Germany is also important for LGC, since they have about two hundred and fifty people who undertake virtually all disciplines including genomics, forensic testing for German police in Cologne and distribution and production of reference materials in Wesel and Luckenwalde.

In India LGC produce reference materials in Bangalore where they have a very successful joint venture growing at nearly twenty per cent a year – an exciting and important part of the future. LGC opened a sales office in Brazil last year and opened in China about eighteen months ago (and have already had to move once because they outgrew the office!). These BRIC territories are all important parts of the LGC future.

The LGC workforce is very highly skilled. Twelve per cent of LGC people hold PhDs, some of them world-leading in their specialisms. LGC overall are about sixty per cent graduate staff, which is clearly essential if they are to keep up their skills base, but it also demands a strong on-going investment in training and development and in providing their people with the very best equipment to enable them to do their job.

Typically, LGC are competing against major pharmaceutical testing companies and others in the scientific arena, and also obviously compete on an international stage as well. So it is important for them to be able to provide the research opportunities and also the scientific instrumentation that attracts people to work at LGC – something we saw when we went around their laboratories.

DR DEREK CRASTON, GOVERNMENT CHEMIST AND MD LGC SCIENCE & TECHNOLOGY

Dr Craston mentioned two areas that the Committee would not see on their visit. One was the Programme Management Group based at Twickenham. This is a science management service LGC provide to government including the Department of Health where they manage about a third of the Department's research funding budget as part of the National Institute of Health Research where research outputs are being translated into the National Health Service to provide patient benefit. LGC also work for other departments like Business Innovation and Skills and DEFRA and do some administration for the Technology Strategy Board. LGC also work for the private sector in areas relating to the broader area of health and healthcare.

The other work not based at Teddington is the recently acquired horseracing forensic laboratory which is just outside Cambridge and tests horses and greyhounds involved in racing to make sure that there is no cheating going on, and no banned substances are being used. LGC also provide services in food testing and pharmaceuticals.

DR STEVE WOOD, HEAD OF REGULATORY SERVICES

The Government Chemist has two functions, firstly as a statutory referee analyst under the four Acts of Parliament covering food, agriculture, medicines and hydrocarbon oils and secondly, the Government Chemist is an advisor to government on the impact of regulations and policy on analytical chemistry.

The Government Chemist may become involved in any statutory analysis where there is a dispute. For example, a formal sample could be taken of an import consignment, which would then be divided into three portions. One portion goes to the owner for analysis and one part goes to the Public Analyst. If there is a dispute

between the two sets of results, the third part of the sample will come to LGC for the referee analysis. This process protects both industry and government. It protects industry by providing an opportunity to redress any issues that are wrong, and it also protects government by maintaining the integrity of the regulatory process. It also assists the courts in the case of dispute where LGC provide accurate and precise results and valid and informed interpretation of the data. So LGC are protecting both the regulated and the regulator through the Government Chemist statutory function.

The primary objectives are to assist smart regulation in order to reduce the regulatory burden. The Government Chemist, by virtue of the accuracy of LGC measurement science, can help prevent disputes through method development, and increase current awareness amongst the scientists involved. LGC perform dissemination and training activities, and publish the methodology in peer reviewed papers to make this information available to the public analysts and to the industries involved. LGC are also seeking out big issues that are likely to arise and work with local government regulation, the food law group and the FSA, so that we can identify trends that might provide clues requiring a response in the future.

The Government Chemist also advises on key analytical issues affecting regulation and enforcement and compliance involving foresight activity. Through the Government Chemist programme, LGC advise industry on the interpretation of their regulations and actions that are required by them to ensure compliance. LGC do this by organising training and dissemination events.

LGC have a very successful partnership with the Medicines and Healthcare Regulatory products Agency (MHRA) and operate two of their laboratories. The work of these laboratories is to assist the MHRA's enforcement officers in ensuring the integrity of products on the marketplace, including protecting against counterfeiting, and to support the work of the British Pharmacopoeia Commission In developing methods that are used to prove the quality of generic medicines that become available on the market and in producing the reference standards that help calibrate equipment and validate the methodology.

LABORATORY TOUR

The introduction was followed by a visit to four laboratories in three groups. The groups were led by Dr Paul Debenham, Director Innovation & Development, Dr Julian Braybrook, Head of Strategy, Measurement Research, and Peter Bedson, Head of Operations, Measurement Research.

The laboratories visited included

1) DNA Crime Stains where buccal swabs were required for elimination before entering laboratories (Ric Treble, Scientific Advisor for LGC Forensics and LGC Standards);
2) Laser dissection/single cell analysis laboratory (Damian Marshall, Principal Scientist, Cell Biology);
3) Isotope ratios in hair laboratory (Ruth Hearn, Team Leader, Chemical Measurement & Calibration); and
4) GMO quantitation laboratory (Malcolm Burns, Science Leader, Molecular and Cell Biology).

The visitors were entertained to lunch and a final discussion session before departing with a vote of thanks to the hosts for such a well organised and informative visit.

To see David Richardson's powerpoint presentation visit www.scienceinparliament.org.uk

ADVANCING NANO-CERAMICS FROM LABORATORY TO MANUFACTURE

Professor Jon Binner
Professor of Ceramic Materials and Dean, School of Aeronautical, Automotive, Chemical and Materials Engineering, Loughborough University

Research in the Department of Materials at Loughborough University is working towards taking fundamental research into nanostructured ceramics through to industrial application; licensing agreements are currently being negotiated for the work based on zirconia and it is hoped that the technology will be launched during 2012.

The research team at Loughborough is working on producing and characterising a range of nanostructured ceramics, including alumina and zirconia toughened alumina, barium titanate, hafnium boride and carbide, yttrium aluminium garnet (YAG) and a range of yttria partially stabilised zirconias. Each material is at a different stage of progress, with zirconia being the most developed. It is now possible to produce fully dense, genuinely nanostructured yttria tetragonal zirconia polycrystal (YTZP) ceramic from powders as fine as 20 nm; this is smaller than the size of a typical virus. The YTZP ceramics have been found to display some extremely useful properties. For example, although zirconia is one of the strongest and toughest advanced ceramic materials, it is very vulnerable to attack by moisture, particularly at temperatures in the range ~100 – 300°C. The moisture causes a catastrophic phase change that can reduce conventional, submicron zirconia into a pile of damp powder in less than one hour at ~250°C. Whilst more resistant grades are being developed, the new nanoYTZP has been found to show no trace whatsoever of the phase change even beginning to occur after 3 weeks at 250°C. Combined with high strength and, for the right grades, high toughness or ionic conductivity, this has led to significant interest being shown in these materials for applications as diverse as hip replacement implants, dental ceramics, solid oxide fuel cell electrolyte and valves for the petrochemical industry.

The work has been able to progress thanks to a series of research grants from EPSRC and the TSB in particular, in combination with excellent industrial support. The Powders Sector of the Materials KTN (formerly PowdermatriX) also aided this process very much. Two EPSRC programmes and a DTI (now the TSB) project over the period 2002-07 got the work off to an excellent start and allowed the basic green forming and densification routes to be developed. The work then continued with an EPSRC Follow-on Fund project, which assessed the potential for commercial exploitation of the technology, before being developed further and broadened in terms of the range of ceramics being investigated via a TSB Collaborative Research project. The team were then able to capitalise on the developments and start to translate them into industry via support from the EPSRC Collaboration Fund. This current grant is allowing a nanozirconia engineering component prototype, the ceramic internals for a petrochemical valve, to be produced. Further support focused on scale up was received from the Royal Society Brian Mercer scheme, whilst additional TSB support is about to start for work in the area of bioceramics.

This sequence of research grants, and the wonderful technology transfer nature of the EPSRC Follow On Fund and Collaboration Fund, has really helped the team to accelerate the process of getting their ideas into industry. Unless something unforeseen happens, it should be possible for the technology to be commercialised within a decade of the start of the research; something that is really quite rare. The work on barium titanate should follow during 2013, with the other ceramics being commercialised over the ensuing years.

The team at Loughborough considers itself very lucky, however. Each time, just when it was needed, there was a Call for Proposals in just the right area and in just the right format. What they believe is needed is to remove some of the luck from this process. A small amount of funding needs to be reserved by both EPSRC (Follow On & Collaboration Funds) and the TSB that can only be applied for by researchers who have already been successful and are developing their ideas steadily closer towards commercialisation. The funding must certainly remain competitive, there must be no diminution of the principle of funding excellence, but such a fund would remove the element of chance that there is a Call in an appropriate area; something that is currently quite restrictive for the TSB in particular.

This development of nanostructured ceramics is an achievement that exemplifies how the availability of successive and appropriate public funding initiatives can lead to effective innovation. Removing the element of chance that has been involved can only improve this process further.

A NEW FOCUS FOR RESEARCH IN THE FOREST BASED SECTOR: THE DEVELOPMENT OF HIGH VALUE, BIOPOLYMER BASED MATERIALS

Professor Philip Turner
Director, Forest Products Research Institute
Edinburgh Napier University

The latter half of the 20th century saw real progress in the development of the forest products industry. Today, it provides essential materials for modern day life from the provision of fuel and structural materials through to paper, packaging, textiles, hygiene products, and a broad range of specialised cellulosic products for the food and pharmaceutical industries.

Excluding wood for fuel and construction, the largest consumption of wood in global markets takes the form of pulp and paper. Traditionally, Europe has been a dominant player in this industry and played a major role in research, development and innovation in both product and process development. Until recently the UK played a small but significant role in this industry. The last 20 years has seen traditional pulp and paper producers come under increasing pressure from emerging economies. To date the European industry has managed to minimise these impacts through technological innovation leading to increased automation, process efficiencies and higher value products. However, competitive pressures remain and are driving the industry down two parallel paths.

The first approach has been to focus capital investment in forests and manufacturing facilities in "low cost" developing countries. This is ensuring the future sustainability of European corporations but at the expense of a marked decline in European manufacturing capacity. The UK has suffered particularly badly from this process with very low levels of investment in competitive manufacturing technology. This has been paralleled by a marked decline in UK based forest products research capacity. By the year 2000, the UK was a relatively insignificant player in forest products research whilst at the same time being one of the world's largest consumers of imported forest products.

The second approach has been to invest in new, game changing technologies. The European pulp and paper industry has a limited window of opportunity to diversify and transform its manufacturing capability into new, higher value materials and products that can build on the forest industries sustainable credentials and replace existing high value, oil based products. The oil industry is an interesting comparator as the pulp and paper industry begins to rethink the pulp and paper mill as a bio refinery. This creates an opportunity to harness the creative potential of UK research capacity.

At the beginning of the 20th century, petroleum refinery was in its infancy producing only a few products and little energy production using the previous technologies developed for coal. The development of petroleum refinery was a protracted process that required an extensive effort to develop the existing petrochemical processes and allied catalysts leading to the highly efficient systems and an extensive range of oil based products that we know today. In the same way, the newly developing lignocellulosic biorefineries industries based on wood and agricultural materials are only just getting started. It will require the development of catalytic technologies and new

. . . By the year 2000, the UK was a relatively insignificant player in forest products research whilst at the same time being one of the world's largest consumers of imported forest products. . .

integrated production systems combined with industry diversification to meet the chemical, material and fuel requirements of the 21st century.

Research over the past decade has highlighted a number of promising opportunities to utilise forest and agricultural biomass. Understanding the structure of biomass at a molecular level opens fascinating new ways for its utilisation. Research is moving beyond classical wood chemistry traditionally linked to large-scale pulping, bleaching, papermaking and fibre making. New research is directed towards an advanced understanding of biosynthetic pathways, molecular-level processes and novel technologies to deconstruct the cell wall, towards a complete utilisation of the various products generated. The three major renewable biopolymer classes – cellulose, hemi cellulose and lignin are moving away from being cheap commodity products. They are now being seen as valuable materials with interesting commercial potential.

One of the more promising areas of research has involved the extraction and utilisation of crystalline cellulose from wood and other plant material. Crystalline cellulose forms the skeletal structure for woody plant material (figure 1). These crystalline structures have a strength to weight ratio higher than that of Kevlar or carbon fibre. One of the biggest challenges has been to extract these nanometre scale structures and recombine them into macro-scale products that can utilise the inherent strength of these materials. There are now a number of chemical and mechanical techniques for extraction of cellulose and each gives different raw material characteristics for different potential applications. However, the development of new, high strength materials from this natural resource is still in its infancy.

Recently developed electron microscopy techniques are offering new insights into the cellulose skeleton within the cell wall, suggesting that it has a complex fractal architecture (figure 1), similar to a number of structures found in non-biological materials. This observation suggests that cellulose structure is largely determined by fundamental physical rather than biological processes. This raises some important questions.

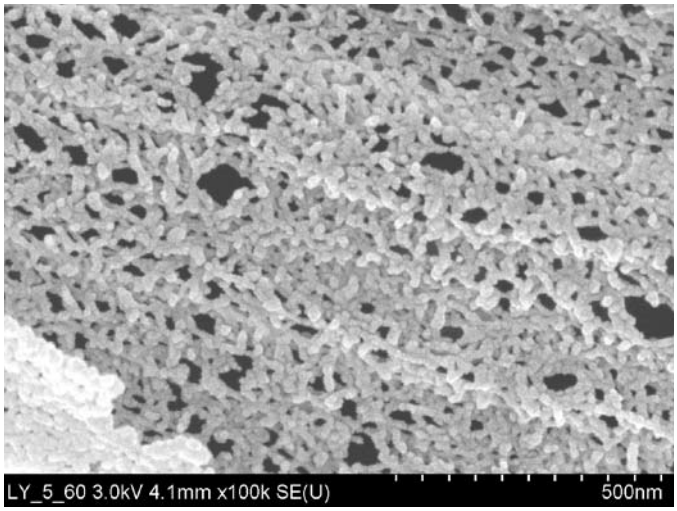


Figure 1. Cellulose skeleton within a wood fibre. Magnification 100 000x

. . . There is an opportunity to rethink research in order to understand better the fundamental interaction of physical and biological systems. . .

In the development of new materials, scientists often attempt to mimic biological processes, which can be extremely complex to understand and replicate. If cellulose assembly is driven by fundamental physical processes, they may be simpler to understand and replicate in the development of new self-assembly processes at the nanometre scale. There is an opportunity to rethink research in order to understand better the fundamental interaction of physical and biological systems. The work requires multidisciplinary collaboration between biology, physics, materials science, systems engineering, micro and nanotechnologies and modelling and simulation.

The chemistry and technology of biomass is experiencing a modern renaissance. The mounting pressures in our society to rely on benign resources and eco-efficient technologies have made the European forest based sector a focal point of activity and interest. The UK research community needs to get on board, this process has started but a lot more needs to be done. It is imperative to adopt schemes of creative information exchange, promoting collaboration and the development of new science and scientists.

The prize could be the development of a whole new platform for the manufacture of new high value materials based on Europe's most abundant, sustainable resource; "its forests".

Research into new materials development offers exciting new opportunities. However, even greater potential economic impact lies in supporting the development of new applications for these materials in industries as diverse as automotive, sports equipment, wind turbine, defence and aerospace. Strategic investment could lead to the creation of a new, high value, sustainable manufacturing base of small, medium and large companies within the UK.

THE P&SC WEB SITE: scienceinparliament.org.uk

Dr Stephen Henley
CEng FGS FIMMM
Resources Computing
International Ltd

I have now been managing the P&SC web site for six and a half years, since late 2004. I have worked with computers for most of my career, although as a practising scientist my 'day job' is in geological consultancy, I have worked with computers for most of my career, and for several years I have also managed web sites for clients both commercial and charitable – starting in 1995 when I was on a research contract with CSIRO in Australia for a year. Most web sites, such as World Gold Analyst magazine or the Ecton Mine Educational Trust, have been related in some way to the minerals industry. For the P&SC, though, the link is a little more tenuous. I was attending the International Geological Congress in Florence in August 2004 and bumped into Peter Simpson and Jane Plant in the lunch queue one day. Peter knew of my computing background we both worked together in the British Geological Survey in the 1970s, and asked if I was interested in helping to set up a new web site for the Parliamentary and Scientific Committee. We agreed in principle there and then, and over the following months worked out the detail, leading to formal agreement at a specially convened Council meeting in Portcullis House on 15th November.

This detail includes a growing database of articles extracted from current and past issues of Science in Parliament – that, in my view, now constitute the most valuable online resource owned by P&SC. There are now 471 articles from every issue since Whit 2004. All articles from issues more than 12 months old are now publicly available. These are all indexed and searchable by author and title.

The website also hosts a free and regularly updated Guide to Science in Westminster by David Dent – the complexity of the overlapping scientific interests of government departments and parliamentary committees is made clear in a very accessible way.

For the Committee's members, probably the two most important areas of the site are the meetings page, which contains details of future meetings (including last minute changes to location or timing), and the Science in Parliament page which includes the latest issues downloadable in PDF format. This supplements the printed copies which are received by parliamentarians and all P&SC members, and it also provides free access to the publications to all employees of member organisations – provided that they know the login code! In the Westminster Estate, all computers linked through the main parliamentary servers have automatic login access to the web site. Starting fairly recently, logged-in members can also download and view presentations given at many of the discussion meetings.

Perhaps, thinking that I had too much time on my hands once the main site was running smoothly, Peter then asked me three years ago if I would be willing to help with SET for BRITAIN (SfB). It seemed interesting, so I decided to take it on. For the 2010 competition, I transferred the rather complicated application form to a new web site, and enabled a simple email application system. However, it very quickly became apparent that the number of applications, combined with unpredictable behaviour of email spam filters, was leading to chaos for everyone, and most particularly the organisers and judges. As a result, for the 2011 competition the decision was made to replace this with a new online database system, where competitors are able to submit their applications online, and with organisers and judges accessing these directly from a database through secure private web pages. The database applications were set up and tested in collaboration with Sue Wharton who brought her invaluable knowledge of past competitions with Dr Eric Wharton. This appeared to work much better and also coincided with an increased number of submissions received. Not only did it mean less work for Sue and the judges, it also meant much less work for me, as I always prefer neat solutions that reduce unnecessary workloads.

One of the more interesting aspects of managing these two web sites has been the challenge of maintaining them whilst travelling the world on my 'day job'. More than once I have sat at a dusty desk in a client's office at a mineral exploration camp deep in the Russian taiga, sorting out email queries or loading a new issue of Science in Parliament via a dodgy satellite link. This year I was doing the same on a wi-fi connection at a bed-and-breakfast while on holiday in New Zealand. Such is the power of the Internet that physical location has become almost immaterial.

So where is our web site going next? We could accept the inevitable – and link to Facebook, Twitter and LinkedIn, three of the most widely used social networking sites. We could set up a discussion forum on LinkedIn if that is considered desirable.

What else? The P&SC site is overdue for a facelift. It still has essentially the same design as when originally set up. Over the next months you will see some changes, with simplified navigation, and improved legibility. However, this is YOUR web site. What do you want to see? How do you want the site to be changed and improved? I have some ideas, and there are many things that can be done technically. But it isn't my ideas that are important, and technical gee-whizzery is pointless if it doesn't do what you want! Please use the contact form on the website, or email me direct on steve@vmine.net, to give me your views. Where should we go next?

MRS THATCHER'S BRITISH TECHNOLOGY WALL

John Baruch
Ex Head of the Department of Cybernetics and Virtual Systems at the University of Bradford. He runs the only autonomous robot publicly available on the web and is a pioneer in providing practical science on the web for school children.

The complete version of this article can be found at http://www.scienceinparliament.org.uk

Economic growth is the tonic that will avert a double dip recession and put a smile on the faces of this Conservative Chancellor and many others. With the same incantation coming out of Washington one would think that it was a universal problem, but not so. India and China are forging ahead with 8%+ growth, Brazil and Russia are not far behind accompanied by a host of emerging economies. We are told that advanced economies like ours come up against a technology wall, where advanced economies are limited to growth figures of 1% or less with the excuse that all growth is dependent on innovation around new technologies unlike developing countries which are still building the basics of their economies. Where has this Technology Wall come from? It was Mrs Thatcher with Lord Waldegrave who polarised scientific research with the "Realising our Potential" programme reorganising the Research Councils and effectively University Research by insisting that research was of industrial relevance. John Mulvey of the Campaign for Science noted that "there was no more money and what there was would have to be spent differently."

New Scientist remarked that: *"Cash-strapped research councils have had to turn down top-priority research proposals or even terminate leading projects because they have to spend their money on 'second-rate' projects that simply meet government-imposed criteria, say sources within Britain's research councils. They blame this state of affairs on a system of government-inspired grants designed to promote collaboration between academic researchers and industrialists.."*

In 1995, more than 70 per cent of the MRC's "alpha-rated" research proposals, which included projects at the cutting edge of science, had to be turned down for lack of funds. In the previous year only 10% were turned down. The funding went into "industrially relevant" research.

The thinking behind "Realising our Potential" was that fundamental research is international. 'Why should Britain pay for it if we can just read about it in the journals and exploit what everyone else is doing? What we need is just those people close to industry who can read the journals and tell industry what to do.' As Nature commented at the time "the changes indicate that the Government thinks scientists should be on tap and not on top". But hopefully someone has learned in 20 years that it doesn't work like that. Only people working in a creative way with science are likely to see its potential for science outside narrow sectional interests. There is lots of science that would generate new industries and jobs but it would compete with the establishment.

Look at leading edge robotics: driverless vehicles eg driverless cars, taxis and trucks. They are all well within the capability of UK research effort to corner the world market with IP, vehicle organising structures, communications systems and legal developments. It would be much cheaper for other countries to learn from us and pay us than to develop their own and so generate a world industry led by the UK.

Driverless vehicles would completely change our lives. They would end the catastrophe of half a dozen people being killed on UK roads with 400 seriously injured every day.

Driverless vehicles would blur the divide between public and private transport. Of course you could still have your own car parked in your garage. Climb into it in a morning and tell it that you wished to go to work. At work you might wish to avoid large parking charges and get it to drive to a pound for the day, returning when you had finished work, or you might hire it to a taxi firm to make it available for others to use for the day, or you might not bother with your own car.

Driverless vehicles have been produced and tested by the main international vehicle manufacturers, but they do not fit in with their marketing philosophy which, almost without exception, is to enjoy the driving experience. Of course governments have committees to advise them on these things and they have representation from industry and from the now "industrially orientated academia." Any Government advisory committee considering driverless vehicles will only reflect the industry view.

What about roads? The same applies to intelligent roads, the model of the road building industry, and to care for old people focused on care homes, and these are just the bits I see as a robotics and instrument scientist.

Innovation and creativity needs independent thought and support for the ideas. Yes we need the links into industry; they are very good, but Waldegrave and Margaret Thatcher threw out the baby with the bath water and now we will have to start winning back the 20 years we have lost knocking down the technology wall with a diverse broad-based healthy independent research structure. Most advanced countries are now increasing their science spend and they too have banking problems but they wish to climb over the technology wall. The British Government seems to be happy to be walled in.

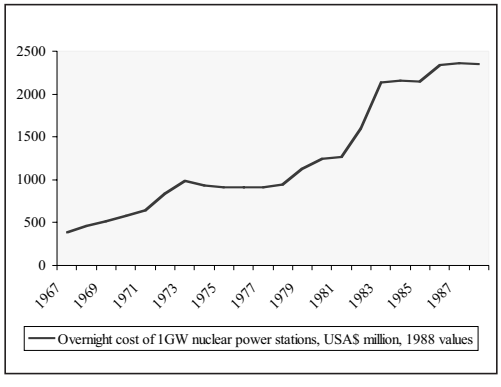
WHY THE UK NEEDS NUCLEAR POWER

Malcolm Grimston
Associate Fellow, Chatham House

The change in the profile of nuclear power in many countries, notably the UK, during the first decade of the new century has been one of the most startling aspects of the rise of energy up political agendas. In 2003 the Government Energy White Paper said: "Nuclear power's current economics make it an unattractive option for new, carbon-free generating capacity and there are also important issues of nuclear waste to be resolved. This White Paper does not contain specific proposals for building new nuclear power stations." Just five years later, the 2008 Nuclear Energy White Paper, by contrast, stated: "The Government has concluded that nuclear should have a role to play in the generation of electricity. Nuclear power is a tried and tested technology. It has provided the UK with secure supplies of safe, low-carbon electricity for half a century. More than ever before, nuclear power has a key role to play as part of the UK's energy mix."

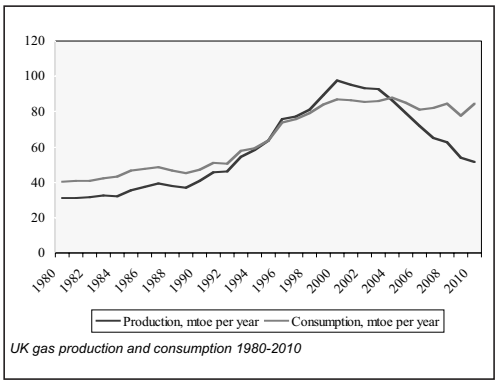
This turnaround followed an equally dramatic fall in the global and national fortunes of nuclear power between the late 1970s and the middle years of the 2000s. The key question is whether the global 'nuclear renaissance' that appears to be under way, albeit modestly so far, should gain momentum, or peter out like the last major wave of investment in the 1960s and 1970s.

We need four things from our electricity supplies – security and reliability; economic competitiveness; environmental sensitivity; and social and political acceptability. After its initial flourish, nuclear power hit problems on all these fronts. In the 1960s and, especially, 1970s, the security of supplies of alternative fuels to nuclear power had looked shaky, but the collapse of OPEC, the decline in power of the coal mining unions and the discovery of significant quantities of gas (including reserves in the North Sea) pushed such fears into the background. As oil, gas and coal prices fell the costs of nuclear power were growing, largely (though not solely) because of the effects of the Three Mile Island accident in 1979. This accident happened in a brand new Pressurised Water Reactor at a time when many such plants were under construction. Huge costs were incurred redesigning these partially built reactors (a much more expensive undertaking than redesigning a plant before construction has begun), servicing the capital which had been invested but was not earning an income, designing new evacuation procedures and responding to more vigorous regulatory requirements.



Environmental concerns about radiation grew (although from the early 1990s there was also international attention on climate change), and the social and political attraciveness of nuclear energy took a very severe blow after the Chernobyl accident in 1986. In the UK the 'dash for gas' in the 1990s ticked all the boxes – there was plenty of gas in the North Sea (indeed we became a net exporter of gas), the new Combined Cycle Gas Turbine (CCGT) technology was cheap and reliable, shifting from coal to gas for power production resulted in reductions in greenhouse gas emissions and gas did not provoke major public protests. The main task for governments of both political colours in the 1990s and early 2000s seemed to be to complete the liberalisation of the market commenced in the late 1980s. Since nuclear power is very heavily capital-intensive it was further disadvantaged by this change, being inherently more risky in economic terms when compared to sources of electricity production which are cheaper and quicker to build (though more expensive to run), notably gas.

Things began to look very different halfway through last decade. The UK became a net gas importer as reserves became depleted, while the failure to build any new electricity capacity for much of the decade raised fears about the ability of the system to cover peak demand.

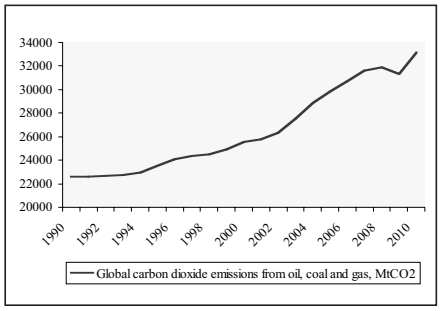


UK gas production and consumption 1980-2010

The geopolitics of oil and gas, especially unrest and military conflict in the Middle East and Russia interrupting oil and gas supplies to

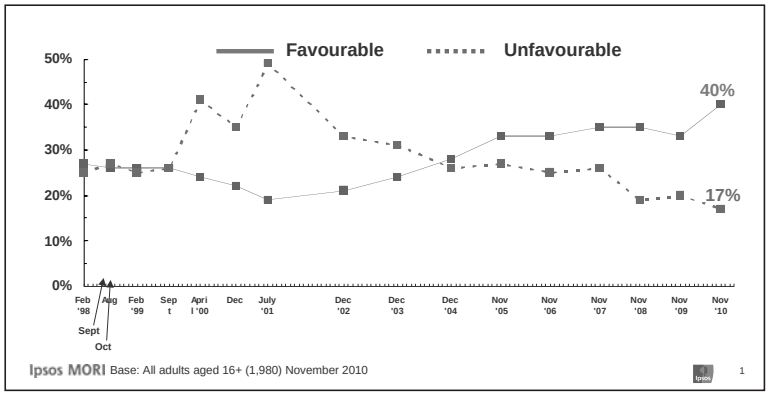
Ukraine and Belarus in 2005 and 2006, revived fears of the dangers of becoming overdependent on imports from that region. Further, as older power stations neared the end of their lifetimes, there was a growing need to install very large amounts of new generating capacity of some description in the UK – government estimates suggest around 35,000 MW over the next 15-20 years.

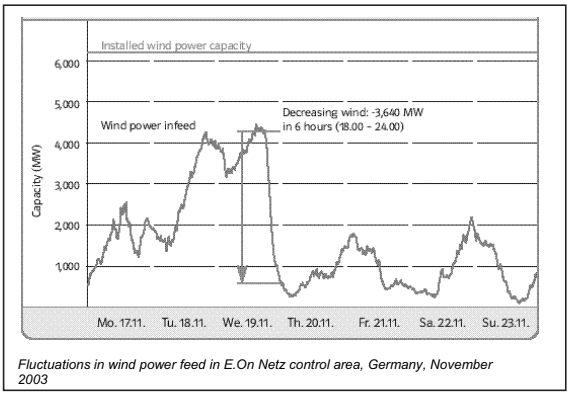
Concerns over climate change grew as global emissions of carbon dioxide rose inexorably.



Public confidence in nuclear power grew considerably after nearly 25 years without a major accident, and several prominent green campaigners who had been opponents of nuclear power publicly revised their stance.

Q How favourable or unfavourable are your overall opinions or impressions of the nuclear industry/nuclear energy?





Fluctuations in wind power feed in E.On Netz control area, Germany, November 2003

USA, Russia, China, South Korea and many other countries (though Germany, Italy and Switzerland stood as counterexamples). Public confidence proved remarkably robust – a poll in The Times in early July 2011 showed the percentage of people in favour of replacing the UK's current nuclear fleet with new reactors falling from 52% to 47% (those opposed growing from 24% to 28%), around the level it had been as recently as 2008. Unlike Three Mile Island or Chernobyl, Fukushima involved old plants (using 1960s technology), which had suffered a huge external challenge from the earthquake and tsunami – remarkably, of the 14 reactors in the affected zone in Japan the 10 newest were in stable 'cold shutdown' within a week. Any redesign lessons can be applied before construction begins, but newer reactor designs such as the Toshiba-Westinghouse AP1000 make much more use of 'passive safety' as opposed to 'engineered safety'. To take an example, the main problem with the reactors at Fukushima occurred because the tsunami flooded the back-up generators which power the pumps which send water into the core of the reactors to remove waste heat. The loss of these pumps resulted in the fuel melting (it now seems) and ultimately in releases of radioactive materials and hydrogen, which caused the explosions we saw. In an AP1000 there is a huge reservoir of water above the reactor containment itself. If all power is lost to the plant, pressure inside the containment would increase, and this would open valves which would allow water to flow under gravity from the reservoir into the containment. This process does not require any power and so would have been effective even during the tsunami.

Climate change is a much bigger policy driver now than it was in the 1980s while in many countries there is an urgent need to build large amounts of new generating capacity of some description (again unlike the 1980s when globally the problem was overcapacity as a result of the recession caused by the oil price hikes of 1973 and 1979).

The nuclear industry, if it is to fulfil its potential in providing very low carbon electricity and reducing the UK's dependence on imported gas, will need to demonstrate that it can build plants to time and cost (even more vital within competitive electricity markets where cost overruns cannot be passed on to captive customers). It will also need to maintain and extend its much more open approach to communication and debate with people about the pros and cons of nuclear technology – the industry's previous secrecy and sometimes arrogance have contributed to a degree of public mistrust.

But the growing need for reliable new capacity, for alternatives to imported fossil fuels, for low carbon sources and for economic competitiveness leaves few attractive options. Many renewable technologies (notably wind, tidal and solar) are inherently intermittent, which makes them poorly suited to providing 'baseload' power, the electricity demand that must be met at the time it arises to keep our water flowing, mass transportation operating and so on.

In the UK the Coalition Government elected in 2010 essentially maintained the pro-nuclear stance of its predecessor, on the assumption that nuclear power did not receive specific subsidies that were not available to other fuels (insurance against major accident being the exception).

The accident at Fukushima certainly led to a pause for thought, but no apparent major change in policy in the UK, or indeed in the

In effect, then, each nuclear plant that is not built will represent a coal or gas plant which is, locking us into greenhouse gas emissions and increasing our dependence on imported fossil fuels. With most of our current nuclear plants coming to the end of their lives over the next decade or so, a rapid start to a new programme is now vital.

NUCLEAR SCIENCE AND ENGINEERING – WHY ARE THEY IMPORTANT TO THE UK ECONOMY?

Robin Grimes
Director, Centre for Nuclear Engineering, Imperial College

Nuclear energy is tempting. It provides a low carbon secure energy resource. Nevertheless, without consistent underpinning science and engineering it would not be possible, or wise, to proceed with this option. This is because nuclear energy generation demands a very high degree of engineering capability to build, control, monitor, maintain and decommission plant. The spent fuel also requires careful handling and its final disposal has not been fully resolved. It is probable that within the reactor pressure vessel, the combination of high radiation fields, temperatures, pressures and corrosion, make this the most extreme of engineering environments. Consequently, it is not sufficient to understand only the pre-irradiation properties and behaviour of nuclear plant. Rather, to optimise performance, reliability and guarantee safety, it is necessary to understand how plant behaviour evolves during operation – particularly how components age and the properties of constituent materials change under irradiation. This demands the application of science and engineering at the highest levels.

Irrespective of the challenges, nuclear energy provides by far the most compact energy source. A single nuclear reaction releases a hundred million times more energy than a chemical reaction. Put another way, one cubic centimetre of conventional nuclear fuel will release as much energy as 500 litres of fuel oil. This makes the nuclear option very attractive, particularly for intensive energy users such as chemical and manufacturing industries, where both fluctuations in cost and reliability of supply are crucial issues.

To address the challenges, science and engineering must provide the understanding and deliver developments and improvements that ensure the continuing safety, security and reliability of all aspects of the industry. In the UK, safety is the responsibility of everyone in the industry and the regulator. The generator must advance arguments based on engineering experience to develop a safety case and the regulator must test and scrutinise the case to ensure that it is robust against both normal and possible accident scenarios. Scientific developments allow new processes to be considered, with the aim to proceed towards even safer and more efficient generation. However, existing reactors are getting older and those extreme conditions are causing parts of the plant to slowly degrade and evolve in ways that cannot always be anticipated from previous experience. Thus, scientific research is crucial to enable possible problems to be anticipated and their effects minimised.

The regulator is currently undergoing significant evolution as it prepares for a new build programme. This is evidenced by it changing from being the 'Nuclear Installations Inspectorate' to the 'Office for Nuclear Regulation'. Having been a nation that pioneered nuclear energy, we have a diverse fleet of reactors. This has demanded a continuous regulatory focused R&D programme so consequently the Regulator is well exercised and able to address a new build programme while progressing life extension of the existing fleet. Post Fukushima there will be a greater international emphasis on safety and reliability. UK companies are at the forefront of developing and applying the required advanced engineering processes and methods to offer enhanced safety and security for plant world wide.

The existing UK fleet are mostly Advanced Gas Cooled reactors (AGR), an almost unique UK design. Near term reactors, for the new build programme, will be Pressurised Water Reactors (PWR), a variant of light water reactors. These are used by the majority of other nations, including France and the US. The UK has one PWR reactor, Sizewell B. Commissioned in 1988 it is our most recent reactor and right now the most recently commissioned power reactor in Europe. We are presently considering different PWR

designs for new build. Importantly for UK industry, reactor build is no longer the domain of a single company – build is an international multi-company venture and as such, UK companies will play a considerable role in the new build supply chain, irrespective of the name on the front of the building.

A major factor in why we have changed over to PWR design is the remarkable increases, over the past 20 years, in the capacity factors of PWR plant. Continuous incremental improvements in plant design and operation have resulted in the proportion of time during which the reactors are available to generate electricity (their capacity factor) increasing from around 70% to over 90%.

A second factor in the success of the PWR reactor is the increase in burn-up of their uranium dioxide nuclear fuel. In a nuclear reactor, uranium atoms undergo fission due to neutron irradiation – that is, atoms are split into two non-identical smaller atoms (fission products). This is accompanied by a significant release of energy and additional neutrons that maintain the (chain) reaction. Conventional fuel relies upon only one isotope of uranium (U-235) to sustain the fission reaction while another isotope (U-238), is slowly transmuted into plutonium (Pu-239), which then also undergoes fission. Eventually the initial U-235 is mostly used up and the fuel becomes inefficient and must be removed from the reactor – it is spent. Increasing the time over which the fuel is usefully generating energy provides an important economic incentive and burn-ups in light water reactors have been increasing steadily from 20 GWd/t in 1970 to over 50 GWd/t at present (10 GWd/t corresponds to approximately 1% of the uranium atoms being used up). While engineering solutions will increase burn-up further (helping to maintain nuclear as an economically attractive energy generation option) this will still mean that only a few per cent of the available uranium is being used. Dramatic increases are possible but require significant scientific advances.

One option that would consume over 70% of the uranium fuel atoms is to use fast reactor technology. In this case, the neutrons interact with the uranium and plutonium atoms with greater energy but the technology only works if the energy density within the core is even greater than in a PWR – about 4 times greater. This is an enormous challenge and an entirely different cooling technology is required (for example liquid sodium). In the UK we did build working fast reactors in the 1970s but the technical problems were too great to make this option economically competitive at that time. A further issue with this technology is that it requires the fuel to be recycled multiple times. That is, useful uranium and plutonium must be separated from the fission products. Such reprocessing technologies were still in their infancy at the time and the waste arising, due to the difficult chemical processes, caused major problems of their own. At the present time India is embarking on a major power generating fast reactor programme and Russia continues to operate fast reactors.

An alternative approach to fast reactors, which also utilises reprocessing, is to use the uranium and plutonium to fabricate new mixed-oxide (MOX) fuel that can be used in conventional PWR reactors. While a much less challenging technology, this would only improve the efficiency of uranium use by a few per cent. Again, the UK has reprocessed not only UK fuel but fuel from overseas reactors to produce MOX and exported it back to the country of origin (eg to Switzerland and Japan). It is not clear at this point if we will continue to offer this service but it has generated substantial revenue.

A final option is to employ the thorium fuel cycle. In this case the thorium isotope Th-232 undergoes transmutation to produce a lower isotope of uranium, U-233, which is able to undergo fission. There are a number of attractive points to this technology, including a greater abundance of thorium compared to uranium and the smaller inventory of very long-lived elements in the spent fuel. However, it does still produce as many fission products and a detailed understanding of how the fuel performs is lacking. Nevertheless, it is a technology that will undergo significant scientific investigation over the next decade and the UK could play an important part, with work presently being carried out, for example, at the National Nuclear Laboratory.

Returning to the diversity of UK nuclear plant, this means we are having to overcome some unique challenges in decommissioning resulting from our being a pioneer nuclear nation. Consequently the UK is already a world leader in decommissioning technologies with companies such as AMEC and SERCO now finding expanding international markets in which to apply their UK engineering experience. They are developing innovative solutions to problems that are arising first here in the UK but will certainly arise later in other countries.

Finally, UK universities are enjoying their own nuclear renaissance with Research Councils UK having increased funding of fission research to ~£50M. There can be no doubt that what attracts academics to nuclear energy research is the challenge of understanding those extreme radiation environments! Furthermore, as John Roberts describes in his article, UK universities are working hard to supply the graduates to fuel industry-based nuclear science and engineering. Much of this involves blurring the boundaries between academia and industry. For example, in collaboration with more than a dozen industries such as Rolls-Royce and Westinghouse, Manchester and Sheffield Universities are developing a Nuclear Advanced Manufacturing Research Centre. This aims to fast forward academic innovation into civil nuclear manufacturing.

In conclusion, the UK is in a good position to capitalise on its historic excellence and pioneering experience in nuclear science and engineering. We have a diverse set of legacy activities that require our companies to innovate and they are integral to the supply chain delivering new highly efficient reactors. Our regulator is internationally respected and we have a rapidly expanding university sector. Nuclear energy has been part of the UK science and engineering identity for nearly 60 years. It is entering an exciting new phase that offers numerous national and international opportunities for industry and academia alike.

NUCLEAR EDUCATION IN THE UK: IS IT RESPONDING TO THE HUMAN RESOURCE REQUIREMENTS?

Dr John Roberts
Dalton Nuclear Institute, The University of Manchester

As of July 1st 2011, following the closure of one of the two reactors at Oldbury, the UK has 18 nuclear reactors at 10 sites producing electricity to the grid. To support the operations at these sites the UK also has fuel enrichment and fabrication facilities along with reprocessing capability at the Sellafield site. Decommissioning is also taking place at 10 sites. Taking account of all these activities the nuclear industry in the UK currently employs around 44,000 people[1].

The government target[2] for maintaining nuclear energy on the grid is to have at least 25 GW of new supply by 2025. This entails at least one reactor being built on land near each of eight existing reactor sites:

Hinkley Point, Sizewell, Heysham, Hartlepool and Bradwell - owned by EDF Energy

Yr Wylfa and Oldbury – owned by Horizon Nuclear Power a consortium of EoN and RWE

Sellafield – owned by NuGeneration, a consortium of Iberdrola, GDF Suez and Scottish and Southern Electricity.

The Committee on Radioactive Waste Management recommendations for the final disposal of the UK's civilian higher levels of radioactive waste were accepted by the Government in 2006. This will entail the construction of an underground geological disposal facility (GDF) with site investigations due to commence in five years, if a volunteer host community can be identified, followed in twenty years by the construction of the GDF.

Together the three areas of decommissioning, new build and geological disposal will require a new generation of nuclear engineers and scientists. The UK nuclear workforce also has an older average age than the UK workforce as well as a greater percentage retiring over the next 15 years[1]. To meet these demands the UK universities with nuclear expertise have developed new undergraduate, postgraduate taught and postgraduate research programmes. Ten years ago the situation was not as healthy, a report commissioned by the Health and Safety Executive[3] stated "if nuclear education were a patient in a hospital it would be in intensive care". It suggested that "immediate action is needed; otherwise nuclear education will slowly disappear" and recommended that "the focus of nuclear education should be on postgraduate courses".

Some nuclear postgraduate courses, such as those at the Universities of Birmingham, Surrey and Liverpool had survived the downturn in student numbers which followed the "dash for gas" in the 1990s but the majority of nuclear expertise had declined to just individuals at the Universities rather than major research groups[3]. To deliver nuclear postgraduate education in the 21st century a consortium approach was required, and so the Nuclear Technology Education Consortium (NTEC) was formed in 2004. NTEC originally consisted of 11 Higher Education Institutes and organisations:

- University of Manchester
- University of Sheffield
- Imperial College London
- University of Liverpool
- University of Leeds
- University of Birmingham
- City University
- Lancaster University
- University of Highlands and Islands Millennium Institute
- Westlakes Research Institute
- Defence Academy, College of Management and Technology

with the University of Central Lancashire joining in 2009. The consortium brought together the nuclear experts to provide 21 different possible Master level modules in one programme. Another significant advantage of the NTEC programme was due to it being a totally new programme it could be designed to accommodate full-time or part-time students. Through discussions with industry partners, who still meet twice yearly as an External Advisory Board, NTEC is delivered in a "short-fat" format rather than day release as this was the preferred model for industry. The modules are all delivered in Monday-Friday blocks rather than day-release. This allows students to have the level of interaction with the programme that is appropriate for their needs, from Continual Professional Development (CPD), postgraduate certificate or diploma or a full MSc in Nuclear Science and Technology, see figure 1. The full MSc can be taken as a full-time programme over one year or part-time over three years.

Bringing together so many universities allows NTEC to provide a unique breadth to the course content with 22 modules now being offered with successful completion of 8 modules being required for a full MSc. This allows the students to tailor the content specifically to their personal needs, whether it is more focused on nuclear technology for the new build programme,

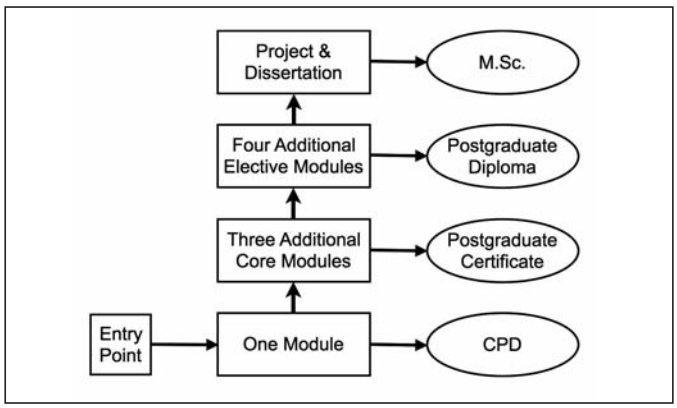


Figure 1. NTEC Programme Structure

or on decommissioning, rather than a one fit for all approach. Consistent with the integration of the programme with industry the MSc students are encouraged to undertake their Masters project within industry, which has led to an excellent track record of the project students being employed by the sponsoring company on completion of their project. In 2011 NTEC is now a mature programme with student numbers increasing year on year. A key feature of the programme, which has enabled the student numbers to grow, is that the most popular modules have been converted for Distance Learning. This has allowed students from outside the UK to access the course, providing they have the required security clearance, as well as increasing the number of part-time students that are already part of the nuclear industry, or want to re-train to become part of the nuclear industry.

The success of NTEC has shown the renewed student interest in university nuclear courses and this has enabled universities to develop more traditional undergraduate and postgraduate courses. Lancaster University was the first in 2006 with an undergraduate MEng programme in Nuclear Engineering. Imperial College London and the Universities of Manchester and Leeds have developed "and/with Nuclear Engineering" undergraduate courses which allow Mechanical and Chemical Engineers and Material Scientists to have 25% nuclear content in their courses, which can ideally prepare them to be Mechanical or Chemical Engineers or Material Scientists in the nuclear industry. The Physics departments at the Universities of Liverpool, the West of Scotland and Nottingham Trent have developed Physics with Nuclear Technology undergraduate degrees. Full-time one year nuclear masters have been developed by Imperial College London and the University of Cambridge, a testament to the demand now being seen for nuclear courses.

Despite the Engineering and Physical Sciences Research Council (EPSRC) decision to stop the funding of any Masters programmes they are increasing their support for nuclear research and in particular their support for PhD students. Two PhD programmes led by The University of Manchester are training over 20 students every year. The Fission Doctoral Training Centre (DTC) has a traditional approach to the research content but provides additional support to the students by adopting a cohort approach to recruitment and training. A cohort of at least ten students is recruited annually to start at the same time. In the first year they have comprehensive postgraduate training and the opportunity to experience different research topics before deciding on their PhD for the final three years. This allows the PhD to establish the same level of networking and support normally only available for taught undergraduate or postgraduate courses.

The Nuclear Industrial Doctoral Centre (led by the University in Manchester in partnership with Imperial College London) has a radically different approach to PhD level training with the "research engineers" carrying out their research primarily in industry with a project of direct relevance to the sponsoring company. This, again, is an excellent example of how nuclear universities and the nuclear industry are working together, not in isolation, in response to the human resource requirements as new nuclear developments take place in the UK.

To maintain the student numbers it is vital that schools, schoolchildren and teachers are engaged. Some examples of this at The University of Manchester include:

- The EPSRC is funding the development of supporting material for the nuclear content of the school curriculum. This is enabling university material to be converted for schools to use in the classroom.
- The Smallpeice Trust, Urenco and the National Nuclear Laboratory are supporting an annual residential course at The University of Manchester for 50 14-16 year olds who are interested in a career in the nuclear industry.
- Supported by the Nuclear Institute the Universities of Manchester, Liverpool and York provide an annual training day on nuclear technologies for schoolteachers.

New web-based developments to support the nuclear universities programme include Nuclear Liaison (www.nuclearliaison.com) and NLTV (www.nltv.co.uk). Nuclear Liaison has been set up to list all the nuclear courses at UK universities along with a Directory of all the nuclear experts at UK universities. This allows prospective students, or universities and industry that are interested in collaboration, to find out all the information on UK nuclear universities in one place. It also provides industry contacts for students that are looking for summer placements or graduate training schemes within the nuclear industry. NLTV has taken this one step further with the introduction of recorded lectures that can be viewed online. This allows a greater dissemination of the information as well as providing a record of the event for knowledge management purposes.

The nuclear universities and nuclear education has come a long way in the last ten years and is now a thriving part of university education in 2011. A key aspect of the continuation of this success is that many of the newly qualified students have already registered as STEM Ambassadors. They are visiting schools to encourage the next generation of school children that the nuclear industry in the UK will provide them with a challenging, stimulating and long lasting career.

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CHERNOBYL 25 YEARS ON, A POLICEMAN'S VIEW

John Slater BSc FRSA MIoD

The catastrophe at the Chernobyl nuclear power plant on 26th April 1986 was no accident. It was a direct result of human error; as such it was completely avoidable and was the consequence of bureaucrats, civil servants and politicians ignoring sound professional and technical advice given by very competent and highly qualified scientists and engineers.

The technical details of what happened are readily available on the internet (Google Chernobyl). This article looks at why it happened and the potential lessons that need to be learned. It is my opinion that, had the professional advice given been heeded, the plant would still be running safely today and for many years to come.

As a retired Scotland Yard Chief Superintendent I was working as a consultant to the Interior Minister of Ukraine in 2009. I was working with the Police and State Security and was given the opportunity to visit the entire Chernobyl site and to talk to people present on the day of the catastrophe and to people currently involved. I was also given access to information by the State Security. I have no means to verify what I was told and shown but I believe it to be true.

There is a 30Km exclusion zone around the Chernobyl power plant. Almost everyone who lived within it has been evacuated, though one elderly couple refused to leave their home and continue to survive with no obvious ill effects. There is then a police manned cordon at 5Km, access on a needs only basis, then finally a 1Km cordon where access is on a timed basis and each entrant carries a Geiger counter to measure the dosage of radiation they have received. Even 25 years on, the longest one can stay safely is about 45 minutes a day. Interestingly, the wild life within the 30Km zone has really flourished, yet within the 1Km zone, there is an eerie silence; no bird song, no sound of insects, no other animals. At Pripyat, the nearest town to the power plant, there is a funfair completely silent and rusting. In a car park there are Soviet tanks, too radioactive to be used. The power plant was deliberately built alongside a river, to provide a water supply. The bridge over the river is so radioactive it has a 20kph minimum speed limit and the fish in the river are worryingly large. I watched one eat a loaf of bread in one mouthful.

Discussions with those involved then and now revealed five major bad decisions by the bureaucrats, civil servants and politicians in charge. The cost of these runs to many billions and thousands of lives. Bear in mind that at the time this was part of the Soviet Union and no one dared disobey an edict of the Supreme Soviet.

Four nuclear power stations were built at the Chernobyl site, scheduled to be up and running by 1st December 1985. This date is the official start of winter and the power demands would increase noticeably as public buildings were then heated. There was a small amount of slippage and, though finished, the safety systems had not been tested. Against the advice of the scientists and engineers, the Supreme Soviet directed that all four power stations would start generating immediately and the safety systems would be tested at a later date. (Bad decision 1). There was no appreciation or acceptance of the fact that nuclear power stations cannot be simply switched on and off.

Eventually it was agreed that any test should wait until the winter was over, however, the civil servants were adamant that a safety test had to happen despite all the warnings from the experts. They conceded that only one of the four plants needed to be tested but ignored the complication and dangers of disabling fail-safe circuits that were designed to react in fractions of a second. (Bad decision 2).

The tests were scheduled to take place on 25th April 1986 at 11am. The experts were nervous as they had no experience of trying to turn off a reactor and all its fail-safe devices. They moved the best technicians and engineers from other shifts to ensure they had the most skilful team. At 10am the Supreme Soviet sent an edict saying that as a large coal power station in Belarus was not working, the test was postponed until 11pm that same day, (when some of the least experienced staff would now be on duty). (Bad decision 3). Despite protestations from the experts, this decision was non-negotiable.

The rest is history, though the death toll need not have been so high. When the fire brigade arrived they checked for radiation. The Geiger counter showed zero. They did not know this was because the levels were 100 times the maximum of their machine. Four hours later, a military Geiger counter was produced and it showed radiation levels from 1 to 6 Sievert (6 is normally fatal). By then it was too late for over 350 firemen. The evacuation of residents was delayed for many hours as policy dictated that Soviet citizens could not be

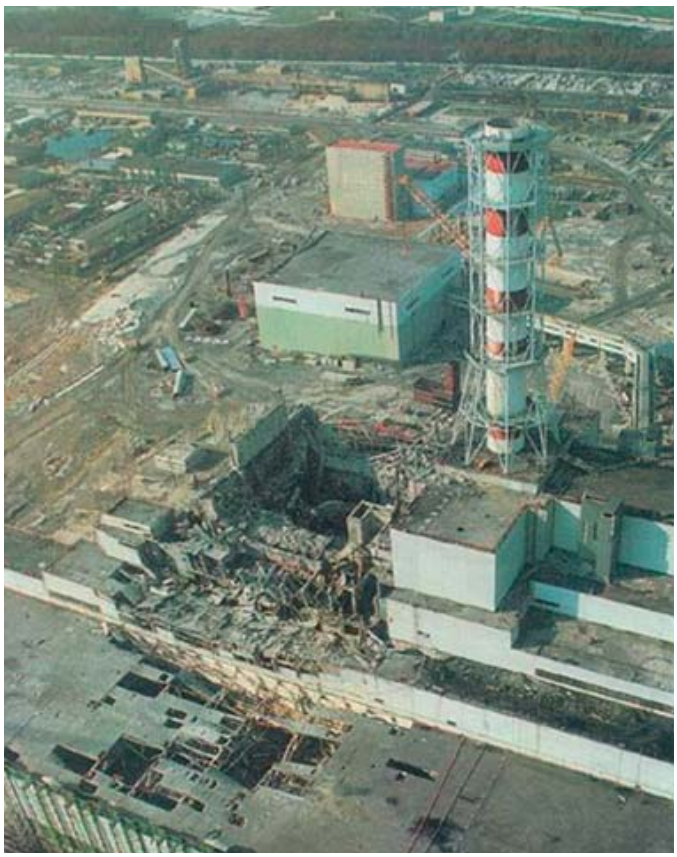


Fig 1 An aerial view of the Chernobyl nuclear power plant, shortly after the disaster in April 1986, which released about 400 times more radiation than the U.S. atomic bomb dropped over Hiroshima

moved until accommodation for them had been identified. So, sadly, the evacuation of the residents of Pripyat and the city of Chernobyl did not start until 2pm on 27th. Many deaths from radiation and subsequent cancers could have been avoided if bureaucrats had listened to and acted upon the expert advice of scientists. (Bad decision 4).

During the evacuation of citizens, they were told they could not take any metal objects with them and were scanned before being allowed on the bus. Many ran home to leave watches and jewellery on the kitchen table before hurrying back to catch the bus. Within 3 months looters had ransacked thousands of these homes and stolen a small fortune of radioactive watches and jewellery. Most of this found its way to the street markets of London, Paris and other major cities of Europe where now there are unsuspecting purchasers with unexpected skin cancer. It is of little consolation to them that no doubt many of the thieves have suffered as a result of the radiation they received.

Unbelievably, the Supreme Soviet directed that the remaining 3 power stations would continue to operate, despite each being within 500 metres of the catastrophe. They remained fully staffed and ran for a further 10 years. Many of the staff have suffered the effects of radiation related illness and death (Bad decision 5). This was despite the advice of scientists and doctors.

The core of the reactor was so hot it melted down through the ground some considerable distance. I was given conflicting information as to whether it had now cooled or was still hot and moving. Those who believed it was still hot expressed concern that it was heading towards aquifers and if it reached them (estimated around 2020) then the resultant super-heated steam might blow the core back out and send masses of radioactive dust into the atmosphere in a repeat performance of 1986.

I am inclined to believe this version, as thousands of tons of concrete have been poured down the hole and placed on top; then recently work has begun on fitting an enormous steel canopy over the top. Why do this if the core has cooled?

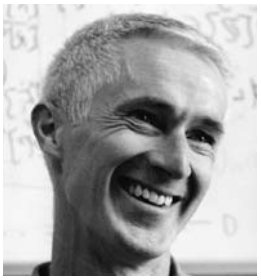
In conclusion, I believe that, despite being the worst nuclear catastrophe to date, Chernobyl should not be quoted as similar to those of 3 Mile Island, (which was the consequence of faulty machinery and poor fail-safe equipment), or more recently in Japan, (which was the result of underestimating the effects of the elements or 'Acts of God'). Chernobyl was no accident or equipment failure, it was the direct result of bad decisions by people in authority who were arrogant and should have known better. As such it was completely avoidable. The advice they were given was accurate, of high quality and based on scientific fact – it would be the same today. To ignore it on the basis of some political need will not make the facts go away; the resultant outcome proved this.

Fig 2 Memorial to the over 350 Firemen exposed to radiation levels ranging from 1 to 6 Sievert at Chernobyl (6 is normally fatal)

Fig 3 Bumper cars in a funfair at Pripyat, the nearest town to the power plant

Fig 4 Radioactive railway bridge with a minimum speed limit of 20kph

MATHEMATICS TODAY



Ken Brown
Professor of Mathematics,
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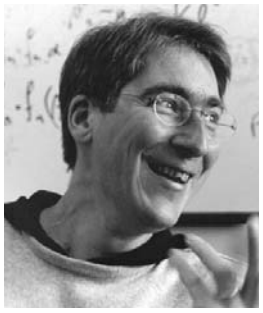

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Mathematics and Its Applications

Faces of Mathematics.
Photographer: Marc Atkins

British mathematics has a stunning history, spanning at least 400 years. To understand the motion of the planets, Isaac Newton developed the mathematical tools that are still used to describe the motion of almost anything.

In the 1860s James Clerk Maxwell wrote down the relativistic equations of light and radio waves, anticipating aspects of Einstein's theory by twenty years. R A Fisher developed the mathematical theory of statistics in its modern form almost single-handedly in the 1920s whilst working at the Rothamsted Experimental Station; and Alan Turing used mathematics to decode the German enigma machines in the 1940s, developing the first computers in the process. In 1994, more than three hundred and fifty years after the problem was first posed, Andrew Wiles proved Fermat's Last Theorem; Wiles will return from the US to a post at Oxford later this year.

To assess the state of current mathematical science, the Engineering and Physical Sciences Research Council (EPSRC) commissions regular reports from international experts. The International Review of Mathematical Sciences 2010 (IRMS 2010)[1], was published this Easter, the first report since 2004. Its conclusion is that 'UK mathematical sciences research is world-leading in some fields, outstanding in many others and strong overall'. The Executive Summary (p iv) adds

"Two major factors that contribute to the present excellence of the UK academic mathematical sciences enterprise are its diversity – in area, group size and size of institution – and its geographically distributed nature."

The report goes on to examine both the activity and the processes involved in mathematical research in the UK. Its publication provides an excellent opportunity for the UK mathematics community to reflect on recent achievements and frame future prospects.

Publication of the IRMS report coincides with far-reaching and controversial changes in research funding policy signalled by the EPSRC's 'Shaping Capability' agenda[2]. The Research Council intends to take a more proactive role in commissioning and sponsoring research, identifying research areas for growth and special support, rather than simply supporting excellence as advised by academic and industrial experts. In what follows we shall try to explain how and why the mathematical sciences must exercise central roles in the culture and the economy of any successful modern society; and we shall also aim to show why EPSRC's current strategy risks making these roles unsustainable for UK mathematical science.

It is hard to overstate the importance and the ubiquity of mathematics. The IRMS 2010 expresses it well (again from the Executive Summary),

"the mathematical sciences provide a universal language for expressing abstractions in science, engineering, industry and medicine; mathematical ideas, even the most theoretical, can be useful or enlightening in unexpected ways, sometimes several decades after their appearance; the mathematical sciences play a central role in solving problems from every imaginable application domain; and, because of the unity of the mathematical sciences, advances in every sub-area enrich the entire field."

However, mathematical science is also a hugely important discipline in its own right, with its own culture and intellectual imperatives, its own history over millennia, and its own 'Grand Challenges'. It is important to see mathematics in its entirety and not be distracted by the crude and misleading distinction between theory and applications, often expressed as 'pure' versus 'applied' mathematics.

Misled by its daily usefulness, we might see mathematical science as a stagnant well of techniques from which one can ladle out exactly what is needed to deal with a given problem. This is far from the truth. The "right" mathematics may be languishing in obscurity, having been developed many years earlier; or it may be in a field with no apparent connection with the matter at hand; or it may well not yet have been discovered.

Many examples can be given of each of these cases. For example, the medical imaging techniques used every day in every hospital in the land depend crucially on abstract mathematical analysis of the early 20th century; and the "matrix formulation of

quantum mechanics", developed in the late 1920s, hinged on the then very obscure – but now school-level – matrix algebra, studied by English algebraists 60 years earlier. Of course quantum mechanics itself was in the 1920s regarded as completely useless, but now underpins our digital universe. A problem we still do not know how to approach is that of extracting the important information hidden in huge data sets. This is one of the key challenges for genomic biology, and statisticians are currently making important advances in developing new methodology to address it.

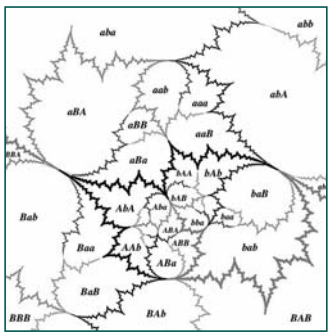
The well and ladle metaphor is grossly misleading in a second way: it wrongly suggests that those working on applications don't themselves produce fundamental mathematics. In fact the reverse is the case. Newton's discovery of the calculus is of course the first and greatest of many British examples. This age-old interchange between mathematical science and physics continues undiminished today: stemming from the pioneering work of Sir Michael Atiyah and his students, the UK has been a world leader for 50 years in the convergence of parts of physics with the 'purest' reaches of algebra, geometry and topology.

Mathematics doesn't just solve problems it provides insights which can lead to more far-reaching advances. In the 1990s Frank Kelly (University of Cambridge), worked on BT's new routing architecture where a major issue is how to deal with blockages in the network. The natural 'technological' solution is to have full knowledge of the state of the system and compute the most efficient route from the blocked point. Kelly showed that the far simpler and more robust method of sending the call to a nearby node at random and then taking the standard route from there was almost as efficient, far cheaper to implement, and far less likely to malfunction. This insight, that a less sophisticated, simple solution can be almost as good and far cheaper than a technically perfect solution, is now a recognised design feature of networks.

The intricate interdependence of fundamental mathematical science and application makes it very hard to steer mathematical research in any meaningful way. This doesn't mean that we shouldn't try, but it does suggest that the best compass to use may be one which seeks out the highest quality and the most promising directions, in each particular field. Mathematicians and statisticians should continue to put huge efforts into seeking solutions to society's challenges, but the health of the core discipline is a vital feature of a country's mathematical research framework.

It could be argued that given the severity of the current economic crisis we should leave fundamental research to other countries and focus on the applications. This is to misunderstand the nature of mathematical research: core and applied mathematics are inextricably interlinked and, as we've tried to show, to spot the right mathematics for a given application requires immersion in the well and can't simply be done by wielding a ladle from above. Moreover, it often happens that deep understanding of the mathematical science actually generates the application. A famous example is the Pagerank algorithm at the heart of Google, which relies on the same matrix algebra that was crucial for quantum mechanics.

How do people actually *do*

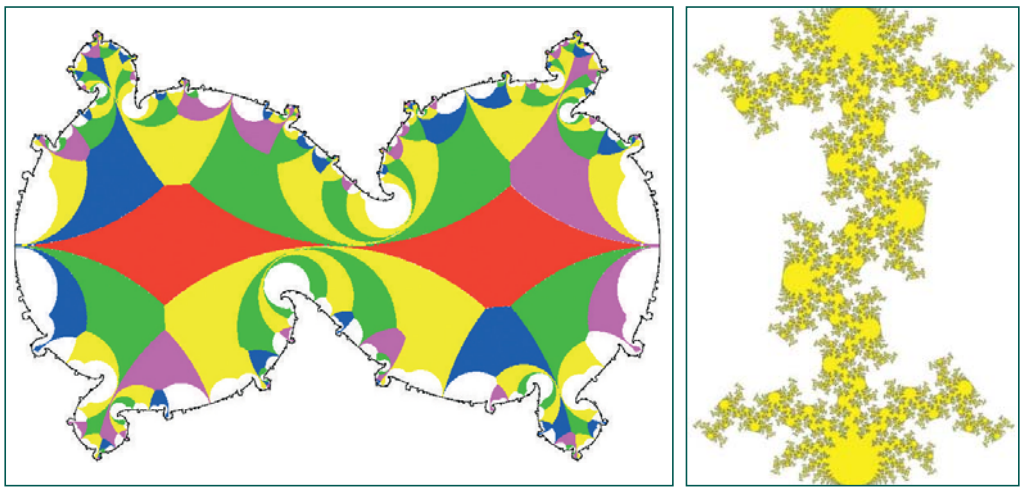


research in mathematics? The answer, typically, is: by reading a bit, perhaps talking to colleagues and students (both down the corridor and across the planet), and by thinking a lot. Consequently, the working research mathematician's requirements are relatively few – good internet access, a quiet and warm place to work, and plenty of time and coffee! Except in some cases involving large interdisciplinary activity, what she or he *doesn't* usually need is a big team working on the same problems in the same place, or expensive equipment. These factors make it easy to achieve the diversity and geographic distribution highlighted as virtues by the IRMS 2010. They also ensure that UK mathematical scientists are well positioned, in terms both of geography and subject coverage, for the absolutely crucial task of teaching undergraduate and postgraduate students.

In both teaching and research UK mathematics is a large activity: 1129 international-level mathematical scientists (FTE) were submitted to the last research assessment exercise compared with 729 in physics and 957 in chemistry[3]. The dual funding (Funding Council/ RCUK) support for UK universities means that research and teaching are linked, so that students taking degrees in mathematical science have the opportunity to see the subject as the living, developing discipline that it is. And it's an opportunity which more and more students are taking: there were 5475 graduating students in mathematical science in the UK in 2007-8, almost as many as chemistry (2965) and physics (2765) combined. The figure for graduate mathematicians has been steadily rising for over a decade now: in 2000 it was 3500[4].

Mathematics graduates are employed in banking, medicine, pharmaceuticals, manufacturing, communications and other advanced technology, teaching, government departments, actuarial and accountancy as well as going into business for themselves. Mathematics is rightly seen as a challenging degree by employers and valued for its transferable skills; indeed postgraduate mathematical scientists have the highest average starting salary among all UK holders of postgraduate degrees[5]. This crucial contribution to the country's economy is only possible by virtue of the wide distribution of research excellence which ensures that mathematics research and teaching is accessible throughout the country.

So much for the scale of the enterprise, but what about diversity and quality? Given the size of the mathematics research community it is not surprising that most areas of the discipline are represented within the UK. British-based mathematical scientists are pioneering world-class work in fields as diverse as models of cancer growth and properties of sequences of prime numbers. They are involved in applications ranging from the analysis of option pricing to the assessment of medical procedures. And their excellence is recognised up to the very highest level: six UK mathematicians hold Fields Medals[6]. This is officially known



With minimal input, these intricately beautiful computer generated fractal graphics are made by repeating simple geometrical operations many times. Behind them lie deep mathematical discoveries of recent years. Reproduced with permission from Indra's Pearls, copyright Cambridge University Press.

as the International Medal for Outstanding Discoveries in Mathematics, but unofficially as the 'Nobel Prize for mathematics'. Two or three of these are awarded once every four years, for work done before the age of forty.

British mathematical science wins financial backing not only from the HE Funding Councils and from the Research Councils, but from European agencies, from charities, from government and industry, and from many outside bodies. To give just one recent and very notable example: the Oxford Centre for Collaborative Applied Mathematics[7] (OCCAM) has been created with £20m backing from the King Abdullah University of Science and Technology (Saudi Arabia).

Inevitably there is room for improvement. The IRMS 2010 criticises the UK for the poor representation of women in mathematics, and also points out that the brevity of UK doctoral training compared with mainland Europe and the US can put young UK mathematicians at a disadvantage compared to their international peers. Both these are points the community and the universities are addressing, but, particularly in the case of women in mathematics, there is some way to go.

Despite the best efforts of people such as Marcus du Sautoy and Ian Stewart, we could do better in telling the public about the excitement and applicability of mathematics – sites such as the excellent Mathematics Matters[8] of the Institute of Mathematics and its Applications point the way here.

Although mathematics is relatively cheap compared with experimental science, 'cheap' does not mean 'free' – money is badly needed to maintain and widen the pipeline for fresh talent, from PhD training through to postdoctoral fellowships and beyond. Research grant support for established mathematical scientists gives them essential opportunities to interact on a global stage with their peers, and provides vital periods of uninterrupted time for research.

A crucial and more subtle point about research council support is often missed – namely, there are unintended negative consequences of low and reducing levels of funding, beyond the straightforward loss of support for current research. University administrations, under pressure to maximise external funding, are increasingly reluctant to make new appointments in fields where research council support is low, so that, over time, the geographic and subject diversity highlighted above will be threatened.

We share the widespread fear that the future of UK mathematical sciences is under threat. The research grant commitment of the EPSRC Mathematics Programme has been in decline since 2007-8, at a time when funding for other disciplines in EPSRC's portfolio was still increasing. At a modest £12m, it was the same in cash terms in 2009-10 as it had been in 2003-4. Over this same period the total EPSRC research grant commitment increased from £378m to £459m, the latter figure including £88m for physical sciences and £72m for ICT[9]. It is in this already very challenging landscape that the EPSRC is now rushing through its ill-considered 'shaping capability' agenda.

This agenda is being implemented before the mathematics community has been properly consulted. It places strategic decisions in the hands of administrators, with priorities such as the centralisation of research that do not necessarily fit the mathematics landscape. There is a real danger that the geographically distributed excellence in UK mathematical science, developed over many years with the support of HEFCE and the research councils, is about to be seriously diminished.

Acknowledgements: We are grateful to colleagues on the Council for Mathematical Sciences for comments and suggestions that have been incorporated into this article.

1 The IRMS 2010 Report can be downloaded at www.epsrc.ac.uk/newsevents/pubs/corporate/intrevs/2010maths/

2 Details of the EPSRC Shaping Capability Policy are at www.epsrc.ac.uk/plans/implementingdeliveryplan/goals/shapingcapability/
Council of Mathematical Sciences (CMS) responses are at www.cms.ac.uk/submissions.html

3 Figures obtained by multiplying the percentage of outputs in quality bands 3* and 4* by the number of academic staff in each RAE submission, and summing over all submissions.

4 Figures from HESA; see www.iop.org

5 Adrian Smith's report One Step Beyond: Making the most of postgraduate education, p. 94 (March 2010)

6 Atiyah, Baker, Borcherds (based in the US), Donaldson, Gowers and Roth.

7 www.maths.ox.ac.uk/groups/occam

8 www.ima.org.uk/i_love_maths/mathematics_matters.cfm

9 Taken from Table 3 of CMS submission to House of Commons Select Committee inquiry on the Spending Review 2010, www.cms.ac.uk/submissions.html
Assembled from tables in EPSRC Annual Reports

RUSSIA AND THE UK BRING STATUE OF YURI GAGARIN TO LONDON

A statue of Yuri Gagarin, the first man in space, was unveiled outside the British Council's London headquarters in the Mall on 14th July 2011 to mark the 50th anniversary of the first manned space flight. The statue, a gift from the Russian Space Agency (Roscosmos) to the British Council, will stand in the Mall for a period of 12 months. It was unveiled by HRH Prince Michael of Kent and Elena Gagarina, the cosmonaut's daughter and Director of the Kremlin Museums, exactly fifty years to the day that Yuri Gagarin met with the Queen as part of his visit to the UK in 1961.

Elena Gagarina said that she was very proud to be unveiling a statue to her father in a city that had welcomed him so warmly 50 years ago; and David Willetts, Minister for Universities and Science, said that the statue is a fitting memorial to a true pioneer of our time, and also serves as an emblem to the greater collaboration with the Russian space agency agreed during his visit to Moscow earlier this year.

Yuri Gagarin was 27 when he journeyed into space on board Vostok 1. His space capsule travelled at a speed of 27,400 kilometres per hour, and orbited the earth in 108 minutes. On landing, he became the most famous man on earth. This statue, showing Gagarin standing on a globe in his space suit, focuses on the human aspect of the extraordinary scientific achievements of the Russian space programme. The statue was commissioned in 1984 by the small town of Lyubertsy, just outside Moscow, where Gagarin trained as a foundry worker from the ages of 15-16. Made by Anatoly Novikov, one of the chief sculptors of the Stalingrad Memorial (now the Volgograd Memorial), it was commissioned to commemorate what would have been Gagarin's 50th birthday (he died in a plane crash aged 34) and is today a site of pilgrimage for cosmonauts before they travel into space. The version in London is an exhibition copy of the original.

Gagarin and the Prime Minister, Harold MacMillan, 13 July 1961
Courtesy of RIA Novosti

On the bus to the launch pad, Gagarin with his back up pilot, Gherman Titov, 12 April 1961
Courtesy of RIA Novosti

Elena Gagarina daughter of Yuri Gagarin, and Helen Sharman, Britain's first astronaut, in front of the statue of Yuri Gagarin

The statue is the culmination of a year of planning by Roscosmos and the British Council and is just one example of the British Council's work to strengthen the relationship with Russia through education, English and the arts. Others who attended the unveiling ceremony included Helen Sharman, Britain's first astronaut. In addition to the statue, the British Council is showing an exhibition, entitled "Gagarin in Britain", in its London headquarters on the life of Gagarin and the early Soviet space programme. It is also publishing a catalogue to mark the occasion.

PARLIAMENTARY LINKS DAY - TUESDAY 28 JUNE 2011

GLOBAL CHALLENGES – SOLUTIONS FROM SCIENCE

Parliamentary Links Day is the largest scientific event held annually at the Houses of Parliament. Organised by the Royal Society of Chemistry, it also involves the active participation of sister societies including the Society of Biology, Royal Academy of Engineering, Geological Society, Institute of Physics, the Royal Society, the Campaign for Science and Engineering, the Royal Astronomical Society, the Council for Mathematical Sciences, and many other scientific organisations. This year's Links Day coincided with the United Nations designated International Year of Chemistry 2011 (TYC 2011) which was launched at the House in January this year and the audience was present by invitation of Andrew Miller MP, Mark Lancaster TD MP and Dr Julian Huppert MP, who jointly chaired the event.

Following a welcome from the Rt Hon John Bercow MP, Speaker of the House of Commons, the programme of addresses and scientific presentations was introduced by **Professor David Phillips OBE FRSC, President Royal Society of Chemistry:** This year we celebrate the 100th anniversary of Marie Curie's second Nobel Prize, in this case for Chemistry in 1911, for the discovery of radium and polonium, and the isolation and study of radium's remarkable properties. Her radiochemical research also led her to improve humankind's life through use of portable radiography units that emanated X-rays to examine for shrapnel and broken bones in World War I. We also celebrate Dorothy Hodgkin, the only British female Nobel Laureate. However, many more women are needed in Science. It is very important to inspire young people sufficiently to encourage them to study chemistry using opportunities such as the water test, for example.

Summaries of the presentations follow.

Professor Lorna Casselton FRS, Foreign Secretary and Vice President of the Royal Society

The Royal Society post of Foreign Secretary was established in 1728 before the government had one. The need and importance was emphasised, for more practical skills to be introduced, especially into universities in Africa, in order to help address their current social and economic requirements by using better technology at the operational level. Policy makers and scientists are also being brought together for discussions under the banner on "People and the Planet".

Dr Shaun Fitzgerald, The Royal Academy of Engineering

Work at the Royal Academy of Engineering has focused on the challenge of energy supply. Fossil fuels are here to stay but their usage will increase. We need to re-consider the manner in which 40% of the energy supply is currently consumed in buildings. Well-insulated buildings with self-ventilation using fresh air would help reduce energy demand.

Dr Mark Downs, Chief Executive of the Society of Biology

Biology plays a critical role in many areas required to meet global challenges. These include Climate Change, Food security, International Trade agreements, Border Security, Criminal Justice, Forensic Science, Diabetes and Diet. Education and training are also very important aspects of the work of the Society.

Dr Bryan Lovell OBE, President of the Geological Society

Climate change is a defining issue of our time, the full understanding of which requires the long perspective offered by geology. Earth scientists can read in detail the geological record of changes in climate that occurred long before we were around to light so much as a camp fire, let alone burn coal, gas and oil. A dramatic global warming event that took place 55 million years ago gives us a particularly clear indication of what happens when there is a sudden release of a billion or more tonnes of carbon into Earth's atmosphere. It gets hot, the seas become more acid and less oxygenated, and there is extinction of life to such an extent that new boundaries are established in the geological record. We are at least a quarter of the way to repeating that ancient natural input of carbon at 55 Ma through our own agency, prospectively establishing a new geological epoch – the Anthropocene. Still worse, we are dumping carbon even more rapidly than happened at 55 million years ago. The increasingly clear message from the rocks to us all is that it would be a good idea to stop pulling that carbon trigger. The message from the rocks to the oil and coal industries is that they are particularly challenged by carbon. The oil industry can respond by playing a key role during the transition to a low-carbon economy, storing carbon safely underground once we've had the use of it. That role can only be played within a regulatory framework that establishes a fungible price for carbon. National leaders can now be convinced of the need for action by the geological evidence: you can't argue with a rock.

Iwan Roberts, Ashok Kumar Fellow, Institution of Chemical Engineers

Ashok Kumar, both an MP and a chemical engineer, who died suddenly, is remembered in

this Fellowship. How does chemical engineering work? The proactive way involves production of data leading to development of new technologies and ultimately new products. The reactive way is exemplified by the releases of contaminated red mud in Hungary which required help from the UK involving Sir John Beddington and Philip Greenish of the RAE. Chemical engineering is on the skills shortage list and graduates are encouraged to work in this area.

Chi Onwurah MP, Shadow Minister for Innovation and Science

In order to help resolve global challenges, the best way is to go to Parliament. Science and politics need to work well together. Newcastle punches above its weight with an outstanding range of scientific activities. These advantages would be challenged by cuts to research. A less prosperous future is threatening hence the need for a public-private partnership. There is a three year funding plan in UK, but a more strategic 10 year plan in China. The Haldane Principle creates the right environment for innovation. Fundamental research is important and Science, Engineering and Business must all be linked together. Direct Government funding for research is required, and there is a need to place science at the heart of the economy and culture.

Andrew Miller MP, Chair of the Commons Science & Technology Committee

Following the General Election, the reformed S&T Select Committee have tackled a broad range of STEM-related topics. Seven reports have been published and more are on the way. The work commenced with an investigation and evaluation of criticisms made of the professional integrity of scientists at the University of East Anglia affected by the hacking of emails related to climate change. This was followed by an assessment of the UK's need for Technology Innovation Centres (TICs) as a national facility essential for promoting industrial and economic regeneration. A review of science advice available to Government in emergencies considered swine flu, cybercrime, solar storms and volcanic eruptions, followed by a review of particle physics and astronomy. The supply of strategic metals, as the title suggests, is very important to industry. The reasons for and likely impacts of a move by the MRC (Mill Hill) to a UCL site at St Pancras to create the UKCMRI, were examined. The Forensic Science Service, Peer Review of Scientific Publications and the urgent need for more Practical Hands-On Science and Fieldwork in Schools complete the current picture.

Rt Hon David Willetts MP, Minister of State for Universities and Science

A message from the Prime Minister was presented in which he expressed his regret that he was unable to attend this important event. He congratulated the Royal Society of Chemistry on the relevance of the themes presented and their timing, with their emphasis on climate change, food and water security, science policy, and the urgent need for the training of a new generation of scientists, and the vitally important maintenance and development of bridges between Parliament, Government and Science. Evidence was provided to Treasury in support of the £4.6B ring-fenced expenditure budget, plus an extra £100m capital. Other matters have been supported including the legal rights of scientists when presenting scientific data for public scrutiny.

Visits have been made to all BRIC Countries who have expressed their respect for British science which appears to be highly regarded worldwide, especially in universities. They are seeking opportunities for collaboration and practical ways to strengthen their ties through such organisations as the British Chamber of Commerce and the publication of jointly authored articles in high profile scientific journals. This is especially noted in Brazil, for example, where the UK science has a very high impact. Many countries are still not yet familiar with the Haldane Principle and its implications for politicians responsible for science budgets. Some countries are unaware that UK politicians, even Ministers of State, are therefore not expected to assume responsibility for signing binding agreements on international collaborative scientific research and have only a limited role in directing and agreeing to such objectives made on behalf of scientists. Indeed that is one of the reasons why UK science, managed by peer review, is held in such high regard internationally. Challenges emerging from China involve the clear recognition by them that ocean acidification arising from coal burning, especially in China, results in a significant impact on oceanic chemistry. Does this require a response from the UK? The good news however is the realisation that understanding and cooperation must be undertaken among and between scientists and not at the political level.

Professor David Cope, Director of the Parliamentary Office of Science and Technology

The recent loss of both Ashok Kumar and Lord Flowers is deeply regretted. POST emphasises the importance to the UK as a whole, and especially to Scotland and Northern Ireland, not just London and the South East. POST is also continuing to extend its influence worldwide, initially in North America, Japan, Chile and also to Africa.

Mr Jonathan Flint, Institute of Physics Council, Chief Executive Oxford Instruments plc,

Investment in science can pay dividends right now, as well as driving long term prosperity. That was the key message given by Jonathan Flint, Chief Executive of Oxford Instruments, and a Council Member of the Institute of Physics. His position as Chief Executive of a publicly listed company and as a council member allows him to straddle the commercial and scientific worlds. It gives a perspective on the difficult path between the spark of a new idea, and seeing the effects of that idea in society at large. Today's global challenges cannot be addressed without a partnership between the commercial and the academic sectors. Businesses form the bridge between science and the consumer. Science is capable of coming up with the solutions to many of society's problems and companies like Oxford Instruments will turn that smart science into commercially successful products. Mr Flint identified examples where his company's advanced technology is contributing to future energy options, from fusion power to low energy lighting, and testing for hazardous materials in the environment. His key message was that investment in science is delivering real economic benefits, today, through the manufacture of the high technology equipment involved. Supplying high performance equipment gives real revenues, real jobs, today, but more should be done to educate people about the power of science and its importance to the world, for the future, and for today.

Dr Jim Wild, The Royal Astronomical Society

As our society and economy grows increasingly dependent on hardware in space, in the air and on the ground, the influence of solar activity on human technology is becoming more and more important. So-called

"space weather" is now included in the UK's National Security Strategy and is being studied for inclusion in the Government's National Risk Register. In order to understand the risks posed by space weather, and ultimately to predict and mitigate against the consequences, the physics of the electromagnetic Sun-Earth connection (initially investigated in the context of natural phenomena such as the magnificent aurora borealis) is now being studied to understand how solar flares and coronal mass ejections can impact upon electricity supply grids, radio communications, aviation safety and satellite operations.

Dr Hilary Weller, Council for the Mathematical Sciences, University of Reading

The UK Met Office weather and climate forecasting models have proved some of the most accurate in the world. However, supercomputers are becoming larger with less power per processing core and the Met Office models are not performing well on these new computers while other forecasting centres are forging ahead. Forecast speed is often limited by the speed at which different processors on a computer can communicate and so if a model relies on lots of communication it will grind to a halt. The Met Office model divides the planet into latitude-longitude grid boxes which get very narrow near the poles leading to an excessive amount of communication. In order for the Met Office to remain competitive, they must move away from a latitude-longitude grid to something more like a football, made of hexagons and pentagons. The Gung-Ho project, joint between Natural Environment Research Council funded academics, the Met Office and the Science and Technology Facilities Council, is carefully scoping the design for a new forecast model which will ensure that the UK remains at the forefront of weather and climate forecasting. This careful design phase is envied world-wide. Conversely, forecasting centres sometimes invest heavily in an untested, flawed strategy as they do not have the time or resources for such careful design.

Presentations were also made by Dr Mike Pitts, The Royal Society of Chemistry, and Imran Khan, Director of the Campaign for Science and Engineering.

WHAT IS THE IMPORTANCE OF PHARMA TO THE UK ECONOMY?

Dr Allison Jeynes-Ellis MB ChB, FFPM
Medical & Innovation Director,
Association of the British
Pharmaceutical Industry (ABPI)

ECONOMIC IMPORTANCE

The pharmaceutical industry is vital in sustaining a healthy population and boosting the overall economy within the UK. This health and wealth agenda has been recognised by the Government as seen in their 'Plan for Growth', highlighting that health research has a pivotal role in the national economy.

Public and charitable sectors' investment in Life Science research is considerable: public investment through Medical Research Council, Technology Strategy Board and National Institute for Health Research; charities including The Wellcome Trust and Cancer Research UK. In more recent times, there has been a real shift with these groups coming together as public-private partnerships working strategically towards common goals, sharing expertise and often risks and benefits.

However, the majority of UK medical research is still supported by the pharmaceutical industry. Pharma spends £12.1m a day on R&D, the largest private sector investor.[1] It employs 72,000 people across the UK and 27,000 of those work in R&D.[2] It contributes 9% of global investment but the market remains low in terms of uptake at 3%. The pharmaceutical trade surplus in 2009 contributed £7bn to the UK economy.[3]

It is vital we remember the UK's strong heritage, for example, in terms of citations with many ground breaking publications and a flow of Nobel prizes, which continue to demonstrate our depth of capability within biomedical research. Data from 2010 show that four of the leading universities in the world were in the UK, and one out of six of the most prescribed medicines today have been invented here. This historical excellence is recognised as world leading but to maintain a global position in R&D we need to address some of the challenges that currently face us.

DRUG DISCOVERY & DEVELOPMENT

Developing innovative medicines is a long, risky and expensive process which takes between 12-15 years and costs up to £1bn per medicine. The risk is clearly realised considering that 25,000 compounds will be synthesised at drug discovery, 25 of these will make Phase 1 clinical trials, only 5 will receive a positive marketing authorisation from the regulatory authorities and only one of these medicines will recoup investment following launch. In addition, there have been many later stage failures recently as hurdles become significantly higher. Hence, the current model of pharmaceutical development is changing as the current one is no longer sustainable. The key concern is that we have to become more successful to combat major illnesses that remain areas of unmet medical need.

This has become of increasing importance given the demographics of our ageing population. Research therefore is very much focused in areas including cancer, diseases of the elderly such as arthritis, and other neuro-degenerative illnesses, particularly Alzheimer's disease. A breakthrough in any of these areas would be good news across all stakeholder groups.

CHALLENGES

Innovative medicines for unmet medical need is the driver for drug discovery. The challenges are many, including: the falling productivity and attrition rates in drug development, the escalating costs of these failures and also of the actual process, and the higher regulatory and societal hurdles to have your medicine used. I am referring here to the need to demonstrate 'value' as well as an appropriate risk/benefit for any new medicine. Competition is also increasing from the emerging markets, especially in China and India who are building their science and clinical capabilities. These countries are often able to recruit many more patients into later phase clinical trials where thousands of patients are needed to compare a new medicine to the gold standard of care. This is a concern for two reasons: firstly we are losing out on contributing to these studies

but in addition we know that the UK is a particularly conservative market and that clinicians who have experience of a medicine are more likely to prescribe it once it receives its licence.

The latest data we have from the National Endowment for Science, Technology and the Arts (NESTA) report shows that in 2010, only 1.4% of patients in global clinical trials were entered from the UK. However, working with the National Institute for Health Research (NIHR) we are starting to see improvement in the UK in terms of attracting and delivering on clinical trials.

The UK has the second lowest uptake of innovative medicines in the EU. There is some variability across therapy areas, but for cancer medicines launched in the last 5 years, we are one of the lowest countries in terms of uptake. This is an issue as not only are we depriving patients of new innovative medicines that they would receive as standard in many other countries, but in addition, this slow uptake impacts on the sustainability of R&D. It also makes it harder to convince companies to place significant research investment here.

WHAT HAVE WE ACHIEVED?

The Office of Life Sciences set up under the previous government, with ABPI as the industry lead for the R&D pillar, has been instrumental in starting to change the direction of this downturn. The skills gap highlighted in the ABPI Skills Report from 2008 is being addressed, in particular, in the areas of clinical pharmacology and in-vivo science. This has continued to be a key area of importance now led by Cogent under the current government.

Open innovation is increasingly embraced as a new model for research, with greater collaboration desired between industry, academia and the NHS. The Translational Research Partnerships have been formed which provide an internationally unique approach to supporting collaboration with the pharmaceutical industry. They provide a single point of access to collaborate with world-class investigators in the UK's leading academic and NHS centres. Working in partnership with industry, they drive early and exploratory development of new medicines, technologies and other interventions.

The TRPs are now operational in 2 broad therapeutic areas (Joint and related Inflammatory disease; and Inflammatory Respiratory disease) and welcome projects from pharmaceutical companies. Other models of open innovation are happening including the MRC-ABPI immune-inflammation collaborative research consortia.

The pharmaceutical industry has accepted that the day of blockbusters is well and truly over and the new world will be medicines for targeted treatment of sub populations, based on understanding the science better or stratified medicine. This will require a coherent, multi-stakeholder strategy to address the challenges this raises in terms of drug discovery, regulatory challenges and in addition pricing challenges in order for these medicines to actually be used. The right medicine at the right time in the right patient is the way of the future, which should improve treatment concordance and also provides a sound economic model whereby the NHS is only paying for medicines it knows are going to benefit the patient. Recently, there has been the launch of the £50m investment by the Technology Strategy Board into stratified medicine focusing on immune-inflammation and cancer.

WORK IN PROGRESS

The Academy of Medical Sciences report on clinical research focused on streamlining and reducing the bureaucracy surrounding clinical trials in the UK and the recommendations of this report were very much welcomed by industry. Embedding a culture of research across the NHS is also vital if we want to attract quality clinical trials. In the last 12 months we have seen a real cultural change with Chief Executives in the NHS wanting to engage with industry in discussing how their Trusts can become involved in ground-breaking research to the benefit of their patients.

Real World Data has been a priority for the ABPI for the last few years, using these data to demonstrate the value of medicines; and widening the UK's appeal for conducting such studies. We have developed a Guidance document, launched in May 2011, which has been well received by our members and the NHS. The Real World Data Guidance document can be downloaded from our website here:

http://www.abpi.org.uk/our-work/library/guidelines/Pages/real-world-data.aspx

We are in the process of finalising a White Paper detailing why we believe the UK can be competitive in developing this area of expertise. This particular approach was highlighted by the Prime Minister recently stating that it would make the UK the most attractive place in the world to place research and develop life-saving drugs. Not only will that benefit patients, but it will help to create new jobs and economic importance.

THE FUTURE

The commitments from the Government in the "Plan for Growth' were all very welcome especially the setting up of a single Health Research Authority to streamline clinical trials. We need to ensure that timelines are met and that the change in culture is evident, and best practice learnings from initiatives such as the North West Exemplar continue to be shared and promulgated across the UK, if we wish to be a global hub for research and development. The business conditions need to be attractive for research to be placed in the UK – the development of the Patent Box, R&D tax credits and improvement to the pricing and reimbursement system, all need to encourage diffusion of innovation across the NHS. The NHS Futures Forum for the first time announced the duty for the Secretary of State to promote research again emphasising the importance placed on research to improve the health and wealth of our nation.

Partnerships and an eco-system for research are clearly the new way of working but we are left with a few unanswered questions.

How can we ensure uptake of innovative medicines within the UK which would encourage further R&D and also benefit patients? Can the Government look at other incentives to encourage research bases to be placed within the UK? How do we ensure we keep the momentum around some of the positive work on-going and deliver?

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1 ONS
2 BIS R&D employment
3 HMRC

WHAT IS THE FUTURE FOR THE RESEARCH-LED PHARMACEUTICAL INDUSTRY?

Richard Ascroft RPh JD
Director of Corporate Affairs, Lilly UK

Richard Ascroft has worked for Eli Lilly and Company since 1993 and held a variety of roles in sales, clinical research management, public policy and market access.

From antibiotics to antiretrovirals, penicillin to proton pump inhibitors, medicines have contributed significantly to creating a healthier world. Over the twentieth century, life expectancy has doubled in some parts of the developed world and innovative medical advances have played an important role in helping people live longer, healthier lives.[1]

There has never been such demand for new medicines as there is today. In the developing world population increases have resulted in growing demand for effective medicines and vaccines, particularly for the world's three most devastating diseases: HIV/AIDS, malaria and tuberculosis. While in emerging economies growing middle classes in countries, such as China, India, Brazil and Russia, are increasingly demanding medical care comparable with that available in North America and Europe.

In countries such as Britain and the United States social and political agendas are being shaped by ongoing ideological and economic debate over how to meet rising medical costs, and how the growing burden should be split between individuals, the state and private payer organisations. Reforming health systems is a very real challenge when faced with the demographic reality; over 15 million people in the UK are currently identified as having a long-term condition[2] and by 2033 people over 65 will account for 23 per cent of the population.[3] Coupled with the current economic slowdown, it is not surprising that payers around the world – both public and private – are persistently pursuing strategies to hold down spending on innovative medicines and demanding greater proof of the value of those medicines.

We know that medicines are a system enabler and that using the right medicine, in the right patient, at the right time, can save money as well as achieve a good outcome for the individual. For example, Alzheimer's disease is often acknowledged as one of the greatest challenges to social and healthcare systems the developed world faces. Yet were a treatment to be developed which delayed the onset of Alzheimer's Disease by five years it could save $550bn per year by 2020 in the United States alone.[4] Even for conditions commonly regarded as already having a number of treatment options, such as diabetes, there remains huge room for improvement.

It is widely accepted that the science behind drug discovery is becoming more challenging, as researchers strive to understand complex conditions such as Alzheimer's disease and cancer.

Additionally, the regulatory barriers medicines are required to overcome are getting higher, with medicines required to undergo evaluations for cost-effectiveness as well as safety and efficacy. It is therefore little surprise that just one in 10,000 discovered compounds becomes an approved medicine for patients, and only 3 out of every 20 approved medicines recoup sufficient revenue through sales to cover their developmental costs.[5]

It is clear that there is an overwhelming need for more innovative medicines to be developed in order for the world to overcome the social and economic burdens which result from poor health. For this to happen there needs to be a robust and thriving global pharmaceutical industry which can only result from urgent action by both industry and governments.

WHAT CAN INDUSTRY DO?

Today the global pharmaceutical industry is at a crossroads. It is clear that the business models of the past – reliant on 'blockbuster' medicines – are no longer sustainable. We can't simply perform the same old rituals and hope for a different outcome. We must build new models of working that are leaner, swifter and more adaptive to the challenges of the global environment: essentially we must 'reinvent invention'.

We must build an understanding of patients' needs

into the earliest stages of research and assess the potential of new molecules in terms of what's truly valued by patients, physicians and payers. We must anticipate the concerns of regulators so that we can answer their questions in our clinical testing. Most importantly, we must increase the speed of research and reduce the cost of bringing a new medicine to market.

At Lilly, we have taken the concept of reinventing invention to our core, and have moved from a pharmaceutical company where we own every aspect of the value chain to one based on collaborative networks. Called 'Fully Integrated Pharmaceutical Network' – or FIPNET – this enables us to work with appropriate partners, including academic institutions and biotech companies, to increase our knowledge and share investment, risk and reward.

In the UK, the Lilly Centre for Cognitive Neuroscience provides an excellent example of our innovation through FIPNET working. Based at our research centre in Surrey, this network brings together a consortium of academic scientists from six leading British and Irish universities and industrial scientists from Lilly who work together to seek to enhance the probability of clinical success for molecules targeted at conditions involving cognitive dysfunction.

In addition, Lilly has established a number of virtual drug development networks, known as 'Chorus', which design, interpret, and oversee early-stage development through a network of connected organisations outside Lilly. Using this approach, Chorus currently manages 15 molecule programmes with a dedicated staff of only 29 scientists and has been able to reach clinical proof of concept about 12 months earlier and at half the cost when compared to the current industry model. Taken together with our own early-stage portfolio, we are now confident that Lilly has the largest pipelines in the company's history with 70 molecules in development, 33 of them in Phase II or Phase III. This is three times as many as in 2004.

WHAT CAN GOVERNMENTS DO?

Changes by the industry alone are not enough. Governments around the world need to take steps to address the challenges faced by the industry, not only to increase the number of innovative medicines reaching patients, but also as the life sciences industry is a potential growth sector which can assist countries in rebalancing their domestic economies.

Currently in Britain the biosciences sector creates and sustains professional, high-value jobs and infrastructure. In the UK the pharmaceutical industry directly employs 72,000 people, 26,000 of them in research and development (R&D) [6] with over 200,000 more employed indirectly. [7] The pharmaceutical industry invests more in R&D in the UK than any other industrial sector – approximately £12 million every day. [8]

Lilly is proud to be a part of the UK's robust pharmaceutical sector. We employ more than 1,400 staff in the UK across three sites; a research centre in Surrey, a manufacturing facility near Liverpool and a sales and marketing operation in Basingstoke. Over the past year, Lilly invested £130 million in R&D within the UK. [9]

However, the Government cannot afford to be complacent and assume that the life sciences sector will continue to invest in the UK. Recent site closures and consolidations by global pharmaceutical companies across the UK highlight the competitive and mobile nature of the industry, with many countries offering substantial incentives to attract investment.

Making investment decisions is multi-factoral, and many companies weigh up a number of factors; including the underlying market conditions, the skills and labour market and the fiscal incentives. The British Government needs to examine its policies in each of these areas to ensure they are integrated and that Britain is offering a truly world-class environment.

Of greatest importance are the underlying market conditions. Every business needs stability across factors relating to the ability to sell its product, including a stable economic environment, open and outward looking markets and a fair regulatory system. For the pharmaceutical industry this also includes swift access to and uptake of new medicines for the local population. In addition, the UK is in the unique position of being a global reference within the pharmaceutical industry; a quarter of the world looks to the UK to reference both Health Technology Assessment and price, further strengthening the importance of the UK environment.

For beneficial market conditions to be created there needs to be a comprehensive assessment of a medicine's value, reflecting the viewpoints of patients, providers, payers, and industry. This value assessment should be reflected not only in pricing, but also in decisions on reimbursement and patient access to new medicines. As the Government moves towards the creation of a new system of pricing and reimbursement for medicines – value-based pricing – it is imperative that they seek to ensure that the true cost of a medicine is valued, including the benefits to carers and wider society. The system for valuing medicines must also recognise and reward innovation, particularly incremental innovation. In modern medicine, improvements in treatments are made incrementally, through a series of small steps. Cancer medicines are a good example, where patients have benefited from important incremental improvements in side-effect profile and mode or ease of administration as well as survival. Any system of valuing medicines must recognise these incremental advances.

Secondly, for the pharmaceutical industry to thrive in the UK the Government must ensure the skills base in the UK remains competitive. A key determinant in any investment decision for the pharmaceutical industry is the availability of appropriately skilled staff. Evidence suggests that access to highly skilled staff remains a concern for the industry and 45 per cent of employers have reported difficulty in recruiting STEM (science, technology, engineering and maths) graduates. [10] Of particular concern is the lack of practical skills – such as in vivo sciences – amongst graduates, and urgent action needs to be taken to ensure Britain does not fall further behind countries such as India and China.

Britain must also improve its offering as a location for clinical trials, which is an area of historic strength for the UK. Yet clinical trials are very mobile, and a perfect storm of unpredictable

and high costs, over-burdening and fragmented bureaucracy and slow recruitment of patients has resulted in Britain's advantage slipping away. Britain has fallen from the third highest market share of clinical trials activity in 2000 to ninth by 2006.[11] The Government has recently announced proposals to combine and streamline approvals under a health research regulatory agency, which we welcome; however, it must not simply add a layer of bureaucracy to an already highly bureaucratic process.

Finally, for Britain to remain an attractive location for investment there must be competitive fiscal incentives. The R&D tax credit system is one of the least competitive in Europe and the UK currently ranks 19th in the OECD ranking of R&D cost savings; a drop from 13th in 2004.[12] The Government needs to demonstrate its commitment to the life sciences sector by increasing their offering to inward investors, and we welcome early progress in this area.

Concerted and co-ordinated actions by the Government and the pharmaceutical industry will enable the sector to continue to grow and flourish. Britain can be at the heart of this growth, and maintain its position as an attractive location for life sciences industries if the Government take comprehensive and decisive action.

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WHAT DOES THE FUTURE HOLD FOR PHARMA IN THE UK?

HEALTHCARE INNOVATION IN THE UK – A Royal Society of Chemistry Position Paper

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The pharmaceutical industry (pharma) has made important contributions to quality of life, longevity, economic growth and education at all levels, and is a key component of the government's growth strategy. A vibrant pharma R&D sector generates outstanding medical and economic benefits and is fundamental to the UK science base.

For decades, the UK had been a world leader in medicines R&D with at least 10 of the top-selling drugs (>$1bn annual sales at peak) having UK-trained PhD organic chemists as named inventors. In 2008, the pharmaceuticals and biotechnology sectors invested £4.3bn in R&D (making it the leading UK sector for R&D investment), employed some 67,000 skilled staff, and contributed around £8.2bn to GDP. Pharmaceuticals have been consistently in the top three UK industrial sectors in terms of trade surplus generating £6bn in 2008.

However, the industry is now under considerable pressure due to pricing constraints on new medicines, escalating R&D costs, losses of billions of pounds of revenue as major patents expire, and stagnant productivity. Consequently, the sector is undergoing substantial contraction with closure of research centres and the loss of thousands of skilled jobs. Unless the UK responds to such significant changes, the future flow of new drugs will slow to a trickle. A new model for drug discovery is urgently required to capitalise on UK's outstanding track record and world class talent and to ensure our future leadership in healthcare innovation.

A WAY FORWARD

The RSC proposes an action plan that deals with four inter-related themes and provides a clear and coherent framework for sustaining innovation and productivity in healthcare, and aligning investment and policy in medicines research along a single, compelling vision. The proposal builds upon the UK's outstanding track record of investment and innovation in drug discovery and unique strengths in terms of talent, training, collaborative networks and funding opportunities.

SCIENTIFIC QUALITY

The basis of the UK's success has been the ability of the UK-based pharmaceutical industry to retain a rich pool of highly talented and well-trained scientists, ensuring that healthcare challenges have been addressed through the application of world-class science.

ADVOCACY

It is critically important for the medicines research community to articulate clearly and consistently how the invention and development of new drug treatments has served to benefit patients and that continued investment in key areas of medical need will be required to address the existing and future needs of an ageing population. Coupled to this is the recognition that chemistry is at the heart of translating biological discoveries into much needed new medicines and that without chemical enablement, most new medicines research would flounder.

FUNDING AND REIMBURSEMENT

At a time of rising R&D costs and diminishing research budgets, there is a clear need for the UK to develop a national strategy for investment and reimbursement that will serve to incentivise medicines research in defined areas of high medical need. A coherent approach would help funding bodies to align their investment priorities and so ensure benefit to patients is realised and return on investment is maximised.

INFRASTRUCTURE

In order to safeguard the UK's scientific leadership in medicines research and underwrite the next wave of innovative medicines, a step-change in research infrastructure will be required to ensure the UK remains at the forefront of the latest scientific advances.

STATUS

The global pharmaceutical industry has come under considerable regulatory and economic pressures over the past years, and continued contraction is now threatening healthcare innovation. New medicines will be essential to alleviate unsustainable pressures on healthcare budgets as the population ages but increasing emphasis is now placed on cost/benefit analyses to justify reimbursement, and negative regulatory decisions after multi-year drug development programmes are wasteful of R&D investment. Safety demands have also escalated such that a single clinical trial for a new cardiovascular agent can involve up to 20,000 patients, while new drugs for diabetes now have to undergo an additional 2-year safety study before approval. Consequently, the costs of discovering and developing a new medicine have escalated to well over $1bn, but return on investment has deteriorated sharply in the face of fierce economic and regulatory pressures.

In addition to external pressures, pharma is losing billions of dollars in revenues as major drugs come off patent, but which are not being replaced at an equivalent rate despite escalating R&D budgets over the past two decades. Biotech was once regarded as an endless source of potential products for pharma, but both sectors have weakened in parallel as venture capitalists are unwilling to wait between 5-10 years for an adequate return on high risk investments. It is essential that UK Biotech is revived through innovative funding mechanisms that balance risk and a sustainable return on investment so that the sector can continue to make major contributions to future healthcare needs.

A common reaction to internal and external pressures was through mergers and acquisitions to create monolithic organisations driven largely by commercial considerations rather than R&D productivity. For example, a recent mega-acquisition created a world-wide research group of over 12,000 scientists with a combined pre-merger R&D budget of $11bn. However, drug discovery cannot be industrialised in the same way as cars or steel and productivity has not increased in pharma over the past decade, although R&D expenditure has ballooned to unsustainable levels. In future, drug discovery will be carried out by smaller and more nimble organisations with clear objectives, reporting lines and accountability.

In response to these economic, regulatory and organisational threats, pharma is going through an extensive round of downsizing with site closures, redundancies and significant budget reductions. The UK has been particularly hard hit with closures by AstraZeneca, GlaxoSmithKline, Pfizer, Merck and Roche in recent years, with thousands of skilled scientists losing their jobs and livelihoods. Of course, individual hardship is also reflected by reduced tax inflow at national and local levels, erosion of a positive balance of payments, reduced industry support for science education at all levels, and for community activities. Contraction of pharma is also a major concern for the next generation of UK-trained research scientists as employment prospects have been seriously threatened, and the nation's science base will be weakened. Whilst these events present significant challenges, there is also a unique opportunity now to redeploy world class medicinal chemists released by pharma as part of a re-shaping of the UK's medicines research landscape. One attractive option is to build this medicinal chemistry expertise into a series of dedicated drug discovery hubs co-localised with therapeutic area clusters as this fundamental skills base barely exists in UK academia.

The economic consequences of pharma downsizing are obviously serious, but such dramatic reductions in research capacity also threaten future healthcare innovation in the UK, particularly in the light of an ageing population. Not only has

the pharma research base contracted but therapeutic areas such as neuroscience and obesity are being downsized, despite high medical need and limited effectiveness of current therapies. In addition, these diseases are particularly burdensome in terms of healthcare costs as illustrated by a recent analysis which shows that the cost associated with the treatment of dementia is twice that for cancer.

Meagre returns on investment have largely forced pharma to exit antibiotic R&D, even though the WHO has forecast a disaster due to rapid and unchecked increases in microbial resistance. Indeed, the devastating effects of HIV and MRSA, for example, underline the need for a strong pharmaceutical R&D sector to invent new drugs to control known and unexpected medical challenges in the 21st century. Given the scale of pharma contraction in the UK, the shortfall in healthcare innovation cannot be made up by academia and charities in their current format as there is neither the scale nor experience. In addition, these bodies largely focus on diseases of the developing world and cancer, and there are little or no drug discovery initiatives in the public sector addressing serious conditions such as obesity and schizophrenia.

The developing gap in healthcare innovation is particularly concerning as the UK has well-established strong academia/industry/clinical research partnerships in drug discovery and development that have taken years to build, but which simply do not exist in developing countries. If these world class drug discovery teams are allowed to fragment, it will be extremely difficult to re-build such quality from scratch. It is essential that the UK's unique medicinal chemistry talent pool is nurtured, supported, and integrated into multidisciplinary translational initiatives as a fundamental core skill to facilitate and exploit innovative biology emerging from UK laboratories. UK medicinal chemists are particularly successful in inventing the synthetic molecules that provide cost effective oral therapies that are the mainstay of any healthcare system. While biological based drugs are making a significant impact, this therapeutic class will not remove the need for affordable small molecule "drug pills" taken by mouth for chronic diseases.

Pharma's response to stagnant productivity was to create monolithic organisations, but the number of NCEs approved by the FDA has barely changed over the past decade, and attrition during discovery and development has remained above 90%. Greater consideration needs to be given to the reasons for compound failure which include poor target validation, suboptimal animal and human safety, heterogeneous clinical trials rather than targeted patient sub-groups, and insensitive methodologies where placebo response can confound a positive signal to a novel mechanism of action. In addition, "chemistry space" needs to be expanded significantly to access hundreds of novel biological targets that are involved in important diseases, but are beyond the reach of current drug templates. International pre-competitive collaborations such as the European InnoMedPredTox, the Innovative Medicines Initiative and the Structural Genomics Consortium are addressing some of these issues, as are a series of precompetitive workshops being coordinated by the RSC across the UK but investment needs to be increased in order to reduce R&D risk.

SPECIFIC ACTIONS FOR MINISTERS

We recommend a UK-wide strategy for medicines that will:

- enable funding bodies to be more effective in supporting a new model for medicines R&D
- revitalise areas of high medical need such as obesity and psychiatric disorders
- ensure reimbursement of new medicines is based on an informed evaluation of risk/benefit and takes into account the full costs of innovation.

The UK must strengthen research that crosses disciplines and sectors, an integral component of drug discovery. Importantly, we need to recognise and capitalise upon the central role played by chemists in medicines R&D. Specifically, science and funding policy needs to:

- encourage industrial, academic and clinical researchers to work together to identify the most relevant disease targets and which patients are most likely to benefit from new medicines in order to maximise the chances of success with clinical trials
- support the creation of a network of Therapeutic Centres of Excellence (such as the Drug Discovery Centre, Imperial College) where experienced medicinal chemists can work alongside disease experts to apply the latest scientific advances to discover new medicines. These centres could be sited at academic institutions, or at repurposed facilities previously part of large Pharma.

The UK needs to be well-equipped and financed to meet successfully the healthcare challenges of the 21st century, particularly for an ageing population. A sustainable drug discovery model, comprising a network of national facilities, spin-outs and CROs working alongside large Pharma, will bring significant medical and economic benefits to the UK, strengthen our science base and provide exciting career opportunities for world class scientists trained in our Universities.

DOES THE PHARMACEUTICAL INDUSTRY NEED A NEW PRESCRIPTION?

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THE BACKGROUND

The pharmaceutical industry is widely regarded as being vitally important to the UK economy. It directly employs 72,000 people and indirectly a further ca 200,000. In 2009, the sale of pharmaceuticals generated a trade surplus of almost £76 billion; more than any other major British industry. So it is not surprising that when signs of a decline emerge there are clarion calls to do something.

The Royal Society of Chemistry has urged more government investment and the development of a sustainable funding model. They argue that this will stimulate growth, liberate associated economic benefits, strengthen the science base and permit exploitation of biology to revitalise biotechnology. Additional economic arguments have also been deployed to justify stimulating recovery following the global economic downturn. For example, new medicines might reduce the cost of healthcare in the future. If drugs could be used to delay the onset of Alzheimer's disease, it has been estimated that this might save Medicare and Medicaid in the USA $447 billion per year by 2050.

But when such claims are made they present only one side of the argument. For example, some drugs have had to be withdrawn because they caused unexpected morbidity and mortality, even though they had previously successfully passed through Phase III clinical trials. In 2010, the widely used anti-diabetic drug Avandia had restrictions placed on its use and is now the subject of 13,500 lawsuits.

Another example of a cost to society is provided by some UK research councils, such as the MRC, who use taxpayers' money to help fund research into new medicines which are then exploited by the pharmaceutical industry; while others, such as the NERC and the ESRC, use even more taxpayers' money to support research into the adverse effects of these and other pharmaceuticals on the environment and human wellbeing.

PHARMACEUTICAL ECONOMICS AND LIFE EXPECTANCY

There is no doubt that some pharmaceuticals have improved the quality and duration of many people's lives. The treatment of infectious diseases was revolutionised by antibiotics, and the most prevalent killer diseases, cardiovascular disease and cancers, are now being tackled, often very effectively, through drug treatment. The costs to health care systems however are immense. In 2008 the NHS prescription drug bill was £8.2 billion having doubled in a decade. Both prescription and non-prescription drug use increase exponentially as we get older because of a rise in the prevalence of chronic diseases and a greater likelihood that more than one disease will occur in a particular individual. Based on current prescribing practices, the Office of National Statistics predicts that the volumes of medicines used could double by 2050. More recent calculations indicate that this increase could occur much earlier, perhaps within the next 10 years. In economic terms this might be viewed as encouraging news for the pharmaceutical industry. Increased drug use means increased sales. But many drugs will no longer be covered under current licence agreements and cheap generic competitive products may flood the market, especially from emerging economies. Yet despite these worrying developments, the 10 major drug companies still managed to generate $644 billion in global revenues in 2009!

The claims of the pro-pharmaceutical lobby concerning health benefits also merit close scrutiny. For example, in the USA the average expenditure on pharmaceuticals per person per year is £630 and average life expectancy is 78.37 years. However, in Ireland, Belgium, Austria, Spain, Denmark, Germany, Italy, Sweden, UK and the Netherlands, where life expectancies are longer, less than half of the USA figure is spent per person per year on medicines.

THE FATE OF PHARMACEUTICALS

In periods of economic turbulence it is not popular to place impediments in the way of rapid economic recovery. Nonetheless, in the past huge costs to society and the environment could have been avoided by heeding early warnings of potential threats – asbestos and climate change providing notable examples. With regard to the pharmaceutical industry, it is the fate of their products following use that is of growing concern.

When drugs enter the body they are metabolised or broken down into other compounds. Often a proportion of the pharmaceutical will pass through the body unchanged before being excreted. Drug-contaminated urine and faeces are then delivered via the drainage system to the sewage

works for treatment. Further breakdown may occur, but still a proportion of the original drug or its metabolites is discharged into river systems. Also, some of the drug may be retained in the solid phase of sewage which is then used as a fertilizer in agriculture. One might imagine that the concentrations of the pharmaceuticals in all of these wastes would be too small to detect – but they are not. Several hundred drugs can now be measured in water, sediment and biological samples taken from the environment, including antibiotics, antidepressants, analgesics and cancer chemotherapy agents. At present, concentrations are generally very low, but as we have seen earlier, pharmaceutical use is expected to rise rapidly in the coming years, driven by the needs of the ageing population. Already, both drinking water and vegetables have been found to contain low levels of drug residues. This is only part of the story. Pharmaceuticals are also used in very large quantities as veterinary medicines, especially in relation to animal husbandry. Here worries relate to antibiotics and antiparasitics used to treat livestock that then end up in soil and groundwater.

IMPLICATIONS FOR THE ENVIRONMENT AND HEALTH

Is there evidence that pharmaceuticals dispersed in the environment can cause problems? Undoubtedly yes. Many countries have reported that ethinyl oestradiol released from the contraceptive pill is responsible for the feminisation of male fish in rivers. On the Indian subcontinent, the anti-inflammatory drug, diclofenac, has killed tens of millions of vultures feeding on the carcases of dead cattle. Ivermectin, previously used in fish farming to kill salmon lice, had to be banned for that purpose because of its damaging environmental impacts. Another key concern from the widespread use of antibiotics is the emergence of antibiotic resistant strains of bacteria such as MRSA and Clostridium difficile (C.diff). But resistant bacteria are not restricted to medical settings. Recent studies show that MRSA is present along the Florida coast and can contaminate people of all ages using the beaches.

COURSES OF ACTION

Are these legitimate concerns or just the unwarranted fears of a few individuals? They are at least sufficiently worrying to provoke the Government's Advisory Committee on Hazardous Substances to set up a sub-committee earlier this year to investigate this issue in detail. The European Environment Agency also published a report in 2010 urging action. They concluded that the situation with regard to pharmaceuticals in the environment looks worse than a decade ago, that we should improve pharmaceutical waste management and that we need robust information to guide the public and policymakers. In its final ever report in March 2010, the Royal Commission on Environmental Pollution specifically highlighted the link between demographic change and the release of pharmaceuticals into the environment. Elsewhere, the Society of Environmental Toxicology and Chemistry (www.setac.org) which has over 5000 professional members in over 100 countries, takes the matter very seriously. In 2005, it established a pharmaceuticals advisory group and is currently conducting an exercise involving the international scientific community to identify 20 key priority questions that should be addressed to inform us about how to deal with drugs discharged into natural ecosystems. Sensible courses of action might include incentivising the development of "greener" pharmaceuticals, which degrade rapidly after use to harmless residues, or to label drugs more effectively to identify those which need special waste treatment. Other innovative practices that the pharmaceutical industry might adopt could include forming stronger alliances with those engaged in preventative medicine and public health. It is neither desirable nor affordable to use pharmaceuticals to treat the rapidly rising number of cases of obesity and related diseases (diabetes, cardiovascular diseases, etc), nor the epidemic of psychiatric disorders (especially depression). There are now literally thousands of programmes around the UK intended to motivate people to spend time being physically active outdoors (eg "Green Gym", "Blue Gym", "Walking your way to Health") to help them avoid these conditions. Collaboration with the pharmaceutical industry might readily lead to combined approaches in which both increased outdoor activity, coupled with appropriate drug therapies, could result in a step change in the health of the population, and associated economic benefits all round.

SUMMARY AND CONCLUSIONS

Pharmaceuticals contribute immensely to the treatment and prevention of disease, and to the quality of our lives. The pharmaceutical industry deserves support and investment. However, the way it has operated in the past must change. More of the same simply won't do. With an ageing population in the affluent West, use of medicines is increasing alarmingly. Similarly, in developing countries with a further 3 billion people to be added to the population by 2050, and the wider availability of low cost, generic products, the use of prescription and non-prescription products will also escalate. Urgent measures are required to plan for the disposal of the resulting pharmaceutical waste. The pharmaceutical industry as well as Government has responsibilities in this regard. The concept of economic externalities to which industrialists are so attached is no longer viable. There are no externalities. Someone has to pay to clean up water supplies and decontaminate land where pharmaceutical residues can be detected. Someone has to pay the additional health care costs resulting from the emergence of antibiotic resistant bacteria, and someone has to pay for the loss of ecosystem services that result from the unintended impact of pharmaceutical residues on wildlife. Responsible innovation by the pharmaceutical industries offers the best hope of tackling these issues. This will require establishing new partnerships between the pharmaceutical industries, the public health sector and those responsible for maintaining a sustainable environment.

RESEARCH COUNCIL CUTS THE PIPELINE FOR MATHEMATICAL SCIENCES

Twenty-five of the UK's leading mathematical scientists, including four Fields Medallists, have written to David Cameron to warn that "central planning and micro-managing research" will have devastating consequences for Britain.

The Engineering and Physical Sciences Research Council (EPSRC) announced in July that researchers from all areas of the mathematical sciences, except statistics and applied probability, are ineligible to apply for fellowships until further notice. As a result, even the best of this year's PhDs in such subjects as geometry, fluid dynamics, number theory, and computational mathematics may be unable to continue their research in the UK.

The scientists say that EPSRC's decision cuts off "an essential part of the pipeline that allows some PhDs to become leading researchers". It was made "without any meaningful consultation of the UK mathematics community".

The scientists argue that mathematics is essential for the fastest growing sectors of the economy, from Google to medical imaging to financial services. "It is foolhardy to claim that one part of mathematics is the only useful one." For one thing, "business applications of mathematics often come from the most surprising and unpredictable sources."

In a separate letter, Professor Margaret Wright of New York University, the chair of the 2010 International Review of the Mathematical Sciences panel commissioned by EPSRC, wrote to EPSRC that the new policy is not even the best way to help statistics, the science of extracting knowledge from data. The IRMS panel recommended other ways EPSRC could help statistics, which have so far been ignored.

David Delpy, Chief Executive of EPSRC, testified to the Commons science and technology committee that EPSRC's Shaping Capability policy is a deliberate move away from the goal of funding the best research. Rather, EPSRC will direct funding to EPSRC-favoured parts of each science.

Delpy claimed that EPSRC's knowledge of "the whole portfolio" means that it does not need to consult the UK's learned societies in particular sciences such as mathematics.

What is the Fields Medal?

The Fields Medal is often considered the highest award in mathematics, the closest thing to a Nobel Prize in mathematics. The Fields Medal is awarded only once every four years, to at most four people. The UK is exceptionally strong in mathematics, with six Fields Medallists.

Why is mathematics important for the UK's economy?

Most new technologies build upon mathematical ideas. Medical imaging relies on mathematical analysis, while search engines use a combinatorial algorithm to judge the importance of different web pages. Climate modelling and industrial design rely on computational algorithms being developed by mathematicians. Mathematical ideas can have multiple and unexpected applications. A direct measure of the importance of mathematics for employers is that students with a postgraduate degree in the mathematical sciences have the highest average starting salary among all subjects.

Why is EPSRC's policy on fellowships not the best way to help statistics?

Outstanding young statisticians can get well-paid jobs in industry, which makes it hard to maintain the current quality of UK statistics in universities. The International Review of the Mathematical Sciences suggested several approaches to help UK statistics, including a flexible grant scheme to ensure that statistics research is supported at a range of universities. They rejected EPSRC's restriction on fellowships as damaging for the whole of mathematical science in the UK.

Sources:

The web page "EPSRC funding crisis: mathematical sciences" has links to the recent letters of protest and news stories about EPSRC's fellowship policy: http://www.dpmms.cam.ac.uk/~bt219/epsrc.html

The Commons science and technology committee questioned David Delpy on EPSRC's policy of Shaping Capability on 14 September 2011. The recording is available at the following website. The MPs start their tough questioning at 9:42, and turn specifically to the mathematical sciences from 10:00 to 10:22. David Willetts, Minister for Universities and Science, is questioned hard on EPSRC's policy of Shaping Capability from 10:46 to 10:53.

http://www.parliamentlive.tv/Main/Player.aspx?meetingId=9050&wfs=true

A reference for EPSRC's funding of research grants in the mathematical sciences, including the cut from £24.2 million in 2007/08 to £12 million in 2009/10, is the April 2011 submission from the Council for Mathematical Sciences to Parliament's Science and Technology Committee: http://www.cms.ac.uk/reports/2011/CSRfinal.pdf

A reference for the statement that postgraduate mathematical scientists have the highest average starting salary among all UK holders of postgraduate degrees is Adrian Smith's report One Step Beyond (March 2010), p. 94: http://www.bis.gov.uk/one-step-beyond

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SUSTAINING THE UK'S LEADING RESEARCH CAPABILITY

Professor David Delpy
Chief Executive, Engineering and Physical Sciences Research Council

As the main UK government agency for funding long term research and training in engineering and the physical sciences, EPSRC aims to maximise the international standing and impact of UK research.

Our goal of Shaping Capability, detailed in our Strategic Plan and published in early 2010, is one of our principal strategies for ensuring a vibrant and effective research base delivering maximum scientific, cultural and economic impact. It recognises that at a time of limited resources and fierce global competition, we must make difficult choices in order to ensure we maintain an excellent and effective capability in all our disciplines.

The concept of shaping is not new. Since EPSRC's inception we have made strategic decisions, for example when balancing funding for disciplines against one another. The difference is the higher level of transparency regarding areas of both higher and lower priority. We are now making strategic decisions across the whole portfolio in each of 111 identified research areas based on an assessment of excellence and national importance and in the context of existing investments. Any changes in the portfolio will take place gradually over time and we will regularly review the shape of the portfolio and the scale of investment in different areas as it evolves.

WORKING IN PARTNERSHIP

Shaping has been an iterative process, sharing ideas with our main university partners, industry partners, learned societies and other relevant stakeholder groups since the publication of the Strategic Plan, and this continues as new funding decisions are being made.

To ensure clarity and objectivity, we were careful to ensure we did not set communities to unhelpfully compete against each other. EPSRC staff have a deep knowledge of the research portfolio across engineering and the physical sciences and have drawn upon a wide range of information in progressing the shaping strategy. We regularly meet with researchers across the country and facilitate workshops with academics and industry to identify research priorities or evaluate past projects and co-develop plans.

Our Strategic Advisory Teams, comprising active academic and industrial researchers, have been actively involved in our shaping strategy. Our Council also maintains an active oversight of this work.

In making decisions about individual research areas, we take into account each area's capability, quality and importance to the UK relative to other areas in the portfolio. We have three broad action categories: 'grow', 'maintain' or 'reduce'. A 'reduce' category does not mean we will stop funding in that area, but it does mean that the competition for funding will be greater than previously. To maintain our flexibility to fund the best research and respond to new opportunities we have not set budgets in each of the 111 research areas.

Decisions on the scientific excellence of individual research projects will continue to be made on the advice of peer review. We will continue to publish the results of peer review panels, the membership of the panels and the funding decisions.

MATHEMATICAL SCIENCES

The mathematical sciences provide an excellent example of how shaping will be achieved in an area where impacts often only occur in the very long term.

We recognise mathematical sciences vital importance in itself and in underpinning research across our portfolio. As with many other disciplines, we have previously shaped specific areas of the maths portfolio including: mathematics for industry and business; statistics; and mathematics for the life sciences. The purpose of these initiatives was to encourage researchers to look at new directions for their research, either to maximise an existing strength, to take advantage of a research breakthrough, or to build capacity in an important and/or emerging area.

Going forward we will be clear about those areas in the mathematical sciences that we envisage will receive relatively more or less funding in future. We will also encourage researchers to actively consider collaboration across the mathematical sciences and with other disciplines they may otherwise have not pursued.

In adopting such approaches research excellence will remain fundamental in our decisions.

FELLOWSHIPS

We have changed our fellowship process to provide greater flexibility for those wishing to apply by now accepting applications throughout the year rather than just once a year. Fellowships are one of the ways we support high performing and/or high potential individuals.

Contrary to what has been suggested, EPSRC is not stopping support for fellowships in mathematical sciences other than in statistics and applied probability.

In mathematics, the immediate focus on statistics and applied probability results from a national need to build capacity throughout different career stages in this area; this decision reflects evidence we have, including from the 2010 International Review of Mathematics. The scope of the areas eligible for fellowship support in mathematical sciences will expand as our shaping initiative develops, with further areas to be announced before the end of the year.

EXCELLENCE AND IMPACT

Long-term science and engineering research is at the heart of discovery and innovation. We must maintain an environment that promotes excellence, encourages innovation, stimulates creativity and drives cultural, commercial and technological advances. EPSRC remains committed to working together with all of our stakeholders to ensure that we can deliver research that is both internationally excellent and delivers long-term impact for the health, prosperity and sustainability of the nation and the world.

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:

Gavin Barwell (Conservative, Croydon Central), Gregg McClymont (Labour, Cumbernauld, Kilsyth and Kirkintilloch East), Stephen McPartland (Conservative, Stevenage), 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), Jonathan Reynolds (Labour/Co-operative, Stalybridge and Hyde), Graham Stringer (Labour, Blackley and Broughton) 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. Stephen McPartland was formally appointed to the Committee on 14 February 2011 in the place of Alok Sharma.

CURRENT INQUIRIES

The evidence base for alcohol guidelines

On 19 July 2011 the Committee announced an inquiry into the evidence base for alcohol guidelines. The Committee invited written submissions on the following issues by 14 September:

1. What evidence are Government's guidelines on alcohol intake based on, and how regularly is the evidence base reviewed?
2. Could the evidence base and sources of scientific advice to Government on alcohol be improved?
3. How well does the Government communicate its guidelines and the risks of alcohol intake to the public?
4. How do the UK Government's guidelines compare to those provided in other countries?

The Committee expects to hold oral evidence sessions in October. The written evidence received in this inquiry will appear on the Committee's website.

Science in the Met Office

On 19 July 2011 the Committee announced an inquiry into Science in the Met Office. The Committee invited written submissions on the following issues by 14 September:

1. How effectively is the Met Office fulfilling its Public Weather Service remit?
2. Is the Met Office's Science Strategy 2010-15 robust and achievable and how will the strategy help to deliver a better service?
3. What are the roles of the Met Office's Chief Scientific Adviser and its other senior scientists? How do they provide comprehensive and up-to-date scientific advice?
4. How robust are the models used by the Met Office for weather forecasting, climate predictions, atmospheric dispersion and other activities?
5. How effectively does the Met Office coordinate its activities with government departments, non-departmental public bodies, the UK research base and its international counterparts?

The Committee expects to hold oral evidence sessions in the autumn. The written evidence received in this inquiry will appear on the Committee's website.

Malware and Cyber-crime

On 19 July 2011 the Committee announced an inquiry into Malware and Cyber-crime. The Committee invited written submissions on the following issues by 7 September:

1. What proportion of cyber-crime is associated with malware?
2. Where does the malware come from? Who is creating it and why?
3. What level of resources are associated with combating malware?
4. What is the cost of malware to individuals and how effective is the industry in providing protection to computer users?
5. Should the Government have a responsibility to deal with the spread of malware in a similar way to human disease?
6. How effective is the Government in co-ordinating a response to cyber-crime that uses malware?

The Committee expects to announce dates for oral evidence sessions in due course. The written evidence received in this inquiry will be on the Committee's website.

Spending Review 2010

On 24 November 2010, the Committee took evidence from the Rt Hon David Willetts MP, Minister for Universities and Science, and Professor Adrian Smith, Director General, Science and Research, Department for Business, Innovation and Skills. On 19 January 2011, the Committee took evidence from a number of Research Councils and from Research Councils UK. On 26 January the Committee invited written submissions on the science and research budget allocations for 2011/12 to 2014/15 by 27 April 2011. The written evidence received is on the Committee's website. On 14 September 2011 the Committee took evidence from Research Councils UK and the Rt Hon David Willetts MP, Minister for Universities and Science.

Practical experiments in school science lessons and science field trips

On 5 April 2011 the Committee announced an inquiry into the practical experiments in school science lessons and science field trips. The Committee invited written submissions by 11 May 2011.

The Committee launched an e-consultation on 9 June 2011 to hear views from students on their school science practicals experiences. There is a link to it on the Committee's website. In addition, in June the Committee visited Quintin Kynaston School, a secondary school in St John's Wood.

On 15 June the Committee took evidence from: Kevin Courtney, Deputy General Secretary, National Union of Teachers, Dr Stuart Hitch, Earth Science Teachers' Association affiliated teacher, Greg Jones, National Union of Teachers affiliated teacher, Professor Chris King, Earth Science Teachers' Association, and Darren Northcott, National Official (Education), National Association of Schoolmasters/Union of Women Teachers.

On 29 June the Committee took evidence from: Paul Cohen, Director Initial Teacher Training Recruitment, Training and Development Agency, Annette Smith, Chief Executive, Association of Science Education, Dr Phil Smith MBE, Co-ordinator, Teacher Scientist Network, and Dr Steve Tilling, Field Studies Council; Beth Gardner, Chief Executive, Council for Learning Outside the Classroom, Professor Graham Hutchings FRS, Chair, SCORE, Sir Roland Jackson, Chief Executive, British Science Association, and Steve Jones, Director, CLEAPSS.

On 4 July the Committee took evidence from: David Knighton, Reporting inspector, Ofsted, Kevin Myers, Deputy Chief Executive, Health and Safety Executive, Dennis Opposs, Director of Standards, OfQual, and Nigel Thomas, Director, Education and Skills, Gatsby Foundation; Nick Gibb MP, Minister of State for Schools, Department for Education.

The written evidence received in this inquiry is on the Committee's website. The Committee's Report was published on 14 September.

ORAL EVIDENCE

The transcripts of the evidence sessions described above and below are available on the Science and Technology Committee's website [www.parliament.uk/science].

The Government Office for Science Annual Review 2010-11

On 7 September the Committee took evidence from Professor Sir John Beddington, Government Chief Scientific Adviser on the Government Office for Science Annual Review 2010-11.

Treasury Chief Scientific Adviser

On 7 September the Committee held an evidence session examining the role of the Treasury Chief Scientific Adviser and it took evidence from Professor Sir John Beddington, Government Chief Scientific Adviser and James Richardson, Chief Scientific Adviser, HM Treasury

Forest research

On 11 May 2011 the Committee announced an inquiry into forest research. The Committee invited written submissions on the following issues by 9 June.

On 13 July the Committee took evidence from: Jacqueline Caine, Science Policy Officer, Society of Biology, Stuart Goodall, Chief Executive, Confederation of Forest Industries, Allan MacKenzie, Departmental Secretary, Forestry Commission Trade Unions, Professor Philip Turner, Director, Forest Products Research Institute, and Dr Allan Watt, Deputy Science Director, Biodiversity Programme, Centre for Ecology & Hydrology; Roger Coppock, Head of Specialist Advisors, Corporate and Forestry Support, Forestry Commission, Brian Harris, Head of Science Strategy for Agriculture, Food and Environment, Biotechnology and Biological Sciences Research Council, Dr Andrew Impey, Terrestrial and Freshwater Science & Innovation Manager, Natural Environment Research Council, and Dr James Pendlebury, Chief Executive, Forest Research; Rt Hon Jim Paice MP, Minister of State for Agriculture and Food, Department for Environment, Food and Rural Affairs, Dr Miles Parker, Deputy Chief Scientific Adviser, Department for Environment, Food and Rural Affairs, and Tim Rollinson, Director General and Deputy Chairman, Forestry Commission.

The evidence session was held concurrently with the House of Lords Science and Technology Committee. The written and oral evidence received for this evidence session is on the Committee's website. No report is expected to be produced at this stage.

The commissioning of X-Ray Photoelectron Spectroscopy services

On 15 June 2011 the Committee agreed to hold an evidence session examining the commissioning of X-Ray Photoelectron Spectroscopy services.

On 11 July the Committee took evidence from: Dr Graham Bushnell-Wye, Prospect, Professor David Delpy, Chief Executive, Engineering & Physical Sciences Research Council, and Professor Colin Whitehouse, Head of the Daresbury Laboratory.

Scientific advice and evidence in emergencies: follow-up

On 8 June 2011 the Committee announced an evidence session following up its report on Scientific advice and evidence in emergencies.

On 15 June the Committee took evidence from: Professor Sir John Beddington, Government Chief Scientific Adviser, Christina Scott, Director, Civil Contingencies Secretariat, Cabinet Office, and Julia Longbottom, Head of China Department, Foreign and Commonwealth Office.

REPORTS

Forensic Science Service

On 1 July 2011, the Committee published its Seventh Report of Session 2010-12, *The Forensic Science Service*, HC 855.

Peer review

On 28 July 2011, the Committee published its Eighth Report of Session 2010-12, *Peer review in scientific publications*, HC 856.

Practical experiments in school science lessons and science field trips

On 28 July 2011, the Committee published its Ninth Report of Session 2010-12, *Practical experiments in school science lessons and science field trips,* HC 1060.

GOVERNMENT RESPONSES

Government Response to the Science and Technology Committee report 'Bioengineering'

On 14 June 2011, the Committee published the Government's Response to the predecessor Committee's Report on Bioengineering, HC 1138.

Supplementary Government Response to the Science and Technology Committee report 'Scientific advice and evidence in emergencies'

On 14 June 2011, the Committee published the Government's Supplementary Response to the Committee's Report on Scientific advice and evidence in emergencies, HC 1139.

Government and the Science and Technology Facilities Council

Responses to the Science and Technology Committee report 'Astronomy and Particle Physics'

On 19 July 2011, the Committee published the Government's and the Science and Technology Facilities Council's Responses to the Committee's Report on Astronomy and Particle Physics, HC 1425.

Government Response to the Science and Technology Committee report 'UK Centre for Medical Research and Innovation (UKCMRI)'

On 13 September 2011, the Committee published the Government's Response to the Committee's Report on UK Centre for Medical Research and Innovation (UKCMRI), HC 1475.

Government Response to the Science and Technology Committee report 'Strategically important metals'

On 14 September 2011, the Committee published the Government's Response to the Committee's Report on Strategically important metals, HC 1479.

DEBATES

On 15 September there was a Westminster Hall debate on the Third Report from the Science and Technology Committee, Session 2010-12, HC 498, on Scientific advice and evidence in emergencies, and the Government's responses, Session 2010-12, HC 1042 and 1139 and Scientific advice and evidence in emergencies follow-up, 15 June 2011, HC 1059-i.

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, Elizabeth Flood, the Second Clerk, Stephen McGinness, or from the Senior Committee Assistant, Andy Boyd, on 020 7219 8367/2792/2793 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.

HOUSE OF LORDS SCIENCE AND TECHNOLOGY SELECT COMMITTEE

The members of the Committee (appointed 22 June 2010) are Lord Broers, Lord Crickhowell, Lord Cunningham of Felling, Baroness Hilton of Eggardon, Lord Krebs (Chairman), Baroness Neuberger, Lord Patel, Baroness Perry of Southwark, Lord Rees of Ludlow, the Earl of Selborne, Lord Wade of Chorley, Lord Warner, Lord Willis of Knaresborough and Lord Winston. Lord Jenkin of Roding and Lord Oxburgh have been co-opted to the Committee for the purposes of its inquiry into nuclear research and development capabilities.

The role and function of departmental Chief Scientific Advisers (CSAs)

In July 2011, the Science and Technology Committee, under the Chairmanship of Lord Krebs, launched an inquiry on the role and function of Chief Scientific Advisers. The inquiry will be looking at a number of aspects concerning the role of CSAs including: the ability of CSAs to provide independent advice to ministers and policy makers; the extent of their influence over research spend; and their role in providing independent challenge and ensuring that departmental policies are evidence-based. A call for evidence was released on 20 July 2011 with a deadline for submission of 16 September. The Committee will start taking oral evidence on 18 October.

Nuclear research and development capabilities

In March 2011, the Select Committee, also under the Chairmanship of Lord Krebs, launched a short inquiry to investigate whether the UK's nuclear research and development (R&D) capabilities are sufficient to meet its future nuclear energy requirements to 2050. The inquiry has examined, amongst other things, the R&D implications of future scenarios up to 2050 and whether the UK has adequate R&D capabilities, including infrastructure, to meet its current and future needs for a safe and secure supply of nuclear energy. A call for evidence was released on 17 March 2011 with a deadline for submission of 28 April. The Committee held a workshop with Government officials and key stakeholders on 5 April and public meetings were held from 10 May to 14 September. The report will be published by the end of 2011.

Behaviour change policy interventions

In June 2010, the Select Committee appointed a Sub-Committee under the Chairmanship of Baroness Neuberger to conduct an inquiry into the effectiveness of behaviour change interventions in achieving government policy goals and helping to meet societal challenges.

Governments across the world are attempting to meet challenges such as the need to reduce carbon emissions and the rise in obesity. As a result, more and more attention is being focused on how behaviour can be influenced using a range of behaviour change interventions that rely on measures other than prohibition or the elimination of choice. The Committee considered the current state of knowledge about which behaviour change interventions are effective, whether the Government's current behaviour change interventions are evidence-based and subject to robust evaluation, and how such interventions are coordinated across departments. The Committee has also looked at the role of industry and the voluntary sector in shaping behaviour patterns and the social and ethical

issues surrounding behaviour change interventions by government.

The inquiry included two case studies. The first looked at behaviour change interventions designed to reduce obesity and the second focused on travel-mode interventions to reduce car use in towns and cities. The Committee published its report on 19 July 2011. The Government response was published on 15 September. It is anticipated that the report will be debated in the House in the current session.

Public procurement as a tool to stimulate innovation

At the end of 2010, the Select Committee, under the chairmanship of Lord Krebs, launched a short inquiry into public procurement as a tool to stimulate innovation within industry. The inquiry focused, in particular, on the Department for Transport and related public bodies, as a working example of the current procurement practices within departments. The Committee published its report at the end of May 2011. The Government response was published on 23 August and the report was debated in the House on 13 September.

STEM Higher Education

On 13 September 2011 the Select Committee appointed a new Sub-Committee under the Chairmanship of Lord Willis of Knaresborough to consider STEM higher education. A call for evidence will be published in October.

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 www.parliament.uk/hlscience. Further information about the work of the Committee can be obtained from Christine Salmon Percival, Committee Clerk, salmonc@parliament.uk or 020 7219 6072. The Committee's email address is hlscience@parliament.uk.

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

RECENT POST PUBLICATIONS

Carbon Footprint of Electricity Generation

June 2011 *POSTnote 383*

In 2006, POSTnote 268 outlined the "carbon footprints" of a variety of electricity generation technologies. Footprint data were scarce at that time, particularly peer-reviewed estimates. This POSTnote provides an updated overview of the evidence base in 2011, including estimates from more than 30 peer-reviewed studies.

Biofuels from Algae

July 2011 *POSTnote 384*

Algae, including seaweed, are a potential source of renewable fuel, food and chemicals. This POSTnote examines the technical, economic and environmental issues around algal biofuels and their relevance to UK and EU policy targets.

Water in Production and Products

August 2011 *POSTnote 385*

The water used for production, known as "virtual" water, constitutes 95% of human water use. As pressure on the world's water supply rises, recognition of the amount of water used within each step of production could play an important role in managing water use. This POSTnote examines how virtual water use is calculated and its application within the global economy.

GM Crops and Food Security

September 2011 *POSTnote 386*

The rising global population requires agriculture to increase productivity at a time when land and water shortages and climate change are putting pressure on food production. This POSTnote examines the potential contribution that genetic modification of crops might bring to increasing food production in Europe, in a global context.

Anaerobic Digestion

September 2011 *POSTnote 387*

Anaerobic digestion (AD) can divert waste from landfill and produce biogas, a source of renewable energy, and "digestate", a fertiliser. This POSTnote examines the potential for AD in the UK, and the main challenges connected with its development.

Marine Planning

September 2011 *POSTnote 388*

The UK's marine resources have substantial economic, environmental and social value. However, increasing demand has led to concerns over their degradation. The Marine and Coastal Access Act (2009) set out the mechanism for marine planning in UK waters and aims to help tackle these concerns. It combines the management of activities and conservation of the marine environment. This POSTnote describes the marine planning process and considers the challenges it will face.

Cyber Security in the UK

September 2011 *POSTnote 389*

The National Security Strategy, published in October 2010, rated large scale cyber attacks as one of the four highest priority risks to UK national security. The aim of this four page POSTnote is to provide MPs and Peers with an overview of cyber security in the UK, focusing on large scale cyber attacks directed at UK National Infrastructure.

CURRENT WORK

Biological Sciences – Animal Health and Biosecurity, Personal Genomics, Improving Livestock, Clinical Trials, Review of Stem Cell Research, An Ageing Workforce, Blast Injuries, Computer Games/Videos and Violence, Biotechnology Patenting, Personalised Cancer Care.

Environment and Energy – Energy Security, Invasive Tree Pests and Pathogens, Natural Flood Management, Sustainability.

Physical sciences and IT – Solar Technologies, Clean Water and the MDGs, Opening up Public Sector Data

Science Policy – Science, Technology, Mathematics and Engineering (STEM) Education: 14-19 Year Olds, Open Access and Open Data

CONFERENCES AND SEMINARS

Examining Science, Technology, Engineering & Maths Education for Ages 14-19

On 14 June, POST organised a seminar to discuss the uptake of science, technology, engineering and mathematics (STEM) subjects by young people and its strategic importance to the future economic competitiveness of the UK. It is also vital to the country's social development, with STEM skills increasingly required to help to improve the quality of people's everyday lives. After a long period of decline, uptake of STEM subjects post-16 is currently rising and is projected to reach 2014 government targets. However, there continue to be several barriers to uptake at school, with notable gender, ethnic and socio-economic disparities. This seminar featured keynote speeches from a number of leading experts in science education, focusing on the state of national STEM education and policies aimed at encouraging greater participation. The seminar provided an opportunity to discuss the various initiatives taking place and the policy challenges that lie ahead.

Dr Therese Coffey MP, Member of Parliament for Suffolk Coastal constituency, chaired the seminar at which invited guests heard presentations from Professor Sir John Holman, University of York, former Director of the National Science Learning Centre and National STEM Director, Mr Tim Oates, Director of Assessment Research and Development, Cambridge Assessment and Chair of the National Curriculum Review Expert Panel, Mr Dennis Opposs, Director of Standards and Head of Qualification Monitoring, Ofqual, Mr Richard Needham, Chair, The Association for Science Education and Dr Penny Fidler, Chief Executive Officer, The Association for Science and Discovery Centres.

The Fukushima Dai-ichi incident: Implications for the international community

On 6 July, POST organised a special seminar, bringing together leading international experts on nuclear power, safety and security from the UK, Japan and France. Adam Afriyie MP, Chair of the POST Board, introduced and chaired the seminar at which invited guests heard presentations from Professor Tatsujiro Suzuki, Vice-Chair, Atomic Energy Commission, Japan, Mr Claude Birraux, President of the Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques (OPECST), France, Mr Denis Flory, Head of Nuclear Safety and Security, International Atomic Energy Agency (IAEA) and Mr Mike Weightman, HM Chief Inspector, Nuclear Installations and Executive Head, Office for Nuclear Regulation (ONR).

Staff, Fellows and Interns at POST

Conventional Fellows

Emma Ransome, Plymouth University, Natural Environment Research Council

Martina Di Fonzo, Imperial College London, Natural Environment Research Council

Joanna Hepworth, York University, Biotechnology and Biological Sciences Research Council

Jennifer Dodson, York University, Royal Society of Chemistry

Heather Riley, Birmingham University, Biotechnology and Biological Sciences Research Council

Clare Dyer-Smith, Imperial College London, Royal Society of Chemistry

Matthew Mottram, University College London, Engineering and Physical Sciences Research Council Fellow

Zoe Freeman, Edinburgh University, Biotechnology and Biological Sciences Research Council

Natalie Banner, Kings College London, Wellcome Trust Medical History and Humanities division

HOUSE OF COMMONS LIBRARY SCIENCE AND ENVIRONMENT SECTION

A Research Paper produced for Members of Parliament is summarised opposite. Papers can be accessed at http://www.parliament.uk/briefing-papers/commons-research-papers/

The Section produces a series of frequently updated notes on a wide of topics. Opposite are summaries of some recently updated notes.

The notes can be accessed online at http://www.parliament.uk/topics/Topical-Issues.htm

For further information contact Christopher Barclay Head of Section Tel: 020 7219 3624 email: barclaycr@parliament.uk

Energy Bill [HL]: Committee Stage Report Research Paper 11/64

This is a report on the House of Commons Committee Stage of the Energy Bill. It complements Library Research Paper 11/36 (Energy Bill) prepared for the Commons Second Reading.

The Bill covers a wide range of topics including issues relating to energy efficiency, including the Green Deal, and energy generation. The most substantial amendments to the Bill relate to the introduction of regulations on the energy efficiency of the private rented sector. A clause on nuclear decommissioning was withdrawn and is to be reintroduced at a later stage by the Government. There were also new clauses relating to carbon capture and storage, and renewables in national parks.

Tar Sands SN/SC/6023

Tar sands (or oil sands) are a naturally occurring mixture of sand, clay or other minerals, water and bitumen. According to the International Energy Agency, Canadian oil sands are expected to assume a rapidly expanding role in meeting future oil demand. However, there are environmental concerns associated with, among other things, the carbon dioxide (CO_2) released during the extraction and processing of tar sands to produce useable fuel. Other environmental issues relate to water use, mining waste and deforestation: the tar sands in Canada cover an area of primary boreal forest larger than England.

There is concern in Canada that new EU standards to promote greener fuels could harm future markets for its oil sands.

Energy from waste and incineration SN/SC/5958

Incineration is the burning of waste to reduce its volume, so that the remaining ash is easier to dispose of. Energy from Waste (EfW) takes this process further by recovering some of the energy contained in the waste. There are a variety of incineration and EfW technologies, such as gasification.

Local opposition to these technologies can be fierce. Concerns are often raised about the health implications and the wider environmental impacts of burning waste. However, Government agencies and many professional groups argue that the evidence shows that they are safe. Many also argue that they can play an important role in sustainable waste management – although the degree to which a plant may be considered 'sustainable' is dependent upon a number of factors.

It is likely that these technologies will play an increasing role in UK waste management as it becomes more expensive to landfill waste.

Septic tanks: new regulations SN/SC/6059

Septic tanks can pollute groundwater supplies and surface water in rivers, streams and lakes. Such pollution can make supplies unusable for drinking and cause damage to the environment, with economic and social consequences.

Discharges from septic tanks from isolated buildings are no longer exempt from groundwater protection legislation. To reflect this, regulations introduced in 2010 now require many septic tanks to be registered or to have an environmental permit by 2012.

In July 2011 the Minister, Richard Benyon MP, requested the Environment Agency to review this approach "to check whether [it] is the most appropriate and whether there might be opportunities for further simplification". Following the announcement the Environment Agency stopped actively seeking owners of many septic tanks, although it still permitted owners to register should they so wish. A consultation will be announced by Defra in coming weeks.

Overfishing and Fisheries Policy SN/SC/2979

European Commission proposals in July 2011 for reform of the Common Fisheries Policy included decentralisation; requiring fishermen to land all the fish they catch; reducing fleet overcapacity by market measures; supporting fish farms. The proposals will now go to the European Parliament and Council of Ministers.

The UK Government's reaction was non-committal. The Scottish Government said the proposals did not go far enough, but welcomed the opportunity to exercise more control over fishing in Scottish waters.

The National Federation of Fishermen's Organisations did not want CFP reform to follow the model of the current cod management plan. Objectives, targets and timetables are set centrally, with a subordinate and highly constrained role for the Member States in implementing the rules.

National Planning Policy Framework SN/SC/6066

The Government published the draft National Planning Policy Framework (NPPF) on 25 July 2011. Consultation will close on 17 October 2011. The Government intends to replace all planning guidance by the NPPF in April 2012. The final version of this 52 page document will be the main factor in shaping planning policy, more so than the Localism Bill, which will probably become an Act in November 2011.

The NPPF includes a presumption in favour of sustainable development. Critics, led by the National Trust and the Campaign to Protect Rural England, have accused the document of handing over too much power to developers, reducing protection for rural England. Supporters of the NPPF welcome the radical simplification of planning guidance and argue that it contains the necessary safeguards, without restricting needed investment.

The draft guidance can already be a material consideration in determining planning applications, but existing planning guidance remains in force.

Town centres, planning and supermarkets SN/SC/1106

This note covers the debate over the way that the planning system protects retailers in the town centre by restricting supermarkets. Until 2009 planning guidance required applicants to demonstrate a need for more supermarket capacity in the area (the so-called "need test").

The Labour Government abolished the need test in revised planning guidance, Planning Policy Statement 4 of December 2009. However, the planning authority is still required to plan to satisfy need for retail outlets and to follow the sequential test.

The Government published the draft National Planning Policy Framework (NPPF) in July 2011. The NPPF will replace all Government planning guidance in April 2012. The impact and sequential tests are retained but the need test has not returned.

Research at the LSE in 2011 suggests that restrictive planning policies have reduced productivity in the retail sector by 20%.

Hill Farm Support SN/SC/894

This note describes the system of allowances paid to hill farmers. The Coalition Government Programme said that it would "develop a system of extra support for hill farmers". The Government announced increased support in March 2011.

Since 1 July 2010, hill farming has been fully integrated into the environmental stewardship part of the Common Agricultural Policy. This is a new uplands entry level stewardship (Uplands ELS). Basically upland farmers are paid a higher single farm payment. Uplands ELS will reward farmers for maintaining and improving the upland landscape and environment.

In February 2011, the EFRA Select Committee called for a return to headage payments – support based on the number of livestock instead of a payment based on area.

The Commission for Rural Communities argued that the uplands contained important public goods and market products, which would not be preserved by the current amount of support for hill farming.

Battery Hens SN/SC/1367

An EU Directive in 1999 banned the use of battery cages from 2012 – allowing time for the industry to replace its equipment without undue cost. There is considerable disagreement whether they should be replaced by so-called "enriched" cages, or whether those cages are almost as bad as the ones being banned.

An EFRA Select Committee Report on the Welfare Laying Hens Directive, September 2011, noted that one third of the EU's egg industry will not be compliant with regulations when they come into force in January 2012. It warned that the compliant industry could

be undermined by cheaper imports of eggs and egg products deriving from caged birds.

Food Supplements Directive SN/SC/4152

The EU market for food supplements containing vitamins and minerals is regulated by Directive 2002/46/EC, known as the Food Supplements Directive. UK Governments have broadly supported the Directive's public safety and trade promoting intentions but have been subject to intense lobbying, particularly regarding future availability of high dose supplements and potential impacts on the profitability of suppliers.

Current controversy centres mainly on the issue of maximum permitted levels. Successive UK governments have argued these should be based on risk of harm and that regulation should be flexible for vitamins and minerals for which there is no evidence of adverse effects. Although a draft proposal on permitted levels was expected from the EC in early 2009, this has been repeatedly delayed.

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, the House of Lords or Westminster Hall on 6th June-20th July, 11th August and 5th-15th September.

A Digest of Parliamentary Questions and Answers for the same period can be found at www.scienceinparliament.org.uk

Agriculture and Biodiversity

Biological Diversity	20.6.11	HoL 1109
Food Security Strategy	5.7.11	HoC 1482

Defence

Radar Industry	13.9.11	HoC 234WH

Education

Student Visas	16.6.11	HoC 327WH

Energy

Coal-fired Power Stations	29.6.11	HoC 303WH
National Policy Statements (Energy)	18.7.11	HoC 678

Environment

Flood and Water Management	8.9.11	HoC 143WH

Health

Cannabis and Psychosis (Young People)	9.6.11	HoC 393
Hospital Food	14.6.11	HoC 751
Information Technology	14.6.11	HoC 205WH
Dental Bleaching	23.6.11	HoC 587
Neuroblastoma	5.7.11	HoC 446WH
Coeliac Disease	7.9.11	HoC 101WH

International Development

Future of CDC	14.7.11	HoC 155WH
Food Security and Famine Prevention (Africa)	15.9.11	HoC 1208

Intellectual Property

Intellectual Property (Hargreaves Report)	7.7.11	HoC 535WH

IT, Telecommunications and Broadcasting

Machine-to-machine Communication	8.6.11	HoC 132WH
Computer Games Industry	29.6.11	HoC 335WH

Science Policy

Research: Science and Technology Committee Report	8.6.11	HoL 326
Public Procurement as a Tool to Stimulate Innovation: Science and Technology Report	13.9.11	HoL GC173
Scientific Advice (Emergencies)	15.9.11	HoC 331WH

Space

Microgravity Research	13.9.11	HoC 1009

Transport

Train-building Industry	12.7.11	HoC 1WH
High-speed Rail	13.7.11	HoC 77WH

PROGRESS OF LEGISLATION BEFORE PARLIAMENT

A comprehensive list of Public Bills before Parliament, giving up-to-date information on their progress, is published regularly when Parliament is sitting in the Weekly Information Bulletin, which can be found at: http://www.publications.parliament.uk/pa/cm/cmwib.htm

SCIENCE DIRECTORY

DIRECTORY INDEX

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The Physiological Society

Hydrocarbons and Petroleum
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Royal Society of Chemistry

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National Physical Laboratory
STFC

Pollution and Waste
ABPI
C-Tech Innovation
The Geological Society
Institution of Chemical Engineers
Institution of Civil Engineers
London Metropolitan Polymer Centre
National Physical Laboratory
Natural Environment Research Council
Plymouth Marine Sciences Partnership
Society of Maritime Industries

Psychology
The British Psychological Society
Economic and Social Research Council

Public Policy
Biochemical Society
The British Ecological Society
British Nutrition Foundation
British Society for Antimicrobial Chemotherapy
Economic and Social Research Council
EngineeringUK
The Food and Environment Research Agency
Institution of Civil Engineers
Institution of Chemical Engineers
Institution of Engineering and Technology
NESTA
Prospect
Royal Society of Chemistry
Society of Biology

Quality Management
GAMBICA Association Ltd
LGC
National Physical Laboratory

Radiation Hazards
Institute of Physics and Engineering in Medicine
Institution of Engineering and Technology
LGC

Science Policy
ABPI
Academy of Medical Sciences
Biochemical Society
The British Ecological Society
British Nutrition Foundation
British Pharmacological Society
British Science Association
CABI
Clifton Scientific Trust
C-Tech Innovation
Economic and Social Research Council
Eli Lilly and Company Ltd
EPSRC
EngineeringUK
The Food and Environment Research Agency
GAMBICA Association Ltd
Institute of Physics
Institution of Chemical Engineers
Institution of Civil Engineers
Institution of Engineering and Technology
LGC
Medical Research Council
NESTA
National Physical Laboratory
The Physiological Society
Plymouth Marine Sciences Partnership
Prospect
Research Councils UK
The Royal Academy of Engineering
Royal Botanic Gardens, Kew
Royal Institution
The Royal Society
Royal Society of Chemistry
STFC
Society of Biology
UFAW

Sensors and Transducers
C-Tech Innovation
GAMBICA Association Ltd
Institute of Measurement and Control
Institution of Engineering and Technology
STFC
Society of Maritime Industries

SSSIs
The Geological Society
Royal Botanic Gardens, Kew

Statistics
Economic and Social Research Council
EPSRC
EngineeringUK
Royal Statistical Society

Surface Science
C-Tech Innovation
STFC

Sustainability
The British Ecological Society
CABI
C-Tech Innovation
EPSRC
The Food and Environment Research Agency
The Geological Society
Institution of Chemical Engineers
Institution of Civil Engineers
The Linnean Society of London
London Metropolitan Polymer Centre
Plymouth Marine Sciences Partnership
Royal Botanic Gardens, Kew
Royal Society of Chemistry
Society of Biology

Technology Transfer
AIRTO
CABI
C-Tech Innovation
The Food and Environment Research Agency
Institute of Measurement and Control
Institution of Engineering and Technology
LGC
London Metropolitan Polymer Centre
NESTA
National Physical Laboratory
Research Councils UK
Royal Society of Chemistry
STFC

Tropical Medicine
Natural History Museum
Royal Botanic Gardens, Kew
Society for Applied Microbiology
Society for General Microbiology

Viruses
ABPI
Society for Applied Microbiology
Society for General Microbiology

Water
C-Tech Innovation
The Geological Society
Institute of Measurement and Control
Institution of Chemical Engineers
Institution of Civil Engineers
LGC
Plymouth Marine Sciences Partnership
Royal Society of Chemistry
Society for Applied Microbiology
Society for General Microbiology
Society of Biology
Society of Maritime Industries

Wildlife
The British Ecological Society
The Food and Environment Research Agency
The Linnean Society of London
Natural History Museum
Royal Botanic Gardens, Kew
Society of Biology
UFAW

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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Website:www.epsrc.ac.uk

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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Website: www.mrc.ac.uk

For almost 100 years, the MRC has been improving the health of people in the UK and around the world by supporting the highest quality science on behalf of UK taxpayers. We 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. MRC-funded scientists have made some of the most significant discoveries in medical science – from the link between smoking and cancer to the invention of therapeutic antibodies – benefiting millions of people.

Natural Environment Research Council

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Website: www.nerc.ac.uk

The UK's Natural Environment Research Council funds and carries out impartial scientific research in the sciences of the environment. NERC trains the next generation of independent environmental scientists.

NERC funds research in universities and in a network of its own centres, which include:

British Antarctic Survey, British Geological Survey, Centre for Ecology and Hydrology, and National Oceanography Centre.

Science & Technology Facilities Council

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Formed by Royal Charter in 2007, the Science and Technology Facilities Council is one of Europe's largest multidisciplinary research organisations supporting scientists and engineers world-wide. The Council operates world-class, large-scale research facilities and provides strategic advice to the UK Government on their development. The STFC partners in the UK's two National Science and Innovation Campuses. It also manages international research projects in support of a broad cross-section of the UK research community. The Council directs, co-ordinates and funds research, education and training.

The Academy of Medical Sciences

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The Academy of Medical Sciences promotes advances in medical science and campaigns to ensure these are converted into healthcare benefits for society. The Academy's Fellows are the United Kingdom's leading medical scientists and scholars from hospitals, academia, industry and the public service. The Academy provides independent, authoritative advice on public policy issues in medical science and healthcare.

Association of the British Pharmaceutical Industry

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Website: www.abpi.org.uk

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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Fax: 020 8614 0470
E-mail: enquiries@airto.co.uk
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AIRTO represents the UK's independent research and technology sector - member organisations employ a combined staff of over 20,000 scientists and engineers with a turnover exceeding £2 billion. Work carried out by members includes research, consultancy, training and global information monitoring. AIRTO promotes their work by building closer links between members and industry, academia, UK government agencies and the European Union.

Biochemical Society

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The Biochemical Society exists to promote and support the Molecular and Cellular Biosciences. We have nearly 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.

British Science Association

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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.

The British Ecological Society

The British Ecological Society
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British Ecological Society
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Website: www.BritishEcologicalSociety.org
Ecology into Policy Blog
http://britishecologicalsociety.org/blog/

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 Nutrition Foundation

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www.foodafactoflife.org.uk

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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Website: www.bps.ac.uk

The British Pharmacological Society has been supporting pharmacology and pharmacologists for over 80 years. Our 2,700+ members, from academia, industry and clinical practice, are trained to study drug action from the laboratory bench to the patient's bedside. Our aim is to improve quality of life by developing new medicines to treat and prevent the diseases and conditions that affect millions of people and animals. Inquiries about drugs and how they work 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 welcome.

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.

CABI

Science and development organization

www.cabi.org

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CABI is an international not-for-profit development organization, specializing in scientific publishing, research and communication. We create, communicate, and apply knowledge in order to improve people's lives by finding sustainable solutions to agricultural and environmental issues.

We work for and with universities, national research and extension institutions, development agencies, the private sector, governments, charities and foundations, farmers, and non-governmental organizations. We also manage one of the world's largest genetic resource collections: the UK's National Collection of Fungus Cultures.

Cavendish Laboratory

UNIVERSITY OF CAMBRIDGE

The Administrative Secretary, The Cavendish Laboratory,
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http://www.phy.cam.ac.uk

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

Founded 1882 Royal Charter 1891

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Website: www.cipa.org.uk

CIPA's members 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

CLIFTON SCIENTIFIC Trust

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Website: www.clifton-scientific.org

Science for Citizenship and Employability, Science for Life, Science for Real

We build grass-roots partnerships between school and the wider world of professional science and its applications

- for young people of all ages and abilities
- experiencing science as a creative, questioning, human activity
- bringing school science added meaning and notivation, from primary to post-16
- locally, nationally, internationally (currently between Britain and Japan)

Clifton Scientific Trust Ltd is registered charity 1086933

C-Tech Innovation Limited

C-Tech Innovation
...advantage through technology

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Fax: +44 (0) 151 347 2901
E-mail: paul.radage@ctechinnovation.com
Website: www.ctechinnovation.com

Leading innovation management and technology development company.
We help companies, universities, government bodies and non-governmental organisations to benefit and grow through innovation. Vast experience of project and programme management, implementation of novel technologies, contract and collaborative research and technology development, business and technology consultancy, commercialization, IP exploitation, market and sector research. **www.ctechinnovation.com**

Eli Lilly and Company Ltd

Lilly
Answers That Matter.

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Website: www.lilly.co.uk

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, severe sepsis, 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

fera
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

The Geological Society
serving science & profession

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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.

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 promoting physics and bringing physicists together for the benefit of all.

It has a worldwide membership of around 40,000 comprising physicists from all sectors, as well as those with an interest in physics. It works to advance physics research, application and education; and engages with policymakers and the public to develop awareness and understanding of physics. Its publishing company, IOP Publishing, is a world leader in professional scientific publishing and the electronic dissemination of physics. Go to www.iop.org

IPEM 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 and by the Engineering Council to award CEng, IEng and EngTech.

IChemE

Institution of Chemical Engineers

With over 33,000 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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Institution of Civil Engineers

ice

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ICE aims to be a leading voice in infrastructure issues. With over 80,000 members, ICE acts as a knowledge exchange for all aspects of civil engineering. As a Learned Society, the Institution provides expertise, in the form of reports, evidence and comment, on a wide range of subjects including infrastructure, energy generation and supply, climate change and sustainable development.

Institution of Engineering Designers

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E-mail: ied@ied.org.uk
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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.

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

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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

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 31 laboratories and centres across Europe and at sites in China, Brazil, India and the US.

The Linnean Society of London

The Linnean Society of London
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The Linnean Society of London is the world's oldest active biological society. Founded in 1788, the Society takes its name from the Swedish naturalist Carl Linnaeus whose botanical, zoological and library collections have been in its keeping since 1829. The Society continues to play a central role in the documentation of the world's flora and fauna, recognising the continuing importance of such work to many scientific issues.

London Metropolitan Polymer Centre

Sir John Cass Faculty of Art, Media & Design

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Website: www.polymers.org.uk

The London Metropolitan Polymer Centre provides training, consultancy and applied research to the UK polymer (plastics & rubber) industry. LMPC is one of the departments within the Sir John Cass Faculty of Art, Media & Design (JCAMD) and provides a broad perspective of materials science and technology for the manufacturing and creative industries. JCAMD contains Met Works, a unique Digital Manufacturing Centre, providing new technology for rapid prototyping and manufacture. The Faculty will offer short courses in a range of polymer, rapid prototyping and practical areas.

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.

The National Endowment for Science, Technology and the Arts

NESTA Making Innovation Flourish

Guy Bilgorri
Public Affairs Officer
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Website: www.nesta.org.uk

NESTA is the National Endowment for Science, Technology and the Arts – an independent organisation with a mission to make the UK more innovative. It operates in three main ways: by investing in early-stage companies; informing and shaping policy; and delivering practical programmes that inspire others to solve the big challenges of the future. NESTA's expertise in this field makes it uniquely qualified to understand how the application of innovative approaches can help the UK to tackle two of the biggest challenges it faces: the economic downturn and the radical reform of public services.

National Physical Laboratory

NPL National Physical Laboratory

Contact: Fiona Auty
National Physical Laboratory
Hampton Road, Teddington
Middlesex TW11 0LW
Tel: 020 8977 3222
Website: www.npl.co.uk/contact-us

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

NATURAL HISTORY MUSEUM
The Science of Nature

Contact: Joe Baker
Directorate
Natural History Museum
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Website: www.nhm.ac.uk

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.

The Nutrition Society

Contact: Frederick Wentworth-Bowyer,
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www.nutritionsociety.org

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

Contact: Dr Benjamin P North
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Fax: 01425 657992
E-mail: ben.north@pharmaq.no
Website: www.pharmaq.no
Web shop: www.pharmaqwebshop.co.uk/shop

PHARMAQ is the only global pharmaceutical company with a primary focus on aquaculture. Specialising in the supply of veterinary pharmaceuticals for the salmon and trout farming industries including vaccines, anaesthetics, antibiotics and sea lice treatments. In the UK we also support an extensive range of biocides and cage and aviary products.

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 and also publishes the latest developments in the field in its two leading scientific journals, *The Journal of Physiology* and *Experimental Physiology.*

Plymouth Marine Sciences Partnership

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The Plymouth Marine Sciences Partnership comprises seven leading marine science and technology institutions, representing one of the largest regional clusters of expertise in marine sciences, education, engineering and technology in Europe. The mission of PMSP is to deliver world-class marine research and teaching, to advance knowledge, technology and understanding of the seas. PMSP research addresses the fundamental understanding of marine ecosystems and processes that must be applied in support and development of policy, marine and maritime industry and marine biotechnology.

Prospect

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Prospect is an independent, thriving and forward-looking trade union with 122,000 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.

The 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

RBG Kew is a centre of global expertise in plant and fungal diversity, conservation and sustainable use housed in two world-class gardens. Kew receives approximately half of 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
- Banking 25% of plant species in the Millennium Seed Bank Partnership
- Restoration ecology
- Inspiring through botanic gardens

Contact: The Director's Office
Tel: 020 8332 5112
Fax: 020 8332 5109
Email: director@kew.org
Website: www.kew.org

Inspiring and delivering science-based plant conservation worldwide, enhancing the quality of life

The Royal Institution

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Twitter: rigb_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 major Public Events Programme designed to connect people to the world of science, 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. The strategic priorities for our work at national and international levels are to:

- Invest in future scientific leaders and in innovation
- Influence policymaking with the best scientific advice
- Invigorate science and mathematics education
- Increase access to the best science internationally
- Inspire an interest in the joy, wonder and excitement of scientific discovery.

The Royal Society of Chemistry

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Website: http://www.rsc.org
http://www.chemsoc.org

The Royal Society of Chemistry is a learned, professional and scientific body of over 46,000 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.

The Royal Statistical Society

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Website: www.rss.org.uk

The Royal Statistical Society is a leading source of independent advice, comment and discussion on statistical issues. It promotes public understanding of statistics and acts as an advocate for the interests of statisticians and users of statistics. The Society actively contributes to government consultations, Royal Commissions, parliamentary select committee inquiries, and to the legislative process. In 2009, the RSS celebrated 175 years since its foundation in 1834.

Semta

the Sector Skills Council for Science, Engineering and Manufacturing Technologies

Contact: Customer Services
14 Upton Road
Watford
WD18 0JT
Tel: 0845 643 9001
Fax: 01923 256086
E-mail: customerservices@semta.org.uk
Website: www.semta.org.uk

Semta's skills service for UK science, engineering and manufacturing employers

- Training needs assessment against a company's business objectives.
- Quality programmes from The National Skills Academy for Manufacturing
- A training management service.
- Access to available funding and accredited training providers.
- Research into training needs to influence governments' support for skills strategies

Society for Applied Microbiology

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Society for Applied Microbiology
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Fax: 01234 326678
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Website: www.sfam.org.uk

*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

Contact: Dariel Burdass
Marlborough House, Basingstoke Road,
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E-mail: pa@sgm.ac.uk
Website: www.sgm.ac.uk

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

Contact: Dr Mark Downs
Chief Executive
Charles Darwin House
12 Roger Street
London WC1N 2JU
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The Society of Biology 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 Cosmetic Scientists

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Secretary General
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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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Chief Executive and Scientific Director
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Email: ufaw@ufaw.org.uk
Website: www.ufaw.org.uk
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.

SCIENCE DIARY

THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE

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www.scienceinparliament.org.uk

Tuesday 8 November
Annual Lunch
Guest of Honour: Dr Mike Weightman, HM Chief Inspector Nuclear Installations and Executive Head ONR

Tuesday 22 November 17.30
Discussion Meeting
Is Scientific Freedom the Elixir of Civilisation?
Speakers: Professor Don Braben, Honorary Professor in Earth Sciences, University College London
Professor James Ladyman, Professor of Philosophy, University of Bristol
Professor Ben Davis, Department of Chemistry, University of Oxford
Professor David Delpy, Chief Executive and Deputy Chair, Engineering and Physical Sciences Research Council

Tuesday 13 December 17.30
Discussion Meeting
What is the Public Understanding of Risk?"
Speakers to be confirmed

Tuesday 24 January 17.30
Discussion Meeting
Peer Review: is it working?
Speakers to be confirmed

Tuesday 28 February 17.30
Discussion Meeting
Ground Engineering - why it matters
Speakers to be confirmed

Monday 12 March
SET for BRITAIN

Thursday 15 March
National Science and Engineering Week Seminar
Mathematics Matters, sponsored by the Council for Mathematical Sciences

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 Kavli Royal Society International Centre at Chicheley Hall, 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 David Attenborough, Margaret Atwood and Lord Rees FRS.

Highlights in the next few months include the following. Details of how to attend all these, plus information on many more events can be found on our website at royalsociety.org/events:

Wednesday 26 October 18.30-19.30
When will we understand Autism Spectrum Disorders?
The 2011 Rosalind Franklin Award Lecture by Professor Francesca Happé, King's College London at The Royal Society, London

Friday 28 October 13.00-14.00
Mary Somerville and the Empire of Science in the Nineteenth Century
at The Royal Society, London

Sunday 30 October 14.00-15.00
Fire and ice: What makes volcanoes dangerous?
Dr Hugh Tuffen, Royal Society Research Fellow: event organised by the Royal Society in partnership with Manchester Museum as part of the Manchester Science Festival 2011 at The Manchester Museum, Manchester

Monday 14 and Tuesday 15 November
Can solar power deliver?
Royal Society scientific discussion meeting at The Royal Society, London

Friday 18 November 13.00-14.00
Radiometers as buttonholes: the extraordinary material legacy of William Crookes
Dr Jane Wess of the Science Museum explores the material legacy of William Crookes, physicist, chemist, entrepreneur and spiritualist at The Royal Society, London

Monday 21 and Tuesday 22 November
Early anatomically modern humans in Eurasia: coping with climatic complexity
Royal Society Theo Murphy international scientific meeting at Kavli Royal Society International Centre, Buckinghamshire

Friday 25 November 13.00-14.00
Publishing Faraday's Candle
Professor Frank James, Royal Institution of Great Britain at The Royal Society, London

Monday 28 November 18.30-19.30
BioInspired Technology: From cochlear implants to an artificial pancreas using microchips
Professor Christofer Toumazou FRS, Imperial College London at The Royal Society, London

Monday 5 and Tuesday 6 December
The global nitrogen cycle
Royal Society scientific discussion meeting at The Royal Society, London

Wednesday 7 December 18.30-19.30
Repairing the code
The 2011 Royal Society Francis Crick Lecture to be given by Dr Simon Boulton from Cancer Research UK at The Royal Society, London

Details of these, and further events in press, will be available on our website at royalsociety.org/events

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THE ROYAL INSTITUTION

21 Albemarle Street
London W1S 4BS.

All events take place at the Royal Institution. For information and to book tickets visit www.rigb.org

Friday 28 October 20.00-21.15
How to make and repair muscles
Peter Rigby, Chief Executive. Institute for Cancer Research

Tuesday 1 November 19.00-20.30
The better angels of our nature: the decline of violence in history and its causes
Is violence really on the decline? Steven Pinker shows that violence within and between societies – both murder and warfare – has actually declined from prehistory to today.

Friday 4 November 19.00-20.30

Leonardo and Mona Lisa. Why?

Martin Kemp will discuss what is arguably the world's most famous painting.

Tuesday 8 November 19.00-20.30

The Serendipity Engine

The Serendipity Engine is a physical manifestation of theoretical and technological interventions that can be used to enhance serendipity on the World Wide Web.

Wednesday 16 November 19.00-20.30

Thinking fast and slow

Two systems drive the way we think and make choices: system one is fast, intuitive, and emotional; system two is slower, more deliberative, and more logical. Nobel Prize winner Daniel Kahneman will argue that only by understanding how the two systems work together, can we learn the truth about the role of optimism in opening up a new business, and the psychological pitfalls of playing the stock market.

Friday 25 November 20.00-21.15

The science and politics of climate change

Sir David King, Director of the Smith School of Enterprise and Environment at the University of Oxford and former Chief Scientific Adviser and Head of the Government Office of Science, will present his expert perspective on the challenges climate change poses to both science and politics.

ROYAL PHARMACEUTICAL SOCIETY

events@rpharms.com
Tel: 0845 257 2570
www.rpharms.com

Thursday 10 November

Blue pill, pink pill? Does gender matter?

In partnership with the National Association of Women Pharmacists and the Medical Women's Federation
at the Royal Pharmaceutical Society, London

Monday 14 – Wednesday 16 November

Tabletting technology for the pharmaceutical industry

In association with the Academy of pharmaceutical sciences
at the Moller Centre, Cambridge

THE LINNEAN SOCIETY OF LONDON

Burlington House
Piccadilly
London W1J 0BF
Tel: +44 (0)20 7434 4479 ext 11
Visit www.linnean.org for further details
Unless otherwise stated events are held at the Linnean Society of London and are free and open to all

Thursday 17 November 18.00

The Linnean Society of London Annual Debate: "This house believes that genetic modification is more of a threat than a promise". Motion proposed by Lord Peter Melchett, motion opposed by Christopher Warkup, organised by Andrew Sheppy FLS.

Thursday 24 November 10.00

The Chagos archipelago: the world's largest Marine Protected Area

A joint day meeting of the Linnean Society of London and the Chagos Conservation Trust supported by Pew Environment Group, organised by Professor Charles Sheppard FLS
Registration required, registration fee £30, download booking form from www.linnean.org

Friday 2 December 18.00

Smashing species: Joseph Hooker and Victoria Science

Dr Jim Endersby, Founder's Day Lecture

Thursday 16 February 2012 18.00

Biodiversity and Parks: Protecting the Best Places

Charles Bescanson

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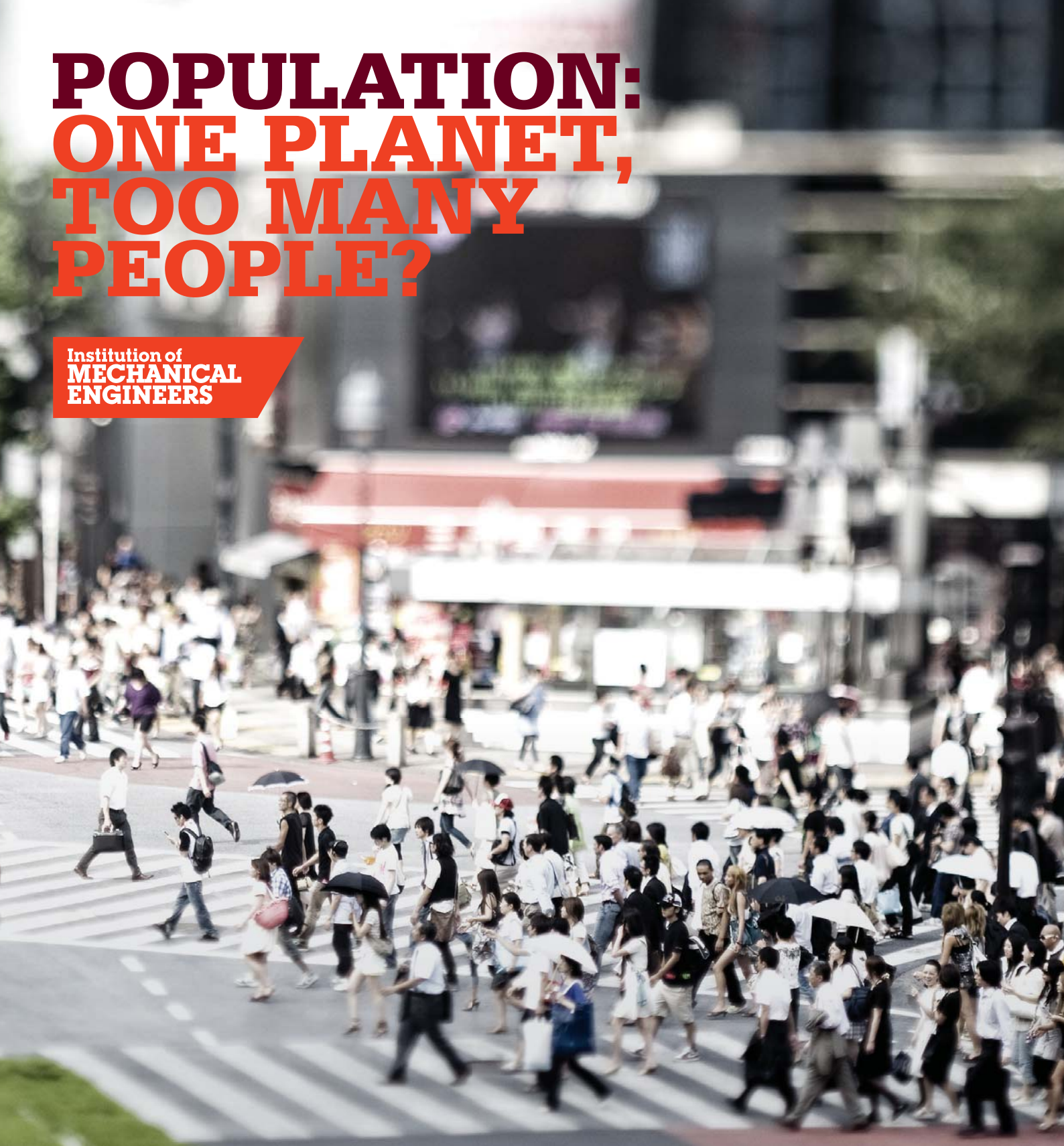
POPULATION: ONE PLANET, TOO MANY PEOPLE?

Institution of MECHANICAL ENGINEERS



POPULATION CHALLENGE FINALS

22 NOVEMBER 2011
3.00PM–5.00PM

GRAND COMMITTEE ROOM
WESTMINSTER HALL

Five international teams of young engineers have reached the finals of the Institution of Mechanical Engineers Population Challenge. Their task is to present a sustainable engineering solution that will help resolve challenges related to food, water, urbanisation and energy in their country.

Judged by an international panel of experts, their solutions will be used as part of the Institution's contribution to the UN Earth Summit 2012 'Rio+20'.

To meet the teams and hear these innovative solutions by the next generation of engineering talent, contact Penny Bosman on **020 7973 1259** or email **p_bosman@imeche.org**

Improving the world through engineering